A FIELD OF POSSIBILITIES

Designing and Playing Digital Musical Instruments

Per Anders Nilsson

Beam Stone, from left: guest musician Evan Parker, Per Anders Nilsson, Sten Sandell, and Raymond Strid. Photo: Mattias Petersson.

Abstract

This thesis focuses on a set of digital musical instruments I have designed and developed with ensemble improvisation in mind. The intention is not to create a universal improvisational instrument, but rather to create a set of instruments which each realize one musical idea. My research addresses the meaning and relations between activities in two stages, what I call "design time" and "play time". In short, *design time* is conception, representation, and articulation of ideas and knowledge outside of chronological time, whereas *play time* takes place in real-time and concerns bodily activity, interaction, and embodied knowledge. In this work aesthetics play a crucial role, and here signify what is important for me. At design time my aesthetic preferences guide the design process, whereas in play time, a subjective aesthetic tenet is that musical improvisation has strong similarities to gaming and play. One hypothesis states that choices made during the design process at the development stages of a digital musical instrument significantly influence ensemble improvisation and musical results at play time. A digital instrument in this work constitutes a field of possibilities, which in play actualizes the aesthetic decisions of its designer, and in cases where the designer and player are one, during play there will be a double influence: directly through the player's actions, and indirectly through the nature of the instrument.

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There is something great about doing things twice because it's never quite the same the second time.

Cornelius Cardew

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Preface

As long as I can remember, I have created and inhabited imaginary worlds. When I was a kid I made up structures and rules for my toy cars creating parking places and one way streets, but I also distinguished between work time and leisure time, in the former playing with various kinds of trucks, and in the latter with sports cars. My miniature railway also kept me quite occupied, especially in wintertime, and of course, sports like ice hockey and soccer offered ready-made imaginary worlds as well. As an improvising musician, I have carried on this interest, and the creation of rule systems has always been important in my music. When I did my master thesis ten years ago, I initially aimed to investigate musicians' behaviors and experiences in relation to applied rules. For various reasons I instead came to write about a sound installation of mine, which by the way catalyzed my transition from being a saxophone player into an electro-acoustic improviser. In this thesis, however, I return to imaginary worlds and music rules systems.

As I see it, all music contains explicit and implicit rules. In this work, the instruments under discussion act as the rules, and by themselves form an imaginary musical world. One question I often have posed myself is: what is it in soccer and other popular sports that attract people? I mean, twenty-two players running and kicking a ball seems meaningless, nevertheless it attracts millions of spectators and TV watchers each week around the globe. Philosophers such as Hans-Georg Gadamer and Johan Huizinga, as well as the writings of several game designers, have convinced me that play in all forms are models of the world, and are irreducible and autonomous phenomena. To play is a natural human need and behavior. Games and sports allow us to understand who we are and the relations between us, as well as our relation with the environment. Also, according to these authorities, art is also play, and what can be said about play can be said about music. I claim that the meaning of improvisation is to improvise; we play for the sake of playing. In this thesis I defend the right to play in a time where utilitarian thinking dominates.

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Participating musicians, particularly Beam Stone's Sten Sandell and Raymond Strid, who also contributed with valuable feedback. Saxophone player Evan Parker who released Beam Stone's CD on his label PSI. Peter Janson, a double bass player who I realized was the role model for one of my instruments, the Walking Machine. Susanna Lindeborg and Ove Johansson in the group Natural Artefacts. However not represented on the enclosed DVD, a substantial part of development and evaluation of discussed instruments was done in that group. I also wish to thank Ove for being my saxophone teacher and mentor.

Opponents at the stage seminars: Sven Andersson, Rolf-Inge Godøy, Sven-Eric Liedman, Christian Munthe, and Andreas Engström. Eva Nässén, coordinator of research at Musical Performance and Interpretation at the Academy of Music and Drama. Teachers in courses: Anders Lindseth, Christine Räisänen, and Karin Wagner. Members of the research project (Re)thinking Improvisation at Lund University, which in addition to my playing partner and concept contributor Henrik Frisk consists of Karin Johansson, Sara Wilén, Stefan Östersjö, Thanh Thuy, Marcel Cobussen, and Håkan Lundström. Erik Jeppsson, videographer, audio recordings, and discussion partner. Anders Bryngel video recording and editing. Åke Parmerud, composer, a long-term friend, and contributor of ideas to my instruments.

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Lastly, I thank my family, particularly my wife Gun for her divine patience, support, and encouragement during these years, without her I would possibly not have made it, our son Arvid and his wife Caroline, my mother Doris, and father Per who passed away 2009, and not least our first grandchild Lova.

Per Anders Nilsson,
October 2011

Preamble

Point of Departure – Mapping the Thesis

This dissertation resides within the realm of academic artistic research. The central matter is a set of digital musical instruments I have designed and developed with ensemble improvisation in mind. My intention has never been to create a universal improvisational instrument, rather, each instrument is made under the motto – one instrument, one idea. A driving force in designing new digital musical instruments was due to a desire to renew improvisation on a personal level, to a certain extent caused by a fatigue in my long-term practice as a saxophone improviser. Bringing electroacoustic music tools into improvisation offered a thrilling challenge.

Personal aesthetics is important in this work, and in short signify what is important for me. Aesthetics acts as guiding referents during the design process, as well as when improvising in context.

In order to facilitate real-time handling and flexibility in my system, a modular approach is utilized; a number of instrument modules are gathered and interconnected within a common host application, which together make up a hyper-instrument. Instrument modules discussed in this work are divided into main instruments, that is, the *exPressure Pad*, the *Granular Machine*, the *SyncLooper*, and the *Walking Machine*, control instruments, which are the *FourToThree* and the *Groover2*, and finally a number of effects processors and readymade software that is integrated within my hyper-instrument.

All musical instruments have idiomatic features, that is, typical playing behaviors that an instrument *affords* its player. Given that a multitude of musicians have played traditional acoustic instruments in different genres over many years, those features has been so integrated into our culture that we barely notice them. In improvised music a musician's personal playing style often overshadows an instrument's idiomatic qualities, however, many improvising musicians deliberately explore and exploit idiomatic features in employed instrument.

Idiomatic features in a traditional acoustic instrument are given and bound to physical laws by means of its construction, whereas idiomatic features in a digital musical instrument are rather made up than given; it is, in principle, possible to create whatever instrument comes to mind. Digital technology is not constrained to physical limitations, but requires precise instructions, which means that an idea must be exactly articulated and translated into appropriate computer commands in order to be implemented. Inherent properties of tools employed, such as software and interfaces, will have a direct impact on digital instruments.

In this work I make a distinction between activities at *design time* and *play time*, and one aim with this project is to scrutinize relations between those activities. Design time is outside time activity, concerned with conception, representation, and articulation of ideas and knowledge, whereas play time deals with embodied knowledge, bodily activity, and interaction in real-time.

After initial implementation, the development of a digital musical instrument proceeds in a stepwise process; in reciprocal action between design work and play, a new instrument gradually takes shape. However, this process never ends, and most instruments discussed in this work are continuously fine-tuned in order to suit different musical situations. In the formation of a new digital musical instrument an instrument maker must articulate ideas and personal knowledge in the process; a personally designed digital musical instrument always mirrors and mediates something of its designer's aesthetic preferences.

Obviously, the feeling of playing a digital musical instrument is a consequence of its design, but by being both designer and player it is possible to deliberately control and fine tune the properties of such an instrument to suit personal taste and current context.

I also claim that the goal and purpose of improvisation is to improvise. By this I mean that the driving force in my music making is about interaction with the environment in real-time, to make up things on the spot, to be in the midst of a collective creative process. Musical output is important as well, however, primarily I see it as a product of activity and interaction, which in turn depends on current conditions.

The included DVD that contains a number of recorded improvisations has two purposes of equal importance. Enclosed examples can be seen as standalone artifacts, which have to be experienced from an aesthetical and musical point of view, before and beyond verbal formation of concepts, as well as providing examples of matters and concepts discussed within the text.

RESEARCH QUESTIONS

My hypothesis states that choices made during the design process at developmental stages of a digital musical instrument significantly influence ensemble improvisation and the music produced. I assume that an instrument mediates the implemented aesthetical ideas of its designer, and given that designer and player are the same person, during play a double influence may be obtained, in direct interaction, and indirectly through the nature of the instrument. With reference to digital musical instruments presented in this work, reflecting two perspectives, my research questions are:

- How do the aesthetic choices made during the process of designing my digital musical instruments relate to the particular structure and capabilities of those instruments?
- How may a personal aesthetic that shapes the design of digital musical instruments relate to playing behavior, interaction, and musical output in ensemble improvisation?
- How do these different connections, provided that they do occur, connect to each other?

FIELD OF RESEARCH

I assume that research and exploration is a normal and necessary activity among artists. Produced artifacts and artistic practices are the result of a preceding and underlying process, which presupposes and triggers artistic output. Artistic research can be many things: it may start from a conceptual idea, society, natural phenomenon, practicing on an instrument, experimenting with new techniques, influences from peers and other art forms, coincidences, etc. In addition, matters such as technical and theoretical skills, personal experience, taste, and artistic context coincides and play a crucial role in the embodiment of an artwork.

Academic research within the arts, as I see it, aims to methodologically reveal and reflect relations between applied concepts, research process, and artistic outcome, which are then communicated in appropriate ways. Artistic research is still a young discipline, at the Faculty of Applied and Fine Arts at University of Gothenburg Sweden, it formally started in 2001, however there have been attempts to integrate art practices and research previously. One such attempt is a forerunner called the KKFU[1] program at the Musicology institution at University of Gothenburg that started early '90s.

Artistic research is practice-based research, a broad field that employs many methods, theories, and attitudes aiming to methodologically reflecting and investigating art, art practices, and processes. This work is about music and applies methods, concepts, inspiration from a blend of music practices and theories, the field of interaction design, and computer music. Music sources consist mainly of African-American grounded improvisation traditions, as well as avant-garde and experimental Western music. Interaction design influences come from two different traditions: on the one hand architecture and industrial design, the latter in its aspect of dealing with the design of interactive electronic/computer-based products; and on the other Human Computer Interaction, HCI, which connects to experimental psychology and computer science in the '70s. Computer music is an interdisciplinary field of research as well, which traces back to information theory in the '50s. In this context, I will emphasize the significance of tools, such as musical instrument and computer software, whose immanent properties by themselves have a major impact in produced artifacts. Finally, it is important to point out that applied theories are tools too, which in this work serve a multifold of purposes: as a means of understanding and conceptualizing my own practice, as active agents within the artistic practice itself, and means of communication.

1. Artistic Creative Research Education (Konstnärligt kreativ forskarutbildning).

Context of Improvisation

A FIELD OF POSSIBILITIES

To develop a new musical instrument is not an end in itself, like putting together a miniature aircraft model where the tedious assembly work is the goal, rather, the goal with digital musical instruments discussed in this work is first and foremost to be used in a context. Therefore, in order to reveal and understand the meaning of presented digital musical instruments, current context must be understood and taken into account. Improvisation is complex environmental interaction, whose outcome is influenced by a vast number of factors. What kind of processes have presupposed, and what conditions will direct an upcoming improvisation? Working as an improvising musician for almost forty years I have gained a lot of experience in this field, both as a saxophone player, and in recent years playing digital musical instruments. As a presupposition in this work, I will here briefly outline what I consider essential contextual factors.

I assert that the most important factor is the group, the improvising ensemble. Common agreements within a group about matters such as style, repertoire, and general approaches make up a musical identity; they determine a frame of playing behavior and ways of interaction. The makeup of the ensemble is crucial: individual players have a major impact on music produced since chosen instruments and personal playing style of participant players is effectively part of the identity. A replacement in one position can change a group's identity significantly.

All improvisation contains sets of predeterminations, some are explicitly expressed, while others are implicit: an improvisation can simply be melodic embellishments, or perhaps prescribe a harmonic and rhythmic frame, while others use abstract sets of instruction such as graphics or text, and finally there are free improvisations without any explicit determinations.

Playing spaces also have an impact; a church gives a significantly different outcome compared to a small club, and the audience influences improvisation as well.

Evidently, a huge number of factors make up current conditions: for the improvising musician, the task is, through a given instrument, to explore and exploit the given situation. Current conditions constitute *a field of possibilities*[2] that a singular improvisation actualizes but does not exhaust.

2. A term coined by Belgium composer Henri Pousseur (1929–2009), further discussed on page 107.

IMPROVISATION ENSEMBLES IN THIS WORK

Integrated in the development of my digital musical instruments are a number of improvisation ensembles, mainly duos and trios. There is one ensemble in particular that constitutes the playground in this work, which is Beam Stone. Another ensemble, duo pantoMorf, has been the platform for developing one particular digital musical instrument. In various ways, each and one of these ensembles contributes to, and is effectively part of the development of instruments presented and discussed in this work.

Beam Stone

Beam Stone is an improvisation trio that consists of myself, digital musical instruments; Sten Sandell, piano, voice, electronics, and Raymond Strid; percussion. Beam Stone was founded in October 2006, but all three members have encountered and/or cooperated with each other in different constellations and conditions since the late '70s. The main reason for the group's creation was because its forerunner, Nilsson/Sandell Duo,[3] decided to expand possibilities in terms of potential sonic palette and musical interaction. The choice of Raymond Strid was deliberate, as his style of playing and musical ideas was judged to fit well into the context. Sandell and Strid have worked extensively together with saxophone player Mats Gustafsson in the trio Gush, however, Beam Stone is a completely different entity, built upon unique concepts. From an information text on Beam Stone:

> The aim with Beam Stone is to explore sonic territories with the guidance of different pre defined concepts. The music may be described as a crossover between electroacoustic music, free improvisation, noise, ambient and contemporary art music. All kinds of sounds, 'musical and non-musical' are used as source material that eventually will be treated, kneaded and developed acoustically and electronically. Each sound his its own narrative, and get its meaning in relation to actual context.[4]

3. A duo with the author Per Anders Nilsson, digital musical instruments, and Sten Sandell, piano, who practiced *musique concrète* in real-time, and exclusively used the piano as sound source, directly and electronically manipulated. The duo has released one CD (Nilsson and Sandell, 2004) and given many concerts in the period 2003–2005.
4. Music genres and traditions that are considered important are presented and further discussed in the Design Time Aesthetics section. Here I only briefly discuss the musical direction of Beam Stone.

Beam Stone started with at least two aims in mind; first and foremost driven by a will and intention among its members to collectively create and develop improvised music; and secondly by means of serving as a kind of playground for my research project. However, I will stress that artistic goals overshadow academic considerations, e.g. that all concerts given by the trio hitherto have been done in public at venues, e.g. clubs and/or music festivals, that normally present this type of music.

duo pantoMorf

duo pantoMorf consists of composer, musician, and researcher Palle Dalsthedt and me, we describe our music as such:

> duo pantoMorf perform improvised electronic music as musicians, NOT looking like we check our email on stage. Our main rule is: if we take our hands away, the instruments go quiet. We use no fancy sensors or esoteric gestural controllers, but very basic stuff that we know well how to play. But we develop new ways of playing them, and – most important – new ways of mapping them to sound, using carefully designed sound engines that allows fingertip control, while retaining a vast sonic potential. Every sound relates to and comes directly from a physical gesture by the player, which makes a huge difference for the audience. There are no ongoing pre-programmed processes, and all is free improvisation, mostly non-beat based. If there is a beat, it is played by us.

The immediate reason to form duo pantoMorf was to create a platform for collective development of a new digital musical instrument aimed for improvisation, eventually named the exPressure Pad. The main question was: How can we explore and control complex electronic sound spaces in improvisation, retaining the millisecond interaction that is taken for granted in acoustic improvisation, but has somehow got lost in electronic music? In order to evaluate that instrument we considered it of great importance to encounter listeners in public concerts. However, I am keen to point out that the aim with the duo first and foremost concerns artistic aims. The music of duo pantoMorf is so intimately intertwined within possibilities and properties of our digital musical instrument the exPressure Pad itself that it is difficult to distinguish between external concepts and instrumental features.

LIMITATIONS

Improvisation, as practiced within the context of this thesis, has its roots in jazz music and offspring styles and directions such as free jazz and free improvisation, in addition to influences from western experimental and avant-garde music from the post World War II period. Therefore, organ and baroque music improvisation will not be covered, neither will improvisation from non-western cultures, except some single cases of direct influence. Furthermore, this work discusses musical instrument taxonomies, but it is not an attempt to make up a general taxonomy of digital musical instruments, or complete and coherent theories of instrument design and improvisation per se. Though design and interaction design play a major role in this work, it is not a thesis about design or interaction design theory either. Rather, I apply concepts from the design field on musical instrument design and music improvisation.

Personal Matters

At the turn of the millennium I found myself at a crossroad regarding the future as a musician and music creator. I had been a practicing improviser on saxophone since the early '70s, and, in principle, practiced the saxophone daily in order to maintain and develop playing skills. This means, in my case, at least 25 000 hours in the practice room, plus participating in countless rehearsals and recording sessions, and attending concerts both as a performer and as listener. Not to forget, the many days spent in the touring bus, and not at least, waiting. What had come out of all this spent time? I had been a fairly good improviser on the saxophone with a distinguished personal sound and playing style. Moreover, it had brought me to many places; given me a lot of friends, a lot of unforgettable moments, and not to neglect, the joy of improvising, the joy of being part of an improvising group, and the joy of collectively working to achieve common goals. Put together, I had become a skilled and experienced improviser, and an accepted member in a community of improvisers.

As a means to survive, I have upheld a part-time position as sound engineer and later as a teacher in such matters at the university level. I became interested in electro-acoustic music, eventually I learned and developed its craft and aesthetics, and started to compose and taught in this field. A peak in my career as composer of *acousmatic*[5] electro-acoustic music hitherto, occurred when I was invited to work at the GRM[6] studio in Paris, and in a public concert at Radio France in 1999, my piece *La Gamme voiture XM* was presented.

Furthermore, in the mid '80s I studied saxophone, music theory, and electro-acoustic music at The School of Music at University of Gothenburg for four years in order to improve musical skills. Among many things we encounter, I will highlight one piece of music that made great impact, that is, Messiaen's *Mode de valeurs et d'intensités* from 1949. Particularly, I found the idea of making up a set of rules that controls event generation amazing. I started to experiment with this concept by making up rules in which dice tosses decided each event, a procedure most related to American composer John Cage, but I have to admit I was not so familiar with Cage's methods at the time.

5. When a listener can only hear, but not see, the sound source. A topic further presented in the Perception in Play chapter.
6. Groupe Recherche Musical.

However, from my first encounter, I had a vision of integrating acoustic instruments and electronic devices in an improvisational setting. Some attempts I did with modular synthesizer systems were promising, but given that the equipment was installed in a studio, and not possible to bring on the road, it did not work. With the introduction of MIDI, digital music technology becomes available for everyone: new synthesizers, the digital sampler, and the digital sequencer offered novel possibilities. However, real-time capabilities were still limited to, in principle, playing the keyboard, despite the fact that some software offered real-time selection and triggering of pre-made sequences.

My music making was pushed into a new direction when the software *Max*[7] was introduced on the commercial market in the early nineties. The real-time capabilities of Max combined with digital sampling technology, despite the limitations of MIDI, opened new possibilities. I started to experiment with musical rule systems in order to generate musical structures, such as Messiaen's Mode de valeurs… described above, but now the tedious procedures with dice were automatically handled by the software. In particular, chaos equations grasped my interest, at the time a popular matter. I find the concept of dealing with initial conditions rather than the outcome fascinating. The idea to set up a rule-system where a small change in initial conditions may cause a big difference seemed applicable for real-time control of a digital musical instrument. Among different applications, I made up a virtual rhythm section, *The Virtual Chaos Band*, which consisted of bass, drums, and piano. The outcome of each instrument was generated by a recursive chaotic equation, so-called *Julia Sets*, and transmitted as MIDI-events into a sampler. An initial condition of the equations, as well as parameters such as density and tessitura was controlled in real-time from a MIDI pedal-board while I played the saxophone. Examples of music produced can be heard on the CD *Random Rhapsody* (Nilsson 1993), whereas the background to the project is discussed in Magnus Eldénius's (1998) thesis *Formalised Composition on the Spectral and Fractal Trails* (p. 137), and in addition included in *Hyper Improvisation*, by Australian improviser and biochemist Roger Dean (2003, pp. 115–6). What I did in this period was to create a virtual improvising group, an environment for the saxophone, and by no means a playing instrument. In the late nineties Max became Max/MSP, an extension that offered real-time manipulation of digital audio on personal

7. Max is an object oriented and real-time operated music software developed at IRCAM in Paris (Institute Recherche et Coordination Musique Acoustistique) at the '80s.

computers. Finally, a possibility to process audio in real-time was at hand.

Again, at the turn of the Millennium I found myself in a crisis in the ancient Greek interpretation of the word, in a crossroad. I had mastered two practices: firstly improvising on the saxophone, and secondly electro-acoustic music composition, as well as some experiences integrating them. In addition, I had knowledge about music theory, including formalized composition and other contemporary music concepts. At the time, I felt that my saxophone playing did not developed any more; I just practiced and played my habits, the already known. To be honest, I was fed up with the daily practicing routines, which more or less had controlled my life for thirty years, and as a consequence my family's life as well. It was simply not fun to practice any more. A further aspect was that I had made a career as a teacher in electro-acoustic music composition in the academy, and was not at all dependent on the saxophone in order to make a living. With the introduction of artistic research as a new research field in the academy, new possibilities opened. A commission for an interactive sound installation, *Ergo:*, was the subject of my Master's project, a project that gave me a reason to thoroughly investigate real-time audio manipulation in Max/MSP, as well as problematizing aesthetical matters. The positive experiences from Ergo:, both from working with the installation itself and reflections made within the Master's thesis, was a tipping point: I abandoned the saxophone and devoted myself to develop a series of digital musical instruments aimed at improvisation. In order to experiment with those new instruments I initiated two improvisation ensembles, Natural Artefacts, and somewhat later Nilsson/Sandell Duo. Both these constellations can be heard on CD (Nilsson 2001, 2004, and 2005). By the time I was accepted as a doctoral student in 2006, the following conditions were met: a set of personally designed digital musical instruments at my disposal; a personal playing style and sound; a group of musicians to work with; a record of performances; and a number of CDs that feature my instrument. In short, I had established a new musical identity as an electro-acoustic improviser.

RELATIONS TO MY INSTRUMENT: THE SAXOPHONE

When I started to design digital musical instruments discussed in this work, I had played the saxophone for more than thirty years in various settings of improvised music, mostly in small groups. This means that I had developed a high level of musicianship, which includes matters such as instrument techniques, music theory, personal playing style, and personal aesthetics.

However, I still remember the very first time I put a saxophone mouthpiece in my mouth, more than 40 years ago. The uncertainty of what to do was total: the form and pressure of the lips, the shape of the mouth cavity, the position of the fingers, etc. The first sound that came out was not pleasant. It sounded ugly and the feeling in the mouth wasn't that pleasant either. The immediate reaction was that it would never work! The commitment of learning to play was so strong, however, that it overrode all the initial difficulties.

The choice of the saxophone – why? During my childhood music became very important, mostly as a listener of records. Eventually I decided to start playing an instrument myself because it wasn't enough just to listen. Not surprisingly, the guitar became the focal point for my attention, but I never succeeded to play like the pop and blues heroes at the time. The fact that there were no role models or musicians around that could help me is a plausible explanation. In the late '60s I became a blues fan and by coincidence decided to try the saxophone in a blues context. After the initial difficulties were overridden I understood that the saxophone suited my musicality and talent better than the guitar. Eventually I started to explore the saxophone literature and discovered jazz. Jazz giants like Charlie Parker, Ornette Coleman, Miles Davis, John Coltrane, and Wayne Shorter became my new heroes. At the beginning of the '70s I found an old 78 rpm record in our neighbor's cellar, namely *Walking Shoes* by Gerry Mulligan. I was blown away by the beautiful sound of the baritone saxophone and it became my main instrument as soon as I could afford one.

The Instrument as an Object

After a few years of practice my relationship with the saxophone became very intimate; I would say that the "object" saxophone was as interesting as the music. One subject of particular interest was the mouthpiece and the reeds, the core of the sound production system. A personal warning: do not mention the word "mouthpiece" to a saxophone player; he/she will never stop talking about it! In addition, matters like the type of pads, adjustments and changes of the clefs positions, pros and cons of different necks were also important.

Although, to my great surprise I discovered that some saxophone players didn't seem interested at all in their instrument, just as long as they worked properly. When asked about their mouthpiece, they respond, "just a minute, I'll go check". I recall an interview in Down Beat at the beginning of the '80s where the saxophone player Joe Henderson said that he still used the original Selmer C mouthpiece that was delivered with his instrument. Such a distanced relationship with an instrument was difficult for me to understand at this time. According to my point of view, a total devotion to the instrument was the only possible approach. I will also argue that a close relational approach is very common. I still remember a situation with Gilbert Holmström and Ove Johansson, two of the most prominent saxophone players in Gothenburg. They had placed themselves on two chairs in a small practice room with their tenor saxophones placed on two stands, almost as a throne. The two musicians quietly stirred at their instrument, interrupted by some comments about features of their instruments now and then. When I entered the room by coincidence, I felt like I stepped into a holy rite, only open for initiated saxophone players. As a young saxophone player, seeing two role models in a situation like this, confirmed and reinforced my own attitude regarding the instrument. Eventually, in encountering other saxophone players with different perspectives and notions, I realized that there was a great variety of approaching relationships between a musician and their instrument. None of them superior to the another with respect to the musical outcome.

Eventually, this very intimate relationship with my instrument became problematic. Too much time was spent on matters like testing mouthpieces and experimenting with reeds so that the music suffered. The solution to this problem was as surprising as it was welcome. At the time, I was experiencing asthmatic problems, something that influenced the saxophone playing badly. I decided to start practicing a sport in order to improve my health. Almost by coincidence road cycling became the choice of exercise. In addition to improved health, the bicycle itself became an object for my great passion and almost unnoticeably replaced the saxophone as the focused object. As a consequence, it became possible to maintain a more rational and distanced relationship to my instrument, giving the music itself much more attention. I then discovered that elite and professional cyclists have different relations to their bikes as well, very much like musicians to their instrument. Obviously, it seems natural that at least a number of us develop very close relationships with our tools and objects and a question open for future research, but it is beyond the scope of this thesis. I will further address relational topics in the sections about instrument and my computer-based instrument.

The Instrument as a Subject

In playing and performing situations however, the feeling of the saxophone as an object vanishes; the instrument, my body, the playing, and the music will fuse into one entity. An ideal that is almost impossible to achieve is the feeling that the instrument as an object disappears and becomes an integrated part of the body, sometimes expressed as a cliché: "when you are one with your instrument". In such situations it is possible to think or conceptualize music; the instrument plays the role solely of mediator of musical ideas. In such idealized situations time seems to stop, the room disappears and the fellow musicians are reduced to their musical sounds and gestures they produce; the only thing that exists is the musical space and me. In particular cases of involvement and concentration, it is possible to maintain such a distant attitude that it feels like watching your own playing. This mental state is often referred to as *flow*.[8]

8. A term coined by Mihály Csíkszentmihályi and discussed in a number of books, notably *Flow* (1996). However, it is not my intention to research flow experiences per se in this work, and therefore chose to leave this subject out.

The Structure of the Thesis

In this work, a set of digital musical instruments I have developed are at the forefront. In order to elucidate different perspectives of subject matter, aspects of designing, playing, and aesthetical impact of those instruments, a breed of theories and concepts from different fields are selected and utilized as tools for analysis and reflection. It is by no means an attempt to present a complete and coherent theory of either musical instruments, improvisation, or design per se.

The main body in this work is divided into nine parts, each mirror and elucidates different aspects of digital musical instruments. Eight of these parts are text chapters:

1. Preamble
2. Methodology
3. Design Time Aesthetics
4. Play Time Aesthetics
5. Perception
6. Instrument
7. Setting
8. Analysis and Discussion
9. DVD disc

Figure 1 outlines content, and from left to right, order of appearance in the book:

Overview of Content								
Lead In	---------- Framing ----------				Application		Result	
Preamble Mapping the Thesis	**Methodology** Methods Design Time/ Play Time	**Design Time Aesthetics** Musical References	**Play Time Aesthetics** Play and Game	**Perception in Play** Affordances	**Instruments** Taxonomies Mapping Instruments	**Setting** Ensembles Improvisation Concepts	**Analysis & Discussion**	**DVD** Video Recordings

Figure 1: Overview of content in A Field of Possibilities.

METHODOLOGY

This chapter describes methods employed in this work. Rather than bringing in an existing preformed research method, I chose to apply a method that departs from my normal artistic practices. I consider this research explorative: there is no hypothesis to prove, and evaluation of undertaken experiments give feedback rather than clear-cut answers. This project scrutinizes relations between two sides of music making, on the one hand activities at *design time*, which deals with activities out of time such as articulations of ideas, designing instruments, composing etc., and on the other activities in *play time*, such as playing and interacting with the environment in real-time. Personal aesthetics play a crucial role in this work. At design time, I implement subjective aesthetic values as properties in digital musical instruments, and at play time, I use these instruments in ensemble improvisation. The research method employed aim to reveal perceived qualities of four deliberately selected aesthetic dimensions in play time, in relation to the design of utilized instrument. The four aesthetic dimensions are: playing the instrument, interaction and musical roles, real and perceived degree of freedom, visual appearance.

This chapter opens with an overview of general conditions, which includes a brief discussion of personal aesthetics that imbue this work. Thereafter I discuss and exemplify the dichotomy design time – play time, succeeded by a description of employed research method in general, including a presentation of the four aesthetical dimensions. The concluding part treats design processes of instruments in this work.

DESIGN TIME AESTHETICS

What aesthetics, and what genres, traditions, and directions of music do I consider important in this work? Basically, a variety of music styles and directions with roots in African-American music are important, such as jazz, and free jazz, and in addition blues and rock music have had certain impact as well. In addition, certain branches of Western post Second World War II art music practices such as serial music and experimental music are also important, either musically, and/or as providers of concepts. Another matter is computer music. The idea to use computers in music making is not new, this field of research has existed for more than fifty years, and many concepts implemented in my instruments can be traced back to experiments undertaken within this field.

PLAY TIME AESTHETICS

By applying concepts from the field of play, game, and sports on music improvisation, it is possible to reveal new meanings and understanding of the subject matter. According to the literature referred to in this chapter, the will to play is inherent in human nature, play is irreducible phenomenon, it is autonomous movement, and play creates its own meaning. One main theme in this work is to scrutinize individual behavior and interaction patterns between participating players during improvisation that emerge as consequences of determinations made up at design time; either as agreements between players, and/or mediated through employed digital musical instruments of mine. I will emphasize here what I consider a novel approach in music analysis, which focuses on performers, and performing activity rather than music produced. By analyzing music compositions as if a game, it seems possible to reveal relations between applied rules, interaction patterns, and player preferences. I apply this concept on a selection of compositions that prescribes improvisation, as well as music included on the DVD.

PERCEPTION IN PLAY

How do we listen, and what do we listen for during play? An important concept in this work is *affordance*, a concept connected to American ecological psychologist James J. Gibson, and American psychologist and designer Donald A. Norman. In the theory *ecological listening* British musicologist Erik F. Clarke applies Gibson's ideas on sound and listening. In the world, we experience meaning according to what a perceptual object affords us, a chair affords sitting, and a glass of water affords drinking. In music, different musical instruments afford a certain playing behavior, a.k.a. instrument idiomatic. One particular improvisation ensemble affords a certain kind of playing, an open composition affords a certain playing behavior, different concert venues affords distinctive ways of playing behavior and interaction, etc. In general, I support an ecological top down approach to perception; it means that we perceive structure before details, which in turns imply that structure is inherent in the perceived object, and nothing we make up. Moreover, theories about perception with origin in phenomenological thinking are presented, such as the theory of object-horizons by French philosopher

Maurice Merleau-Ponty, and different listening modes by French music theoretician Pierre Schaeffer.[9] These ideas are also applied on my digital musical instruments such that tt elucidates how I intentionally change focus and zooming level when playing my instruments. Furthermore, by repeatedly being exposed to certain relations, for instance sequences and/or combinations of pitches, as melodies and sequences of chords typical for a genre, we become trained and used to that particular genre.

INSTRUMENT

What is a musical instrument? At a first glance a question simple to answer, but a closer look reveals that it is not and to a certain extant it is connected to a parallel question, namely, what is music. In this chapter, I discuss musical instruments by presenting some different notions and theories about criteria that define and categorize subject matter. Are there any significant differences between acoustic and digital musical instruments? A brief discussion treats the analog vs. digital, and tries to answer that question. Moreover, a presentation and description of concepts and terms that I use in my design work are included. Finally, the main part of the instrument chapter presents digital musical instruments I have designed. A thorough presentation is made of the complete digital musical hyper-instrument including background, implemented concepts, mappings, interface, GUI (Graphic User Interface), aesthetics behind, playing behavior, etc.

SETTING

In this chapter, I present and discuss participating improvisation ensembles, treating style and genre, musical identity, as well as performance practices. One section, called Controlling Improvisation, describes and discusses a variety of organizing concepts for improvisation employed in this work, such as freedom, constraints, and form issues in addition to performance

9. Regarding Schaeffer's (1966) main oeuvre *Traité des objets musicaux*, I mainly use *Guide des objet sonores* by French composer and theoretician Michel Chion (1983) as source of information. English translation of all quotes from Chion's book is made by John Dack (Senior Research Fellow, Lansdown Centre for Electronic Art, Middlesex University) and Christine North (former Senior Lecturer in French Language and Literature, Middlesex University). In direct quotes from Schaeffer's work, I put the original French in a footnote.

practices. In order to elucidate subject matter, references to appropriate passages on the enclosed DVD-disc are interleaved within the text.

ANALYSES AND DISCUSSION

This chapter presents analyses and synthesizes the result in this research project. The first sections treat general matters such as practicing and preparations, whereas the concluding section presents analysis and discusses the result in this project.

I claim that every improvisation musician regardless genre aims to develop a personal *style* of playing. Are there any significant differences between playing acoustic instruments and digital instruments? To develop a personal improvisation style takes time, regardless instrument, and is to a great extant a product of individual practice, among jazz musicians also known as *woodshedding*. One conclusion in this work asserts that practicing methodology on digital musical instruments is considerably different from practicing acoustic instruments.

Undertaken analysis employs the methodology outlined in the Methodology chapter. In short, it scrutinizes perceived qualities of playing my instruments in context in relation to its design. In order to systemizing the research, four predefined aesthetic dimensions frame the analysis. Furthermore, I outline what I consider significant contribution to the field of research, and finally, presenting ideas for further research based on the result in this work.

DVD

Improvisation is real-time activity, and subsequently has to be experienced as such, but a task difficult to arrange within the realm of this work. Therefore, in order to bring about music in this work, a number of deliberately chosen video recordings with Beam Stone, duo pantoMorf, and bass player Peter Janson are included. Enclosed DVD-recordings are done at public concerts with some exceptions and has two purposes, firstly to show what a public performance with those ensembles can be, as well as presenting my music, and secondly to be seen as examples of my instruments in action. In addition, the DVD presents experiments done in the studio: recorded solo performances with a few deliberately selected digital musical instruments of mine. Two additional tracks present video recordings where I present and demonstrate some of the instruments discussed in this work.

Methodology

To understand is to experience the harmony
between what we aim at and what is given,
between the intention and the performance
– and our body is the anchorage in a world.

Maurice Merleau-Ponty

Introduction

This work scrutinizes meaning and relations between activities at design time and activities at play time. In short: design time deals with conception, representation, and articulation of ideas and knowledge outside time, whereas play time deals with embodied knowledge, bodily activity, and interaction in real-time. A broader discussion of subject matter is presented further down in this chapter. This chapter presents and discusses utilized methods: the first part presents applied research methodology, whereas the second part outlines methods employed during the development process of discussed instruments.

This research connects to, and takes inspiration from the field of interaction design, a term first proposed by American interactions designers Bill Moggridge[10] and Bill Verplank[11] in the late '80s. Regarding design processes I mainly refer to Verplank, whose ideas I find inspiring and compatible with my own notions. According to Swedish researcher Jonas

10. Bill Moggridge is a founder of IDEO, one of the most successful design firms in the world and one of the first to integrate the design of software and hardware into the practice of industrial design, and is Consulting Associate Professor in the Joint Program in Design at Stanford University. www.designinginteractions.com/bill (August 2011).
11. Bill Verplank is an American designer and researcher. At Xerox from 1978 to 1986 he participated in testing and refining the Xerox Star graphical user interface [...]. He helped establish the Interaction Design Institute Ivrea and is a visiting scholar in haptics in the Music Department at Stanford University. www.designinginteractions.com/interviews/BillVerplank (August, 2011).

Löwgren,[12] interaction design relies on two traditions. Firstly on industrial design and architecture dealing with the formation of interactive electronic/computer-based products. The second interpretation is considered an extension of Human Computer Interaction, HCI, which can be traced back to experimental psychology and computer science in the '70s. However, game designers and game researchers show that interaction design concepts may be applied to non-electronic games such as Chess and Othello as well. One major assumption in this work applies concepts of interaction design in general, and game design in particular on music improvisation. Swedish game researchers such as Staffan Björk, and Sus Lundgren,[13] as well as British and American game theoreticians,[14] provide essential concepts in order to outline a play time aesthetics in this work. A central concept in this work is *affordance*; a term coined by Gibson (1986). Furthermore, Norman (1998) provides valuable insights and concepts of relations between decisions at design time, and the behavior and interaction it gives rise to at play time. Affordance is further discussed in the Perception in Play chapter. I am keen to point out that the meaning of the terms design and designer in this work goes beyond mere product development, rather, it deals with designing conditions for activity and interaction. I regard myself as a music designer rather than composer. In his book *On Sonic Art* British electro-acoustic composer and author Trevor Wishart (1966) suggests such a proposal:

> In the future it might therefore be better if we referred to ourselves as *sonic designers* or *sonic engineers*, rather than as composers, as the word 'composer' has come to be strongly associated with the organisation of notes on paper (p. 5).

A similar notion can be applied on music improvisation as well, in this work I show what may happen when playing with my instrument in context. It is beyond the scope of this work to discuss and problematize design processes in particular, neither to present a general and coherent theory.

This chapter elucidates methods employed, or in other words, describes the

12. Jonas Löwgren is an interaction designer, researcher and teacher. Currently employed as professor of interaction design at Malmö University, Sweden. www.interaction-design.org (August, 2011).
13. Interaction Design Collegium, Department of Computer Science and Enginering, at Chalmers University of Technology / University of Gothenburg, Sweden.
14. David Parlett, Jesse Schell, Stephen Sniderman, and others. See Play Time Aesthetics chapter.

way I usually work. Noteworthy to point out, applied research methodology is derived from and in many respects similar to my working method, however with modifications that aim to systemize the research. Moreover, this research is considered explorative: there is no hypothesis to prove, rather, aesthetic choices made at design time may be regarded as open questions, whereas undertaken experiments, to improvise in context with presented instruments, gives feedback rather than clear-cut answers. A series of video-recorded improvisations is presented on the attached DVD, which at the same time shall be seen as documented experiments, as well as standalone work of arts, outside verbal conceptions. Subsequent analysis aims to reveal possible connections and influences between design time decisions, interaction in play time, and musical outcome in those recordings.

Personal aesthetic preferences are a key concept that guide choices at design time and play time, and furthermore constitute the analytical framework in this work. A work of art is an aesthetic statement, and as soon as it goes public, it is open for discussion. It is worth noting that concepts of taste and aesthetical judgment have been subject to profound philosophical investigations, however, an in-depth discussion on subject matter in general is beyond the scope of this work, and therefore I restrict myself to discuss aesthetics from a personal point of view. As a general assumption in this work, the term personal aesthetical preferences, hereby aesthetics, signify what is important for me, and treats conceptions of how (my) music is organized, what it sounds like, and how and where to perform. In other words, it is about form, content, and context. Occasionally, when discussing general matters I use the term taste as well.

Aesthetics and taste are difficult matters to discuss, and every attempt risks being caught in circular reasoning: inherent aesthetics in instruments discussed in this work mirror my taste, while the design of those instruments in turn are based on my taste. Nevertheless, aesthetics dictates largely the outcome of artistic practices, and I attempt to point out at least some of the most significant aspects of my aesthetics. During the course of the years my taste has matured, and gradually become verbally accessible. Furthermore, I claim that my aesthetics is a product of sustained practice as an improvising musician, as well as composer and educator of electro-acoustic music.[15] In essence, my aesthetics is about to explore, re-use, refine, and to combine a limited set of existing prescriptive music concepts, rather than forcing the

15. For further details, see Personal Matters on page 9.

invention of new ones. A major aesthetic standpoint is a preference for the ambiguous before the clear-cut: minor before major, process before sonata forms, open chords before tonal cadenzas for instance. Another important factor states that it simply must be fun to play, and if it is, the musical result usually is interesting. Details regarding form, content, and context of my music are discussed throughout this work. Moreover, the Design Time Aesthetics chapter presents and discusses musical influences that play an important role in the creation of my instruments.

Research Method

A basic assumption of this work is that aesthetic choices made at design time during development of an instrument may influence interaction and musical outcome in play time. As a point of departure, there is a mutual relation between activities at design time and activities at play time. In order to improve and to refine an instrument under development, analysis and evaluation of the perceived experience in play time became the basis for further activity at design time, which was followed by new experiments in play time, and so on. In other words, in the reciprocal action between activities at design time and play time an instrument gradually takes shape. Further discussions in this chapter treat employed working method and design process.

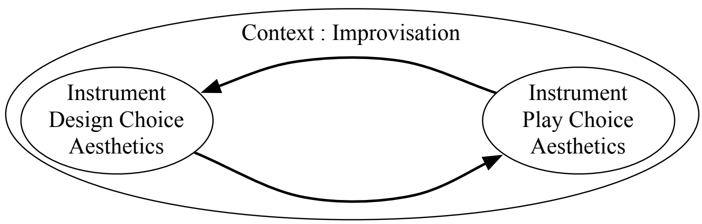

Figure 2: In reciprocal action between activities at design time and play time, an instrument gradually takes shape. Aesthetic choices play a crucial role at both stages.

To play in context with an instrument under development is compatible with undertaking an experiment, and at such occasions, it is possible to experience and evaluate qualities that guide future aesthetic choices during re-working and improvement at design time. However, in order to systemize and to make this research manageable, I have chosen to break down experienced qualities into four distinctive aesthetic dimensions as the basis for analysis, selected with the aim to cover what I consider essential instrumental and musical qualities. The four aesthetic dimensions are:

a. Playing the Instrument
b. Interaction and Musical Roles
c. Real and Perceived Degree of Freedom
d. Visual Appearance

Those dimensions are presented later in this chapter. Before proceeding, I would like to emphasize that analysis of proposed aesthetic dimensions are not scientifically validated; rather, analysis mirrors subjective experiences. This is a notion compatible to Swedish interaction design theoreticians Lars Hallnäs and Johan Redström (2006), who argue:

> Design is not science; its practice is not scientific. Designing things can never be a deductive correlate to empirical investigations. As design involves basic elements of interpretation and aesthetical choices there will always be hermeneutical gaps in all attempts to build a web of quantifiable science covering the design process. (p. 63)

In this research, the aim is not to describe each single part of the step-by-step development process in minute detail. Rather, analysis is applied in a limited number of cases with instruments considered "play-ready". The empirical material consists of selected sections in the enclosed collection of improvisations, recorded at "real" playing situations. The selection is subjective and done with an aim to find what I consider "typical" and interesting occasions. The aim of this research is to reveal relations and possible influences on interaction and musical outcome in improvisations at play time as a consequence of aesthetical choices made at design time. The reflections presented are based on analysis undertaken at subjective selections of a set of recorded improvisations with the four aesthetic dimensions as a frame of reference.

Play time aesthetics are not identical to aesthetics at design time: the intentional focus deals with interaction with the environment and musical outcome, rather than a focus on instrumental properties. As a basic aesthetic assumption, I equate music improvisation with game playing: a game as well as improvisation defines a goal, a playing space, and sets of open and hidden rules that frame the activity. This topic is discussed in-depth in the Play Time Aesthetics chapter.

In order to shed light of subject matter I occasionally intersperse quotations made by the Beam Stone members in this text. During the inauguration week in Gotland 2006, as well as in one occasion in Stockholm 2007, we recorded verbal comments and reflections regarding our music and performance practices.[16]

16. All quotations labeled "Gotland 2006" and "Stockholm 2007" are transcribed and translated by me. Swedish original is placed in a footnote.

DESIGN TIME – PLAY TIME

I distinguish between two modes of music making in this work; one is about conception, representation, and articulation, and the other mode is about what happens in the flux of time.

I call them *design time* and *play time* respectively, terms that are chosen because they relate well with the main subject in this work; designing and playing digital musical instruments. Design time, on the one hand, is outside time activity that deals with articulation and application of ideas and knowledge. On the other hand, play time is about real-time activity where interaction with the environment, embodied knowledge, and the present are at the forefront. Improvising soprano saxophonist Steve Lacy was once asked by composer and improviser Fredric Rzewski (2004), in 15 seconds, to explain the difference between composition and improvisation: "In fifteen seconds the difference between composition and improvisation is that you have all the time you want to decide what you say in fifteen seconds, while in improvisation you have fifteen seconds" (p. 267). A quote that pinpoints one important difference between design time and play time: during the composition process, which goes on at design time, a composer has time to select, test, listen, reflect and refine, while an improviser at play time must make all decisions on the spot. Lacy's statement, according to Rzewski, implies that the only difference between improvisation and composition is available time for decision making, which makes improvisation real-time composition, but he claims that it consists of two essentially different mental processes. This issue is discussed further down. One composer that has touched upon ideas compatible with my notion of design and play time is French-Greek composer Iannis Xenakis. In *Formalized Music* Xenakis (1992) discusses this dichotomy, and he claims: "Music participates both in space outside time and in the temporal flux" (p. 264). Moreover, in *No Sound is Innocent* British improvising percussionist Edwin Prévost (1995), while referring to British composer Cornelius Cardew as being both a composer and musician, talks about "the two modes of music-making" (p. 59). Finally, San Francisco based improviser, instrument builder, and author Tom Nunn (1998) distinguishes in *Wisdom of Impulse* between the *intellectual mind* and the *intelligent body* (p. 40). As shown, the idea of two modes of musical time is not unique. Rather, a number of writers have addressed this topic from different standpoints: from an improviser's point of view, in addition to Prévost, and Nunn, British improviser Derek Bailey (1992) in *Improvisation: Its Nature and Practice* Xenakis from a composer's position, whereas Cardew and Rzewski approached from both perspectives. In the following sections I will further elucidate, and clarify my standpoint, however, it is not my intention to make a comprehensive investigation of the subject matter.

How do design time and play time connect to each other? It is through the instrument. In *Instruments and the Electronic Age* Norwegian musicologist Tellef Kvifte (2007) discusses this subject. A certain action performed on a certain instrument results in a certain sound. Kvifte asserts: "the concept of playing technique, in its common usage, refers to what people do with their instruments to accomplish desired musical results" (p. 87). Moreover, playing technique is intimately bounded to music theory and music produced. Kvifte presents an image (Figure 3) that draws upon this:

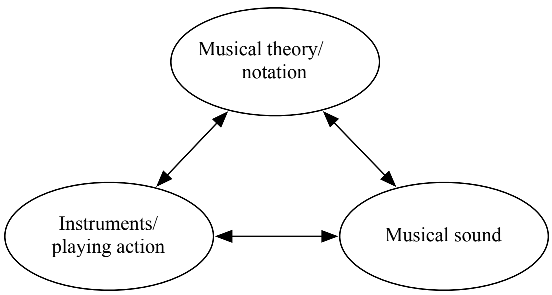

Figure 3: "A selection from the social field called 'music'" (from Kvifte, 2007, p. 88).

Kvifte argues about relations between instrument/playing, musical sound, and music theory/notation:

> The instrument and playing action are meaningful because of their relationship to sound and theory. The theory is meaningful because of its relationship to the sound and the instruments, and the sound is meaningful because of its relationship to the instruments and theory (p. 89).

To call a piano key "C", establishes a connection between music theory and instrument, since C is a theoretical concept, and by playing it on a musical instrument, we experience it as music. Kvifte claims that all musical cultures, and subcultures, acquire theories of music. As soon as someone classifies and gives names to sounds, it is music theory. All three elements in Kvifte's triangle are of equal importance, it is unthinkable to conceive music theory without music, or a theory without any kind of sound generation device. The output from any instrument must be understood as music, and as Kvifte asserts, a musician aims to experience music, rather than physical variables. Accordingly, it is only in relation to an instrument and to the activity of playing, that theories applied at design time are meaningful. Implemented theories and playing techniques are interdependent, and necessary to take into account when discussing my instruments.

Design Time – Composition

Design time is activity outside time, and is about expression, articulation, and application of ideas is based on personal experience and knowledge. Rzewski (2004) claims that the most basic form of composition is about transferring information from short-term to long-term memory, to memorize an idea and write it down: "This process of transference is also one of translation: reforming an impulse or feeling so that it can be expressed in some kind of symbolic language" (p. 267).

Furthermore, musical pre-conceptions such as scales, church modes, larger form matters, fugal structures etc. are outside time as well. Xenakis (1992) asserts: "One could say that every temporal schema, pre-conceived or post-conceived, is a representation outside time of the temporal flux in which the phenomena, the entities, are inscribed" (p. 264). This implies as well that repeated listening to a recorded improvisation reveals form matters, initially unknown. Prévost (1995) puts it this way: "Recording, which makes an improvisation available for repetition, classifies it: creating a form that could not have been imagined in advance" (p. 60).

Nunn (1998) asserts: "The intellectual mind accumulates knowledge through Education and problem-solving, and extends its own bounds through Imagination" (p. 40). According to Nunn, imagination is a vital property in (free) improvisation, so vital that it is sometimes taken for granted. It is about problem solving and/or emotional responses. We respond according to personal cultural experiences and education.

Pre-conceptions at design time aid a designer to structure and outline the imagined and intended object, whatever that is. By doing, testing, feeling, reflecting, and re-working a designer can keep on working as long as she wishes until the result "feels right".[17] while composing music with graphical symbols,

17. See discussion about design process of digital musical instruments further down in this section.

the entire structure is visible and accessible, time freezes, and it is possible to overview a piece of music entirely. A composer can arbitrarily jump between different passages in the piece, zooming in on details, or maintain an overall view. If we apply American music theoretician Curtis Roads's (2002) taxonomy time scales, it is feasible to gaze upon a work with respect to different time scales at will: the macro level deals with overall form, meso level with phrases, whereas sonic objects and to a certain extent micro level deals with single events.

What do dictionaries say about composition? Oxford Music Online states that composition is: "The activity or process of creating music, and the product of such activity," and explains the origin of the word, the Latin *composit-* and *componere*, which means to put together. The Swedish national encyclopedia (Nationalencyclopedin)[18] also refers to Latin, and states that composition is a: "term within music that contain both the art of composing, and the single piece of music" (NE on line, my translation). Moreover, Oxford Music Online defines improvisation as a situation "in which decisive aspects of composition occur during performance. The distinction hinges on what performers are expected to do in various situations and on how they prepare themselves to meet such expectations" (Oxford Music Online). Obviously, composition is both activity and an artifact, or product. In other words: "Composers remain in the frame of music-making even in absentia: this is their grip on the future" (Prévost, 1995, p. 59). Furthermore, a composition as a product regulates and prescribes a performance, and again with reference to Cardew, Prévost argues that the word composition refers "to possible *future* activity" (p. 60). A score allows and preserves a certain identity in upcoming subsequent performances.

Play Time – Improvisation

Play and improvisation is activity and interaction in real-time, it takes place in the present and there is no way to reverse time in order to make changes and refinements of the already performed since played is played: "In improvised music, we can't edit out the unwanted things that happen, so we just have to accept them" (Rzewski, 2004, p. 269). What is the salient feature of improvisation? Improvisation according to Rzweski: "this process has more to do with reflexes than language" (p. 267). In a music performance, a sequence of events

18. (NE online) Komposition, (lat. composi´tio ʼsammansättningʼ, ʼsammanställningʼ, ʼanordningʼ, av compo´no ʼställa sammanʼ, ʼsätta ihopʼ, ʼdra sammanʼ, ʼfoga sammanʼ, ʼordnaʼ m.m.) begrepp inom musiken som innefattar såväl konsten att komponera som det enskilda musikverket.

unfolds in real-time, a musician expresses and articulates directly with the body, by means of reflexes of embodied knowledge, through an instrument. In an essay about the human voice, Swedish-Brazilian philosopher Marcia Sá Cavalcante Schuback (2010) writes:

> Music is togetherness, simultaneousness, ecstasy; it can in itself be beyond and outside itself. It is the exterior's inner, and the inner's exterior. Music is the madness of continuity, a non-distance between body and reality. Musicians think with the hands, with the voice, with the body. It is happy hands to remind of Schoenberg's opera. They think in a more elaborate way than the discursive that goes on with terms and words. This is because body and soul is simultaneous, immediate, the moment's most intense presence. (p. 16, my translation.)[19]

Experiencing music, to play as well as to listen, is direct interaction with the environment, with all senses simultaneously. Play time is present time; it goes on at meso level, which is also compatible with notions of now (see page 130) It is not about thinking and reflecting in an intellectual way, rather, as claimed by Schuback, it is thinking and doing at the same time, thinking with the hands, with the body, with the mind. Doing is thinking, and thinking is doing. Improvising is to let the unplanned and unexpected happen. It is to be in the midst of the flux of time. According to Nunn (1998): "The Intelligent Body responds to the Personal Contexts of Training and Experience within Biological Context of the Limitations of the Body and Level of Instrumental Technique" (p. 40). In a play situation, we get the use of personal abilities and accumulated knowledge acquired of time, the intelligent body processes and reacts on physical stimulus immediately, before and beyond conscious perception, and lets things happen.

A music score is a set of instructions with the intention to guide and control activity during play. The more precise the score, the less room for improvisation, and vice versa. Prévost (1995) makes a distinction between the interpreter, and the (free) improviser:

19. The original: "Musik är samhörighet, samtidighet, extas, det kan vara i sig bortom och utanför sig. Den är det inres yttre och det yttres inre. Musik är kontinuititetens galenskap, ett icke-avstånd mellan kropp och verklighet. Musiker tänker med händerna, med rösten, med kroppen. Det är lyckliga händer för att påminna om Schönbergs opera. De tänker på ett mer elaborerat sätt än det diskursiva som sker med begrepp och ord. Detta på grund av att kropp och själ är samtidiga, omedelbara, de är ögonblickets mest intensiva närvaro."

> The musician is always the man (or woman) of the moment, hired to interpret or recreate the ideas that the composer consigned by way of marks, to paper. An improvisation, by contrast, demands total creativity involvement by the musician, with no reference to any 'composed' formulation (p. 59).

For instance, jazz standards are most often presented as a melody and a harmony skeleton, and it is up to performing musicians, in the moment, to outline a song by means of improvisation within given constraints. In contrast, a score from a modernistic composer such as Brian Ferneyhough contains very detailed and precise playing instructions, which give little room for improvisation. However, it is all about play regardless of the degree of detail in the instructions: for the improvising musician the task is to, on the spot, make decisions about the continuation, while a classical performer is aware of, and can prepare for future actions. An improviser relies largely on embodied knowledge. She must be prepared in order to be able to improvise, to be able to meet and take care of the unknown and emergent. Such preparation is done in the practice room,[20] and during the course of years, by means of practice and experience, a library of music behavior patterns is accumulated and embodied in the improviser.[21]

AESTHETIC DIMENSIONS IN ANALYSIS

When improvising in play time, an improviser explores and exploits an instrument in context,[22] and at design time focus is directed towards implementation and refinements of deliberately selected qualities of the instrument. During the development process efforts oscillate between activities at design time and play time: feedback gained at play time guides further choices in design time in a loop-like fashion. As discussed in the Instrument chapter, digital technology affords implementation of articulated ideas. On the one hand a computer forces a programmer to explicitly express an idea in minute detail in appropriate code,[23] but on the other it affords a great deal of

20. Practice is further discussed on page 274 in the Analysis chapter.
21. A topic beyond the scope of this work, and therefore not further discussed. For further reading, I refer to Pressing (1984, 1992, and 2002) who has done a great deal of research in this field.
22. Solo or ensemble play, primarily aimed to make music, not just mere tests of an instrument.
23. Here I refer to computer languages in general.

possibilities and freedom to tailor an instrument to suit the designer's taste. Because of this freedom, a piece of software mirrors knowledge and aesthetics of its designer to a certain extent.

What kind of feedback gained at play time is considered important at design time? What decisions at design time may influence interaction and musical outcome in play time? I have chosen to use four aesthetic dimensions as analysis categories, that I judge sufficient to cover important and necessary qualities of an instrument in play. In essence, these dimensions are divided in subjective experiences, contextual relations, issues of freedom and choices, and finally matter such as the look of the software and programming efficiency. It is worth noting that the aim of employing these dimensions is by no means to create a complete and general taxonomy of digital musical instrument qualities, rather to elucidate what I consider significant areas of qualities. The four dimensions are (without order of importance): a) playing the instrument, b) interaction and musical roles, c) real and perceived degree of freedom, d) visual appearance.

Playing the Instrument

To explain and to define the feeling of playing an instrument is not an easy task, but a matter most musicians recognize and usually have strong opinions about. According to my personal experiences, instrumentalists that play the same family of instruments use a professional vocabulary based on a mix of instrumental features and typical performing actions. This vocabulary can be difficult to understand for non-practitioners, possibly not the employed terms in themselves; rather, it refers to phenomenon only meaningful to practitioners of a particular instrument. Saxophone players can discuss the feeling of their instrument with other saxophone players. As an example, one major topic is the feeling of the reed: Judgments might state that a reed is hard, soft, buzzy, dead, open, locked, shows good or bad response, quality of resistance, etc., whereas more abstract judgments may assert that the sound is unfocused, with or without a kernel, or perhaps that individual notes release easy.

With instruments of mine such an instrument-specific vocabulary does not exist; there simply does not exists a community of players that play those instruments. Nevertheless, it is possible to discuss the feeling of playing those instruments. A controller such as a piano-type keyboard, a set of pads, a mouse, a gamepad, etc., can be chosen to control, "to play", a digital musical instrument; in principle any device with capabilities to transform human gestures into computer data can be used. One essential feature when playing a musical instrument is feedback: in reciprocal action a player's physical gesture gives rise to a sound, which is heard and evaluated, and in turn guides further actions ad infinitum. This topic is further discussed in the section about iterative processes on page 44. The perceived feeling of playing a digital instrument is a consequence of qualities regarding the controller of choice, and the mapping (see page 167) to a utilized sound engine. After a choice of interface is made and a basic mapping is implemented, much effort is expended in order to test different mappings: it may be a decision to map pitch and sample selection to the x and y-axis for the right thumb,[24] and selection size and playback speed to the x and y-axis for the left thumb. A trivial change perhaps, but it may have a huge impact when playing the instrument in context. A basic concept in this work is *affordances*,[25] and by swapping the mapping of two music dimensions perceived affordances of the instrument change.

A fast and direct response from physical action to sound when playing an instrument gives the feeling of control, and it helps the player to understand the instrument. Reactivity indicates a player's ability to react to changes in an ongoing improvisation, which may demand another type of behavior. In order to find a vocabulary that deals with subject matter, it seems feasible to search for references at the neighboring field of game design. In *The Art of Game Design,* American game designer Jesse Schell, among many other things, discusses the perceived feeling of playing a certain game. Schell (1998) emphasize one important quality, namely the perceived feeling of control. One concept he discusses is whether an interface feels *juicy*. A juicy interface, in contrast to a dry one, gives a player the feeling of control, that is, a gesture performed on the controller is directly and proportionally visible and/or audible. Schell also introduces the concept of *second-order motion*:

> That is, motion that is derived from the action of the player. When a system shows a lot of second-order motion that a player can easy control, and that gives the player a lot of power and rewards, we say that it is a **juicy** system – like a ripe peach, just a little bit of interaction with it gives you a continuous flow of delicious reward (p. 233, emphasis in original).

24. In this example I refer to the Gamepad controller and the Granular Machine, see page 191.
25. The *Theory of Affordances* is coined by Gibson (1986), and is further discussed on page 125.

Schell states that juiciness is an often overlooked quality in games, but nevertheless important to take into account. In parallel, I regard perceived juiciness of great importance in digital musical instruments as well, the feeling of control enhance interaction with fellow players, it frees the player from thinking of the instrument itself, and it makes playing more fun. Second-order motion at an instrument appears when the perceived audible output feels greater than the physical effort it took to create it. The feeling of the instrument is an aesthetic dimension of huge importance, and is possibly the first thing to evaluate when testing an instrument at play time. However, when an instrument is considered play ready, the basic feeling of an instrument remains, except minor changes that are done in order to improve and/or adapt an instrument to specific demands.

Interaction and Musical Roles

The aim of designing my digital musical instruments is to develop tools for music improvisation with specific properties, that is, to play musical instruments in context. At the heart of improvisation there is interaction in real-time: with fellow players if any, but also with the space, the audience, etc. In order to make the concept of interaction more manageable, I chose to split it up in a number of aesthetic sub-dimensions: direct gestural interaction, soloist – accompaniment interaction, indirect interaction, and mediated interaction. One important concept is *musical identity*. One meaning of identity in music is related to sonic identity, the sound of the instrument. This matter is further discussed in the Design Time Aesthetics chapter. Nevertheless, another meaning asserts that the specific types of interaction that exist between participating musicians, in many cases contributing to the musical identity of a group.

Direct gestural interaction can be characterized as a conversation with sounds; it deals with the situation when participating musicians directly interact on a gestural meso time scale (see page 132). None of the active participants is the designated leader/soloist, neither follower/accompanist. This type of interaction requires juicy instruments that afford direct gestural control, where a physical gesture is directly and proportionally audible. See discussion about play and control instruments starts on page 187, as well as the discussion of playing my instruments starts on page 270.

Soloist – accompaniment interaction occurs when one player is the obvious leader, and when one or more participating, musicians take an ancillary role. A typical example is traditional jazz: we have a soloist, and a rhythm section that supply the soloist with a rhythmic and harmonic frame, but also support and enhance the ongoing solo.

Indirect interaction appears when participating players seemingly do not interact in a direct manner. This type of interaction can occur in free improvisations, when participators explore individual paths, with no detected synchronized behavior. Another example comes about when active musicians deliberately perform asynchronous loops in order to achieve a desired common effect. The musical outcome of this type of interaction is the sum of the ongoing activities, while the focus on individual musicians is an attempt to explore a certain space, or to perform a given task.

Mediated types of interaction only occur in conjunction with a particular instrument. In other words, interaction and instrument are inseparable. The most obvious example is real-time sampling and processing of a fellow player. Recorded and selected recorded material constitutes the sound source for my playing, and features of the employed instrument will significantly influence the audible output. Therefore, I consider the interaction that occurs between me, as the player of the digital instrument, and the fellow musician, as mediated by my instrument. Another kind of mediated interaction come about when a digital musical instrument is set to, or designed to, perform automatic behavior. At such occasions aesthetical choices at design time entirely control audible output, and participating players can either go with or against, but cannot influence the behavior of the instrument at all. Yet another kind of mediated interaction may occur when perceived output from any digital musical instrument performs idiomatic behavior to a high degree, notably from existing music genres, which may influence fellow players to adapt their behavior to that particular musical genre.

Real and Perceived Degree of Freedom

One central issue in improvisation is the number of available meaningful choices in a given situation. With conventional acoustic instruments, this relates mostly to the skills of the performer, whereas instruments discussed in this work largely confine players due to design decisions. On the one hand, a highly skilled acoustic player, both technically and theoretically, will never runs out of ideas in an improvisation. Whatever situation occurs, he will most likely find creative solutions in the toolbox. On the other hand, most of my instruments do not afford such flexibility, since human instrumental behavior in many cases is implemented as qualities within the design of those instruments. To compensate for this lack, there are a variety of instruments available, and therefore one alternative is to switch instruments. A related topic is perceived degree of freedom, which may, or may not coincide with real freedom. Regarding perceived feeling of freedom, one parallel can be made to game design. Schell (2008) asserts: "We don't always have to give the players true freedom – we only have to give the player the feeling of freedom" (p. 284). I can only confirm Schell's statement, the perceived feeling of freedom is as important as real freedom. However, I assume that perceived freedom at selected recorded passages can be difficult to capture in analysis, subject matter that is covered in the general reflective discussion of playing my instruments. As analysis undertaken in this work, I restrict myself to discuss and to outline real choices in given situations: what really happened, and what possibly could have happened. Freedom in improvisation is discussed further on page 246.

Visual Appearance

This aesthetic dimension may play a secondary role, but should not be completely ignored either. I chose to call it visual appearance, and it is mainly about the look of the GUI, and in addition, I include the degree of "elegance" and efficiency of the program code. The look of the GUI is not merely a matter of the visual appearance of the software, and there are certainly a multitude of attitudes and philosophies in GUI design. During the course of an improvisation, which indeed can be stressful, a well-designed GUI helps the player to make proper choices, which facilitates interacting with fellow players and focusing on the music. The GUI of instruments in this work does not display a great deal of coherent design philosophy, and if there is, it is there to facilitate playing in context. As a personal rule of thumb, I prioritize displaying what I consider musically meaningful information at play time, while hiding data that deals with preparation and internal software settings, e.g. window sizes and sensitivity, in sub windows. Moreover, adjacent functions such as sample selection, presets, mode selection, and current parameter s are gathered in separate color-coded windows.

The degree of elegance in the data code is on the one hand a matter of professional pride, showing off programming skills. On the other hand, a well structured and efficient program code enhances performance, facilitates development, error correction, and reusability of old code, and makes the software much easier to comprehend. However, in this work, I do not analyze and comment on efficiency and elegance of data code, except in cases where it directly influences playing.

Design Process

In this section, I discuss the design and development process of my instruments. The design of digital musical instruments aims for expressive and personal music tools, as well as to bring in deliberately selected musical qualities into ensemble improvisation, such as sonic identity, gestural behavior, allowed interaction, style markers, etc. How does the design process of a digital musical instrument unfold, and how does the process start? Based on aesthetic choices, a huge number of factors will confine and have an impact on the final instrument: matters such as limitations and inherent properties of employed hard and software, choice of interface, applied theories, cognitive abilities, and performing context are examples.

After more than twenty years as a developer and player of digital musical instruments of various kinds and purposes, I have gained a huge amount of experience in this field. Moreover, I assume that my way of working is compatible with other developers, which personal contacts with peers in the field confirms. As a matter fact, there is a large international community that works with Max/MSP, my software of choice, that shares and exchanges modules, and furthermore offers advices and helps each other regarding programming problems. Most likely, a design process starts with an inspirational idea that leads to some kind of criterion, that is, a description of imagined/desired properties of the new instrument. From there, after the initial idea for a new instrument module is hatched and loosely formulated, the design and development is basically carried out in steps (Figure 4): the inspirational idea must be articulated and conceptualized, and after that implementation in appropriate form takes place. Eventually, if the idea turns out to be fruitful, and after cycles of development, a new digital musical instrument is created. At all stages, there is feedback involved, partly between development stages, and partly as referential checks against the original idea/criterion.

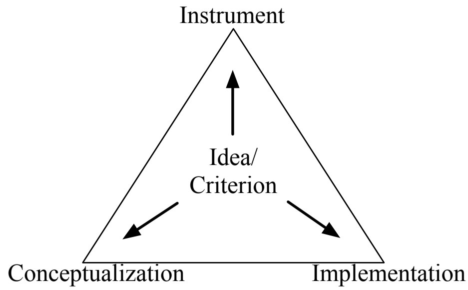

Figure 4. Development stages of a digital musical instrument after the inspirational idea is hatched. Idea/criterion act as a reference that guides the development of a new instrument at all stages of the process.

It is almost never the case that an instrument is ready after initial implementation. Rather, a first implementation allows a designer to briefly test and evaluate, firstly to check whether the idea is worth further investigation, and secondly if the conception feels right. Moreover, in order to make implementation more efficient, with respect to overview, error correction, fine tuning, etc. it is convenient to split up the programming work into a number of small problems to solve, in essence employing modular thinking. In addition, this working flow facilitates the creation of a personal library of instrument modules, which later can be re-used in other projects. One example of division is to discriminate between sound/event generation modules and mapping, that is, the link between the physical interface and generating modules. Furthermore, and obvious, at initial stages of the development process it is convenient to focus on the kernel of the idea.

INSPIRATIONAL IDEAS

When discussing the origin of a made artifact, such as a digital musical instrument, it can be very hard to recall the very first thought, the trigger, the ignition, the inspiration or whatever it is called, that gave rise to the idea. I assume that the emergence of an idea can depend on many things: a concept from music literature, encountered by listening, reading, and playing, inspiration from peers, a natural phenomenon, perceived affordances in available tools such as software and interfaces, aspects of existing instruments, concepts from other scientific fields, aesthetical choices, etc. And lastly, an idea for a new instrument may pop up during play, for instance by applying non-intended playing techniques to an existing instrument, or perceived lack of fitness in existing instruments in certain performance situations. I am keen to point out that it is very unlikely that one might invent a completely new instrument; rather, the newness rather implies the re-combination of existing elements. The following list points at sources of inspiration to instruments discussed in this work:

New or alternative ways of using existing sound processors and generating engines, for instance delays, filters, granulizers, sequencers, and sound synthesis, etc. It could either be hardware devices such as effect boxes, or a software application. In many cases, I have gained experience, and internalized the behavior of such processors previously, when composing electro-acoustic music. In both cases, the idea is to adapt and integrate those applications from tedious parameter tweaking into a real-time played instrument. This is the largest group of my digital musical instruments, which includes the Granular Machine, the SyncLooper, the Groover2, the FourToThree, and the Munger.

Affordances of new, or newly discovered, hardware interfaces can give rise to ideas of new mappings, which in turn can become the basis for a new instrument. In many cases, affordances of a new hardware interface that opened up the idea to adapt existing non real-time processors into real-time operation, in the former group. One example of mine is the use of the Game Pad interface (Figure 25 on page 182) on the SyncLooper and the Granular Machine. Another example is the collaboratively developed instrument, the exPressure Pad[26] family, where the Trigger Finger (Figure 47 on page 217) interface afforded a challenge to create a new instrument.

Musical ideas and imaginings of the behavior of future instruments. Inspiration might be idiomatic elements from different styles of music, for instance jazz, or applying the sound world of electro-acoustic composition in an improvised setting. One example of the former is The Walker, a module within the Walking Machine, and an example of the latter is the Granular Machine and the exPressure Pad family.

A fourth group is special purpose instruments made for a special occasion, and/or a piece of music, where the application is compatible with a composition. In my personal library, there are a number of such devices, but I judge

26. Developed in cooperation with Palle Dahlstedt.

that they fall outside the scope of this work, and will therefore not be discussed further.

CRITERION

Criterion, in this work, is a requirement specification, a brief description of desired and imagined characteristics and properties of a new, but not yet materialized instrument. In relation to the design process, its place and role is somewhat difficult to define; sometimes it forgoes the inspirational idea, at other times it is made up after, or perhaps in direct conjunction with the idea. It is feasible to state that criterion act as a reference that guides the development of a new instrument at all stages of the process. In certain cases a clear cut criterion is not carried out, rather it only exists as a vague and intuitive idea within one's mind, while at other times it is expressively lined out, but nevertheless, it actively guides the development process. In this work, a specific and articulated criterion was used regarding some of the instruments, e.g. the Walking Machine, the exPressure Pad, and the FourToThree, whereas others such as the Granular Machine were developed in a more intuitive way. Descriptions of design criteria are included in the discussion of individual instrumental modules, starts onpage 38.

CONCEPTION

Within the conception stage of development, the inspirational idea and/or criterion must be articulated and represented in one or another way. The purpose with the conception is to make up a model, a map that describes and gives an overview of the basic structure of the imagined instrument. Constitution of a list of meaningful musical parameters is mandatory. At this stage a block diagram, a graphic representation of functional modules and principal flow of control and audio signal can be valuable and helpful. One example is the block diagram of the exPressure Pad on page 219. In certain cases, a verbal description suffices, yet in other cases, a graphic representation of mapping is necessary, or perhaps a brief sketch of the GUI is convenient, in order to define, understand, and represent the problem to solve. It helps to divide the task into a number of sub tasks, with the aim to define and create a set of functional modules, one after another.

implementation

The implementation phase deals with interpreting and translating a conception into appropriate syntax within the software of choice. At the very early stages of development, implemention, and testing of only a few modules is prudent, in order to get some feedback regarding the conception. As an example, omit hardware interfaces and use keyboard and mouse if e.g. sound generation is at the forefront, or if the featured idea is a certain mapping concept, and make initial tests with a simple sound engine. When programming computer software, the programmer must be very precise; a computer does not accept vague instructions, rather it demands clear instructions in minute detail. The program I use, Max/MAP, is modular and operates in a graphic environment. This means that the software contains a number of predefined functional modules, which are called, placed, and interconnected on the GUI at the computer. A module in Max/MSP can vary in complexity, from arithmetic functions such as addition and multiplication, list handlers, MIDI in and MIDI out, to loop players and filters. It is not my intention to present Max/MSP here, but to give an idea of the program. As I will further discuss in the Instrument chapter, computers are merely an open frame, it is empty form without content. An interesting observation is that during the implementation phase, the realization of the instrument is open to influences from a number of fields: other musical domains, psychoacoustics, mapping, interface design, personal references and preferences, and interpretation of a genre/subgenre, to mention a few. The reason is because of the open frame nature of computers, which afford an interdisciplinary approach. See next paragraph for an example.

design process in this work: an example

I provide one simple example of implementation, a little module that creates accents, called *veladd*. Moreover, it is also an example of a module that resides in my personal library, and has been re-used in many occasions. The programming of the veladd module traces back to the beginning of the nineties, in conjunction with a virtual improvisation ensemble application, *The Virtual Chaosband*, where its output was based on chaos equations, (see Dean, 2003, pp. 115–6, and Eldenius 1998, p. 137). In this work, it is used e.g. in the Walker, and the FourToThree. An example is provided on the DVD, *Facing x*, in a duo with bass player Peter Janson, from 13′50″ until the end. In this example, we hear veladd in action: in the Walker as well as the ride cymbal generated by the FourToThree. The idea with veladd is to give more life and musical qualities into a computer generated stream of MIDI notes, which indeed can be lifeless and mechanical. Criterion was how to emulate the way a jazz drummer applies accents when playing the ride cymbal: within the steady stream of notes, now and then an accent appears, and at best it adds energy into the groove. Those accents can occur at various metric placements, neither too often nor too sparse, and sometimes in dialogue with a fellow musician.

The conception is simple and straightforward: I figured out, by analyzing drummers, and also based on my personal experience that a musically suitable estimation would be to randomly generate an accent in the range between each one to each fifteenth event, and in events in between maintain small variation. The accent generator was programmed in Max:

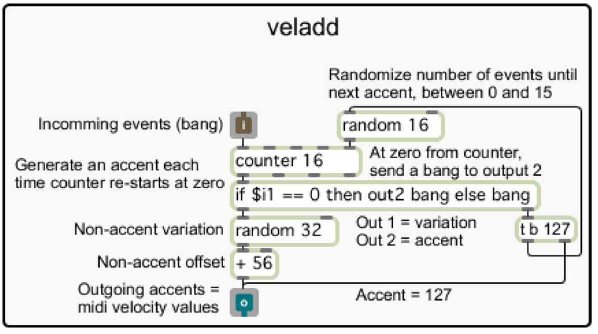

Figure 5: veladd generates and adds accents to a MIDI stream.

Another example is the Walker, a jazz bass application. The inspirational idea and criterion was how to create a digital musical instrument that emulates practices and behavior of double bass players within freer forms of jazz, while still maintaining a steady pulse? By making use of my personal experience as a jazz player on the saxophone, including knowledge of what a bass player actually does, I made up a conception. I decided to get rid of the idea of a metric 4⁄4 pulse, in favor to a unit pulse train, where successive durations were formed additively, and with accents imposed and randomly placed, a practice connected to the music of Ornette Coleman for instance. Regarding pitch generation, I went for an intervallic approach, and assigned basic musical parameters to interval size and position relative to current intervals. The implementation makes use of probability distribution methods to generate new intervals as well as durations, methods connected to information theory, as applied by Xenakis (1992) and computer music pioneers in US in the '50s,[27] in addition to theories of additive rhythm connected to procedures utilized in serial music. For accents, the choice falls on the little veladd app. Evidently, in order to implement made up criterion, an idiomatic jazz bass instrument, concepts were taken from a variety of fields that are not associated with that particular genre. The Walker and its predecessor are further discussed on page 203.

AN ITERATIVE PROCESS

The following paragraph outlines a model of design processes and interaction of the discussed instruments. Its content is inspired from ideas by interaction designer Verplank (2009), partly taken from his compendium *Interaction Design Sketchbook*, and partly from personal conversation.[28] This aim and purpose in the development process of a digital musical instrument is to create a suitable tool for ensemble improvisation, but how to know when the instrument is ready? Is it ever ready? A simple answer is that an instrument is ready when I judge it to be fit enough in relation to firstly, original criterion and conception, and secondly, current context. Given that context is never identical, a personal digital musical instrument is never ready, since continuous small adjustments and changes are necessary. Before going into details, I will stress that a digital musical instrument during the development process may start to have a life of its own. It seems that the development is as much driven by an inner logic of the imposed idea, which may take the instrument under development into surprising and not foreseeable directions, relative the original conception. This is a well-known phenomenon reported by many artists in all art forms. Despite this, the development goes on in cyclic fashion in stages of design work, tests, evaluation, and design work again. The process is about reciprocal actions between design time and play time.

27. Probability distribution in music is further discussed in conjunction to the discussion of the Walking Machine on page 209, and with additional references at the computer music section on page 69.
28. At Stanford University, November 2010.

Most likely, the first iterations of development take place privately[29] in order to make it a playable instrument. When I regard that the instrument is good enough, further tests may take place in context, with an improvising group. Evaluation from tests in group playing imply further development test cycles in private, and eventually the instrument is ready for public performances, which in addition constitutes a bench test and leads to further refinement of the instrument. The design and development process is an iterative, spiral like process. Figure 6 is a model that visualizes the process, as I see it.

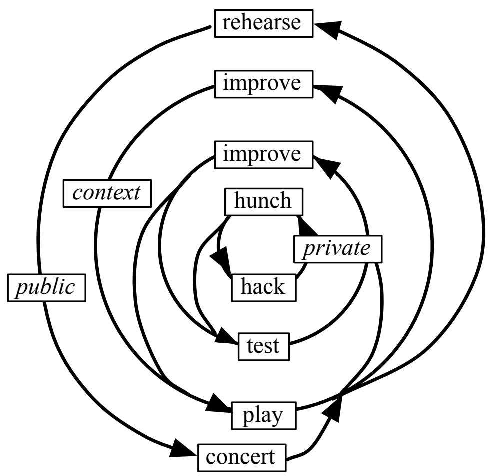

Figure 6: Development goes on in reciprocal action between test, play and improvement. With inspiration from Verplank (2009).

At initial stages of the process, the inner circle, development is only briefly based on a made up conception of the future instrument, it rather focuses on experimentation and tests of thinkable solutions of various inherent problems, sometimes carried out intuitively and in an unstructured way. Verplank (2009) describes this stage as *hunch* and *hack*: a hunch, an intuitive guess, is followed by a hack, a raw implementation, followed by new hunches and hacks (p. 5). The circle outside signifies work that can be

29. I compare this activity to practicing, woodshedding, on an acoustic instrument, which is discussed in the Setting chapter.

done as soon as a playable prototype is at hand, which probably is a very raw implementation that at least has some of the desired features. At this stage, it is possible to work in a more structured fashion. Notice that this phase mainly goes on privately; at least with no artistic ambitions and it rather focuses on functionality. The next circle means playing in a context, with an ensemble, and here artistic and expressive aspects of the instrument are at the foreground. Either, the new instrument is considered fit to be used in public, perhaps with minor changes that can be made on the spot. Alternatively, which is a more likely scenario, prescribes further private development. Eventually, the instrument is ready for a public concert, which is the ultimate decisive test. Experiences and reactions from a concert may demand further development of the instrument, both privately and in context.

INTERACTION

What about interaction? Does the instrument behave as imagined and as prescribed in the criterion? Verplank (2009) has made up a general model that describes interaction between a user and a computer. Verplank claims that interaction designers answer three questions: "How do you know? How do you do? How do you feel?" (p. 6).

- To know is to understand the relation between doing and caused effect.
- To do is about bodily activity.
- To feel is to perceive effects of doing.

In essence, it departs from the idea that activity at design time is based on knowing, about understanding, making models, and creating maps, as the basis for future interaction. By doing, for instance, testing an implementation by turning a knob, the doer feels the effect of a performed action. In turn, this give rises to knowledge of the perceived connection, the mapping, between a performed action and result. In turn, this knowledge constitutes the basis for further fine-tuning, to make up better maps and implementations, and so on. I have discussed and exemplified this matter in connection to pre-development stages of the Granular Machine (see Instrument chapter). In a personal conversation, Verplank made me the following drawing that illustrates the interaction process. (Figure 7):

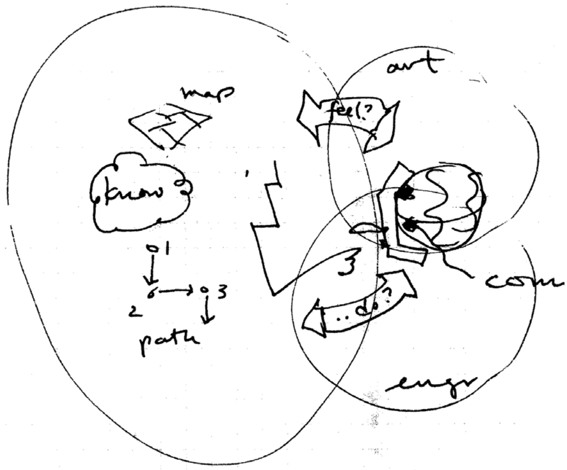

Figure 7: Verplank's model of interaction, given in a personal conversation. Used with kind permission.

This model exemplifies a simple model of interaction, which links to his basic questions of know, do, and feel:

> Even the simplest appliance requires doing, feeling and knowing. What I DO is flip a light switch and see (FEEL?) the light come on; what I need to KNOW is the mapping from switch to light. The greater the distance from input (switch) to output (light), the more difficult and varied are the possible conceptual models; the longer the delay between doing and feeling, the more dependent I am on having good knowledge (Verplank, 2009, p. 6).

In contrast, assume that the lamp is connected to a dimmer, which allows adjustment of the intensity of the lamp in conjunction with the mood of the operator. A handle allows for expressing yourself through the lamp. Switches are about precision, used to control states, and handles[30] are about expression of gestures in a continuum. It is possible to transfer this reasoning into a digital musical instrument as well. With switches, on the one hand, it is possible to control a setting, a play mode, turning effects on and off, and on the other hand, a knob, which can take many shapes, allows carrying out and

30. Handles denote sliders, knobs, joysticks, pressure pads etc, that output continuous data proportional to performed gesture at the control.

mediating continuous gestural movements. In his model (Figure 7), the lower right circle represents engineering, and the upper right art. Within the big left circle, the map corresponds to conception, while the path is the mapping, a description, and order of necessary steps and actions to undertake in order to achieve a certain goal. The unifying link between engineering and art is the computer, which allows implementation of conceptualized ideas, as well as being the tool for expression in play.

Design Time Aesthetics

The music I'm playing at present wouldn't be what it is now
if I hadn't been doing jazz from the outset.

Jan Garbarek

Introduction

In this chapter, the aim is to elucidate musical references in relation to implemented qualities of discussed instruments. In essence, the discussion touches upon aspects of music styles, theories, and traditions that in various ways has been important for my music making in general, focusing on designing digital musical instruments within the context of this work. A common denominator asserts that sound, by its own means, constitutes an important musical dimension. This chapter starts with a discussion of music of sounds, aiming to frame subject matter, followed by a section that treats improvised music whose common denominator and catalyst is jazz, emphasizing significance of sound. Thereafter I discuss selected methods and concepts employed in experimental and avant-garde music from the '50s and onward, which play an important role in this project. Finally, I touch upon the interdisciplinary field of computer music, including examples of forerunners to instruments discussed in this work.

One common practice among improvisers is to use commonly known musicians, material, styles, etc. as aesthetic references. In my own tradition, jazz and close offsprings, it is common to refer to records, a musician, or a particular group when explaining how to play unknown material. Such a reference embeds a huge amount of information: it may entail phrasing, groove, functional and relational roles, type of interaction between musicians, allowed freedom in relation to presented material, etc. It is worth noting that my intention is by no means to write a history or coherent theory of neither improvisation, experimental, nor computer music. Rather, the content in this chapter is primarily a collection of referential prescriptive and descriptive concepts.

I assume jazz is a well-known form of improvised music, covered in numerous books, and therefore not necessary to present profoundly. Discussions regarding jazz applications are interspersed in various places in this book: personal matters, play time aesthetics, and instrument presentations, particularly the The Walking Machine on page 203. In jazz, tradition is as important as creativity and originality. A jazz musician must be able to demonstrate intimate knowledge of the standard repertoire, at the same time avoiding being a "copy-cat". On the one hand, jazz prescribes a set of established conventions to follow and on the other an experimental, and researching attitude is encouraged, which entail constant development. Since the '70s however, I argue that jazz has become praxis, a definite style with a fixed set of conventions that regulates and delimits what is, and what is not jazz; in other words, a canon is established.

I claim I play jazz with respect to attitude, but not to content and form. In all essence, I share Norwegian saxophonist Jan Garbarek's statement,[31] quoted in the heading above. Finally, the creativity, experimentalism, power, and uncompromising researching attitude of jazz masters such as Charlie Parker, John Coltrane, and Miles Davis comprise a great source of inspiration in this work.

31. Uttered by Garbarek in an interview I did with him in Oslo late '80s. Quotation in my Swedish translation from Norwegian: "Vad beträffar min musik för tillfället så bygger den på att jag startat med att spela jazz, hade jag inte gjort det så hade inte musiken varit som den är."

Music of Sounds

What is the sound of music in this work? In essence, it is a music of sounds. A strong trend in 20th century music, particularly after World War II, has been to explore and exploit sounds. In order to exemplify, some movements and music genres comes to mind: *Dadaism*, *futurism*, *serialism*, *experimental, electro-acoustic music*, *free improvisation*, and in recent years *ambient*, *noise*, and *glitch*. There are numerous examples: *Intonarumori*, the noise instruments by Italian futurist Luigi Russolo; the Dadaist poets such as Kurt Schwitters; Edgard Varèse's *Ionisation* from 1931 that featured percussions and sirens. Electronic audio equipment opens music composition for experiments with non-musical noise sounds.[32] In Paris at the late '40s, Schaeffer started to experiment with electronic sound compositions, which eventually became known as *Musique concrète*. In Cologne, Karlheinz Stockhausen experimented with serial concepts and pure sinusoidal electronic sounds. Cage's prepared piano[33] and his silent piece 4′33″ are other examples[34] In the '60s, as offsprings to Cage, new music practices emerged, for instance in pieces by piano player David Tudor, Musica Electronica Viva (MEV)[35] in Rome, and AAM in England, which I will return to. In recent years, within styles such as *experimental rock*, *noise* and *glitch*, Alva Noto, Fennesz, Ryoji Ikeda, Cabaret Voltaire, Merzbow, and Sonic Youth are all examples of artists that explore music of sound.

In Western art music, from the 16th century and onwards, tonal harmony had been the driving force, and musicologist Christopher Small (1998) states that harmony is at the core of musical drama: "The sequence of chords controls everything that happens in the piece; every note and every melody is as it is, and every accent falls where it does because the harmony requires it to be so" (p. 126). By means of a rational discourse, the development of

32. It is common to categorize sounds from other sources than traditional musical instrument as noise, but the notion of what a musical instrument may be, have changed during the last hundred years.
33. By attaching small objects like bolts and rubbers to the strings, Cage transforms a piano into a huge percussive instrument that consists of 88 different sounds. The piano was challenged in several ways; the way a piano should sound, and given that each note is a unique timbre and interesting in itself, the idea of a tonal system looses its meaning, as well as an emblem of Western fine art music.
34. See further down.
35. Robert Ashley, Alvin Curran, Fredric Rzewski, and Richard Teitelbaum.

utilized material such as melodies, rhythmic cells, and motives, is treated as being a discursive language. In the sonata form the conception of growth and development are at the forefront; a subject is formed, and implies the notion of musical ideas by means of logic of sound. At the end of the 19th century the functional harmony system had lost much of its organizing power and reached a dead end. The serial system that appeared in the beginning of the 20th century, did not change that.

A basic assumption in a music of sounds asserts that a sound is meaningful in itself, and not its function or position within a functional system. I emphasize that the concept sound in this work covers more than mere timbre: it may be a groove, a melody cell, an intervallic pattern, a gesture, an instrument, an ensemble, a record, playing behaviors, types of interaction, repertoire, etc. To perceive a sound is to perceive the identity of that sound, which is an intentional[36] subjective phenomenon. Nunn (1998) asserts:

> Identity is a product of PERCEPTION. Something is perceived, whether by improviser or audience listener, as having Identity, because some kind of musical emphasis has been placed upon it (p. 78).

It is feasible to say that the sound, or identity, of a group is the sum of its members' personal playing styles, plus explicit and implicit agreed upon conventions of allowed behavior and patterns of interaction. According to Schaeffer (Chion, 1983, p. 48), in *the law of permanence – var iation*, sonic identity is a *genre*, or a repertoire, of sounds and/or music behavior (see page 157). Becker et al. (2006) state that sociologists never attempt to deal with occasional behavior: "No, we look for an explanation of a kind of behavior that happens repeatedly, to which we give the name 'social structure' or something similar, which connotes regularity, durability, and predictability" (p. 29). A definition, I claim, in essence is compatible with sonic identity. Furthermore, a musical work[37] has identity as well. Small (1998) reasoning about identity and the role of the score:

36. I mean an intentional object in Brentano's sense; a mental state directed toward an object.
37. It is beyond the scope in this work to further discus the ontology of musical works. I refer to *The Imaginary Museum of Musical Works* by American philosopher Lydia Goehr (1992), who shows that it is a subject with a multitude of opinions and definitions. However, Goehr claims: "Generally, it seems not to have occurred to theorists […] that the work concept might not function in all musical practices of whatever sort" (p. 79). Presumably, music produced in this work is such a practice.

> A score, of course, is not a musical work. It is not even the representation of it. It is a set of coded instructions that, when properly carried out, will enable performers not only to make sounds in a specific combination, called a musical work, but also to repeat that combination as many times as they desire. Players and listeners learn to recognize that combination as a *unity* and to give it a name, which may be symphony no 5 in C minor (p. 112, my italic).

Small emphasizes repeatability as important in order to give a music work *unity*, which I interpret as compatible with identity and sound. Nunn (1998) states that the notion of identity is different in free improvisation: "In free improvisation, an Identity may well be a melodic or rhythmic motive, but it may be a number of other things to" (p. 78). He exemplifies Identities with gestural shapes, rhythmic character, harmonic changes, sonic textures, etc. When discussing various musicians, music groups, and works in this chapter, it is the perceived musical identity that is the focal object, and not the underlying structures and methods.

THE LEGACY OF ANTON WEBERN

The unique dialectic between sound and silence inherent in the music of German composer Anton Webern[38] points beyond structural tonal organization, towards a music of sound. An important matter is *Klangfarbenmelodies*, explored by Schoenberg and Webern in the tens. The idea is about locking pitches with timbres and durations in order to make up timbre melodies. One piece of music based on such idea is Messiaen's *Mode de valuers et d'intensites* from 1949, which has influenced my own music a lot.[39] Webern's influence is noticeable in post World War II avant-garde music, notably Pierre Boulez and Stockhausen, which further developed Webern's ideas into *synthetic timbre serialism*. According to German musicologist John-Philipp Gather (2003): "[…] the conceptual key to post-war serialism lies in its fundamental aesthetic choice: timbre–as a non-linear, multi dimensional open ended concept and a new listening approach–replaced the traditional hierarchies based

38. Gather (2003) makes in his thesis *The Origins of Synthetic Timbre Serialism and the Parisian Confluence*, 1949–1952, an in-depth analysis of this important period in 20th century Western music. A propos Webern, Gather claims: "the Romantic era did not finish with Schoenberg but rather with Webern" (p. 329).
39. Referred to in personal matters on page 9.

on pitch and rhythm" (p. 7). Instruments and musical parameters are treated with equal weight. It is a big difference to what Webern's music sounds like, than how it was made, which is important in this setting. In the seminal book *Experimental Music: Cage and Beyond* British composer and musicologist Michael Nyman (1999) provides an example:

> The Americans on the other hand were not so interested in how Webern's music was written and constructed, as in how it *sounded*. They found that his music was made up of a unique dialectic between sound and silence, that the sounds were heard in silence, that silences was an integrated part of the music fabric (p. 38).

Furthermore, Nyman refers to Christian Wolff, who has noticed another audible result of Webern's serial procedures:

> That within this controlled, note-to-note procedures there emerged indeterminate, extra-serial configurations, irrational non-linear static spatial groups. This was due to Webern's technique of repeating notes of the same pitch, always in the same octave position, in different permutations and transpositions of the row (p. 38).

Webern has also influenced free improvisation. In *Derek Bailey and the Story of Free Improvisation* Brit Ben Watson (2004) asserts: "The composer Anton Webern brought atonality and attention to negative (or silent) shapes into music. By applying these to rock/jazz practice, Bailey kick-started a new genre" (pp. 338–9).

Cage claims that the most important aspect of music is silence: "The opposite and necessary coexistent of sound is silence" (in Nyman 1999, p. 32). A rhythmic structure is open to sounds as well as silences, Nyman states: "The 'empty structure' would be plotted beforehand and it acted as a pre-formed frame which could then be filled with any sounds or silences to taste" (p. 33). By employing chance methods to determine the order of successive sounds within the already constituted structure, the meaning of each sound is determined by its immediate surrounding, what was before, what comes after, and coincidental superimpositions. An extreme exponent of this idea is Cage's silent piece from 1952, *4′33″*, which in principle is an empty frame.

Prévost (1995) suggests, with references to AMM,[40] that a "painterly" view of sounds can replace a traditional systematic organization:

> A sense of the effects of colour and texture of sound is analogous to a painterly aesthetic and is perhaps necessary in the absence of a systematics of scales and tones to provide a structural basis and an inner coherence for the work (pp. 16–7).

AAM's concept meta-music prescribes to play with sounds and to utilize non-conventional sound sources such as radios and electronics.[41] One of AMM's presuppositions is: "To play as if there had never been any such things as music before" (p. 19). By means of heurism, we learn to reveal meaning and to understand the emergent relations between perceived sounds. In *Ecological Listening*, presented in the Perception in Play chapter, Clarke (2005)[42] asserts that sound perception and meaning are closely connected. Clarke claims that listeners directly perceive and experience meaning when listening to a sound, that a sound means something in itself. Prévost (1995) suggests a dialogical approach in order to explain subject matter:

> Dialogue is the interactive medium in which the products of heurism are tested. Sounds are placed: placed in contrast to, in parallel to, in imitation of, in respect of, without regard to, other sounds (p. 3).

The sound itself is at the focus of attention and gives meaning. Nunn (1998) claims: "SOUND must be emphasized as the 'starting point' of free improvisation (as opposed to a pre-existing style, theme, instrumental technique, etc)" (p. 37). A basic idea at AAM was, according to Prévost, about "de-constructing", as well as "re-constructing", in the realm of Cage's and Tudor's prepared piano[43] practices. Cardew (1967) claims:

40. A British improvising ensemble that started in the mid '60s by three British musicians: saxophone player Louis Gare, percussionist Edwin Prévost, guitarist Keith Rowe, and somewhat later composer Cornelius Cardew joined.
41. AAM was not first to utilize radios and other "non-musical" sound sources. As early as 1939 John Cage used turntables and radios in his *Imaginary Landscape no 1*.
42. Ecological listening is further discussed on page 122.
43. See footnote 33.

> Informal 'sound' has a power over our emotional responses that formal 'music' does not. In that it acts subliminally rather than on cultural level. This is a possible definition of the area in which AMM is experimental. We are searching for sounds and for the responses that attach to them, rather than thinking them up, preparing them and producing them. The search is conducted in the medium of sound and the musician himself is at the heart of the experiment (p. xviii).

Musical sounds do not have the exclusive right to have a history, nor only natural sounds; in addition, sounds created by technology have a history as well.

To summarize: Webern has had a great influence on post World War II music, however, as much in terms of what it sounds like, as methods employed and aesthetics behind the sound.

OFFSPRINGS OF JAZZ

Free jazz emerged from jazz in the late '50s, highlighting personal expression, rather than to subordinate to a functional harmonic and metric framework. One musician intimately connected to free jazz is Ornette Coleman, whose music sounds like jazz, without applying its strict regulations; time signature may change arbitrarily, and tonality is floating. In *Free Jazz* German musicologist Ekkehard Jost (1994) states:

> Coleman is consistent in eliminating the bonds of functional harmony and divisions into bar-patterns. But he holds fast to what could be called the traditional superstructure: the schematic order of theme, solo improvisation, and theme, with the tempo remaining constant (p. 139).

Coleman abandoned traditional concepts of scales and chords; in short, he stacks improvised melodic phrases over a steady jazz beat,[44] while retaining the superstructure of jazz, and emphasizing sound. In an article in Down Beat[45] saxophonist Julian "Cannonball" Adderley (2009) claims: "Ornette says he has discovered that the alto saxophone has 32 available natural pitches, from D-flat to A-flat in the second upper middle register of the

44. Towards the end of the '60s time dissolved, for instance in his seminal LP *Science Fiction*, recorded 1969. Noteworthy, Coleman's electric band Prime Time is not considered a major aesthetic influence in this work.
45. A leading American jazz magazine.

piano. Each tone to him is a separate sound" (p. 77). Furthermore, Adderley cites Coleman regarding his approach to chords: "Chords are just names for sounds, which really need no names at all, as names are sometimes confusing" (p. 77), which imply that his music does not rely on a (conventional) tonal system.[46] Bass player Charles Mingus (2009) gives words for a similar notion. Initially he criticizes Coleman as only being able to play in a few keys, such as C, F and D, but eventually he realizes that Coleman must be judged differently: "It doesn't matter about the key he's playing in – he's got a percussional sound, like a cat with a whole lot of bongos" (p. 78). This conception is similar to Cage's prepared piano[47] a decade earlier. Concepts of Coleman have significant influence within design of the Walking Machine (see page 203 and DVD).

The *free jazz ballad* employs a melody as the base for an expressive solo, most likely performed on a wind instrument over a rhythm section playing in a free floating time. One example is *Acknowledgement* on *A Love Supreme* by Coltrane (1964). Emphasis is put on expressiveness, "to speak out"; the personal voice and sound are at the foreground. In this work, as an experiment, I perform *My Funny Valentine* as if a free jazz ballad on a digital musical instrument as if a saxophone (see page 318, and DVD).

The *AACM* (Association for the Advancement of Creative Musicians)[48] in Chicago, e.g. Art Ensemble of Chicago and Anthony Braxton, experimented to apply and integrate 20th century Western music composition practices with the African-American tradition, and created new and aesthetically coherent music with a clear identity. Most instruments in this work are made according to this approach: to merge and implement influences and traditions from various fields and make it your own.

American pianist Cecil Taylor's music goes beyond boundaries of jazz. In *Structure Unit* from 1965 all instruments have equal roles; it is a true collective music. Jost (1994) claims that Taylor created a new musical quality, namely energy:

46. Coleman is known for the so-called *Harmolodic System*, which is the subject for speculations and interpretations. Personally, I have not seen a complete written out rule-system, and a hypothesis claims that it is a set of playing conventions, rather than a systemized theory.
47. See footnote 33.
48. AACM member trombonist George Lewis (2008) gives in *A Power Stronger than Itself* an extensive survey of this movement.

> Energy is not equivalent to intensity (measured in decibels) as some of my jazz practitioner countrymen,[49] champions of misunderstood freedom in jazz, often assume. Energy is, more than everything else, a variable of time. It creates motion or results from motion. [...] the kinetic impulses from Cecil Taylor's music are based on the rise and fall of energy (p. 69).

There is no objective tempo in Taylor's music; rather, Jost claims that it is about *impulse density*, that is, the number of musical impulses per time unit, where the relative density creates an impression of different tempi (pp. 72–3). Moreover, it is difficult to distinguish improvisers soloing *over* composed melodies, rather, melody cells act as incubators of new ideas, points of references, and inducers of energy in the midst of an improvisation. Taylor's music reminds one of the music of modernistic composers such as Webern and Stockhausen who treat all musical parameters with equal attention. It is particularly one aspect that bonds Taylor's music to jazz: the very high energy that creates an imaginary and ubiquitous fast pulse. At lower energy levels and below a temporal threshold it loses its jazz quality: "When neither swing nor energy determines the rhythmic progress, his music approaches very closely the avant-garde music of the West" (p. 73). In this work, influences from Taylor are present in the Grey Zone pieces at the DVD and discussions of employed instrument, starts on page 295.

It is feasible to state that free improvisation have its roots in jazz, which Prévost (1995) affirms: "Many of the so-called 'first-generation' of improvisers who emerged in the UK during the '60s had had considerable previous involvement in jazz" (p. 1). In addition, influences from modernistic Western art music – particularly Webern – are present. Moreover, influences from experimental composers and performance practices such as the New York School[50] composers and the Fluxus movement are evident. A central activity in free improvisation is to explore sound production capabilities on customarily used instrument. Nunn (1998) claims that the step from jazz into free improvisation connects to the significance of sound:

> We could say that when the underlying generative principle shift from a basis in other music (i.e. tunes) and from a basis in style, to a basis in sound itself, this is where jazz leaves off and free improvisation begins (p. 16).

49. I assume Jost refers to Peter Brötzmann, who is presented further down.
50. Earle Brown, Cage, Morton Feldman, and Christian Wolff.

British bass player and composer Gavin Bryars affirms: "But I have become very involved in the instrument and I think a lot of things I did were to see what the instrument could do. […] We spend a lot of attention, individually and collectively, on single sounds" (Bailey, 1980, p. 91).

The Joseph Holbrooke trio[51] was a pioneering British free improvisation group. Drummer Oxley was aware of contemporary jazz by the likes of Coltrane, Eric Dolphy, and Albert Ayler, while Bryars was into avant-garde composers such as Cage, Boulez, Messiaen, and Stockhausen. Bailey (1992) asserts:

> This combination of interests, enthusiasm, obsessions, which of course overlapped in all directions, led logically and organically to a situation where the only way to pool our efforts and the only comprehensive expression of this confluence was through a freely improvised music (p. 86).

Drummer Tony Oxley reflects in Watson (2004): "Sometimes I felt the way Derek was playing, that this kind of thing could be far more interesting if you could be more of a percussionist than a timekeeper and play a musical role rather than a functional role" (p. 64. By discarding traditional form schemata in jazz, the roles of the instrument change as well, and the division in soloist and accompaniment become meaningless.

One musician who has had a great personal aesthetic impact is German saxophone player Peter Brötzmann. As an art student in Germany, he encountered international fluxus artists Nam June Paik and Joseph Beuys as teachers. According to Brötzmann, Beuys encouraged him to seriously take up the saxophone as his means of expression in art. Brötzmann has a cheer power and directness; his saxophone speaks directly to a listener, surpassing conscious concepts. Another musician is mention worth as well, namely British saxophone player Evan Parker who have taken active part in Beam Stone, the principal group in this work. During the course of the years, free improvisers have developed a number of playing techniques and licks, which now are commonplace and characteristic for this community of players. According my point of view, influential pioneering players such as Bailey, Brötzmann, and Evans have had an enormous impact. In addition, traces

51. Guitar player Derek Bailey, bass player Gavin Bryars, and drummer Tony Oxley. The "real" Joseph Holbrooke was a British 19th century composer, considered "the British Wagner", however Bailey et al. did not perform any music by him.

from the forerunners and/or catalyzers of free improvisation, such as free jazz and Western avant-garde music, are often noticeable in current performances. Some examples: the widespread use of extended techniques on all instruments: harmonics and overblowing on the saxophone, as practiced by Coltrane and Pharoah Sanders for instance; remounting the instrument and playing on its parts; scratching and attaching various objects on the piano strings, which points back to American composer Henry Cowell and Cage; pointillist playing, and short sounds and clicks connected to the music of Webern and Stockhausen. Cluster techniques on the piano connect to practices of Cowell and Cecil Taylor, as well as threading a stick between the strings on a guitar or double bass, and finally the cymbal glissando: the techniques to first hit and then quickly bend a cymbal. According to Oxley, it emanates from Cage's *Construction in Metal* (Bailey, 1992, p. 88): sinking a gong in a bucket filled with water directly after excitation made a glissando effect. Oxley did not know about Cage's method, and invented another technique to achieve a similar effect. I consider this family of playing techniques and the sounds they produce emblematic for free improvisation. In order to describe its identity, I make use of Schaeffer's law of permanence and variation, presented on page 157. The sonic identity of free improvisation is a genre, or repertoire, of playing techniques and sounds, rather than a music genre.

EXPERIMENTAL AND AVANT-GARDE MUSIC

In the '50s and '60s American and British composers such as Cage, Brown, Wolff, and Cardew experimented with music that focused on process rather than result. In the foreword to *Experimental Music*, producer Brian Eno states that this music, at the time, was regarded as anti-academic, and written for non-musicians: "It made a point of being more concerned with how things were made – what processes had been employed to compose or perform them – then with what they finally sounded like" (Nyman, 1999, p. xi). What was the experiment? Eno poses a new question: "what also could music be"? Experimental music is, as Cage (1973) defines it in Silence: "[…] but simply as of an act the outcome of which is unknown. What has been determined?" (p. 13). In this credo Cage affirms that experimental music makes up determinations of which the outcome is unknown. Nyman states that it all started with Cage's silent piece in 1952, also known as 4′33″. The silent piece actualizes three aspects of music: "Composing's one thing, performing's another, listening's a third. What can they have to do with each other?" (in Nyman

1999, p. 2). With the silent piece Cage shows that a composition need not contain any intentionally produced sounds to be considered a musical work. The performer has to solve a task to mark the duration, to delimit time in and time out (see page 86 about unwritten rules in games). Finally, listening is something else, the sound component in the piece consists of accidental sounds that happens to occur in the venue. However, in Figure 7 on page 47 Verplank shows that these three activities may have something to do with each other; a certain conception implies a certain action, which in turn give rice to an experience. An experimental work may not prescribe performers activity in detail; decision-making is partly up to the musician's discretion. A central concept is to give the performer a task, a problem to solve, and certain rules give rise to a certain behavior. One example of this approach is the music of American La Monte Young, in *Composition 1960 #7* for instance, the score consists only of an open fifth, the notes B and F#, and the instruction: "to be held for a long time": and *Composition 1960 #10*, "draw a straight line and follow it". What will eventually come out is wholly or partly unknown for the composer, the performer, and listeners, but is largely a consequence of initial condition, that is, application of rules.

SOUNDS AND STATISTICS

After World War II, influenced by new scientific fields such as cybernetics and information theory,[52] a number of composers undertook experiments with statistics in composition. One such branch is probability math, widely used in computer music, and one composer intimately connected with such concepts is Xenakis (1992). In his seminal book *Formalized Music*, he gives a background and provides examples of musical applications that use probability distribution concepts.[53]

One important topic in this work is sound statistics and its relation to aural perception. Xenakis treats subject matter, but I chose to use a classification by Stockhausen (1989), which defines three types of statistical sound events: *points*, *groups*, and *masses*.

52. Cybernetics is attributed to German communication scientist Norbert Wiener, and information theory was developed by American researcher Claude E. Shannon.
53. A recent book is *Music and Probability* by David Temperley (2007) that presents a survey and a mathematical foundation of the use probability math in music. The main body of his work is focused toward analysis of tonal order and rhythmic probabilities of traditional melodies.

A *point* is a single and isolated sound event. With inspiration from Second Viennese School composers, particularly Webern, a style emerged that eventually became known as *pointillist* music at the beginning of the '50s: "A music in which all the possible characteristics were differentiated from note to note" (p. 35). I have touched upon one example of this music previously, namely Messiaen's *Mode de valeurs et d'intensités* from 1949, and another is Stockhausen's *Punkte* from 1952. It is worth noting, within free improvisation circles pointillist playing is commonplace, and one example is *Click Piece* by British percussionist and music pedagogue John Stevens, presented on page 112.

A *group* is a coherent chunk of distinctive events that have at least one characteristic in common, for instance duration, timbre, or dynamic. Stockhausen (1989) claims that a group may contain from one up to maximum seven events, else it becomes a mass. I can see a parallel to the *Magic Number of Seven*, G. A. Miller (1956), which claims that we perceive the world in chunks of seven plus minus two items (see page 132). This is also compatible with a phrase, and according to Roads taxonomy of time scales, it goes on at a meso time level.

A *mass* occurs when we cannot perceive individual notes in a group, in such a case it transcends into a swarm and according to Stockhausen (1989), the shape of the mass is important: "When you perceive the swarm as a shape, it becomes a single entity" (p. 41). The shape of a mass can take many forms, with respect to frequency range, a shape can be narrow or broad, and it may evolve over time. Xenakis (1992) experimented with perception of densities of sonic events as well, and he found that at a certain level of density our perception shifts from hearing individual events to perceiving a mass, a swarm:

> These sonic events are made out of thousands of isolated sounds; this multitude of sounds, seen as a totality, is a new sonic event. This mass event is articulated and forms a plastic mold of time, which itself follows aleatory and stochastic laws. If one then wishes to form a large mass of paint-notes, such as string pizzicati, one must know these expression of chain of logical reasoning (p. 9).

Eventually, these ideas led up to granular synthesis techniques, which are discussed and explained in-depth by Roads (2002) in *Microsound*. Roads defines two main types of sound masses: the cluster of sustained frequencies and the cloud. In the former type, the development of the music relies on changes of individual notes in a sustained cluster, whereas the latter uses so-called "statistical clouds of microevents" (p. 15).[54] In statistical clouds, the field is the set of elements and the sequence is the texture, which may be constant or evolving, and yet another property in this context is density, which relates to the number of events within a given time unit. Cloud textures demand a different organization:

> In contrast to the combinational sequences of traditional meso structure, clouds encourage a process of statistical evolution. Within this evolution the composer can impose specific morphologies (p. 15).[55]

As examples of compositions that utilize cloud techniques Roads mentions tape pieces by Xenakis, e.g. *Concret PH* (1958), *Bohor I* (1962) and *Persepolis* (1972), certain compositions by Stockhausen from the '50s and, as an example of particle textures: *De natura sonorum* (1975) by Bernard Parmegiani. Roads also provides taxonomy of cloud textures, with terms directly derived from meteorology.[56]

A salient feature when working with sound masses presumes that one must not deal with single events, rather to determine the shape and tendencies with respect to development of the mass. One example of a composition software that employs such a concept is Barry Truax's POD (see page 70), which works with tendency masks. In this work, the Granular Machine (see page 189), and the Munger (see page 226) operate in the same manner.

Other conceptions of sound masses relate to theories of soundscapes.[57] Without going into this field in detail, since it falls outside the scope of this work, I present a few concepts that I consider important. In his thesis *Noise Design*, Swedish researcher and sound designer Björn Hellström (2003) explores a great number of such concepts, and particularly *metabolic effect* and *ubiquity* have been used prescriptively in this work.

54. Roads refers to Xenakis (1992) and Wishart (1996).
55. Roads (2002) give examples: "Cloud evolutions can take place in the domain of amplitude, (crescendi/decrescendi), internal tempo (accellerande/rallentendo), harmonicity (pitch/chord/cluster/noise, etc.), and spectrum (high/mid/low, etc.)" (p. 15).
56. *Cumulus*, *Stratocumulus*, *Stratus*, *Nimbostratus*, and *Cirrus* (p. 16).
57. Term coined by Canadian Richard Murray Schafer (1977), author to *The Tuning of the World* and one of the initiators to *World Soundscape Project* hosted at the Simon Frazier University in Vancouver, where Barry Truax is active, as well as the CRESSON institute in Grenoble, France.

Metabolic effect (p. 222) is a perceptual effect, and a quasi-stable sound field. It is made up of a mixture of a finite number of sounds that behave dynamically and varied. A salient feature states that we can perceive this effect twofold. Intentionally we may direct our attention towards the whole, then we perceive a static sound field, or, we may direct our attention at singular events, which reveal an unstable and dynamic sound field.

Texture is a useful concept in order to define and characterize a certain sound mass. Stockhausen (1989) asserts that texture is a better word than structure for this type of phenomenon, since we do not perceive any single events, and according to Hellström (2003): "this type of motion is subjected to the inward shape of sound, and it requires active attention when focusing on the textural qualities." (p. 212). In acousmatic music a texture most often is described in terms of metaphors: it can be grainy, harsh, glossy, stable, broad, narrow, etc. In *Spectromorphology: Explaining Sound Shapes*,[58] British composer and theoretician Denis Smalley (1997) differentiates between gesture and texture as two forming principles in acousmatic music. The provided taxonomy defines textures with respect to motion, spectra, density, and space.

Ubiquity (Hellström, 2003, p. 223) is spatial and temporal diffusion, a sound source impossible to localize, and it seems like the sound comes from everywhere. A similar condition may occur if more than one musician uses digital musical instruments. Sometimes during concerts, I pose myself the question: who is making that sound? Sometimes it turns out that it emanates from my own instrument. After a rehearsal, Sten Sandell, Beam Stone's piano player, expressed it like: "I thought I was doing something and stopped, and then it was Per Anders" (Gotland 2006).[59] This is most common in concerts in bigger venues, when live electronics are distributed throughout in-house public address systems and monitor speakers are used on stage. Loudspeaker systems are discussed on page 172 and onwards.

58. According to Smalley (1997): "Spectromorphology is not a compositional theory or method, but a descriptive tool based on aural perception" (Smalley 1997, p. 107).

59. The original: "Jag trodde jag höll på med en grej och la av, och så var det Per Anders."

MUSIC AS PROCESS

Experimental music is more about how music develops and proceeds rather than music result. Eno asserts: "It was a music, we use to say, of process rather than product" (Nyman, 1999, p. xi). In process music a listener can hear the process that forms the piece during the course of a performance. The forming process is the music, and no sound is more important than any other; everything is audible and there is no underlying hidden structure. American composer Steve Reich (2004) asserts: "The distinctive thing about musical processes is that they determinate all the note-to-note (sound-to-sound) details and the overall form simultaneously" (p. 304). Process music is not result oriented, rather, focus is directed towards conditions that controls the process: "[…] by running this material through this process I completely control all the results, but also that I accept all that results without changes" (p. 305). This means that all effort at design time attempts to make up processing rules, and at play time the material runs through the process, while the sounding music is a result of this process. One example of overt process music is Cardew's *The Great Learning, Paragraph Seven* from 1967, presented on page 113. A peculiar property of process-based music, particularly repetitive works, has to do with the fact that they are self-referential, representing nothing outside itself. In Mertens (2004) Phillip Glass claims: "Music no longer has a meditative function, referring to something outside itself, but it rather embodies itself without any mediation" (p. 309).

One offspring from the experimental music tradition is minimalism,[60] and musicologist Kyle Gann (2004) proposes to divide minimalist music in two different groups: "Pulse-based music versus drone-base music" (p. 301). One seminal pulse-based minimalist piece is Terry Reilly's in C from 1964. This piece consists of 53 melodic cells, patterns, of variable length, which might repeat arbitrarily number of times at the performers' discretion. The audible result, often called *resulting pattern*, is the sum of coincidental current audible patterns. However, all patterns shall be played with respect to a common unit pulse, and once set in motion, it is self-organizing. Perceived meter shifts continuously depending on current resulting pattern. Another salient feature is *additive processes*: a basic pattern may evolve by adding material, like a note

60. A term coined by British composer Michael Nyman in the late '60s, but nevertheless a not much liked term among composers active in this field. Despite that, in this work I chose to use minimalism since I judge the term widespread and accepted.

or a phrase. Other examples are Reich's tape music pieces *It's Gonna Rain* and *Come Out* from 1964 and 1965. Both this pieces explore the *phasing effect*, an effect that occurs when playing identical material from two instances, with a slight difference in speed. La Monte Young's minimalism represents drone-based music, and differs significantly from Reilly's, and Reich's. The goal is to establish a drone "[…] of very stringently selected, harmonically related frequencies (overtones) above this drone" (Nyman, 1999, p. 141). His music comprises a set of rigorously selected and controlled frequencies, allowing only certain combinations, and participant musicians have very few choices. Another salient feature in minimalist music is its static harmony, either just one sustained chord, as the open fifth in La Monte Young's piece Composition 1960 #7, or an oscillation between a limited set of chords, or an effort to stay within one diatonic scale.

SOUND PLAYING IN THIS WORK

Featured ensembles Beam Stone and duo pantoMorf are in essence sound improvisation ensembles. Beam Stone pianist Sten Sandell reflects about sound and its meaning, which frame the essence of our music well:

> For me this covers what we are doing, and it is about that each sound, by itself is a so-called primal-sound that eventually combines with two others. Thus, the sound in itself is a narrative, right, without much of gestures, but dynamics, but… Each sound that occurs from each person makes up a new polyphony, I believe. Thus, sounds are by themselves interesting (Gotland 2006).[61]

Sandell's statement about sounds is a cornerstone of Beam Stone's music. However, I am keen to point out that our music is not just about an effort to produce an arbitrary stream of sounds, and it is up to listeners, including participant musicians, to create meaning. Rather, I argue that we play with sounds, we interact with sounds, and we articulate sounds. In relation to AMM, a group that Beam Stone has been compared to, their *metamusic* attempts to a great extent to listen, to perceive, and to experience the

61. The original: "För mig är det ett heltäckande sak som vi gör, och det är att varje ljud i sig är ett sk urljud som sen kombineras med två andra. Alltså ljudet i sig är en berättelse va, utan så mycket gestik, men dynamik, men… Varje ljud som kommer från varje person bildar en ny flerstämmighet, tycker jag. Alltså ljud i sig är intressanta".

relationships of sounds that are played: “Sensing, evaluating and acting, in creative dialogue, are the medium of the meta-musician” (Prévost, 1995, p. 3). Primarily we are musicians, and according to percussionist Strid, our music is not un-phrased:

> But I think that we also work with phrases, and our different ways of phrasing, which are… for me it is very important to bring it in… that you don’t need, and that we have different roles. This has to be said as improvising musicians and musicians, sometimes we take the soloist role, sometimes an accompaniment role, that we are neutral ensemble musicians (Gotland 2006).[62]

One example of phrasing and interaction with sounds can be heard at *Angle of Repos*. At the beginning of the recording a dialogue between percussion and electronics occur. Another example of sound playing is *Amalgamation*. This improvisation is performed under the guidance of the applied concept amalgamation, further discussed on page 263. The basic idea with this piece is simple, to create a sound body. The task is creating a collective sound mass, with as little personal expression as possible. One way to create a sound mass is to play many notes per time unit, which will be perceived as one mass of sound, as discussed previously on page 61. We could have done that, but instead we chose to play slowly evolving continuous sounds for a long time, at least on the percussion and the exPressure Pad, my instrument of choice. One property of a mass is its shape, the change of pitch range in relation to time, and in this case produced shape is an effect of chosen tools and playing behavior, and not predetermined. In a sense, what we do is close to a drone, but since the output from individual players is quite unstable, the output can also be regarded a swarm of micro events. However, Stockhausen also defines negative shapes as windows within a mass, silence. In his orchestral piece *Trans* from 1971, which basically consists of a continuously evolving sound mass, compatible to metabolic effect, two such windows occur: all acoustic instruments stop playing for almost a minute, only the tape loop is heard sparsely, and then the play continues. At the ISCM version of Amalgamation,

62. The original: “Men tycker att vi också jobbar med fraser och våra olika sätt att fra-sera, som är ju,… för mig är det väldigt viktigt att det får komma in… Att man inte heller behöver, och sedan har vi olika roller, det måste man ju ändå säga som improvisationsmusiker och musiker, ibland är vi rollen av solist, ibland är vi roll av att ackompanjemang, att vi är neutrala ensemblemusiker…”.

two such windows are predetermined in advance, and appear at 3′41″–3′50″, and 4′54″–5′02″.

An example of statistic sound playing is *Grey Zone*, both versions, which aims to create metabolic effect by means of playing with high, but controlled density. This concept is further discussed on page 291.

I do not regard music presented in this work strict process music in Reich's meaning:

> The distinctive thing about musical processes is that they determine all the note-to-note details and the overall form simultaneously. One can't improvise in a musical process – the concepts are mutually exclusive (Reich, 2004, p. 306).

I agree with Reich, in an improvisational context note-to-note procedures are not predetermined and controlled. However, digital musical instruments in this work do allow for applying concepts connected to minimalist practices. Most obvious is the *Groover2*, the asynchronous four-voice loop player, whose main design criterion was to create an instrument aimed at the generation of phasing effects and resulting patterns. At the beginning of *Facing x* on the DVD, until approx. 5 minutes the Groover2 plays multiple double bass loops. Momentarily shifts in texture are randomly generated, but manually triggered, and cannot be regarded as a process. Rather, its role is to create a background and dialogical partner for the bass improvisation with a flavor of minimalism. Another digital musical instrument in this vein is the *FourToThree*, a sample based two-voice polyrhythm generator. In *Angle of Repos*, from 4′16″ to 6′10″, the bass layer is an example of a process-based texture. In this work, we use process based concepts to produce sonic layers within the whole, rather than for organizing the entire music.

In a more general remark, I will also put light on the intentional focus at initial conditions, and not the product, as compatible with process music practices. In line with Reich's notion, I accept the result whatever it might be.

Computer Music

The purpose with this section is twofold: to briefly introduce the field of computer music, and to present forerunners and concepts with significance for discussed instruments.

Computer music appeared in the '50s as a new interdisciplinary research field that involved scientists such as mathematicians, computer and electronic engineers, psychologists as well as composers and musicians. Most of the early development took place in the USA at a handful companies and institutions, e.g. RCA (Radio Cooperation of America), Columbia and Princeton Universities and probably most important: Bell Telephone Laboratories in Massachusetts, which was the leading institute in this field for decades. Since the '70s a number of other institutions have been in the forefront of the development of computer music, notably *IRCAM* (Institute de Recherche et Coordination Acoustique/ Musique) in Paris. *CCRMA* (Center for Computer Research in Music and Acoustics) at Stanford University and more recently research centers has been created in many places, e.g. *CNMAT* (Center for New Music and Technologies) at University of California Berkeley, *CRCA* (Center for Research in Computing in the Arts) at University of California San Diego, University of Dartmouth. Examples of centers in Europe are *Institute of Sonology* in Utrecht, the Netherlands, SARC (Sonic Arts Research Centre) in Belfast and CNRS in Marseille as well as Scandinavian institutes including *NoTAM* (Norsk senter for Teknologi i Musikk og Kunst) in Norway, *DIEM* (Danish Institute of Electronic Music) in Denmark and not to forget *EMS* (ElektronMusikStudion) in Stockholm, Sweden.

THE MUSIC MACHINE

In the early '50s as an offspring to the, at the time, new scientific field *information theory,*[63] a number of researchers started to experiment with electronic and/or computer technology in order to make music. One of the first attempts to scrutinize the musical possibilities of such technology was undertaken by the electronic engineers Harry F. Olson and Herbert

63. Claude Shannon is considered the father of *Information Theory* and in his and Warren Weaver's article *A Mathematical Theory of Communication* (1948) a mathematical ground for information was established. Norbert Wiener's research about probability theory and John Pierce's *Symbols Signals and Noise* is also important in this context.

Belar at RCA who constructed a machine around electro-mechanical relays, structured in a binary fashion. Their machine produced new melodies on basis of the probability distribution of intervals and rhythms derived from a number of popular Stephen Foster songs.[64] The Olson and Belar machine showed interesting results but according to British electro-acoustic studio director and researcher Peter Manning (2004):

> [...] they (Olson and Belar) provide a clear example of the consequences of a serious breakdown in communication between scientists and artists concerning the essential characteristics of their respective disciplines (p. 87, my parenthesis).

Manning claims that Olson and Belar did not understand the creative process of composition, because they assumed that the characteristics of a musical work contained all necessary information for a simulation of the creative process. Composers will most likely use the outcome of such a machine as raw material for further refinement and elaboration, and not as a substitute for human creativity. A composer has a free will; a certain event may follow the next according to the rules, but may also be broken intentionally. One of the RCA synthesizer's main features was firstly its modular design, each module was accessible in arbitrarily order, and secondly that the machine afforded programming, a major advantage comparing to the time consuming, manual multi stage process employed by for instance Stockhausen at the Cologne studio.

On the commercial side the *Electronium* by Raymond Scott[65] is worthy of mention. The Electronium asks the composer/operator to suggest a theme, and then to make modifications and variations with respect to melody, rhythm, and timbre by turning knobs and switches that control underlying random processes.

COMPUTER-BASED COMPOSITION PROGRAMS

One of computer music pioneers is Lejaren Hiller, who in 1956 composed the first computer created composition, *The Illiac Suite for String Quartet*, named after the computer he used. Roads (1996) refers to Hiller and Isaccson:

64. Technical details of this machine and its successor the RCA synthesizer are explained thoroughly in Manning's Electronic and Computer Music (2004, pp. 83–97).
65. Raymond Scott is presented in the CD-box *Manhattan Research Inc.* (Blom 2000).

> Hiller's celebrated experiments with automated composition proved that the computer could model any formal procedure: from the canons of traditional harmony to the tenets of serial technique: both deterministic and stochastic methods could be coded. […] Hence, software appeared as a logical extension of the aesthetic of formalized composition (p. 834).

Roads (1996, pp. 836–44) provides examples from the first generation of music composition programs: *Stochastic Music Program* (SMP) by Xenakis, G. M. Koenig's *Project 1* and *2*, and Barry Truax's *POD* programs. SMP dealt with stochastic processes based on formulas developed scientifically in order to describe the behavior of particles in gasses. A number of Xenakis' works were composed with SMP, notably *Eonta* from 1964. Project 1 featured selection principles from the entirely random to deterministic with control of parameters such as weighting for size of chords and total numbers of events generated. POD employed a feature called *tendency masks*, first developed by Koenig in Project 2, that is, frequency-time regions whose overall statistic behavior over time is described graphically, in addition to control of parameters such as density and duration, leaving the generation of single events to the computer. Figure 16 shows an example where different shapes and colors (shades) represent different timbres.

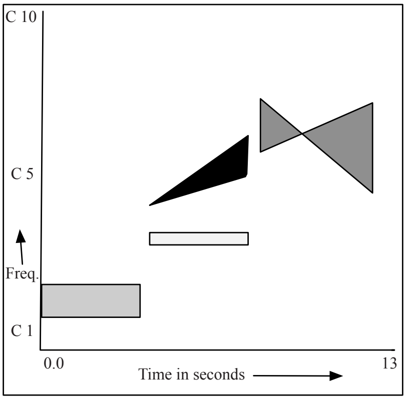

Figure 8: Tendency Masks in POD, in Roads (1996, p. 843).

The POD program afforded a composer the possibility to work at higher structural levels of music comparing to traditional composing, and according to Truax:

> Selection principles and tendency masks allow composers to work on a higher level of musical architecture than that of individual notes. 'The composer is not only concerned with the nature of the individual sound event, but also with … larger groups of events, including entire compositional sections' (in Roads, 1996, p. 842).

One of the undisputable fathers of computer music is the American Max Mathews, who died in 2011, worked at Bell Labs from 1957 until his retirement in 1987; from then until 2007 he worked at CCRMA at the Stanford University as a senior researcher. His boss at Bell Labs, John Pierce,[66] encouraged him to take some working time experimenting with digital audio. This work resulted in software called Music I, eventually Music II through V. With digital technology Mathews realized a possibility to create a universal musical instrument, similar to what Schaeffer envisioned in connection to his turntable-based instrument almost ten years earlier.[67] French acousmatic composer Evelyn Gayou (2007) quotes Mathews in the *Portraite Polychrome*[68] series:

> We had Claude Shannon's mathematical sampling theorem to guide us. Shannon invented information theory, which was very important in 1948. Musically and acoustically, Shannon's theorem suggests that digital samples can make any sound the human ear can hear. This means that the computer has the potential to be the universal musical instrument – something that cannot be said about any other instrument. You may love the violin as I do, but it cannot sound like a trombone (p. 9).

In the late '60s, Mathews and Dick Moore developed probably the first hybrid synthesizer that operated in real-time: the *Groove*. In the same issue of Portraite Polychrome, French composer Jean-Claude Risset (2007) asserts that

66. Pierce was at the time director of research at Bell Labs and is known, among other things, to have coined the name transistor.
67. "The Most General Music Instrument Imaginable" (in Gather, 2003, pp. 214–6).
68. Portrait Polychrome is a series of personal portraits published by GRM, (Groupe Recherche Musical) in Paris. www.ina.fr/grm.

the instrument featured digital control of arbitrary assignable parameters, nowadays known as mapping, and the patching was exclusively stored and accessible for each individual user (p. 43). The Groove performer has certain choices; the easiest way involves only trigging of pre-defined events:

> At the opposite end, one can use the system like an instrument, by playing on the keyboard or other devices and asking the computer to directly send the data to the synthesizer. The performer then has maximal control, but he or she must satisfy the same requirements as a performer of a musical instrument (p. 44).

In the '80s Mathews developed the Radio Drum and later the Radio Baton, whose interface consists of a "baton" whose proximity and position with respect to a defined surface is measured and used as control data that is mapped to parameters in a sound engine.

INTERACTIVE DIGITAL MUSIC SYSTEMS

I will make a brief résumé of a number of computer-based improvisational systems, which deal with virtual co-musicians, whose behavior is either directly derived on live actions from one or more musicians, and/or created inside the computer under influence from the musician's behavior. American researcher and professor Robert Rowe (2001) discusses and gives in *Machine Musicianship* examples from this field. However, two composing systems are considered the first interactive instruments. In 1967, American composer Joel Chadabe[69] set up the CEMS (Coordinated Electronic Music Studio) at the State University of New York in Albany by assembling standard sequencer and synthesis components made by Robert Moog's company, and at the beginning of the '70s Salvatore Martirano constructed his *SalMar* system, (Rowe 2001, p. 288). One common notion of such systems states that the programming is the piece, for instance expressed by Berkeley based composer Edmund Campion in connection to his composition *Natural Selection* from 1986 "In many respects the patch is the piece" (p. 288). A special case is interactive improvisation, virtual co-players that improvise together with acoustic musicians, and according to Rowe is a programming challenge:

69. Chadabe is professor emeritus at the State University of New York in Albany, and the president and founder of EMF (Electronic Music Foundation).

> Interactive improvisation poses perhaps the greatest challenge for machine musicianship. Here the machine must contribute a convincing musical voice in a completely unstructured and unpredictable environment (p. 277).

One of the first to develop and perform improvised music with electronic and computer-based instruments is Richard Teitelbaum. Together with some other composer/performers, e.g. Fredric Rzewski and Alvin Curran, he formed the Italian based group MEV in the '60s. One piece by Teitelbaum is his SEQ TRANSMIT PARAMMERS for piano and computer from 1998. This piece employs techniques for recording, transforming and playback, capturing salient features of the performing pianist's style and expressivity. Campion's *Natural Selection* is another example:

> The compositional algorithms of Natural Selection are predominantly sequenced and generation techniques, in which stored materials are varied during performance as a function of the analysis of incoming musical gestures (Rowe 2001, p. 289).

Furthermore, Rowe exemplifies Amnon Wolman's composition *New York* for two players, one human, and one computer-based. The software employs a number of transformation techniques based, not on analysis, but on "systematic random variations of the incoming material over time" (p. 298).

The American trombone player, and author George Lewis (2000) created the program *Voyager* in the late '80s, which is designed to act as "virtual improvising orchestra" according to Lewis. The software listens and analyzes the behavior of an improviser and creates its musical outcome accordingly.

> *Voyager* is a nonhierarchical, interactive musical environment that privileges improvisation. In *Voyager,* improvisors engage in dialogue with a computer-driven, interactive 'virtual improvising orchestra.' A computer program analyzes aspects of a human improvisor's performance in real time, using that analysis to guide an automatic composition (or, if you will, improvisation) program that generates both complex responses to the musician's playing and independent behavior that arises from its own internal processes (p. 33).

Other examples are Rowe's (2001) own software *Cypher*, and an IRCAM project supervised by Gerhard Assayag called *OMax,*[70] as well as the *Continuator*

70. http://omax.ircam.fr, Paris (April, 2009).

by French researcher and piano player François Pachet at Sony inc. is worth mentioning (Pachet, 2002).

The undisputable pioneers of computer orchestras are The Hub (The Hub 2008) and its predecessor The League of Automatic Music Composers emanating from the Mills collage in Oakland, California. Other examples are the Princeton Laptop Orchestra (PLOrk) and its sibling the Stanford Laptop Orchestra (SLOrk). Many laptop orchestras perform rule-based improvisation pieces regularly. One example is the piece *Waxlips* by The Hub member Tim Perkis who says that the aim with his piece was to keep the necessary pre-planned structure to a minimum. The rules state:

> Each player sends and receives a note on request. Upon receiving the request, each should play the note requested, then transform the note message in some fixed way to a different message, and send it someone else (in Rowe 2001, p. 309).

The rule is applied constantly for all the members throughout each section, while one member could start a new section by "spraying" out a great number of new requests.

COMPOSE, CONTROL, AND PLAY

In many computer-based systems, the role of the computer may be either a playing partner, or provider of material. In recent laptop music the "mail-reader musician" is a common phenomenon; with this I mean that there is no connection between performing actions and audible output; the performer may possibly be reading mail. The performer rather *controls* the system, then *plays* it; a notion already expressed by Raymond Scott in connection to his Electronium: "The Electronium is not played; it is guided" (in Roads, 1996, p. 828). In a personal conversation Chadabe expresses similar ideas and compares it to flying:

> And then you have more complex models, which I call 'a fly by wire model' because it's like flying a complex airplane, an Airbus 240 for example; it's just a 'fly by wire airplane' where the pilot doesn't fly the airplane. The pilot tells a computer what he wants the airplane to do, and the computer flies the airplane. [71]

71. Personal conversation in New York City, March 2006.

I suggest there is a continuum regarding the level of real-time control in digital instruments. At one end we have the "push-the-button" instrument that automatically generates its output on the basis on pre-programmed instructions, the Olson and Belar machine is an example. A mid point position is systems that allow changes of selected parameters that affect its behavior accordingly. At the other end there are instruments that respond to physical gestural input in a continuum. I will address this topic more in connection to the discussion that treats classification of my personal instruments. Chadabe continues with a distinction between two somewhat different digital musical instrument models, the *improvisational partner,* and the *sailing model*:

> The first model, let say the improvisational partner, the improvisational model which you can think as a conversation model between two people. At the moment Robert Rowe is working very strongly in that direction and George Lewis was one of the pioneers of this with his piece Voyager. The second model however is a completely different model for interactive instrument and I refer to it not as an improvisational model, rather sailing a boat on stormy seas. Because in this case, the surprise, the novel information is analogous the wind and the waves. So, your job as a performer is to keep your boat, or your composition steered in a particular direction, while its been… The control of the position of the boat is being shared by the wind and the waves, simulated by random number generators. But the wind and the waves know nothing about you. There are not analyzing your input. They are just acting simultaneously on the course on the boat. This is what I being doing.[72]

In the mid '80s, the M[73] software was launched, a program that featured Chadabe's "sailing model" whose output was based on real-time interactivity that employed probability distribution of transitions of durations. Discussed applications exemplify mainly compositional systems that allow certain freedom and interactivity between a human performer and a computer.

72. Personal conversation in New York City, March 2006.
73. Chadabe developed and commercialized the softwares Jam and M together with David Zicarelli, John Offenhartz and Antony Widoff in the late '80s.

Play Time Aesthetics

Yes, improvisation is a sport *too*, and a spectator sport,
where the subtlest interplay on the physical level can throw into high relief some
of the mystery of being alive.

Cornelius Cardew

Introduction

A major aesthetic tenet in this work is that musical improvisation has strong similarities to gaming, play, and sports. This should not be seen metaphorically; rather, to improvise is to play a game. In parallel to a game, improvisation implies and defines a goal; it contains open and hidden rules, and it defines a playing space, which altogether frames the activity. A multitude of writers from different fields have profoundly and methodologically scrutinized game and play ontologically, and treated matters such as the meaning of play, and experiencing play, including philosophers Johan Huizinga and Hans-Georg Gadamer, and the psychologist L. S. Vygotsky. Moreover, interaction design researchers and game designers deal with matters applicable to improvisation as well: e.g. application and meaning of game mechanics such as rules, definitions of play spaces, skills, narration and form strategies, in addition to computer technology issues like designing hard and software, interfacing concepts, etc.

This chapter is divided in three main sections: the first discusses play and game ontologically; the second discusses general game concepts such as goals, rules, spaces, skills, randomness etc; while the third applies concepts of game and play to music. Finally, I am keen to point out that this attempt is by no means intended as another general theory about music improvisation, rather, it is a personal aesthetic standpoint that aims to frame conditions of how instruments discussed in this work operate.

Meaning of Play and Game

What is play? In *Homo Ludens* Dutch philosopher Huizinga (1955) asserts that play first and foremost is a function of the living: "All the same, we cannot say that beauty is inherent in play as such; so we must leave it at that: play is a function of the living, but is not susceptible of exact definition either logically, biologically, or aesthetically" (p. 7).

In the literature, three features of play are emphasized: participation is voluntary, it contains rules, and it creates its own meaning. To play is to enter an *Imaginary World* or *Imaginary Situation,* terms that Russian psychologist Vygotsky (1978, p. 93) coined with respect to children's play. Furthermore, he states: "[…] every imaginary situation contains rules in a concealed form, we have also demonstrated the reverse – that every game with rules contains an imaginary situation in a concealed form" (pp. 95–6). Music, particularly improvisation, bears all the signs of play, it takes place within, and constitutes an imaginary world, it contains rules, and are entered into willfully: "Play we said, lies outside the reasonableness of practical life; has nothing to do with necessity or utility, duty or truth: All this is equally true of music" (Huizinga, 1955, p. 158). Either, rules emerge from the imaginary situation per se, or a fixed explicit set of rules creates an imaginary situation.

In his main work, *Truth and Method*, Gadamer (2004) discusses the meaning and nature of play. A fundamental notion in Gadamer's reasoning is concerned with the idea that play is an autonomous natural phenomenon: "It is the game that is played – it is irrelevant whether or not there is a subject who plays it" (p. 104). A significant feature of play is the movement to and fro: we talk about the play of the wind, waves, colors, and do not necessarily thinks about what is actually blowing, or which colors are playing, or for that matter who is playing, rather, we think about the nature of the movement in itself. A player plays a game as much as she is played by the game. Huizinga (1955) shares this opinion: "Any thinking person can see at a glance that play is a thing on its own, even if language possesses no general concept to express it" (p. 3). Distinctive games differ from each other by means of attitude. Think about soccer or ice hockey, it is easy to recognize a game regardless if it is Champions League, NHL, or kids playing in the backyard. What is game? Oxford Reference Online writes:

> In many languages a term synonymous with play, but distinguished in English as specifying a certain activity associated with play (as opposed to a general activity performed playfully) which is contextualized and structured according to certain rules […].[74]

American game inventor Stephen Sniderman (1999) claims: "A game is a play activity that consist of an object […] and constraints on the player's behavior […]" (p. 1). Nordic game researchers Sus Lundgren, Karl J. Bergström, and Staffan Björk (2009) quote a definition by B. Suit[75] that emphasizes problem solving and non-utilitarian aspects of gaming: "The voluntary effort to overcome unnecessary obstacles (p, 2)". Huizinga (1955) also stresses the voluntary in play as decisive: "First and foremost then, all play is voluntary activity. Play to order is no longer play: it could at best be but a forcible imitation of it" (p. 7). Lundgren et al. (2009) also point out that some definitions of a game may well include a broad range of activities, e.g. free play and physics testing, and therefore: "We limit them to intentional goal-driven activities and refer to this as gaming" (p. 1). Schell (2008) discusses game design in general. After examining different notions he comes up with the following list of ten qualities that constitute a game:

> 1) Games are entered willfully; 2) Games have goals; 3) Games have conflict; 4) Games have rules; 5) Games can be lost and won; 6) Games are interactive; 7) Games have challenge; 8) Games can create their own internal value; 9) Games engage players; 10) Games are closed, formal systems (p. 34).

Schell asserts that the list of ten factors is too big, and at the same time probably misses some points. Therefore, he argues for a more distinct definition that covers all essential features of a game in one sentence. By collapsing all ten qualities into voluntarily problem solving, Schell proposes: "A game is a problem solving activity, approached with a playful attitude" (p. 37). A definition that also resembles Suits definition of a game.

When we play, we cannot take it seriously since it is just play, but at the same time we must take it seriously in order to make it meaningful: "Seriousness is not merely something that calls us away from play; rather, seriousness in playing is necessary to make the play wholly play" (Gadamer, 2004, p. 103).

74. www.oxfordreference.com. (September, 2011).
75. Taken from Suit (1990) *Grasshoppers: Games, Life, and Utopia*. Broadview Press.

What make play and games meaningful? First, play creates its own meaning as an activity separated from daily life, and according to Huizinga (1955):

> It interpolates itself as a temporary activity satisfying in itself and ending there. Such at least is the way in which play presents itself to us in the first instance: as an intermezzo, an interlude in our daily lives (p. 9).

By playing and within play we represent something about ourselves. Within a game, the player has a task, and to succeed with this task is to represent the game, which in turn means to represent oneself: "The self-representation of the game involves the player's achieving, as it where, his own self-representation by playing – i.e., presenting – something" (Gadamer, 2004, p. 108). Therefore, I will argue that game playing is a way of understanding the world, and here within lies its meaning: "We are always conscious of the game's relation to the world in which we live, the world in which the game is one small world" (Sniderman, 1999, p. 4). Gadamer's notion that play is self-representation of man aligns well with Schell's (1998) notions with respect to the meaning of game and play:

> These micro-realities have effectively distilled the essential elements of reality for a particular problem that manipulations of this internal world, and conclusions drawn from it, are valid and meaningful in the real world (p. 36).

This suggests that the problem space of a game is a simplified model of the real world, a made-up structure in analogy with a real-world structure. In *Gödel, Escher, Bach* the American logician Douglas R. Hofstadter (1999) claims that such analogies give meaning per se: "The perception of an isomorphism between two known structures is a significant advance in knowledge – I claim that it is such perceptions of isomorphism which create meanings in the minds of people" (p. 50). When we experience isomorphism, we consider something as true, but I would rather use meaning.

When human play comes to its consummation by being art, Gadamer (2004) calls it a transformation into structure: "Thus transformation into structure means that what existed previously exists no longer. But also that what now exists, what represents itself in the play of art, is the lasting and true" (p. 111). Players, as well as spectators, experience a similarity with regard to the structure of the game, and the representation of it. The player ceases to be, and is disguised: "A man who is disguised does not want to be recognized, but instead to appear as someone else and be taken for him" (p. 111). However, this is only imaginary, since he upholds continuity with himself, but withholding it from the spectator who experiences the game as going on in a closed world. In other words: "Like an actor, we must be able to take on a role but never give up our sense of self" (Sniderman, 1999, p. 6).

It seems plausible to conceive art as a model of nature: "Inasmuch as nature is without purpose and intention, just as it is without exertion, it is a constantly self-renewing play, and therefore appears as a model for art" (Gadamer, 2004, p. 105). In *Silence*, Cage (1973) wrote of a similar idea: "The traditional function of the artist is to imitate nature in her manner of operation" (p. 194).[76] In a seed, a genetic code regulates how growth proceeds, while the final shape and size of a particular organism is a consequence of its interaction with the environment, rather than a materialization of a predestined form.[77] This is compatible to playing a game, where the outcome of singular play is a result of players' interactions with the game at that time, rather than a fulfillment of a predetermined sequence of actions.

An important aspect of encountering art is concerned with the recognition of something of yourself, which is the joy of recognition: "The joy of recognition is rather the joy of knowing *more* than is already familiar" (Gadamer, 2004, p. 113). Small (1997) states that to play creates meaning: "Those taking part in a musical performance are in effect saying – to themselves, to one another, and to anyone else who may be watching or listening – *This is who we are*" (p. 134). Within a music improvisation context, improviser Prévost (1995) offers a similar notion:

> The successful performance occurs when musicians and audience chose the occasion and exercise self-determination. At such moments there is certainty, if only momentary, about what it means to be a human being. And it offers a powerful insight into the energising dichotomy of individual/social existence (p. 109).

In play, which can be many things, such as a game, sport, theater, or music, we represent something of ourselves, and our relations to the world. In line

76. According to Swedish writer Torsten Ekbom (2009, p. 92) Cage's quotation emanates from Coomaraswamy's book *The Transformation of Nature in Art*, who, also according to Ekbom, in turn got the quotation from Thomas Aquinas's main oeuvre *Summa thelogica*: "ars imitator naturam in sua operatione".
77. This issue is connected to theories of genetics and evolution and goes beyond the scope of this work.

with such an idea, a game, a match, as well as an improvisation, is meaningful by itself regardless of pre-conceptions and intentions. In play aspects of life are represented.

The nature of games and play appears when we experience them. A play console, a board, a display, or a score is not the experience: "It itself belongs to the world to which it represents itself. A drama really exists only when it is played, and ultimately music resounds" (Gadamer, 2004, p. 115). Games must be played, and music must be performed and listened to in order to create experience as a participator; games and music enable experience. Gadamer means that music also has an ideal wholeness, but its true being appears only when it is played, a decisive difference with regards to an aesthetical point of view:

> If art is not the variety of changing experiences (Erlebnisse) whose object is filled subjectively with meaning like an empty mold, we must recognize that 'presentation' (Darstellung) is the mode of being of the work of art (p. 115).

Small (1997) states that all activity related to music is *musicking*[78] (to music): playing an instrument, attending a concert, listening to a CD, and even listening to elevator music:

> Properly understood, then, all art is performance act, which is to say that it is first and foremost activity. It is the act of art, the act of creating, of exhibiting, of performing, of viewing, of dancing, of wearing, of carrying in procession, of eating, of smelling, or of screaming that is important, not the created object (p. 108).

A spectator is an active part of the play space, which Gadamer (2004) expresses with a well-known metaphor: "– that it is precisely this fourth wall of the audience that closes the play world of the work of art" (p. 163). By watching and listening, a spectator may understand the meaning of the play better than the players: "In fact it is experienced properly by, and presents itself (as it is 'meant') to, one who is not acting in the play but watching it. In him the game is raised, as it were, to its ideality" (p. 109). Finally, in *Sync or Swarm* American ethnomusicologist David Borgo (2005) makes a phenomenological inspired survey of the nature of music improvisation, and he comes to a similar point of view:

78. Musicking is present participle of the verb *to music*.

> In light of these phenomenological and experimental findings, we argue that musical meanings are best located in the act of listening rather than at the structural level of notation or even sound. Just as a painting becomes more than simple brushstrokes when viewed as a whole, music lives when it is heard and understood (p. 67).

In other words, only by playing, watching, and listening we can experience play, regardless of whether it concerns soccer, chess or music.

Game Design

What does a game consists of? Fundamental rules, objects, and procedures of a game are usually called *game mechanics*, which are static properties that always exists, whereas *game aesthetics,*[79] as defined in this work, describe dynamics – *interactions* – between game mechanics and a player during game play. Despite many attempts, there exists no common agreed upon taxonomy of game mechanics and game aesthetics. Game producers may advertise games as sports games, war games, or strategy games for instance, information that does not explain much of the underlying mechanics and aesthetics of those games. This section begins with a presentation and discussion of properties of game mechanics, while the concluding part treats aesthetics such as narration, player types, and interaction patterns in relation to different types of games.

game mechanics

Linear art works such as pre-composed music, movies, theater, and literature share a common feature, namely that they contain a predetermined and fixed story, aesthetics, and technology. A game may also feature those properties, plus its mechanics, and according to Schell (2008): "Game mechanics are at the core of what a game truly is. They are interactions and relationships that remain when all of the aesthetics, technology, and story are stripped away" (p. 130).[80] Moreover, Schell derives his proposed taxonomy of game mechanics from his own experiences as a game developer, in addition to various written sources, and his purpose is primarily pedagogical. He divides game mechanics in six sub categories: *Spaces, objects* (goals), *actions, rules, skills*, and *chance*, and the text in this section is structured according to these categories. However, with one exception, action, which is about allowed actions and their consequences in different games, are considered too game specific to make sense in this text.

79. Proposed by Leblanc (in Salen and Zimmerman 2005).
80. Schell's notion of game aesthetics does not exactly coincide with the definition I have chosen. Rather, I support the notion that the aesthetics are types of interaction, caused by the game design. This topic is further elucidated in the game aesthetics section.

Spaces

One prerequisite of a game is the playground or game space. Huizinga (1955) asserts: "All play moves and has its being within a playground marked off beforehand either materially or ideally, deliberately or as a matter of course" (p. 10). No playground, no play. All participants in a particular play constitute an imaginary world when they enter the *magic circle* and play starts. The concept of the magic circle is attributed to Huizinga (p. 10), and is equal to an arena, a stage, or a screen. A playground may be physical: a field of grass, a rink of ice, a chessboard; or virtual/mental: for instance in card games, quiz, or computer games. In *Parables for the Virtual* the American philosopher Brian Massumi (2002), poses a question: what is the condition of soccer? He states that applied rules determine and regulate the play, but are not its condition; it is the field: "No field, no play, and the rules lose their power" (p. 72). Furthermore, the field is polarized by its two goals, which also limits the outside:

> It is more fundamentally a field of potential than a substantial thing, or object. As things, the goals are signs for the polar attraction that is the motor of the game. They function to *induce* the play (p. 72).

In terms of force, in every moment the polarity of the goals defines every point in the field, and intensity increases when the ball is near one of the goals. While the goal, the field and present players *induce* the play, the ball *catalyses* it. Therefore, the ball is the subject of the play. Alternatively, more precisely: "the subject of the play is the displacement of the ball and the continual modifications of the field potential those displacement effect" (p. 73). Therefore, the soccer player directly plays the field of potential, which is composed of *modulations*, an *effect* of contingent intermixing of elements. Movements undertaken by the players during the course of play continually influence and actually change the potential of the field, or playing space. Shell (2008, p. 131) proposes a game space taxonomy that consists of three basic dimensions: 1) discrete or continuous; 2) number of dimensions; 3) bounded areas, either connected or not. A further discussion of subject matter is beyond the scope of this work, since I assume that such a level of detail is not applicable in music improvisation.

Goals

One important aspect of a game is about the *object* or the *goal of the game*. In order to comprehend a game goal, Schell (2008) lists three important qualities (pp. 148–9):

- Goals must be concrete and easy to understand.
- Goals must be achievable.
- Goals must be rewarding to achieve.

The most obvious goal in a game is to win, to eliminate, and/or strike out concurrent players in various ways. In soccer and ice hockey, the team that makes the most goals wins and boxing is literary about dominating the opponent. However, other goals may be to achieve something, like to win at solitaire, or to socialize and to cooperate to achieve a certain task, or perhaps to solve a problem. Schell differentiates between short-term, and long-term goals. Short-term goals might be to win the next ball, the next round, or to collect enough points or to solve a problem in order to go on to the next level. Long-term goals may be about winning the game, or perhaps winning or solving a series of subsequent games or problems. By balancing short-term goals and long-term goals in a game, a player finds pleasure and challenge throughout play.

Rules

All games contain rules, and are considered the most fundamental of game mechanics. As Huizinga (1955) states: "All play has its rules. They determine what 'holds' in the temporary world circumscribed by play. The rules of playing are absolutely binding and allow no doubt" (p. 11). In short, rules and goals control a game within a given space. In essence, game rules are prescriptive, proscriptive, and instructive. In the following section two different views of games will be presented: firstly a taxonomy of rule categories in games, and secondly, a reflection of the presence and effect of unwritten or tacit rules in games. A great variety of formal human systems, such as politics, law, language, music, sports, philosophy, and business may well be regarded as games. Huizinga claims that play precedes and presupposes the development of organization in human society and institutions; rules follow emergent unformalized activity. According to Massumi (2002) official rules encapsulate these variations: "They frame the game, retrospectively, describing its form as a set of constant relations between standardized terms" (p. 71).

In his taxonomy of rules, *Rules OK* game historian David Parlett (2005), first makes a distinction between explicit and implicit rules, and secondly, distinguishes between orally transmitted and written rules. In order to visualize the relations of rule categories, he presents the following diagram (Figure 9):

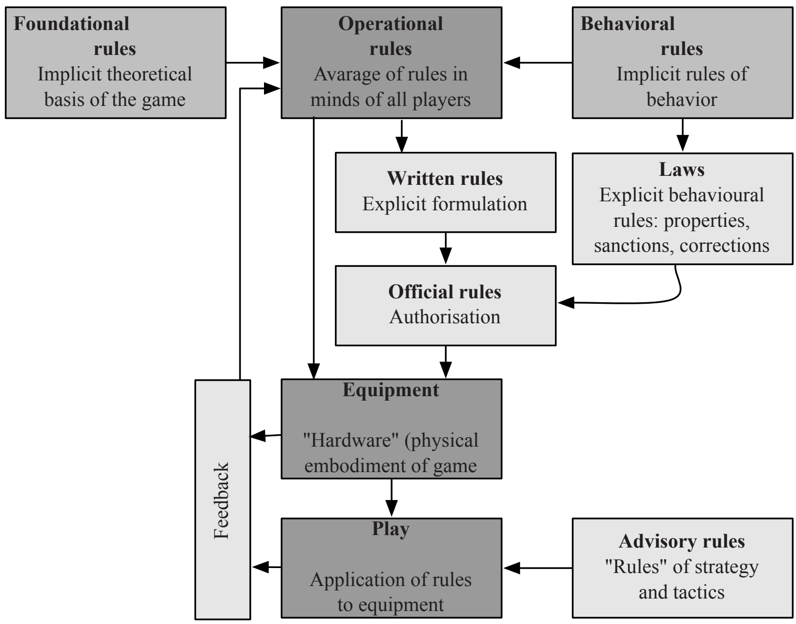

Figure 9: Parlett's taxonomy of game rules (p. 8).

All games have *operational rules,*[81] which are the *explicit rules* that may be verbalized, and when applied produce the play of the game. Basically: "the rules of a game are something inherent in the game itself – or, more accurately (since a game is essentially a mode of behaviour), an abstraction existing in the minds of all its players" (p. 2). In addition to explicit rules, there exist at least two sets of *implicit rules*, which are *foundation rules* and *behavioural rules.* The foundational rules define the principal formal structure of a game, and serve as the abstract basis of the explicit operational rules. Behavior rules are equal to unwritten rules. Many games have no *written rules*, since playing is a cultural behavior and most often, a game is taught

81. Following Salen's and Zimmerman's (2005) terminology.

verbally. Parlett makes a distinction between *book games* and *folk games*:

> Players are only likely to call on books and printed rule-sheets when they are passionately concerned with what they like to call the 'official' rules – that is, those authorised as prescriptive and proscriptive. One consequence of this tradition is the fact that book games tend to remain relatively static over long periods of time, and are less likely to vary and evolve than most folk games (p. 4).

By means of verbal transmission and cultural differences, it is likely that game rules develop local variations over time. There are many reasons for this, such as the person explaining the game does not know it thoroughly, or perhaps does not know the rules about situations that appear rarely, and when they occur players have to make up their own solutions.

A basic prerequisite states that all participant players in a game follow the same rules. According to Parlett: "This brings us on to perhaps the most fascinating and paradoxical characteristic of games – namely, that they are at the same time both competitive and cooperative" (p. 5). Sometimes it turns out that the written rules of a game may cause unfair situations, or make it too complicated, and therefore slight changes of the rules may occur. *Laws* are modifications, exceptions or clarifications that are applied to written rules of a game, most often used in serious competitive settings in order to enhance and/or balance the game. When laws merge with written rules, it becomes *official rules* of a game, and perhaps eventually convert into the revised written rules of the game. *Advisory rules* deal with strategies in order to succeed in a game. Schell (1998) also mentions *house rules*, which imply that players may tune the rules in order to adapt the game for special purposes, such as making the game more fun, or decreasing playing time. Many games have different *modes*, with different set of rules; often organized in one main mode and sub-modes. In traditional games and sports, participants have to learn and memorize the rules in different modes by heart.

One remark by Schell deserves to be emphasized: in many computer-based games, the rules in various modes are already implemented into the design, which means that forbidden actions are impossible to do: "In a sense, what used to be a 'rule' now becomes a physical constraint of the game world" (p. 148). As a consequence, in many complex computer-based games, it is rather a matter of discovering and understanding inherent constraints than memorizing rules.

Official rules and agreements control a system in order to secure stability, fairness, democracy, behavior or whatever objects there are. However, "the entire set of rules governing the system cannot be spelled out" (Sniderman, 1999, p. 2). The official rules of a game are most likely a description. Sniderman exemplifies with the game Tic-Tac-Toe.[82] It may be easy to describe the procedure and object of playing Tic-Tac-Toe, but what about times between moves? In order to sort things out, a set of meta-rules has to be introduced, but they may also be subject to interpretation and discussion, and demand a set of meta-meta-rules, and so on. When playing simple games, it is wiser to trust in mutual tacit understanding and acceptance. Another situation occurs in professional settings, such as chess tournaments, where time between moves is under rigorous control. No game or sport exists in a vacuum, rather: "It is impossible to determine where the 'game' ends and 'real life' begins" (p. 3). Therefore, it is not only enough to know the official rules of a game.

In this context, two interesting questions arise: How do we start play? How do we know that the play is time in?[83] In most sports there are regulations on how to start: in ice hockey the referee drops the puck and the match clock starts to run; in road bicycling the official judge lowers her hands at kilometer zero; in tennis the server seeks the opponents gaze and they both make a gesture of acceptance; the symphony orchestra starts when the conductor gives a sign; and a jazz group may count to four. Most likely, the play has been preceded by warm-up activities such as tennis players hitting the ball to and fro, ice hockey and soccer players doing collective exercises. However, when practicing sports or games for leisure, the border may be blurry. The transition from warm-up into playing, may only consist of a nod of agreement, or someone in the group says, "ok let's go". Furthermore, in certain genres of music such as folk music and jazz play may start when someone, often the leader, starts playing a tune, which causes the rest of the group to join in one by one. This is particularly common when rehearsing: "None of us can say how we know that we are in fact playing a particular game (rather than, say, just practicing), but we generally have no trouble knowing that we are" (p. 4). Obviously, a comprehension of important governing rules, official as well as tacit, of a particular game or sport is necessary in order to understand and play it.

82. We'll play on a 3×3 grid, we'll alternate turns, we'll play only in empty squares, I'll play X's, you play O's, I'll play first, and the first player to get three of his/her symbol in a row, column, or diagonal wins the game. Aren't these *all* the rules of tic-tac-toe? (Sniderman, 1999, p. 2).
83. The concept of time in and time out signify whether the play is active or at break. In certain sports, e.g. Ice Hockey, each team is allowed one 30-second time out during a match.

Chance, Skills, and Probability

Chance is at the heart of many games. Think about all games that involve dice, while other examples are card games such as poker, where the outcome to a certain extent relies on the luck of given cards. Most often, playing such games is a matter of calculating the probability of gaining and winning, short-term as well as long-term, and making moves accordingly. Traditionally, games are divided into three categories with respect to skill and chance: games of skill (*Chess*), games of chance (*Chutes and Ladders*[84]), and games of mixed chance and skill (*Backgammon*). Parlett does not distinguish between skill and chance games, and proposes to replace this division with a continuum, where *unpredictability* or *uncertainty* resides in one end, and *controllability* at the other. He states that there is no universal skill for gaming, rather, people have different skills, and chose to play games that suit their talents, or vice versa: different games require different skills. According to Parlett (2008, p. 2), it is wrong to chunk randomization with imperfect information. He gives a few examples: In randomizing games, such as *Chutes and Ladders*, the element of uncertainty gives no free choices, since players act under the compulsion of dice decisions. In backgammon the opening array and following moves are predetermined and visible to all players, that is, *perfect information of present and past*, whereas randomness that is introduced from rolls of dice, represent *future imperfect information*. Bridge deals with *past imperfect information* and *information-perfecting*, it opens randomly, but thereafter it is about interfering or deducing the opponent's lay of cards. Backgammon demands an ability to set up positions that both enhance possible future casts of the dice, and at the same time limits an opponent's favorable future casts. I will not further scrutinize on different skills and talents with respect to gaming, since it is beyond the scope of this thesis.

One important attribute is secrets, what is hidden, and what is open information. On the one hand, in board games such as chess, everything is open and visible, and on the other, in card games like poker, a great deal of information is hidden. By changing information from secret to public, a game's

84. Built on an old Indian game about fate. For two or more players. The playing board has 100 numbered grid squares, in certain squares on the grid ladders or snakes are drawn that connect two squares together. By rolling a die the player jumps the same number of steps on the grid, if the square contains a ladder, jump upwards to the connecting square, or if it contains a snake, go backward similarly. First to 100 wins.

character is dramatically shifted. One example is standard *draw poker* where one player can only guess an opposite player's cards based on the bet she makes, while in *stud poker* some cards are public and some private. As a consequence, while those games are still poker, they feel very different.[85] With of computer-based games, it is implied that the game itself (the computer) knows all states of all objects all the time.

Most often, foundational rules in games that employ chance involve a branch of mathemathics called theory of probability. Without going into the math of probability, a topic covered in many books, I will give a few examples.[86] Curiously, this branch of mathematics emerged out of a gaming problem.[87] In 1654, the French writer and gambler Antoine Gombauld de Chevalier de Méré presented the French mathematicians Blaise Pascal and Pierre de Fermat the following gaming problem:

1. In four rolls of a single die, de Chevalier wins if at least one six comes up.
2. In twenty-four rolls of a pair of dice, de Chevalier wins if at least one 12 comes up.

de Chevalier estimated his chances to win equally good in both cases, but it turned out that he won in the first case while he lost in the second. Why?[88]

85. In Schell (2008, p. 138).
86. Probability math in music are presented in connection to statistics of sounds on page 61.
87. The example is provided in Schell (2008, pp. 154–155).
88. The probability of a certain outcome always falling between 0 and 100 percent, where the former denotes that it never will happen, and the latter that it will happen every time, and for instance 75% chance means that it will happen three times of four. To start, one must know the maximum possible number in order to obtain 100%, which in this case is six times six four times (6×6×6×6) = 1 296. By calculating chances of six vs. non-sixes to come up in four strikes, and than divide the sum with the maximum number we will obtain a number between zero and hundred, which is probability in percent. In the first game the chance of a six to come up in four strikes distributes such as: four sixes = $^{1}/_{1296}$; three sixes and one non-six = $^{20}/_{1296}$; two sixes and two non six = $^{150}/_{1\,296}$; one six and three non-six = $^{500}/_{1\,296}$. By adding chances, which sums up to $^{671}/_{1\,296}$, and then make the division, the chance to win in the first game is 51,77%, which obviously gives de Chevalier a good chance. In the second game with two dice, things get more complicated, and a somewhat different method is used. In this case it is easier to determining chances that twelve not will come up in 24 rolls, and then invert the sum. Chances for two sixes in one single roll to come up is $^{1}/_{36}$ and subsequently non two sixes is $^{35}/_{36}$. By multiplying $^{35}/_{36}$ 24 times we will obtain 50.86% of non-twelve, therefore the chance of winning is 49.14%, which means de Chevalier will loose.

A calculation showed that the probability to win in the first case was 51.77%, and in the second 49.14%. This example illustrates that there is a big difference in outcome from two dice, compared to, let us say a 12-sided "super" die. One random generator produces an even distribution, while two parallel random number generators will produce a so-called probability distribution curve, which emphasize numbers in the middle and rarely distributes very high and low numbers (Figure 10). It is possible to use this feature in games to distribute virtual skills randomly, which assures that most characters have average skills and only a few have extremely high or low skills.

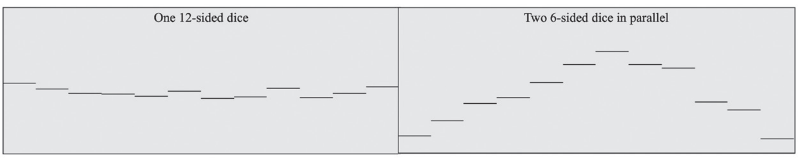

Figure 10: Two simulations of 1 000 rolls of dice; the leftmost one single "super" dice; and the rightmost two normal dice in parallel generates a Gaussian distribution curve.

All games imply that a player has to exercise and develop certain skills. However, most games demand more than one skill from its players. Schell (2008, p. 151) lists three basic types of skills):

- *Physical skills* involve strength, dexterity, coordination, and endurance. Examples are many sports, as well as games such as croquet and darts.
- *Mental skills* deal with memory, observation, and problem solving. In this group chess, Othello, bridge, and mahjong are examples.
- *Social skills* are about reading and fooling an opponent, team work, etc. Poker and many other card games, and SimCity, etc. are examples.

One important distinction to make is to distinguish between *real skills* and *virtual skills*. The former deals directly with a player's ability, while the latter is about skills in game characters that a player controls. An example would be a swordfighter in an adventure game who may increase skill by means of reward within the game. Therefore, virtual skills may improve independently of the player's non-virtual skills, or for instance, based on a player's mental or problem solving skills. As Schell states: "Virtual skills are a great way to give a player a feeling of power" (p. 151). It is easy to think that a game is just about one skill, when in reality it is a blend of many skills. By listing necessary skills, the game designer will have a good overview of the demands of a player.

GAME AESTHETICS

Game aesthetics is not a clear-cut topic, and particularly the interactive aspects of game play are often ignored in discussions regarding this subject. Schell (2008), for instance, defines game aesthetics as: "This is how your game looks, sounds, smells, tastes, and feels" (p. 42). His notion implies that the purpose of game aesthetics is to reinforce the created game world. However, it seems more fruitful to limit the definition of game aesthetics to matters that are active with respect to play experience: "The interplay between a game's rules and the player's interaction with them which, in combination lead to an aesthetic of game play" (Lundgren et al., 2009, p. 1). In this work, game aesthetics are the dynamics that occur between a player and a game as a consequence of its design: aesthetic choices at design time such as selection of purpose and rules afford certain activity and interaction patterns at play time.

Narration in Games

In many traditional games, such as card games and chess, there is no fixed predetermined story to unfold. Each new play creates a new story within given constraints. With the advent of computer technology, game designers were offered even more possibilities of interaction and storytelling: the player could be invited to be a character within a game, or the computer could act as an active counterpart. Schell (2008) asserts that an important feature of a good game is its ability to create stories:

> A good game, however, tends to generate series of events that are interesting, often so interesting that people want to tell someone else what happened. From this point of view, a good game is like a story machine – generating sequences of events that are very interesting indeed (p. 265).

Furthermore, he states: "Designers of these games never had these stories in mind when they designed the games, but the games produces them, nonetheless" (p. 265). Think about all the stories that all kinds of sports events generate. Here an example from professional cyclist Michael Barry: "The riders who finished the Tour de France a month ago share stories while teammates smile, not exactly able to comprehend the story, as the bond built between the Tour de France teammates separate them from the rest " (Barry and McMillam, 2010, p. 178). In television and in newspapers, participants share their experiences by telling their stories, and experts analyze matches, races, or whatever event had taken place. In such events a story has unfolded, and the game itself provides the framework that confines the sequence of events. Schell (2008) asserts that a game is: "– to create a system that generates great stories when people interact with it" (p. 265). Schell points out and distinguishes two types of common narrative strategies in game design: *The string of pearls* (Figure 11), and *the combinatorial explosion* (Figure 12).

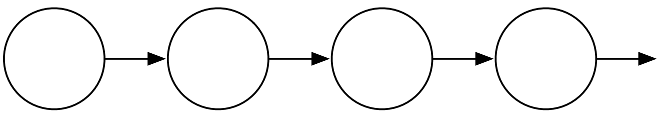

Figure 11: The strings of pearl model. No interactivity is involved regarding story (the string), and a player is given some freedom within each moment (the pearl), which contains a fixed problem to solve. (Image in Schell, 2008, p. 264).

The string of pearl prescribes a player to solve a fixed sequence of predetermined tasks. After finishing one story, the player can continue with more stories. The combinatorial explosion allows choices: each time the game is played the player can chose between a number of different paths, each and one with a different task to solve, in order to fulfill the game.

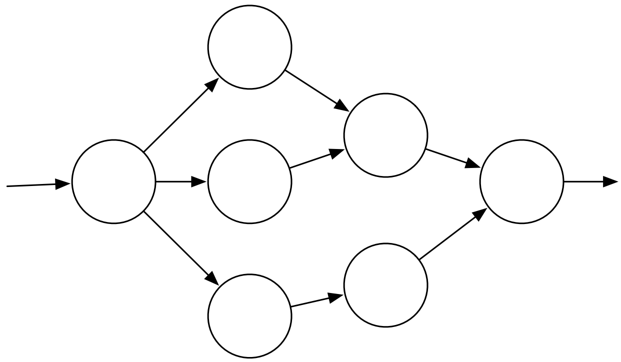

Figure 12: The combinatorial explosion allows a player to take different paths to arrive at the goal. (Image in Schell, 2008, p. 267).

The number of choices increases exponentially with the number of possibilities, which is the combinatorial explosion. Too many choices confuse the player and make the game hard to understand. Schell poses a question: is it meaningful to come to the same conclusion by travelling different paths? In addition, designers have to make paths that a player may not ever enter. One idea is to experiment with multiple endings, which may bring doubts to a player whether it is the real ending, etc. I assume that an in-depth discussion of subject matter leads beyond the scope of this work and stops here. I rather point to some interesting notions in game design regarding narration that may be applied to music.

As an example, I assume that a game such as chess can be regarded as a combinatorial explosion type of game narrative. Each move represents an alternative path, but each new move also re-draws the map of possible paths for the next move, and the number of possible paths decreases during the course of play, until the game reaches a state with no more choices available, one player is in checkmate.

Finally, Schell poses another important question: “Which is most challenging – to create a great story or to create a system that generates great stories when people interact with it?” (p. 265). This question is relevant in music as well.

Player Types

One way to approach various game experiences among players is to describe and distinguish game preferences based on player types (Figure 13). Different games attract different players types. However, within one single game, it is possible to maintain different playing attitudes. Schell refers to two taxonomies of different playing attitudes: one by video game designer Marc LeBlanc, and another by game designer Richard Bartle.[89] Leblanc suggests a taxonomy of game pleasures that consists of eight categories: *sensation*, *fantasy*, *narrative*, *challenge*, *fellowship*, *discovery*, *expression,* and *submission*. A far more interesting taxonomy with respect to music, according to my point of view, is Bartle's taxonomy of player types:

- *Achievers* want to achieve the goals of the game. Their primary pleasure is challenge.
- *Explorers* want to get to know the breadth and the limits of a game. Their primary pleasure is discovery.
- *Socializers* are interested in relationships with other people. They primarily seek the pleasures of fellowship.
- *Killers* are interested in competing with and defeating others. This category does not map well to LeBlanc's taxonomy. Interestingly, Bartle characterizes them as primarily interested in "imposing themselves on others," and includes people who are primarily interested in helping others.

Achievers are interested in acting on the world; explorers are interested in interacting with the world; socializers are interested in interacting with players; and killers are interested in acting on players. (in Schell, 2008, p. 110).

89. Both these taxonomies are presented in Schell (2008, pp. 110–1), however included in the anthology *The Games Design Reader: a Rules of Play Anthology* by Katie Salen and Eric Zimmerman (2005).

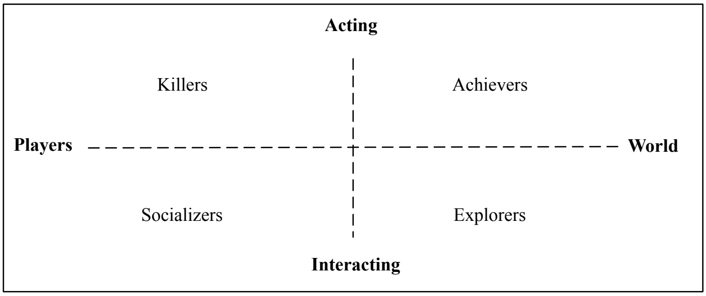

Figure 13: Bartle's taxonomy of player types, in Schell (2008, p. 111).

Schell also points at additional "pleasures" among players: *anticipation*, *delight in another's misfortune*, *gift giving*, *humor*, *possibility*, *pride and accomplishment*, *purification*, *surprise*, *thrill*, *triumph over adversity*, *wonder* (p. 111). In Salen and Zimmerman (2005) players are categorized with respect to their "lusory attitude" – attitude towards rules and practice – and order them in five player types: *standard*, *dedicated*, *unsportsmanlike*, *cheat* and *spoilsport*. However, Parlett (2005) suggests a sixth category, the *technical player*. A technical player is characterized by an interest in technical possibilities and principal issues of a game, rather than in competing.

Interaction Patterns

One attempt to create a systematic general categorization of games is made by game researchers Björk, Lundgren and Jussi Holopainen in *Game Design Patterns*. In academia, according to Björk et al. (2003), most descriptions, and taxonomies has been based upon concepts from film and theater that focus on the narrative aspects of games. However, such viewpoint risks missing the interactive nature of games, which probably is its most significant feature: "With interaction we mean both the interaction between players playing a game and the interaction between players and the game" (p. 4). According to Björk et al., a game may be described according to three different categories: *bounding*, *temporal* and *objective*. Bounding consists of *goals*, *rules*, and *game models*; temporal deals with *actions*, *events*, *and conditions*, *evaluation functions*, and *closures*; while the objectivity category consists of *players*, *interfaces*, and *game elements*. Furthermore, game elements contain *control/action structures* and *information structures*, which control allowed actions and what knowledge a player may have of a game state respectively. The authors exemplify with the children's game *Paper-Rock-Scissors.*[90] According to the authors, game pattern concepts may be used in various ways such as idea generation, analyzing tool and problem solving, etc. Taxonomies of Schell and Björk et al. share many features, and I chose to use selected concepts from both of them, which I present in the following discussion.

By listing and defining a number of interaction properties Björk et al. establish a taxonomy of game play aesthetic properties, and propose a list that consists of the following categories: *rule consistency, simplicity, chance, emergence, rule cohesion, tempting challenge, meaningful choice, varying strategies, game balance, minimal excise, integrated theme, accurate simulation, gamer interaction, gamer elimination, skill, micro management,* and *limited play time.* Some of these properties, such as skill and chance, coincide with items in game mechanics; however, it is possible to uphold two different views of them. On the one hand game mechanics feature procedures and methods that are used at design time, such as the function of dice and other chance methods; and on the other the aesthetics is about interactive matters that only appear during play. I will present a few properties briefly.

Rule consistency is an aesthetic virtue, however there are examples of games where rules change during play. *Simplicity* is rules that are easy to understand and are well defined, which makes a game more accessible. Simple rules do not necessarily imply that a game must be simple: *Emergence* may occur in games that feature few rules, which generates complexity, and chess is a typical example. *Rule cohesion* describes the integration of rules, and if effects caused by an omitted or changed rule are severe, the rule set is cohesive. *Tempting challenge* denotes that a game must be challenging

90. Paper-Rock-Scissor is a well-known game pattern, sometimes called triangulation, and its structure is to be found in other games as well. This structure may be implemented such that choices have immediate effect, like in the game of origin, or long-term effects. Basically, the pattern promotes *tension*, which is released when choices are revealed, or effects of strategy are apparent. Description: This pattern is based on the children's game with the same name. It means that players try to outwit each other by guessing what the other ones will do, and by tricking other players to make a wrong guess on one's own action. The original game is very simple; after a count to three both players make one out of three gestures, depicting rock, paper or scissors. Rock beats scissors, scissors beat paper and paper beats rock. That there is no winning. Strategy is the essence of the pattern: players have to somehow figure out what choice is the best at each moment. (Björk et al., 2003, p. 6).

and doable at the same time. This connects to the notion of *Flow,*[91] which in turn is a matter of skill with respect to task. *Meaningful choice*: A game must offer choices; otherwise, it is no game at all. The level of difficulty normally increases with the number of offered choices. *Gamer elimination* appears when interaction is taken to its extreme, that is, exclusion from further play, by means of bad performance or bad luck. *Limited playtime* means that many games, and notably sports, have time constraints. Moreover, Lundgren et al. (2009) identifies eight different aesthetic ideals: *Light games, pottering, emergence, meditation, player adaptability, reenactment, camaraderie,* and *meta-game.*[92]

91. A concept coined by Csíkszentmihályi (1996).
92. I provide one example of game aesthetic ideal, namely *emergence*: This group features games like chess and Othello. Primarily focus is on *emergency*, but *simplicity* and *rule consistency* are present as well. An *integrated theme* may explain the basics of the game, but rarely play an active role with respect to *emergence*. Furthermore, the lack of theme makes *accurate simulations* impossible. The ideal of getting the maximum out of minimal rules also excludes *micro management* and favor *minimal excise*. A gamer skill is often connected to exploring *varying strategies*, and to displaying superior skill is a way to provide *tempting challenges*. Typically, games of this type rely very much on aggressive *gamer interaction*, with *gamer elimination* as the ultimate goal. *limited play time* is rarely explicitly written out, but most likely regulated in official tournaments. Noteworthy, most emergence games have evolved during a long time, rather than being designed. A plausible explanation is that that *game balance* is hard to achieve without extensive testing, and therefore, exceptions from *rule cohesion*, is a product of fine-tuning of the rules over the course of a long time.

Game Design Applied to Music

By applying terms and concepts from the field of game and play on improvised music, including analysis of player type preferences and game aesthetics, it seems possible to reveal hitherto covered meanings in music. In this section, firstly, matters are applied to general musical concepts, and secondly I discuss a number of musical styles, including specific pieces, which contain improvisatory elements, much like a game. I will emphasize that this particular way of applying game design theory to music is my own idea. However, to equate improvisation with a game is by no means unique, as an example, in addition to the heading quote by Cardew, improviser and composer Fredric Rzewski (2004) asserts:

> Improvisation is a game that the mind plays with itself, in which an idea is allowed to enter the playing field, in order to be kicked around in pleasing patterns for a moment before being substituted for another idea (p. 267).

Undoubtedly, another source of inspiration is a sub-genre of contemporary music called *Game Pieces* (see page 118). Noteworthy, Game Piece is a prescriptive concept; in practice an open composition, while my contribution also opens the possibility for using concepts from game and play as tools for analyzing music.

As stated previously, a score is not the music; it is a set of instructions for a sequence of actions to be undertaken by players in performance. With reference to a distinction between game mechanics and game aesthetics described on page 84: it is the goal and rules that define and control a game, but is not the game, whereas aesthetics arise out of mechanics in playing the game. Composing is about designing rules of music behavior and interaction, and by interpreting and applying given rules in real-time play; the result is perceived and experienced as music. To paraphrase Cage: composing is one thing, and playing is another thing (see discussion about design time and play time starts on page 27). Moreover, some compositions rigorously regulate activity, or music behavior, while others give more freedom to participating players. All this can be said of a game as well. A composition as well as a game, as product, is the result of activity at design time with the intention to control future activity at play time.[93] To compose is similar to design game mechanics.

93. Cardew points at composition as an activity for possible future activity, (in Prévost, 1995, p. 60). See also Design Time – Play Time, starts on page 27.

Aesthetics that appear at play time are a consequence of applied mechanics, that is, an effect of goal, rules, and procedures that are decided at design time.

General Musical Concepts

Narration and Rules

One common critique against improvised music, particularly in freer forms of improvisation, is that that it handles musical form poorly, and all activity focuses on the gestural meso time level, while paying no attention to the larger macro time level. Most likely, the answer to this critique from the improvisers themselves assert that musical form at macro level is simply not an issue. Seen in retrospect, all music has form; a certain sequence of events did unfold in time. Some improvisations do not contain any predeterminations regarding form, while in other, music form is predetermined to a certain extant. However, in all improvisations there are a number of contextual preconditions: participating musicians, employed instruments, playing space, etc., and the unfolding of events is a consequence of interaction and decisions made in real-time within these conditions. A game or sport is about interaction with the game and with fellow players. A match of soccer can be really boring for 80 minutes, and then the last ten minutes can be amazing; a cycle race can be exciting from kilometer zero until the end, or just interesting the last 10 km. The same is true with improvisation, sometimes it is interesting throughout, or at other times is can be boring. This is a risk every improviser has to take into account. Before the event happens, no one knows what will happen, but as soon as it is finished a narrative exists. A good game tends to generate series of events that are interesting and that people like to tell stories about (see page 93). Similarly, the talk after a concert in the bus, or at the bar, most likely is about what happened during the concert. To play is to generate stories.

To the question of rules: one experience I believe I share with many improvisers is about that, occasionally, improvisation is easy, while at other times it feels terrible difficult to produce anything meaningful. There are certainly many plausible explanations, but quite often, it is a feeling of lack of meaning and belonging. When improvisation does not work, it feels like not finding one's place in the space, or disability to speak and understand a language properly. In order to describe this space, concepts such as syntax, language, rules, culture, and social context may be used. In idiomatic music, such as baroque and jazz music, the concept of syntax is widely used by means of defining allowed organization of the tonal material:

> All ways of musicking have some kind of syntax, some way of controlling the relationships between the sounds that are made: it is a necessary condition for the creation of shared meanings between those taking part (Small, 1998, p. 122).

Depending on genre, formal rules explicitly constraint, for instance melodic, harmonic, and rhythmic properties: rules for harmony, voicing, and substitutions, and in certain four-part music rules about parallel fifths. Unwritten rules are about performance conventions and techniques such as phrasing and timing matters, allowed instruments, timbral ideal, etc. Context includes tradition and history, social contexts, performing venues, etc. From this follows that the formal musical syntax only deals with one part of the playing space, and to fully understand a music genre it is mandatory to apprehend all aspects of the constituting space.

It seems plausible to apply Parlett's (2005) taxonomy of rules on music improvisation; however, it must be done with great caution. Firstly, *operational rules* are *explicit rules*, possible to communicate verbally, and effectively inherent in a genre. In addition, there are two sets of *implicit rules*, which are *foundational rules* and *behavior rules*. Foundational rules define principals behind operational rules, chord substitution rules in functional harmony based jazz is an example. Behavior rules deal largely with playing conventions discussed above, that is, the unwritten rules. In parallel to games, it seem possible to distinguish between *folk games* and *book games*, which equal orally handed over traditions, such as folk music and New Orleans style jazz on the one hand, and score based music such as open work pieces and Stockhausen's intuitive music on the other. One striking parallel is the development and local variations of rules. Before jazz fake books appeared in the '70s, notably *The Real Book*,[94] a great variety of harmonizations of jazz standards was commonplace. This was probably due to the influence of word of mouth, from major and/or local players, who set a standard. Alternatively, maybe someone copied a recorded version, especially if the artist was well recognized. In other words, jazz until the '70s was in essence an oral tradition, despite the fact that most songs were written compositions

94. The Real Book was an unauthorized publication comprising transcriptions of standard jazz tunes that appeared in the '70s. This book contributed to establish an "official" jazz repertoire, and become widely used in (jazz) music education.

in the first instance. However, the printed versions of jazz standards that appear in The Real Book have largely defined the "real" or at least referential versions.[95] Curiously, transcriptions in The Real Book are mostly based on singular recordings. I will here provide an example from *The Improvisation of Musical Dialogue: a Phenomenology of Music* by musicologist Bruce Ellis Benson (2003) that sheds light on this topic:

> A particularly poignant example of the supplementation by performance can be seen in history of Thelonious Monk's tune "Round Midnight" composed in 1944. When it was first recorded by Cootie Williams, he felt free (as would most jazz musicians) to embellish the melody. But those embellishments were there picked up by the sheet music versions, since they were based on the recording rather that something written. Then, when Dizzie Gillespie recorded it in 1946, he included both an introduction and a coda that originally had been part of his standard rendition of "I can't get started" Those changes so affected the identity of "Round Midnight" that Monk himself adopted them. By the time Miles Davis recorded the tune in 1955, not only did he follow the by-then 'standard' changes but also included three new measures at the end of the first choruses (as a kind of interlude). The result is that, today all those embellishments have become part of the identity of 'Round Midnight' (p. 153).

What once was a singular version of a particular jazz song is incorporated as the *official rules*, and possibly the revised *written rule*. According to Parlett, *laws* are temporary modifications, exceptions and clarifications mostly undertaken to balance a game, which may eventually become part of the official rules. In jazz music, such as the *Round Midnight* example, this is commonplace. Another example is the chord sequence Coltrane features in *Giant Steps,*[96] which was also used in the bridge of his version of the standard tune *Body and Soul* (Coltrane 1958), and is now considered a "legal" alternative harmonization. Other examples are *house rules*, where rules are incidentally changed, but may not become official rules.

95. Some transcriptions in The Real Book are poorly made, and in local communities, quite often, "official" corrections circulate.
96. Giant Steps is presented and discussed further on in this work.

Game Aesthetics and Game Play Properties

The presented taxonomy of game aesthetics proposed by Lundgren et al. (2009) deals with rules and procedures in different games in relation to interaction patterns they give rise to in play. In an attempt to apply this taxonomy to music improvisation, I restrict myself to apply only a limited number of properties to music in order to exemplify the concept. It is worth noting that many music analyzing tools deal with the musical work, the composition, whereas the intentional focus in this attempt is directed towards performers. Further down in this section a number of pieces of music are analyzed with applied rules from game and play.

Rule consistency: In many ways a music genre presupposes consistency, otherwise it will loose its identity. However, in parallel to certain games, which may change rules during play, a musician to mention here is jazz trumpeter Miles Davis. In *A Sense of the Possible: Miles Davis and the Semiotics of Improvised Performance* author Chris Smith (1998) retells the following story:

> For 'Aida' (1980), he told (bassist Marcus) Miller to play an F and G vamp, but when Miller stuck resolutely to the chords, Davis stopped the band. 'Is that all you gonna play?' he asked. 'I heard you was bad. You ain't playin' shit.' So Miller filled in his wamp ornately on the next take, and Davis stopped the band again. 'What are you playing?' he asked Miller. 'Just play F and G and shut up' (p. 261).

Inevitably, Miles deliberately changed rules and according to Smith this was intentional in order to create ambiguity for participating musicians.

Simplicity might be to imply very simple prescriptive rules of behavior and interaction. Wolff's *Play* (see page 153) and Stevens *Click Piece* (see page 112) are examples. It may also be to prescribe to improvise over one bass figure in one key for instance.

Chance has been used in music in many different settings and traditions, and probably most known is Mozart's musical dice game *Musikalisches Würfelspiel.*[97] By applying methods and theories from different scientific fields, a more deliberate use and integration of chance operations

97. In Mozart's piece chance is confined to make decisions of selection and assemblage of the final form from 272 pre-composed bars. www.amaranthpublishing.com/MozartDiceGame.htm (April 2009).

into contemporary music composition took place after World War II. Cage started to use the I Ching to determine new events within compositions, and one of his first works that was made accordingly was his piece *Music of Changes* from 1951. Thus, he used elements of chance during the composition process, while the ready score remains fixed.

Emergence is always present in freer forms of improvised music, if we presuppose and accept that such music begins with no or open predeterminations. Musical outcome emerges out of activity and interaction within given conditions among the participating musicians.

Tempting challenge is about attempting to perform music that demands and challenges musicians to transcend their playing skills, most likely technically skills, such as ability to play fast, employing extended techniques, playing very strong or soft, or perhaps duration skills. One example is music written by Swedish composer Claude Loyola Allgén, and another is music by British composer Brian Ferneyhough. Yet, other examples can be to perform the "impossible", like playing a complete transcribed Beethoven symphony on a violoncello.[98]

Gamer elimination is perhaps not particularly common in music, but competitions in first and foremost classical music comes to mind. Nevertheless, in jazz, jam sessions may sometime develop into a pure competition between competing musicians. Legendary tenor battles come to mind, which were undertaken between giants such as Lester Young, Coleman Hawkins, and Ben Webster back in the '30s, '40s, and '50s.

Secrets in Music

In music improvisation, the idea of secrets may not be directly transferable from the game world, but I will rank previous common experiences among musicians in the same category. Let us assume the following scenario: a trio consists of two musicians that have played together for many years while the third only knows them from records and concerts. By means of common experience, the two former musicians have developed playing habits that are secret for the third musician.

98. I have heard Swedish cello player Peter Schuback doing exactly this at a conference about artistic research in Gothenburg, arranged by the Artistic Faculty at University of Gothenburg in autumn 2009.

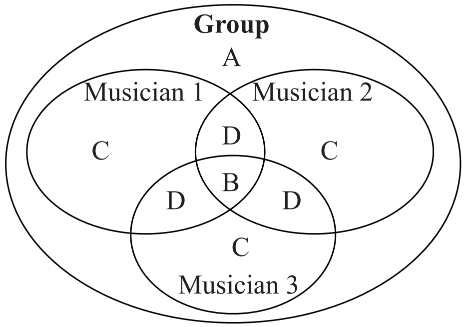

Figure 14: An improvising group may share and/or have secrets to each other: A = common agreements of rules and procedures; B = common shared personal knowledge; C = private knowledge; D = private knowledge shared by two. Based on a diagram in Schell (2008, p. 139).

In the case of an improvisation trio, A is open information of common agreements such as aesthetics, repertoire and playing behavior; however, computer software may take the role as the decision maker with respect to playing behavior and/or selections of material, and as a consequence controlling the sequence of unfolding events and overall form to a certain extent. In a sense, the computer knows more than the musicians do. One such example is Lewis's (2000) *Voyager* software where implemented musical rules and given input from a player generate musical output. A more "low-tech" solution of this concept is to let an external person, or one band member making decisions about temporary playing constellations. British composer Bryars experimented with secrets in music in the early '70s. As an example: in *Serenely Beaming on a Five-barred gate*[99] he uses 64 tape recorders, each one contains two channels of identical prerecorded spoken verse by Patience Strong, which feeds the headphones of 64 performers. Each performer has to reproduce what they hear in a certain way into a microphone, which in turn feeds into headphones of 32 other performers, who listens to two readers each in separate channels. In turn, they have to repeat what they hear, and the result feeds to 16 performers in the same manner, and so on all the way down to one performer. The vast amount of sonic content in the piece are hidden for both performers and audience,

99. Presented in Nyman (1999, pp. 93–4).

who only are able to hear the last performer in the network, and no performer hears more than the sound provided in their respective headphones.

Skills in Music

In order to play an acoustic instrument, a player needs physical skills acquired through deliberated practice carried out on that particular instrument, and no short cuts are given; mental skills in order to read music and to handle various kinds of tasks; and social skills to be able to cooperate with other musicians. However, with digital musical instrument the situation might be different. By means of mental and social skills, and a possible fourth category, *aesthetic skills,*[100] a player can control and play a number of software instruments simultaneously, which may be previously "non-practiced" or new inventions. Since virtual skills, such as ability to play very fast and rhythmically exact may be built in, where control is made from one single controller of choice, necessary physical skills are fractional compared to playing an acoustic instrument. In a sense, this topic is at the core of my dissertation and is discussed more thoroughly in the Analysis chapter.

THE OPEN WORK

One particular genre of music or compositional method that deals with game-like elements is a branch of post World War II contemporary music known as the *open work,* or the *open score*. In the seminal article *The Poetics of the Open Work,* written in 1959, Italian author Umberto Eco (2004) explains the open work by referring to composer Pousseur,[101] who claims: "is not so much a musical composition as a *field of possibilities*, an explicit invitation to exercise choice" (p. 168). An open work offers freedom to the performer, a field of possibilities, but is still constrained to material and procedures provided. This notion is compatible to Mussami's *field of potential*, described in the spaces section in the Play Time Aesthetics chapter, on page 85.

100. By aesthetic skills I mean deep, internalized knowledge of concepts and performance practices of certain traditions and genres, and in addition, knowledge of other fields of importance. Or in other words: the ability to artistically express an aesthetic problem.
101. Quoted from a description by Pousseur of his piece *Scambi*. Noteworthy, Eco's essay was written in 1959, and discusses music works that in essence consists of traditionally notated parts, whose order of performance are indeterminate. However, I claim that his reasoning also is meaningful in even more open compositions that were made after his essay was published.

A salient feature in an open work implies that a musician has to make choices during a performance and by applying Parlett's vocabulary: it contains imperfect future information regarding musical form. Furthermore, this is also compatible with the notion that a game must offer choices; otherwise, it is no game at all.

According to Schell (2008), there exist basically two types of narratives in games: *the string of pearls* is about a fixed sequence of events, while *the combinatorial explosion* allows a player to chose among different predetermined options. The former is compatible with a traditional score, to perform a number of movements in a fixed sequence. In contrast, the latter example equals an open work in such a way that it does not specify the sequence of movements. For instance, Pousseur explains his piece Scambi: "It is made up of sixteen sections. Each of these can be linked to any two others, without weakening the logical continuity of the musical process" (in Eco, 2004, p. 168).

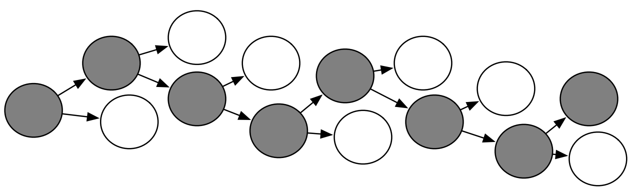

Figure 15: Scambi can be seen as a game with multiple endings, any section can be linked to two other sections. One performance actualize the composition. Another choice at any instant will change the outcome.

Musical form comes out of choices made by the performer (Figure 15), which will vary from time to time. In the Scambi notes, Pousseur expresses a similar notion:

> Every performance explains the composition, but does not exhaust it. Every performance makes the work an actuality, but is itself only complementary to all possible other performances of the work (p. 171).

A performance of an open work is compatible with playing a game, and one single performance actualizes the game, but is only one singular outcome of all possible outcomes of that particular game. An open work consciously operates with elements of uncertainty, and asks performers to explore inherent possibilities, which makes it a compositional and performative principle.

Other examples of works in this spirit are e.g. *Treatise* by Cardew (1965) whose score contains abstract graphical elements, and provides no further information, and it is up to the performer's discretion, based on interpretation, to choose instrument and playing behavior. Yet another example is *Play (Stones)*[102] by Christian Wolf, which instructs performers to make sounds with stones, plus a brief note of advice regarding playing behavior. In the '60s, parallel to this development, free improvisation materialized, a music where all explicitly made up determinations where thrown out. In principle, the only thing that remains is a field of possibilities, and the task for participating musicians is to explore this field.

JAZZ MUSIC

In traditional jazz music, form and content are regulated by the tunes, while praxis of performance and ensemble constellations rely upon convention and regularities, rather than formal regulations. During the '20s and '30s musicians such as Louis Armstrong, Coleman Hawkins and Lester Young methodologically start to develop jazz improvisation. In the very early phases of jazz development, an improvisation most likely involved embellishing a melody, while these musicians during soloing deliberately lose all connections to the original melody, and instead use the underlying harmonic structure as the springboard for improvisation. This development reached a peak during the be-bop era in the '40s and in offspring styles such as hard bob in the '50s. Musicians in that era, notably Charlie Parker and Thelonius Monk, developed an advanced musical/harmonic syntax that primarily constituted a framework of chord substitutions, based on functional harmony. A hallmark of a be-bop improviser was to outline and vary the sequence of chords in an elegant, innovative, and correct way, but at the same time being personal. One very common chord formula within harmony-based jazz is the so-called II-V-I progression (e.g. Dmi7-G7-C). By reinterpreting the tonic, in this case C, replacements of dominant chords at a tritone distance, and/or displacements of complete II-V-I sequences to different intervals, in addition to other rules for replacements, it is possible to create alternative logical harmonic paths with respect to the original. To "play" (in Huizingian sense)

102. The piece is presented in the Instrument chapter.

with the sequence of chords is a salient feature of harmony-based jazz.

Giant Steps

One extreme example of functional harmony based jazz is Coltrane's (1960) Giant Steps whose underlying harmonic structure constitutes a well-defined space, derived from the syntax of be-bop. The dynamic of the piece relies mainly on a harmonic invention by Coltrane, where underlying harmonic cycles consists of II-V-I sequences that ascend and descend in third or tritone steps. The chord sequence is as follows:[103]

B/D7 (I)/(V7	G/Bb7 1)/V7	Eb I	Ami7/D7 (II7/V7
G/Bb7 I)/V7	Eb/F#7 I/(V7	B I)	Ami7/Bb7 II7/V7
Eb I	Ami7/D7 (II7/V7	G 1)	C#mi7/F#7 (II7/V7
B I)	Fmi7/Bb7 II7/V7	Eb I	C#mi7/F#7 (II7/V7)

It is beyond the intention of this work to go into musical details, but it is noteworthy to point out that the chord sequence emphasizes constant harmonic modulation, rather than clear-cut tonality. The formation of the sequence implies a semi-constant movement forward and upward, each II-V-I sequence at the end of each four bar period charges and induces new energy into the next four bars in a perpetual fashion. Note that the tonic in the third bar in each four bar group forms an ascending augmented chord: Eb, G, B, and Eb, which contributes to the feeling of perpetual upward motion within the cycle, and then starts over again. In addition to the given sequence of chords, it prescribes a fast tempo, around 300 BPM. Moreover, the piece presupposes a jazz context, where the rhythm section plays a so-called walking bass. Since the relatively short sequence of chords is repeated, despite the use of functional harmony, is it hard to perceive much of narrative development seen over the entire piece, the soloists dispose their solos at their own discretion, and seemingly play until they feel ready. Giant Steps affords a play space that contains explicit rules, which govern the sequence of chords and tempo, and implicitly presuppose that participating

103. Chords from the Real Book and functional analysis from Berliner (1994, p. 80).

players master current praxis, including functional harmony and its notation in this context. One may say: "The particular nature of the game lies in the rules and regulations that prescribe the way the field of the game is filled" (Gadamer, 2004, p. 107). Giant Steps is a play that is set in motion by the musicians, and according to Gadamer: "The movement of play has no goal that brings it to an end; rather, it renews itself in constant repetition" (p. 104). My own experience of playing Giant Steps confirms that it is all about playing the right notes at the right time, and by doing so the task is achieved. The tempo is high, and chord changes frequent, which limit choices to a few chord inversions. In *Thinking of Jazz*, John McNeal shares his experiences of playing Giant Steps:

> Although compositions like Giant Steps are fare too more difficult than others technically, they have their own built-in interest. If you just make the changes and the tempo, it's going to be pretty amazing" (Berliner, 1994, pp. 232–33).

The rhythm section gives words to similar opinion: "… there are so many changes, and they move so quickly, all the rhythm section has to do is keep the rhythmic flew going and comp" (p. 399). As McNeall says, Giant Steps is interesting in itself means that a player is as much played by the piece, as playing it. What is the meaning of playing Giant Steps? There is no meaning outside the piece itself, to succeed with the task, to master the piece, is its meaning: "The real subject of the game […] is not the player but instead the game itself" (Gadamer, 2004, p. 106). As a musician, I have a task, and to succeed with the task is to present it. This means, if I solve the task I represent the play, since the play is limited to self-representation. Seen in the rear-view mirror 50 years later, Giant Steps and similar pieces marked an end to this type of improvisation. There were no way to continue in the same direction, and therefore new approaches, such as modal and free jazz emerged out of, and sometimes in opposition to this type of jazz.

Giant Steps attracts *achievers* since it is a *tempting challenge* to get true obstacles of explicit rules which shows *rule consistence* as well as *rule cohesion* to a high degree, but to a certain extent it will attract *explorers* as well, who may explore and challenge the limits of acquired *skills*. It has very little of *emergence* qualities. However, *gamer interaction* is high since the structure is so rigid, and tempo fast, which asks for togetherness and cooperation, and *player elimination* is present as well, since a player may fall out and most likely stop playing. On the original release pianist Tommy Flanagan manages to improvise about one and a half chorus before losing track of the chords, so that Coltrane took over.

CLICK PIECE

Brit John Stevens is considered one of the pioneers of free improvised music. In his book *Search and Perfect* a number of group exercises and pieces, developed since the '60s, are collected. One of his pieces is *Click Piece*, and the instructions say: "The aim in this piece is to produce the shortest, most precise sound possible" (Stevens, 1985, p. 63). Noteworthy, the instructions prescribe no regulation of allowed numbers of musicians or instruments. In a note that accompanies the piece it is written:

> When the piece starts, the clicks are disparate – they sound scattered. As the piece develops and people become more consistently repetitive with their clicks, the clicks of the group seem to draw together, as thought by a magnet, sometimes to the point of the whole group (particularly a small unit) coinciding on a click. The excitement and attractiveness of this event disturbs the concentration of the players, and once again, the clicks become disparate. Clicking together should not be a conscious aim (p. 64).

The given instructions say nothing about coordinated interplay, rather, they emphasize that players should search for the perfect click individually on their instrument. As Stevens points out, the challenge is to produce a series of identical perfect clicks. Therefore, synchronicity that may occur is purely accidental, and as Stevens states, when this does happen, the players are caught by surprise and this disturbs the concentration towards the main task. I have used this piece in numerous improvisation workshops, and it appears that most participants find this piece very attractive to play. It seems that the constraints of playing behavior of a given task – the search for the perfect click on your instrument – liberates the participants from the duties of being a creative and clever improviser. Instead, music emerges out of the individual activity automatically, and therefore, interplay among musicians occurs more or less unconsciously. Contextual matters such as number of participants, instrumentation, and physical space has a direct influence on the audible outcome as well. It is also noteworthy to point out that this piece is a performance piece in its own right, not just an improvisation exercise, with a strong and appealing identity.

Click Piece attracts *explorers*, the task is to explore an instrument, and also *socializers* since everyone in the group is basically doing the same thing, that is, clicking. The rules of the Click Piece rely on *simplicity*, but first the piece supports *emergence*, and there is *rule-consistency* throughout.

Tempting challenge is about using the instrumental *skill* of sound control. *Gamer interaction* occurs as a consequence of the given instructions, and is basically a relationship between the player and the game, the application of rules on a given instrument, and to a minor extent between players.

THE GREAT LEARNING

Cardew was one of the most influential experimental composers in the '60s, and several of his pieces are now classic, e.g. the graphic score *Treatise*, and *The Great Learning*, based on a book by Confucius, which comprises seven written paragraphs. Cardew takes corresponding paragraphs in Confucius's oeuvre as point of departure, for instance, paragraph two takes advantage of the way Chinese signs are drawn, and regards brush strokes as musical gestures, subsequently transformed into music notation. I discuss paragraph seven, a movement for choir.

Cardew prescribes a mixed choir, men and women, amateurs and professionals, with a number of 50 to 60 singers. The piece is constructed as a network process, and participating singers are asked to perform according to the instructions in the score at their own individual pace. The score looks as follows:[104]

>	sing 8	IF
	sing 5	THE ROOT
	sing 13(f3)	BE IN CONFUSION
	sing 6	NOTHING
	sing 5(f1)	WILL
	sing 8	WELL
	sing 7	GOVERNED
	hum 7	
>	sing 8	THE SOLID
	sing 8	CANNOT BE
	sing 9(f2)	SWEPT AWAY
	sing 8 AS	
	sing 17(f1)	TRIVIAL
	sing 6	AND
	sing 8	NOR
	sing 8	CAN
	sing 17(f1)	TRASH
	sing 8	BE ESTABLISHED AS
	sing 9(f2)	SOLID

104. English translation by Ezra Pound. Presented in Nyman (1999, p. 7).

	sing 5(f1)	IT JUST
	sing 4	DOES NOT HAPPEN
	sing 6(f1)	HAPPEN
	hum3(f2)	
>	speak 3(f2)	MISTAKE NOT CLIFF FOR MORASS AND TREACHEROUS BRAMBLE

At the start, performers have to chose a pitch arbitrary, and sing the word IF for the length of a breath eight times. The next line, sing 5, THE ROOT, has to be sung five times, but now with a pitch audible to neighboring singers, a consistent rule throughout the piece. Certain lines, e.g. BE IN CONFUSION, (f3) prescribes that any three of the total 13 times should be loud. In addition, certain lines should only be hummed. Moreover, singers should move around in the room, however, only between lines. The arrows at left indicates a sign from the conductor to start, a possible collective restart at THE SOLID, and that the last spoken line may be qued or omitted at the conductor's discretion, which means that the piece either ends in unison, or with a last single voice.

The piece involves individual and collective tasks; individually, to sing each phrase for the length of a breath and the choice of first pitch is free, and collectively, since all pitches of consecutive phrases must be audible in the vicinity. Basically two processes are active simultaneously: pitches, which start in a complex chord, and develop towards one unison drone, while the text starts simultaneously but diverges over time. Ideally, the unison drone should not occur too fast, but if this is the case, the conductor may restart the process with arbitrary pitches at the line THE SOLID. Possibly two significant factors will have an impact on the final pitch and speed of the process. Firstly, resonances in the room reinforce certain frequencies that afford selection, and therefore the pitch of the drone becomes different from room to room; professional singers tend to attract less educated singers in their choices of pitches. Another interesting feature to point out is the forte lines. A phrase such as BE IN CONFUSION contains significant fricatives, and when performed loudly by a singer, a singular voice liberates and stands out from the collective for a short while. In my opinion, these features make up the sonic identity in the piece.

Paragraph Seven attracts *socializers* and to a certain extent *explorers*, the former since it is a piece with a strong social component, and at the same time explorative in its nature. *Gamer interaction* deals with the game itself, sing for the length of a breath; other players, choose a pitch that is present in the neighborhood; and the physical space, which *randomly* affects the frequency of the final pitch. *Emergence* is a strong component since the sonic result is a consequence of its rules and not prescribed per se, and *rule consistency* as well, where the few exceptions probably are made by means of *game balance*.

PROZESSION AND INTUITIVE MUSIC

The concept *Intuitive Music* was coined by Karlheinz Stockhausen. From being a serialist composer in the '50s, Stockhausen's music evolved towards open structures in the '60s, manifested in pieces such as *Plus Minus* (1963) and *Prozession* (1967), and eventually moved into text based instructions, almost koan-like in character, notably *Aus then sieben Tagen* from 1968. Without aiming to discuss Stockhausen in-depth, which is beyond the scope of my project, I present examples of Stockhausen's rule-based open compositions in order to elucidate and exemplify a game-like approach to music making. A collection of Stockhausen lectures in England at the beginning of the '70s is available in the book *Stockhausen on Music* (1989). One lecture is entitled "Intuitive Music" and discusses *Prozession* and selections from *Aus den sieben Tagen*. To begin with, Stockhausen (1989) discusses improvisation: "I try to avoid the word improvisation because it always means there are certain rules: of style, of rhythm, of harmony, of melody, of the order of sections, and so on (p. 113). From my horizon, Stockhausen looked for new concepts of composition that involved improvisation, and by giving performers deliberate tasks he forces them to go beyond entrained behaviors, to forget themselves, while still being able to maintain a stable identity in consecutive performances of a single piece.

Prozession

Prozession contains only transformation signs: plus, minus, and equal signs. The piece defines and utilizes four relative musical parameter pairs in its structure: higher/lower, longer/shorter louder/softer, and more/less segments. A plus sign means that the next event should be higher, longer, louder or contain more segments than the previous event, a minus sign the opposite, and in the case of an equal sign, do the same as the last event heard or played. Musicians are instructed to use earlier material by Stockhausen, such as *Piano Pieces 1 – XI*, *Microphonie*, *Momente*, *and Kontakte*, etc. In this sense, *Prozession* is an open work determined in content, but indeterminate with respect to structure and form (in Cagean nomenclature). In addition, there are supplementary rules that say that if a new performance sounds like the previous when starting, make a new start; and likewise if an end reminds of a previous ending, continue and find a new ending. It is thinkable to exchange the content in *Prozession* with other material; despite the fact that Stockhausen was very restrictive with his scores, however, it is likely that the piece should retain much of its identity regardless material. Obviously, *Prozession* is very demanding, since he asks performers to memorize the material, which must be available instantly, and performed with regard to a given transformation sign. By all means it is a closed game.

The piece attracts *achievers* and *explorers* since it contains *tempting challenge*. *Emergence* is also a strong component with respect to audible outcome. Furthermore, the play demands a great deal of instrumental and intellectual *skills, and gamer interaction* is also strong since determination of new events relies to a big extent on the other players' behavior, and the piece shows *rule consistency* throughout as well as *rule cohesion*. *Varying strategies* applies to selection of material on the fly, while *game balance* is evident due to additional rules about possible similar occurrences at starts and endings.

Aus den sieben Tagen

The instructions in Aus den sieben Tagen (From the Seven Days) from 1968, contain a text that directs performers into certain playing behaviors and states of mind. Bailey (1992) interviews British instrument-maker, and composer Hugh Davies about *Intensitat* from the seven days, the text of which is as follows:

> for ensemble
> INTENSITY
> play single sounds
> with such dedication
> until you feel the warmth
> that radiates from you
> play on and sustain it
> as long as you can[105]

Davies points out elements in the instructions that refer to musical structures, for instance: "play single sounds" means that a player, for each sound, is allowed to play more than single pitches and most likely will produce textures, or short phrases. The following lines suggest that performers probably introduce new material individually now and then, and probably a tendency

105. In Bailey (1992, p. 79).

towards increasing intensity will occur as musicians become more involved in the music making. Likewise, the ending will be either a collective stop or a fast decay. Davies compares this piece with free group improvisation, but a significant difference is that he is aware of performing a composition by a composer:

> […] One remains aware of the composer influencing the performance from distance through his score. And the structural indications in the score discussed above ensure that those elements at least will make the result completely different from a free improvisation (in Bailey, 1992, p. 80).

Moreover, Davies claims that, on the one hand, a performer has to be very conscious of playing a definite composition, and on the other, in this particular type of score, it is not necessary to be fully conscious of what to play as one "becomes the music". Stockhausen (1989) exemplifies with another text from the seven days, IT (p. 120):

For ensemble

IT

(IT is the title)

Think NOTHING
Wait until it is absolutely still within you
When you have attained this
Begin to play

As soon as you start to think, stop
and try to re-attain
the state of NON-THINKING
The continue playing

– and so on.

At each performance of IT, by the same or different ensembles, the unfolding of events show similarities according to Stockhausen. It begins with short sound events, occasionally longer sounds appear, which stop when new sounds are introduced. Eventually longer sounds are superimposed, and a dense texture builds up quickly, a state that lasts for a while, until interrupted by a sound out of context, which causes long silences. One potential risk that might ruin the piece is the introduction of preformed, and known idiomatic material, such as jazz "licks" or Indian percussion patterns or: "[…] citations, when you are reminded of something that you already know" (p. 121). Sometimes players cease to listen, and it turns into "rubbish" playing, and in certain circumstances becomes very aggressive and totalitarian, therefore: "Don't play all the time, and don't get carried away" (p. 122). An ideal ensemble size consists of four, maximum five players, and a decisive quality of the players is the ability not to play, which facilitates the formation of spontaneous duo and trio constellations. Essentially, to succeed with IT Stockhausen advises an intuitive approach while playing. Instead of consciously thinking about instrumental technique, the other players behavior etc., the only concern should be Now! Now! Now! Now! Now!. In other words: stop thinking. It is claimed previously that it is not necessary to be fully conscious when playing intuitive music, however, Stockhausen goes a step further by saying, the ideal is to forget yourself:

> Musicians must learn to become the opposite of egocentric; otherwise you only play yourself, and the self is nothing but a big bag full of stored information. Such people are closed systems. But when you become like what I call a radio receiver, you are no longer satisfied with expressing yourself at all. There is nothing really to express […] You become a medium (p. 125).

The provided examples from Aus den sieben Tagen show an approach to music composition that on the surface mostly deals with control of the player's attitude, rather than playing behavior. Nevertheless, as both Davies and Stockhausen attest, from performance to performance, those pieces display a stable identity, and it rather implies that a certain playing behavior is inherent in the text, to a greater extent than first imagined. Finally, we must not ignore the musicians' anticipation of what Stockhausen expected to happen.

Socializers are attracted by this piece. *Gamer interaction* is a strong feature since a player interacts directly with the game space and co-players, and rule *consistency* is not so high, which asks for *varying strategies* with respect to *emergent* qualities.

GAME PIECES

One approach of music making that directly makes use of game and play concepts is *Game Pieces*. This concept connects to the American saxophone player and composer John Zorn. He asked himself: "How can I involve these musicians in a composition that's valid and stands on its own without being performed, and yet inspires these musicians to play their best, and at the same time realizes the musical vision that I have in my head"?[106] In other words: what does the organization principle looks like that will give maximum freedom to participating musicians while, at the same time, preserving the identity of a work? During the '70s Zorn did a number of pieces inspired from sports, for instance *Ice Hockey* and *Lacrosse*. However, his most well known game piece is probably *Cobra*, which is built upon a text based Japanese war game from the '70s. Basically, the rules of Cobra regulate with whom, and when a musician may play, but control almost nothing of the musical content, except in one case that says that performers have to play in a recognizable musical style. In Bailey (1992) Zorn discusses Cobra:

> Where I really started eliminating the time-line, eliminating the idea that the composer has to create in an arc, was in a piece like Cobra where the sequence of events can be ordered at any time by anyone. There I just created relationships, abstract concepts that the players can order in any way they want so that, at any moment in the piece, if they want something like play a solo or play duo, or have the whole band play, they can actualise that (p. 76).

Cobra

In Cobra,[107] the number of musicians has to be ten or more, and there are no rules that specify type and number of allowed instruments. A prompter coordinates the play, which is concerned with accepting and rejecting requests from the players. The rule system consists of roughly twenty different sub systems that may be called by any musician, and if accepted, the prompter cues it at the downbeat of a card. Those cards contain simple graphic symbols (Figure 16).

Figure 16: Examples of cards in Cobra (www.zula.ca/history/cobra_2003.html, January 14, 2008).

106. John Zorn: www.zula.ca/history/cobra_2003.html. (January, 2008).
107. This short description of the rules of Cobra is primary found in the interview with Zorn in Bailey (1992, p. 76–7), from www.zula.ca/history/cobra_2003.html, (January, 2008) and in personal conversations with musicians that have participated in Cobra.

Certain ques deal with permutations of players, that is, formation of small temporary configurations such as duos or trios within the larger group. Therefore, at a downbeat, a group of new players will take over, and do something different. Duo games prescribe that a designated player chose another player to play with. Other systems deal with trading, which means that performers bounce ideas among each other, such as a relay event. Yet, other systems are concerned with musical change, where the already active group of musicians, on a downbeat, change musical style, or the opposite: the group changes while retaining the style of music. Moreover, there are memory systems as well, which mean that memorized sequences, previously played, have to be replayed on request. A salient feature in Cobra is the guerilla, which is when a number of players may take control of the game. A guerilla action may be terminated upon request of a non-guerilla player, a spy, or even suicide is possible.

A central concept in Cobra is to give performers a task, which also connects it to the tradition of experimental music, as discussed in Nyman (1999):

> For each experimental composition presents the performer with a task or series of tasks which extends and re-define the traditional (and avant-garde) performance sequencing of reading-comprehension-preparation-production (p. 15).

The previous quote by Zorn: "How can I involve these musicians…" implies that participating musicians have to be mature improvisers with a personal language, since he asks them to do what they are good at, to improvise. Various performances of Cobra show a list of internationally regarded improvisers, performers that an audience most likely recognizes. Therefore, the meaning of Cobra, as I see it, is to create new relations and context by superimposition of the already known in unexpected ways.

As Zorn states, Cobra deals with personal relations to a great extent and therefore attracts *socializers*, as well as killers, and *achievers* to a certain extent. Rules vary with respect to different sub-systems, but *rule consistency* and *rule cohesion* is high. The musical output shows *emergent* properties, and is based on performers' initiative, as well as applied rules.

Perception in Play

What am I hearing,
what exactly are you hearing?

Pierre Schaeffer

Introduction

This chapter aims to elucidate matters that guide decision-making in play time. In essence, it deals with two questions for the performer: how do I listen, and what do I listen for? I assume that an ecological approach is applicable in music improvisation, given that interaction with the environment goes on continuously, and with all the senses. In this setting, I regard the instruments, playing constraints, fellow musicians, spaces, audience, and other factors as active agents in the environment. A key concept is the theory of *affordances,* and in a theory of *ecological listening*. A classification of time scales in music is presented, which is important in connection to discussions about instrument properties, gestures, musical form, and music genres.

The final section touches upon human perception in general, and discusses listening in particular from a phenomenological point of view. It includes concepts from Merleau-Ponty (2002), particularly his *object-horizon structure*. In *Traité des objet musicaux*[108] Schaeffer (1966) presents theories that in many ways are inspired and influenced by the works of Edmund Husserl and Merleau-Ponty. His work treats subjects such as modes of listening, e.g. *reduced listening*, and *object-structure chain*, as well as introducing the concept of the *sonic object*. Each subject is exemplified with music applications.

108. Chion's (1983) *Guide des objet sonores* comprises the main source of information for this discussion. See Footnote 10.

Ecological Listening

In *Ways of Listening* Clarke (2005) presents the concept of ecological listening, which is based on Gibson (1986). In addition, Clarke references a number of equally important works, e.g. by Albert S. Bregman, W. L. Windsor,[109] as well as *Spectromorphology* by Smalley.

To hear and recognize a sound is to understand its perceptual meaning, and by contrast, to not recognizing a sound is to fail to understand its meaning. According to Clarke (2005): "In ecological theory, perception and meaning are closely related" (p. 6). I provide one example from everyday life: say I hear a periodic sound when I am biking that occurs from the tire touching the mud screen. If I understand the meaning of the sound I will stop and fix the problem, but if I do not understand the meaning of the sound and continue, a puncture may occur. However, a theory of musical meaning may not take perception into account:

> Assume that sounds are picked up in one way or another, form basic units of some kind, (notes, motifs, melodies, textures, etc), and are organized into structures, but that the perceptual processes involved play little or no role in a theory of musical meaning (p. 7).

One notion about our perception, which may be called *standard-information-processing*, asserts that reality is a "maelstrom of sensory stimulation which perceiving organisms organize and interpret" (p. 12). In other words: structure is not in the environment but is created in the perceiver's mind. The standard-information-processing approach claims that understanding is built up stepwise from concrete low-level details into an abstract whole, a so-called bottom-up approach. This is, according to Clarke, a common notion regarding musical perception. In contrast, the ecological approach implies that structure is immanent in everything and people acquire structures directly when perceiving something. The top-down approach describes a conception in which recognition of general structures comes before perception and the understanding of details:

109. Clark refers to *Auditory Scene Analysis: Perceptual Organization of Sound* (Bregman,1995), and various writings by W.L Windsor, e.g. the unpublished thesis *Perception and Signification in Electroacoustic Music*, City University, London (1995).

> The standard-information-process account tends to be disembodied and abstract, as if perception was a kind of reasoning or problem-solving process, reflecting the strong influence of cybernetics, information theory, and artificial intelligence on cognitive psychology (p. 15).

When perceiving music, Clarke claims that humans seem to be aware of "high-level" features directly and immediately, in contrast to lower-level features that the standard-information-processing suggests must be processed first.

According to the ecological theory, perception is a self-tuning process. That is, environmental information intrinsically reinforces the perceptual system such that the system self-adjusts in order to optimize its resonance with the environment: "Resonance is not passive: it is a perceiving organism's active exploratory engagement with its environment" (p. 19). One important concept in ecological psychology is the action of *progressive differentiation* in the context of perceptual learning. A newborn is equipped with undifferentiated perceptual capacities that, on exposure to the environment, eventually take shape, and permit previously unnoticed distinctions to become detectable. The vast majority of perceptual learning happens passively, which is to say that there is no explicit training involved, no supervisor that points out characteristic features and suitable responses. In addition to this passive perceptual learning that continuously happens in a rich environment, directed perceptual learning also occurs. Clarke gives an example from music: inexperienced listeners e.g. children, tends to regard a chord as a single entity. This notion is not wrong: a chord is by definition a collection of notes played simultaneously with homogeneous timbres and similar dynamics.[110] However, if an instructor points out that a chord consists of a number of components, then the perceiver may become aware of previously undetected features that have always being there.

> Awareness of this information is nearly always achieved by a perception/action cycle: the learner is encouraged to 'sing the middle note' or produce some other kind of overt action which has the effect of directing attention and consolidating the new perceptual awareness – a 'reinforcement' of the perceptual information through the perception/action cycle (p. 24).

110. An example Clarke takes from Bregman (1995).

Clarke states that the three factors of perception/action, adoption and perceptual learning are by no means predetermined or mysterious: “The tuning of a perceiver’s perceptual system […] is a consequence of the flexibility of perception, and the plasticity of the nervous system in the context of a shaping environment” (p. 25).

ECOLOGICAL LISTENING APPLIED ON MUSIC

In this work, ecological listening is considered a general point of view. I sympathize with Clarke’s assumption about the top-down approach in perception; we perceive the wholeness, structure, before details. In a performance situation, according to Clarke, we are aware of, and place our attention on general sonic activity rather than the details. By being exposed to certain combinations of sound events repeatedly, we become attuned to certain sonic structures. One such example is idiomatic music: certain sequences and combinations of sounds and timbres are more common than others, and by repetition, a listener gets tuned to them, and almost unconsciously achieves the skill of recognizing and assessing that particular music. I assume that exposure to unexpected and unusual combinations and/or sequences of sound events, such as unknown music or music with less fixed conventions, will challenge previously tuned resonances and create surprise. In order to be able to evaluate the design of new digital musical instruments, tuning seems important as well. Given that the design of many instruments presented in this work are inspired by music I am attuned to, such as electro-acoustic music practices and jazz, my evaluation of the new instruments is bound to be based, to some extent, on comparisons with these previously tuned resonances.

Affordances

The theory of *affordances* was presented by Gibson (1986) in his book *The Ecological Approach to Visual Perception.* A central tenet of his theory is the claim that values and meanings in the environment are directly perceived in terms of what they afford an observer. For instance, air affords respiration, water affords drinking, and a chair affords sitting. Affordances in the environment are measured in neither standard physical quantities nor phenomenological values; rather, they must be measured in relation to both the observer and the environment:

> An important fact about the affordances of the environment is that they are in a sense objective, real, and physical, unlike values and meanings, which are often supposed to be subjective, phenomenal, and mental. But, actually, an affordance is neither an objective property nor a subjective property; or it is both if you like. An affordance cuts across the dichotomy of subjective – objective and helps us to understand its inadequacy. It is equally a fact of the environment and a fact of behavior. It is both physical and psychical, yet neither. An affordance points both ways, to the environment and to the observer (p. 129).

Gibson (1986) claims that the spaces between and around obstacles and barriers in an environment afford a certain human behavior; the topography implies a behavior based on perceived constraints and possibilities within the environment, such as seeking to avoid injuries and/or achieve a certain goal. A little mouse, for instance, perceives different affordances in the environment because of its small physical size relative to a human, and behaves accordingly. A key concept among ecologists is the *niche*, the place that species of animals occupy and/or utilize in an ecological system, and Gibson suggests that a niche is *a set of affordances*. Furthermore: "The niche implies a kind of animal, and the animal implies a kind of niche. Note the complementarity of the two" (p. 128). In our world we classify and give name to a vast number of objects, natural as well as artificial, based on different criteria. Violins and saxophones are musical instruments, pots and pans are utensils, and chairs and tables are furniture, and so on. However, it is the perceived affordances that primarily give meaning to an object, and Gibson is keen to point out that it is only objects detached from, and of comparable size to the animal in question that offer affordances. What about man-made objects? According to Gibson: "This is not a new environment – an artificial environment distinct from the natural environment – but the same old environment modified by man" (p. 130). He also claims that it is a mistake to separate environments, cultural or natural, into distinct physical and mental worlds. There exists only one world where we all live together, although we humans have changed it in order to suit our needs. Therefore, we perceive affordances as much from virtual man-made environments, such as the rules in a game or a sport, as we do from the natural world. A set of particularly rich and complex affordances are offered from other humans as they are recognized as detached objects that dynamically change shape on their surface but yet retain sameness. Humans exchange affordances reciprocally, interacting with one another. Yet another class of affordances are the possible perceptual misinterpretations of affordances, such as the misperception that a glass door affords free passage or that a curtain affords an impassable barrier. An affordance can be positive or negative, some affordances are advantageous, and some are disadvantageous or even dangerous: "Positive and negative affordances are properties of things *taken with reference to an observer* but not properties of the *experiences of the observer*" (p. 137, italics in original). To summarize:

> The possibilities of the environment and the way of life of the animal go together inseparably. The environment constraints what the animal can do, and the concept of a niche in ecology reflects this fact. Within limits, the human animal can alter the affordances of the environment but it still the creature of his or her situation (p. 143).

As human animals, we are free to behave and change affordances within the limit of the environment, but we are still the beings defined by our situation.

Norman (1998) presented a modified definition of affordances in *The Design of Everyday Things*.[111] It is beyond the scope in this work to undertake an in-depth comparative analysis of Gibson's and Norman's definitions, but I want to introduce one of Norman's concepts, namely the difference between *knowledge in the head* and *knowledge in the world*. Knowledge in the head deals with facts and rules, such as remembering the capital cities of Europe or knowing to stop at red light. Knowledge in the world is external knowledge, whose meaning is revealed only on exposure. Norman summarizes this as "out of sight, out of mind" (p. 72). Moreover, he asserts: "Knowledge

111. The original version, released in 1988, had the title *Psychology of Everyday Things*.

in the world acts as its own reminder. It can help us recover structures that we otherwise would forget" (p. 80). One example might be using a memory technique such as putting a book in your shoes in order not to forget it when leaving the house; other examples are the mapping of functions in everyday things, such as which button operates which burner on a stove.

AFFORDANCES IN MUSIC

It seems plausible to apply affordances to certain issues in this work. The notion of the affordance can cast a light on and emphasize the importance of environmental influences in improvisation: an instrument affords a certain behavior, certain music rules afford a certain interaction between participating musicians, and so on. Improvisation, especially in freer forms, rely to a great extent on what people may do, and can do, with their instrument in addition to contextual matters. Therefore, I claim that perceived affordances of agents such as musical instruments, software, participating musicians, and play spaces play a vital role in the creation of improvised music.

An acoustic musical instrument is a man-made detached physical object in the world, which affords sound making.[112] A drum affords hitting, and a flute affords blowing. In practice, basic sound production techniques of common instruments in a certain culture are well known and do not have to be discovered by the novice player. However, based on their construction, different instruments offer a range of playing behaviors that are inherent in the instrument in question: a trombone affords sliding, a guitar or a harp affords strumming, a saxophone affords growling, etc. These features used to be called instrumental idioms and are commonplace knowledge. By experimenting with so-called extended techniques, musicians try to expand the available sonic palette of their instrument. It may be increasing the pitch range, inventing new excitation techniques, or experimenting with new excitation and sound altering objects, among other possibilities. An acoustic instrument is a physical object, and it is not possible to limit it completely to certain properties, such as just one way of producing sound. Within the physical limits of an instrument's construction, there are always new ways to explore. One example that contains both of Norman's concepts is a musical score. The knowledge in the head is the rules of intepreting the musical

112. There is a more extensive discussion about the definition of musical instruments in the Instrument chapter.

symbols, whereas the knowledge in the word is the sequence and properties of the individual notes in a particular score. A digital musical instrument has to be designed in minute detail, and it is possible to build an instrument that is limited to doing only what it is intended to do. A digital piano for instance responds with pitch and velocity in relation to a player's finger position and excitation force when hitting a key. There are no strings to scratch or no possibility of mounting objects on it to employ extended techniques. A synthesized flute, most likely performed on the keyboard, offers a flute-like sound in chromatic steps, perhaps with vibrato and portamento options. But, to give just one example, it is not possible to remove the flute body and play the mouthpiece alone. I claim that digital simulations of acoustic instruments, particularly ones simulating a non-keyboard instrument played from a keyboard, are poor musical instruments. However, by designing complex digital instruments with rich sonic palettes and inherent idiomatic behavior, that afford flexible exploration of playing behavior, then we have created a class of true musical instruments in their own right.

Gibson (1986) states that we perceive the most complex affordances from other humans, as they afford interaction with one another. An improvising ensemble demonstrates this very clearly, since the music produced largely relies on the interaction of the players with each other. In other words improvisation is about reaction and interaction on perceived affordances from fellow musicians. An improvisation group is compatible to a niche: "In ecology a niche is a setting of environmental features that are suitable for an animal, into which it fits metaphorically" (p. 129). Likewise, an improvisation group must be suitable for participating musicians to fit into, and its identity is determined both by individual players' behavior and from the environment.

As in the discussion in the Play Time Aesthetics chapter, I assume that explicit and implicit rules guide all improvisations. Explicit rules, such as harmonic structure and style constraints, specify and afford certain playing behavior, while concepts that are more abstract direct the play into certain areas of interaction and musical outcome. In such cases, applied rules and concepts do not regulate the activity in detail, rather, they point towards a certain direction into which the participants move. In other words, musical rules and concepts afford a certain playing behavior and interaction similar to what happens in a physical environment: "The airspaces between obstacles and objects are the paths and the places where behavior occurs" (p. 131). An improvising concept, or set of rules, gives rise to a certain playing behavior, not explicitly, but because of perceived affordances.

Finally, I present some obvious examples of affordances in the environment beyond the group itself, namely physical and social spaces. The space where an improvisation takes place has a great impact on the music produced. Firstly, acoustics regulate playing possibilities in a very direct way. A large hall with a long reverberation time, such as a church, affords sparser playing, since textures which are too dense drown out and cancel each other, while a dry space affords more energetic playing. Secondly, the social context is also crucial. A jazz club that allows drinking and eating affords up-tempo and dense music, while a concert hall or a church may afford meditative and less dynamic music.

Time and Music

Time in music is mostly linked to traditional notions of musical form and rhythm. However, musical activity implies involvement in different time scales, from the infinitesimal to infinity. I will present some different conceptions of time scales in music that are useful to refer to in this context. Firstly, I present two definitions of now, followed by a discussion that treats time scales in connection to music, proposed by Roads (2002). Secondly, I explore a notion of time from the phenomenological point of view of authors such as philosophers Merleau-Ponty (2002), Schaeffer (1966), and Norwegian musicologist Rolf-Inge Godøy (2006).

NOTIONS OF NOW

Without going deeply into this complex matter, I will here point out two perspectives regarding the conception of now: the physical and the perceptual. The physical now takes place at the infinitesimal level and it seems plausible to regard the so-called *Planck time interval*, a candidate which is the time it take light to travel the Planck scale.[113] Roads (2002) states: "One could call the Planck time interval a kind of 'sampling rate of the universe', since no signal fluctuation can occur in less then the Planck interval" (p. 35). The perceptual now, or present, takes place at several levels and in the case of a sound event, analysis goes on in several steps determined by the nature of our short-term memory. One theory that treats the notion of now is the chunk theory, presented in the seminal paper *The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information*, by G. A. Miller (1956). In this paper, Miller claims that we perceive the world in chunks, which consist of seven plus or minus two units. Yet other, but related ideas, state that a time interval is necessary in order to perceive anything. In *The Experience and Perception of Time,* Robin Le Poidevin (2011)[114] describes our perception of now such as:

113. The Planck interval is 3.3×10^{-28} seconds. (Roads, 2002, p. 35).
114. plato.stanford.edu/entries/time-experience/ (October 2011).

1) What we see, we see as present.
2) We see motion.
3) Motion occurs over an interval.

Therefore: What we see as present occurs over an interval.

Earlier in the same article, reference was made to the 19th century psychologist William James:

> How long is this specious present? Elsewhere in the same work, James asserts 'We are constantly aware of a certain duration-the specious present-varying from a few seconds to probably not more than a minute, and this duration (with its content perceived as having one part earlier and another part later) is the original intuition of time'.

It is also claimed that the perception of the present depends on our short-term memory, which varies from person to person and from one sense modality to another. In recent years, the chunk-by-chunk concept of perception and cognition is supported by neurocognitive research that finds that our attention is divided in typically less then 3-second intervals (Pöppel quoted in Godøy 2006).

American-Australian psychologist and musician Jeff Pressing's twin concepts *feedback* and *feedforward* relate to notions of now. Timescales are typically in the span of 300–500 milliseconds for more complicated tasks, and 150–200 milliseconds for discrete responses.[115] These figures are in line with reported real-time limits among practicing improvisers. Pressing (2002) states: "Feedback is a signal received by the organism from observation of self or the environment that is used to correct or adapt its behavior towards a desired state" (p. 1). The complementary concept of feedforward is about short-time anticipation and preparation of new actions: "Feedforward is advance information about the environment or the organism's own body, used to prepare for action" (p. 1). This relates to an important feature of musicianship, namely the ability to "pre-hear" internally chosen actions without relying on either memory or auditory feedback. It has turned out that the time scales involved in feedback processes are quite often too slow to guide the generation of proper new actions. Therefore, performers often base their actions on

115. Glencross as referenced in Pressing (1984, p. 356).

anticipation of what co-performers are likely to do. This, according to Pressing, is possible because performers (that are practitioners of a certain style) often share compatible performance models.

TIMESCALES IN MUSIC

Roads (2002, pp. 3–41) distinguishes between nine categories of musical time, here ordered from the shortest to the longest: *infinitesimal, subsample, sample, micro, sound object, meso, macro, supra* and *infinite*. As a performing musician and digital musical instrument designer, I encounter issues concerning a broad range of time scales on a daily basis: digital sampling, granular synthesis, gestures, and musical form, for example. I use this taxonomy of time scales to elucidate the operational time range of various matters under discussion.

Infinity is a fundamental notion in mathematics and is implicit in the theory of Fourier analysis, a proven theory with important applications in sound analysis and processing. According to Roads "the Supra time scale spans the durations that are beyond those of an individual composition" (p. 9). This group spans over weeks, months, years, decades and even longer. Here we find phenomena such as music festivals, the historical range of a particular style, a certain stylistic period of a composer, the era of use of an instrument, etc. Other examples are music education over the course of years, cultural tastes that change over decades, and the time it take to compose a piece of music.

The macro time scale includes the notion of musical form. Richard Wagner's *Ring Cycle*, Stockhausen's opera *Licht*, a Japanese *Kabuki* theatre performance, and a game of Cricket are examples of events which touch the upper limits of time in this group. Roads (2002) claims that a listener perceives events on the macro level in retrospect through recall. Such memories, however, are usually distorted, as we cannot remember time as a continuous flow. Composers place references such as cadenzas and repetition regularly in order to orient the listener. In addition, subjective factors, such as aesthetic preferences, previous exposure to the music in question, and so on also play a role regarding the perception of the macro time scale.

The meso level group deals with phrase structures and is measured in seconds. According to Roads this local, as opposite to global, time scale is very important in composition; it is here that matters such as contrapuntal relations, sequences, themes, variations, development, and juxtaposition take place. In an electronic music context a related notion is *sequence* and *field* (Wishart 1996), and Roads (2002) defines field as the sounding material or elements, the vocabulary of the piece, and sequence is the order or grammar of the particular piece (p. 14). Another related theory that deals with the meso level is Smalley's (1997) *spectromorphology* concept. In addition to sequences and phrase structures, Roads (2002) adds another organizational principle on the meso scale: *the sound mass*, which is discussed on page 61.

Into the sonic object group Roads places single events such as a tone produced by an acoustic instrument or sung by a singer, which may last from a fraction of a second up to several seconds. Schaeffer's concept of the *sonic object* (objet sonore)[116] is placed in this group as well, which could include any sound from any source. As Roads states: "The sensation of tone – a sustained or continuous event of definite or indefinite pitch – occurs on the sound object time scale" (p. 17). The lowest frequency we may hear as a tone is estimated to be in the range from as low as 8 Hz up to 30 Hz, but according to the German 19th century acoustician Herman von Helmholz, the lowest definite pitch we may perceive is approximately 40 Hz.[117] Below 8 Hz, there is a perceptual grey zone: it is too fast to be perceived as a pulse, and too slow to be perceived as tone. A sonic object operates on the same time scale as traditional notes, but what is the difference between them? Roads (2002) argues that a "conventional" note is homogeneous with respect to four properties, namely: *pitch*, *timbre*, *dynamic* and *duration*. This means that a note is perceived to be static during its lifecycle, which also implies that a note with certain properties is equal to another note with the same properties in another measure of the music.

> The merit of this homogeneous system is clear; highly elegant structures having been built with standard materials inherited from centuries past. But since the dawn of the twentieth century, a recurring aesthetic dream has been the expansion beyond a fixed set of homogeneous materials to a much larger superset of heterogeneous musical materials (p. 18).

We cannot speak of homogenous notes but heterogeneous sonic objects and the only way to identify them is through properties that they do not have in common.

116. I use the English translation sonic object, whereas Roads use sound object. Regarding sonic objects, see page 139.
117. As a reference: the low E on a double bass is at 41.25 Hz. In most literature on acoustics, human aural perception is limited to the range 20–20 000 Hz.

The micro time scale deals with transient audio phenomena and implies a vast range of sounds, from the edge of our auditory perceptual threshold (hundreds of microseconds) up to the duration of a short sound (≈100 ms), and it spans the entire audible register (20–20 000 Hz). Microsounds are omnipresent in our world:

> We may not take notice of microacoustical events until they occur en masse, triggering a global statistical percept. We experience the interactions of microsounds in the sound of a spray of water droplets on a rocky shore, the gurgling of a brook, the pitter-patter of rain, the crunching of gravel being walked upon, the snapping of burning embers, the humming of a swarm of bees, the hissing of rice grains poured into a bowl, and the crackling of ice melting (Roads, 2002, p. 21).

On a traditional instrument, we find microsounds in fluttering and short bursts, with shakers, small bells, the guiro, and a drum roll. In acoustics and computer music, acoustic quantum, grain, glisson, grainlet, short-time segment, Gabor atom, wavelet, FOF, FOG, Vosim pulse, and pulsar are all examples of microsound. Our perceptual system has limitations with respect to microsound. For instance, pulses that are executed with less the 200 ms separation are perceived as a long fused note. Our listening senses are such that for an interruption within sine waves a 20 ms fluctuation in a 600 Hz sine wave is clearly detectible; however, on complex notes an interruption in the same time span is hardly noticeable.

In the sampled time scale, the sampling frequency determines the time lattice. Assume a compact disc that utilizes a 44 100 Hz sampling frequency, the samples follows each other at every 22.675 millionth of a second. There have been attempts to bring the sampled time scale under conscious compository control, for instance with the Gendyn program by Xenakis, but time has proven this task to be too complex. (Roads, 2002, pp. 30–1).

The subsample time scale deals with fluctuations that occur in less than two sample periods. The most prominent phenomenon is that of aliasing, the so-called mirror frequencies which are generated when the input signal exceeds half the sampling frequency. This is the so-called Nyquist limit, which is at 22 050 Hz on a compact disc. Aliasing is generated according to the formula: aliased frequency = sampling frequency – input frequency. The resulting artifact is a tone whose frequency is derived from the sampling frequency, and therefore does not necessarily feature an integer relation with the input frequency; this results in distortion.

The shortest time scale is the infinitesimal level, and deals with quantum theory, a subject beyond the realm of this project.

Godøy (2006) proposes three terms with respect to time in music, namely *micro*, *meso,* and *macro.* Micro denotes the continuous sound stream, divisible down to sample level; meso is the mid- or gestural level; and the macro level denotes the large-scale continuity level that gives, according to Godøy, "a conceptual apparatus when zooming in and out of sounds as well as gestures" (p. 152). As we can see, Godøy's taxonomy of musical time scales defines three levels, where macro and micro in all essential are equal to Roads, but Godøy's model lacks his specific sonic object level. In my view, Roads' meso and sound object levels fit into Godøy's meso level. Godøy's focus on the meso level does not imply a denial of the other continuing levels; in fact, they exist simultaneously. Moreover, Godøy claims that the concept of holistically perceived chunks, with the sonic object at mesa-level, concurrent continuous micro-level sound on one side, and cumulative memory images at macro-level on the other is not incompatible with perceptual theory.

Time scales in this work

In this work, I use time scales descriptively in order to define and frame actual subject matter under discussion in relation to duration. In accordance with Godøy (2006) I limit time scales to three levels: micro, meso, and macro. Micro denotes short durations, from samples to the length of individual grains; meso is the mid, gestural level, which comprises Roads's sonic object and meso categories, whereas macro signifies musical form. The digital musical instruments I discuss operate mainly at the meso level, with some exceptions, and I will here provide some examples. The shortest controllable object is the individual *grain* in the Granular Machine and the Munger, which can be set to be as short as five milliseconds, and up to 1 000 milliseconds, from micro to meso length. The Schaefferian sonic object (see page 139) is a useful concept in "live" musique concrète applications, when performing real-time sampling and processing of fellow musicians and other sound sources. Sound content is stored in a *sound buffer*, which can be of arbitrarily length, only confined by the available working memory of the computer, and in practice unlimited. However, the buffer length employed is usually set between five to ten seconds. Longer buffer lengths, at the upper limit of the meso level are usually used, since it is possible to select fractions of buffer content at the performer's discretion. The exPressure Pad operates mainly at the gestural, meso level, covering a range from short clicks at micro level to sustained sounds of up to a minute in length. In a sense, the exPressure Pad is like any acoustic instrument: it sounds as long as a player puts energy into it. The Walking Machine also operates at the gestural level, while internal effects can sustain a performed gesture for up to 30 seconds, effectively creating an output which is perceived as a repeating gesture. Finally, some instruments can be set to endless automatic playing, but the output is either loops and sequences at meso length, or a drone tone.

To summarize, instruments in this work allow control of musical parameters in a time span from five milliseconds up to approximately one minute, with an emphasis on meso length. This is not coincidental, since improvised music primarily is about gestural interaction. As touched upon in the discussion of interactive music systems (see page 165), there do exist computer-based improvisation systems that deal with, and to a certain content control larger forms: *Voyager* by Lewis and IRCAM's OMax are examples. I regard such applications to be composition systems rather than instruments. In this work, decision-making regarding musical form at the macro level is left to be determined by the aesthetic choices of participating performers. Organizational matters in improvisation are further discussed on page 246 and onwards.

Intentional Objects

In this work, the concept of intentional objects is important, and in this setting, I use intention in Brentano's sense: a mental state directed towards an object. Two related theories treat relations between perceived objects, and context: Merleau-Ponty's *object-horizon structure*, and Pierre Schaffer's *object-structure chain*.

Merleau-Ponty (2002) states that a perceived object is always seen in relation to a surrounding horizon. When I look at an object I will see it in a certain way from a certain angle, and it would obviously appears differently seen from another side. However, I know that it is the same object despite the fact that it looks different from different angles. To see an object is either to have it on the edge of the visual field, or to respond to its call by concentrating upon it. Fixing the eyes on an object is to be anchored within it, but this anchoring is itself only a new modality or continuation, as an exploration within the object, of a movement that has been previously carried out over all objects that constitute the landscape. In one movement, the landscape closes, and the object opens. To look at an object is to "plunge" into it: "More precisely, the inner horizon of an object cannot become an object without the surrounding objects becoming an horizon, and so vision is an act with two facets" (p. 78). The object-horizon structure makes it possible to distinguish objects, and their relative position, from each other: "To see is to enter a universe of beings which *display themselves*, and they would not do this if they could not be hidden behind each other or behind me" (p. 79). To look at an object is to come to it and inhabit it. However, by inhabiting an object I may also see it as a habitation open for my gaze, since all objects are mirrors of all other objects. Objects can be seen as long as each of them make up a system or a world; and as long as each object treats the others as viewers of its hidden aspect, its permanence is guaranteed. An object is seen from everywhere.

The object-horizon structure may also apply to time. Present time is a fixed point in time that is dependent of all other times to be determined. Each present time permanently emphasizes a point in time: "[…] so that the object is seen at all times as seen from all directions and by the same means, namely the structure imposed by a horizon" (p. 80). The now retains the immediate past, as the future will do with present time. These double horizons of *retention* and *protention* imply that the now become an identifiable fixed point in objective time.

It is only through language and time that one may encounter earlier or other's appearances. Even with exploration and imagination of all possible viewing angles, it is impossible to cover an object entirely. Similarly, my present condenses past and future time, but it is only an intention to grasp the past, it is only as I see it now, and it may be false. The synthesis of horizons is only presumptive, and only has precision and certainty in the close vicinity of the surroundings of an object. More remote parts of the surroundings are not within my grasp. We believe in a truth of the past, and rely on a world Memory:

> The positing of the object therefore makes us go beyond the limits of our actual experience which is brought up against and halted by an alien being, with the result that finally experience believes that it extract all of its meaning from the object. It is the ek-stase[118] of experience which causes all perception to be the perception of something (p. 81).

My body is one of the objects in the world, and it is my viewpoint of the world. Similarly, I treat my personal perceptual history because of my relations to the objective world. My present time is my viewpoint on time, a point among others, and my being will be a mirror, an abstract aspect of universal time. Positing objects exceeds the perceptual experience of synthesizing horizons, as the idea of a universe where relations are mutual determinations; it exceeds the idea of a world: "I now refer to the body as an idea, to the universe as an idea, to the idea of space and time" (p. 82). Conscious life is characterized by its tendency to posit objects, and consciousness is self-knowledge that takes hold of itself into an identifiable object. Despite this, the positing of one single object means death, since it forces experience to congeal. We must rediscover the origin of the object at the core of experience, and describe the appearance of its being in order to understand how, paradoxically, as Merleu-Ponty claims, there is *for us* an *it-self*.

With the terms *object* and *structure* Schaeffer (1966) defines the perceived relation between object and context. We perceive object and structure by means of identification: each object is part of a context and a single object can in turn be described as a unique structure of constitutional objects, which then can be identified and described in yet smaller units:

118. Merleau-Ponty "uses both the French word *extase*, or Heidegger's form ek-stase" (p. 81).

> – Every object is perceived as an object only in a context, which includes it.
> – Every structure is perceived only as a structure of objects which composes it.
> – Every object of perception is *at the same time* an OBJECT in so far as it is perceived as a unit locatable in a context, and a STRUCTURE in so far as it is itself composed of several objects (Chion, 1983, p. 56).

Schaeffer calls this relationship *object-structure chain*, and may either go towards the infinitesimal, or inversely, towards the infinitely big.

SONIC OBJECTS

One of Schaeffer's original and most influential ideas is the concept of *sonic objects.*[119] In *L'onde electrique* musique concrète pioneer Jacques Poullin (1954) wrote:

> The possibility of arbitrarily selecting a fragment of sound, by cutting it out and over and over again as many times as desired, makes it possible to consider this fragment as an acoustic 'object' which may or may not be broken down into still more elementary objects. This object has material existence. It may be physically and musically analyzed and a value judgment may be applied to it individually and independently of the combined phenomena from which it has been extracted. After analysis, this object can be classified and noted down in accordance with a certain number of criteria by which it can be identified and recognized; it can be transformed by electroacoustic manipulations and can give birth to new objects (p. 3).

A sonic object is not an instrument, nor a piece of magnetic tape, nor the groove on a shellac disc; it is a perceptual intentional object. It is worthwhile to emphasize that sonic objects, despite this process of arbitrary selection, can be recognized, described, and classified with respect to perceived features. Each new object will have their own start and end, somewhat similar to the way that magnets, when cut into pieces, will still have a north and south pole in each new part. However, an arbitrarily selected fragment might induce

119. I have found four different translations the original Objet sonore into English: *Acoustic objects* by Jaques Poullin (1954); *sonic object* is used by Gather (2003); *sound objects* in Hellström (2003); and *sonorous objects* by Godøy (2006) and in a translation from Schaeffer in Audio Culture (2004). I chose to use sonic objects since it resembles the French original.

artifacts which are not present in the original, such as quick changes in timbre. Therefore, Schaeffer advises us to make cuts at natural discontinuities in a sound stream, by the principle of *stress-articulation* (Chion, 1983, p. 114). Moreover, as stated in the previous section about time scales in music, a sonic object is equal to a gesture, that is, a sonic event with duration from approximately 0.2 seconds up to 3 seconds.

By referring to Manning's (2004) well-informed summary of the history and theories of Schaeffer, in addition to Chion (1983), I give a brief introduction with the aim of shedding some light onto Schaeffer's classification of sonic objects. Around 1950, during the years of development of musique concrète, Schaeffer realized the necessity to create a classification, a *solfège*, of sonic objects. In this taxonomy, he sorted sonic objects according to *tessitura*, *timbre*, *rhythm*, and *density*. Somewhat later, in 1952 Schaeffer published *A la recherché d'une musique concrete* where he presented an "operational language for the synthesis of musique concrete" (Chion 1983, p. 28). Among other things, Schaeffer presented a provisional list of twenty-five elements that covers a wide range of aspects and properties of sonic objects. The list includes several groups of elements, some of which concern the initial action to create and record sounds (*prélevement)*, and material classification of sounds based on their duration, complexity or status as recipients of transforming processes. One group deals with the practices of composing musique concrete, for instance preparation, montage, mix, and spatialisation. Schaffer presented a taxonomy that went beyond the routines of musique concrète. According to Manning (2004) the categorization was based upon:

1. Evolution of pitch parameters in relation to time.
2. Evolution of intensity parameters in relation to time.
3. Reciprocal relationships between pitch and intensity.

Schaeffer presents the two concepts *typology* and *morphology*. Typology categorizes objects by characteristics based on physical properties of a sound, in essence gesture types. Morphology describes, in more detail, features of sound objects, down to small timbral and/or textural fluctuations. As previously stated, the first step in the process of making musique concrète is to cut out a fragment from a continuous audio stream taking account of stress-articulation. Fundamental sorting is based on three typology criteria, which according to Schaeffer is equal to gestural types:

- Impulsive types/punctual gesture
- Sustained types/continuous gesture
- Iterative types/iterative gesture

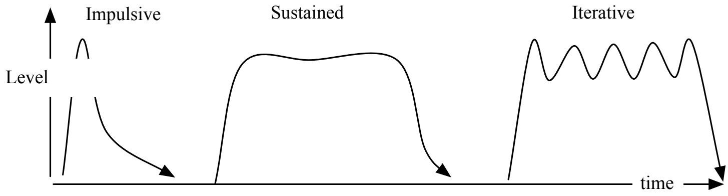

Figure 17: Schaeffer's three envelope types in sonic objects. Image after Godøy (2006).

In addition to this first sorting, the pitch and harmonic content has to be examined. A class called *mass* defines if the object have a definite, complex, instable or evolutionary pitch. An object of the categories *impulsive*, *sustained,* or *iterative* might be paired with one with a *mass* of *tonal*, *complex* or *varied*.

The criterion for being a suitable object includes the rule that anecdotic[120] objects are not suitable for use in a musical context (Chion, 1983, p. 74). Sonic objects may be moved from one category to another depending on context and the attention they received. Moreover, a suitable object will subsequently be evaluated with respect to its morphological properties such as pitch and/or spectral content, usually referred to as timbral features when fluctuations are small, and as textural features when variations are big. The morphological parameters deal with intrinsic features of a sonic object:

- *Shape* = overall envelope
- *Mass* = pitch and spectral features
- *Grain* = fast small variations
- *Harmonic timbre* = spectral distribution
- *Motion* = slower and larger distribution (*allure* in French)

The top-down nature of these concepts enables exploration from overall shape down to fine details of sonic objects. This approach of analyzing sonic

120. Sounds that give obvious associations to its source of origin.

objects, which goes from larger structures into finer details, is compatible with Clarke's notions of ecological listening (see page 122). Schaffer's taxonomy is primarily aimed at composition and analysis of acousmatic works, and his taxonomy contains more than 50 000 different combinations.[121] This makes it very tedious and inconvenient to use, and in practice not applicable in improvisation. However, taken as an inspiration, and as a way to understand how an improviser is listening during the course of an improvisation, I assert that Schaeffer's ideas are valuable. This subject matter is discussed further down.

Schaeffer introduced the two concepts *context* and *contexture*: context signifies the large-scale context and contexture signifies the intrinsic features of an object (Chion, 1983, p. 61/Schaeffer, 1966, pp. 503–504, 521). With these terms, the sonic object became central, with the large-scale context on the one side and faster sub-features on the other.

INTENTIONAL OBJECTS IN THIS WORK

I understand and play music through an instrument, and at the same time, I play on an instrument. In music improvisation as well as composition, different aspects of a musical space are explored such as gestures, timbres, textures, or structure and so on. In Merleau-Ponty's terms, I may plunge into an intentional object and let other aspects of the space rest. Intentionally, I direct my attention toward certain qualities in an object that displays itself, but I am still aware of the surrounding landscape, the horizon where it all takes place, which in fact defines the intentional object. I may chose to change my focal point during the course of an improvisation, and perhaps intentionally shift between different attitudes.

My hyper-instrument consists of a number of instrument modules gathered and interconnected within a common host application (Figure 18). One could apply Merleau-Ponty's *object-horizon structure*, and Schaeffer's *object-structure chain* concept to this instrument. Each instrument module features a distinctive musical concept. Some instruments, such as the Walking Machine, consist of a number of sub-modules, while others consist of one single module. A music generation method is implemented within each module, based on aesthetic choices made at design time. In play, depending on

121. Manning (2004) states that Schaeffer's taxonomy: "provides for some 54,000 different combinations of sonic characteristics, a daunting indication of the scale of the task facing any prospective morphologist" (p. 36).

intentional "zooming", as described in the object-structure chain theory, object-horizon relations shifts: to play one module is to "plunge" into that module, which then become the intentional object, whereas the entire hyper-instrument makes up the horizon.

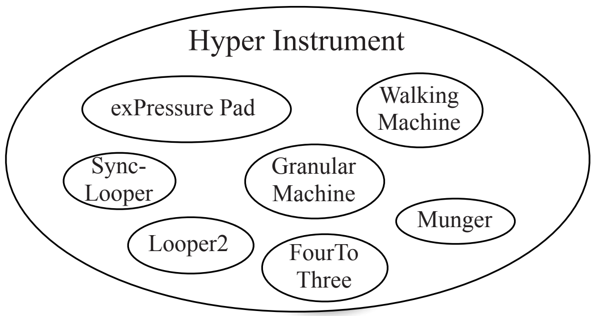

Figure 18: Any module within my hyper-instrument may be the intentional object, while the others constitutes the horizon.

When playing in an ensemble with other musicians, the hyper-instrument may become the intentional object, and the fellow musicians the horizon.

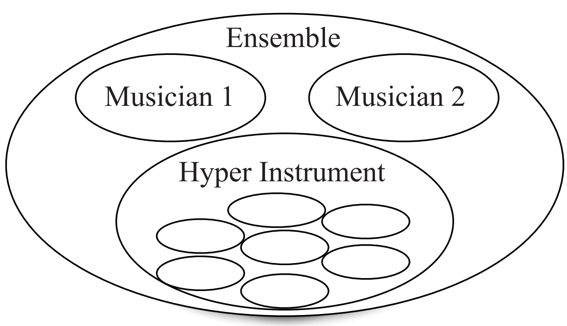

Figure 19: The hyper-instrument is the intentional object, while fellow musicians are the horizon.

To paraphrase Merleu-Ponty: my instrument is my viewpoint on the music world, and at the same time, it is one of the objects in that world. It is my being-in-the-music-world. Merleau-Ponty's concepts of *retention* and *protention* as well as Pressing's *feedback* and *feedforward*, are applicable in improvisation, given that all actions happen in real-time. That is, choices are made in relation to history and anticipation of new events. In certain improvisations, the intention intentionally shift, from the whole to a detail, whereas in other improvisations, the intentional object is predetermined. I give two examples, one of each kind. I discuss this matter further in the Analysis chapter.

An example of an individual intentional object can be heard on *Angle of Repose* on the DVD, from 4′16″ until 6′00″. The sonic horizon of my hyper-instrument is the irregular heartbeat in the low register that the FourToThree generates, while fellow musicians play very sparsely. At 5′25″, I start to play the Granular Machine with a sampled chord-like texture from the piano as sound source. Exploration and the processing of an actual sonic object constitute my intentional object. One can tell by looking at the video that I am very absorbed with this activity.

One example of a collective intentional object is *Amalgamation*, both versions. In this case, the intentional object is predetermined, which means that participants share an intentional object known in advance, that is, a collective sound body. Our attention is intentionally directed toward the collectively created body of sound, and we adjust individual behavior accordingly. The created sound body, the sum of all activities, constitutes the horizon, while individual playing behavior in relation the whole is the individual intentional object.

Modes of Listening

Schaeffer (1966) presents a phenomenology of listening, and introduces a number of concepts, notably *ordinary listening*, *acousmatic listening*, and *reduced listening*. His taxonomy of ordinary listening modes takes subjective and objective qualities of the perceived sound into account, while acousmatic and reduced listening connect to electro-acoustic music practices. Post-Schaefferian composers and writers such as François Bayle (2007), Chion (1983), Simon Emmerson (1986), Godøy (2006), Smalley (1997), Lasse Thoressen (2002), and Wishart (1996) have further developed Schaeffer's concepts, presented as new theories, and/or explanatory discussions regarding his ideas. As far as I am concerned, the most important aspect of Schaeffer's theories is recognizing the importance of being aware of differences between physical and semantic qualities in a perceived sound. The former is about timbral and morphological qualities, such as the speed of the attack and decay, or whether a sound is pitched or noisy; the latter deals with the meaning of a perceived sound, notably the origin of the sound, as well as other subjective associations. Schaeffer (1966, pp. 112–20) describes four basic modes of listening:

a. *Pure listening:* traditional listening where we recognize sounds and their sources, but sometimes, something that we thought we heard was just seen. This explains why we can confuse sounds from quite different instruments, such as a string and a wind instrument.
b. *Listening to effects:* listening to a sonic object where the cause of the object is hidden. Repeated listening helps us to gradually unveil features of the object.
c. *Variations in listening*: Repetition reveals variations in listening to a physically constant signal. We gradually become more and more aware of subjectivity in general.
d. *Variations in signal*: with electronic manipulation such as changing speed, transposition and fragmentation, it is possible to perceive different versions of a sonic object.

Figure 20, presented in Schaeffer (1966, p. 116), distinguishes four different *ordinary* listening modes:

- *Listening.* Taking the origin of a sound into account.
- *Hearing*. The basic order of perception; listening passively without paying attention to specific features of the sound.
- *Attending.* The perception of particular features of a sound.
- *Understanding*. Semantic perception wherein the sound is treated as a code or sign.

In addition, he also describes dichotomies of abstract/concrete and objective/subjective. The former pair denotes whether the features of the sound are confined to a perceptual/semantic level (*abstract*) or include causal references from the outside world (*concrete*); the latter refers to the difference between encountering the sound itself (*objective*) or actively being engaged in an activity with respect to the perceived qualities of a sound (*subjective*).

UNDERSTANDING inside level : signs outside level : values *Emergence* of the contents of sound, and reference and confrontation of the notion of the sound from the outside	LISTENING inside level : indications outside level : exterior events *Emission* of sound	1 and 4 : objective
ATTENDING inside level : perceptual qualification outside level : sound quality *Selection* of certain aspects of sound	HEARING inside level : rough perception, outline of the sound object outside level : rough sound object *Reception* of sound	2 and 3 : subjective
3 and 4 :abstract	1 and 2 :concrete	

Figure 20: Schaffer's sound perception modes, English version as shown in Hellström (2003, p. 73).

Acousmatic listening is a situation wherein a listener only perceives sound, and cannot see the origin of that sound. The term acousmatic listening originates from Pythagoras lecturing behind a curtain; his disciples listened to their master without seeing him.[122] Wishart (1996) defines acousmatic listening as "the apprehension or appreciation of a sound-object independent of, and detached from, a knowledge or appreciation of its source" (p. 67). Wishart argues that anyone who has worked in a studio with recorded material has experienced acousmatic listening (p. 67); even the slightest transformation of a sound cuts off the link to its origin, a phenomenon Schaeffer experienced with the *cut-bell* recording[123] in 1948. Schaeffer (2004) poses the question: "What am I hearing?… what exactly are you hearing – in the sense that one asks the subject to describe not the external references of sound it perceives but the perception itself" (p. 77).

Schaeffer's work with radiophonic art at the French radio in the late '40s was an essential step on the way to the emergence of *musique concrète* around 1950 (Gather, 2003, pp. 212–4). During the making of a radiophonic piece, in order to select sound effects stored on 78-rpm shellac discs the operator had to listen to certain effects repeatedly. During such sessions of repeated listening, Schaeffer discovered that the physical cause and significance of a sound disappeared; only the phenomenon of the sound itself was left. He called this listening mode *reduced listening (*ecoute reduit) and it became one of the cornerstones of his thinking (Chion, 1983, pp. 33–4). Smalley (1997) describes reduced listening as a form of technical listening, a mode for professional composers to use in their work of investigating and working with sonic objects:

> Reduced listening comes about through concentrated listening to a sound event, a common activity in the electroacoustic composing process. It is an investigative process whereby detailed spectromorphological attributes and relationships are uncovered (p. 110).

122. In the '70s François Bayle proposed the term *Acousmatic Music* as a general term for music performed on loudspeakers. Acousmatic music is now a widely used and accepted term in many countries.
123. According to Chion (1983), Schaeffer realized that recognition of a timbre was as much connected to the temporal form as to the harmonic spectrum of the sound. Schaeffer coincidentally cut of the attack of a recorded bell sound, and perceived it as a flute sound (p. 20). This incident became known as *la cloche coupée* (the cut-bell), and happened to play an important role in the development of *musique concrète*. Also discussed in Gather (2003, pp. 214–5).

Repeated listening is a means to achieve a reduced listening condition. As repeated listening was performed on turntables during the early years, the concept was called *locked-groove* (sillon fermé) listening. In addition to being a performance practice, the locked-groove listening became a research strategy: repeated listening enables the listener to focus on the intrinsic features of a sound, disconnected from its context. According to Schaeffer (2004): "It is the listening itself that becomes the phenomenon to be studied" (p. 77). This strategy connects to Husserl's phenomenological concept époché,[124] to bracketing the world out in order to perceive things as they are, without everyday contextual associations. Reduced listening is a tool for investigation and for shifting listening attention intentionally, from the contextual to the inherent features of sound.

> Nothing can prevent a listener from making it waver, passing unconsciously from one system to another, or from a reduced listening to a listening which is not. One can even be pleased with that. It is by such a swirl of intentions that the connections are established, that information is exchanged (Schaeffer, 1966, p. 343).[125]

Criticism of reduced listening points out the difficulty of ignoring the contextual associations of a sound. Common arguments are that it is impossible, and not even desirable. Smalley (1997) points out certain problems with reduced listening: after one has perceived very fine intrinsic audible features in a sound, it may become very difficult to regain a normal listening mode, with all references to the outside world in place. Low-level investigation, such as focusing entirely on the background at the cost of the foreground, tends to magnify details of minor importance. Moreover, Smalley states: "While the focal changes permitted by repetition have the advantage of encouraging deeper exploration, they also cause perceptual distortions" (p. 111). Wishart (1996) argues against reduced listening because it dislocates the environmental context and therefore is not rewarding: "Our mental apparatus is predisposed to allocate sounds to their source." (p. 129). For me, reduced listening is a conscious free will choice, and I find that it is

124. See Chion (1983, pp. 31–2).
125. The original: "Rien ne peut empêcher un auditeur de la faire vaciller, passant inconsciemment d'un système à une autre, ou encore d'une écoute *réduite à* un écoute qui *ne l'est pas*. On peut meme s'en féliciter. C'est par un tel tourbillon d'intentions que s'effectuent les raccords, que s'echangent les informations" (Translation by Dack).

possible to learn to move between reduced and ordinary listening modes.

LISTENING IN THIS WORK

When practicing a musical instrument, one practices reduced listening. By repeating a pattern or a gesture repeatedly, inherent qualities of the played sequence are revealed. As Smalley (1997) asserts, reduced listening is a technical listening mode, a powerful tool to use consciously and with great care. Once mastered, reduced listening can be useful in real-time improvisation as a means to make analyses on the run.

One important way of performing with granular synthesis applications, *shadowing* (see page 291) on the Granular Machine, attempts to do instant analyses of the recorded audio stream in real-time, as a basis for selection and further sound processing. Employing concepts developed by Schaeffer and his successors can be helpful in achieving this goal. As previously asserted, in my personal experience, there are far too many categories and sub-categories in Schaeffer's taxonomy of sonic objects, and therefore the system is not applicable in real-time contexts. Therefore, I consider Schaefferian concepts more as inspiration than as exact rules which can help us detect different qualities in a perceived sonic object. We must also remember that there is a huge difference between working in an electro-acoustic music studio, a design-time activity with the possibility of repeated listening, and being in the midst of an improvisation at play time.

Let us return to the questions Schaeffer posed at the beginning of the '50s: What am I hearing?… what exactly are you hearing? And, I would like to add, what am I listening for? Let us start with the question of *who* is listening. There is a big difference between a concert listener and a participating musician. As a performer, I have often heard these kind of comments from the audience after a concert: "It's like a movie, I just close my eyes and a lot of images come up", or "I saw a landscape before me", or perhaps "It sounds like a crowded city", or "This music makes me nervous". This is most common when practicing sound improvisation, as discussed in the Design Time Aesthetics chapter, as Beam Stone and duo pantoMorf does. In other words, many listeners have perceptual associations with extra-musical phenomena while listening to our music. Why?

Smalley (1997) argues that such experiences connect to *sound-binding* (see page 163): we have a tendency to search for and identify the physical cause of a perceived sound. If sound-binding is weak, we intuitively make up a possible source, and different images may come up. Norwegian musicologist Alexander Refsum Jensenius (2007) asserts that *action-sound links* in electronic and digital musical instruments always are made up and therefore weak (see page 161). In addition, when practicing extended playing techniques on traditional instruments, the perceived connection between a performed gesture on an instrument and the audible result can be weak as well. When playing material that in one or another way can be identified with an idiom such as jazz, the most likely reactions from the audience are judgments about whether the music swings, or whatever is relevant for a particular genre. Another aspect is the visual component: a listener sees one thing, and hears another. I recall a comment from a spectator/friend[126] in conjunction to the GAS concert with Beam Stone, (enclosed on the DVD): "When I look at the drummer it looks like he is just messing around and moving stuff, but when I close my eyes I can clearly hear the music and the interaction that goes on".

Before continue this discussion of listening experiences during a performance, I would like to emphasize that in improvisation it is necessary to intentionally loosen conscious attention, to let things happen, to hand activity over to the body without thinking too much. In an interview that appears in Borgo (2005), British saxophone player Evan Parker makes a comparison to a juggler:

> In attempting to juggle or balance an object in gravity, there is, in one sense, clear effort, and intentionality. Yet a desire for too much conscious control – thinking too hard about the task at hand – can lead to continual corrections that eventually upset the delicate system. When witnessing a juggler at the peak of her performance, one can focus on the specific moves and the rhythmic quality of the performer tossing and catching items in succession, but the items in flight and the entire system itself tend to take a life of their own (p. 51).

It is like stepping outside oneself, watching oneself, to be played as much as to play. In many cases listening goes on in the background, bypassing the conscious mind, but nevertheless our listening may have a great impact on our playing behavior and decision making whether we put conscious attention to it or not. At times conscious attention and effort is intentionally focused on instrumental activity, such as keeping up a groove or creating a texture, while listening becomes a second-order priority. Once set in motion the task is to

126. Colleague, saxophonist, and cycling mate Jan Gustafsson.

maintain the system, like the case of juggling in the quotation above. One example of this type of behavior can be seen at the beginning of *Shuffle* with duo pantoMorf at the DVD: all effort and concentration is concerned with keeping up the energetic pattern on the instrument.

Being a musician in play, how do I listen? Sitting calmly in my studio as I do now, I will undertake an experiment, trying to recall and reveal how I listen. First, I will argue that in a performance situation there is not much time to undertake structural sound analysis. Rather I listen and react instantly with my body to whatever catches my interest. I rarely get any "concrete" visual images like the listeners above; rather it is about shapes, colors, textures, movements, and transformations in space. It is like being in an imaginary landscape, densely or sparsely furnished with sonic objects, which can be dull or bright, open or closed. However, what might be called sonic metaphors can emerge, textures and soundscapes that remind one of natural phenomena, like wind, water, or gravel in motion. But they have more to do with aural images than visual ones.

In a performance situation, I argue that I consciously oscillate between *reduced listening* and *normal listening*. In accordance with notions from ecological listening, analysis ranges from higher order structures down to small details. Sometimes inherent sonic features, at other times the semantics of perceived sonic output constitute the basis of our play and interaction. In the case where a sonic metaphor is detected, like wind or water, most of the effort is spent on inherent sonic qualities, which is of most use if it seems important to maintain the metaphor. However, I can also listen consciously to certain qualities, notably rhythmic repetitive patterns which may catch my interest. First I try to analysis it, and then decide whether I should hook up with it or let it go. I think that I compare the immediate aural image with my memorized personal library of sonic images. I may recognize a pattern, and based on previously learned behavior I do something meaningful with it. Analysis, selection, and treatment of recorded sonic objects depend mostly on embodied knowledge.

What first catches my interest is the character of perceived gestures and tessitura, with a focus on changes in density and pitch over time. Here Schaeffer's typology is of value. Whether a perceived gesture contains a pulse, is groove based or irregular is also important. I also notice harmonicity, whether a perceived sound is pitched or noisy. The following list is made with the aim of clarifying important dimensions of perceived sounds during improvisation. The order of the items does not necessarily correspond to analysis order;

rather, analysis in real-time deals with many qualities simultaneously. For example, one can analyze and define a sound as being simultaneously pitched, irregular in pulse, of mid density, and going from low to high pitch. Here follows a subjective list of listening criteria:

- Tessitura: perceived frequency register: low-high, broad-narrow.
- Gestures: pitch movement: upward, downward, or constant; density/intensity: increasing, decreasing or constant; pitch and density evolution: upward and retarding, or upward and increasing.
- Pulse: regular-irregular; stylistic references.
- Timbre/Texture: pitch-noise; dark-light; stable-unstable.
- Tonal identity: tonal-atonal; stylistic references.
- Timbral identity: sonic metaphors, wind, water, friction, metallic, wood, etc.

A number of concepts that derive from Schaeffer may be discerned. An important aspect of the musique concrète practice is to arbitrarily chose and cut out a sonic object of suitable length from a sound stream, taking natural discontinuities into account according to Schaeffer's *stress-articulation* principle, and making the selection. I argue that during performances, notably in shadowing sessions (see page 291), I analyze sounds according to the *typology* and *morphology* qualities as defined above. In other words, I practice musique concrète in real-time. All this is done in accord with the Schaefferian terminology, if not explicitly and verbally articulated as such.

During performances with the Granular Machine, the waveform display on the GUI (see Figure 72 in the Appendix) helps me to detect and select suitable parts of currently playing sounds for real-time manipulation. During performances I intentionally limit my focus to a few features of actual sonic object at a time, a consequence of our inability to handle too much information at a time. Effect processors integrated within the Granular Machine provide the ability to manipulate and vary the sounds being created, and other modules in the system can operate automatically while I focus on the main instrument I am using at the moment – the Granular Machine, for instance.

Instrument

Musical sounds must be
produced by instruments.

Lydia Goehr

Introduction

This chapter contains three parts. The first part is a presentation of various classification criteria and notions of musical instruments. The second part consists of a presentation of selected important concepts, such as mapping and sound diffusion. And the third is a presentation of a personal set of digital musical instruments, the hyper-instrument, which is the hub around which this work revolves.

What is an instrument? An instrument is a tool, a means to achieve something, which in a certain way becomes invisible, since activity with tools is most likely not a goal in itself. American philosopher Aden Evens (2002) states in *Sound ideas: Music, Machines, and Experience*: "An instrument disappears in its use, is absorbed by its use, and the more effective it is, the more effectively it disappears" (p. 82). We use dozens of tools every day without thinking about them, e.g. the vacuum cleaner, the dish brush, a hammer, a pencil, or even the automobile. The task is the focus, and the tool utilized is just a means to accomplish the task. When we are banging a nail into the wall, we are focusing on the nail, and not the hammer. Regarding a musical instrument Schaeffer (1966) claims: "Instrumental activity, the visible and first cause of every musical phenomenon, has the distinctive quality that first and foremost it tends to cancel itself out as material cause" (p. 43).[127] According to Schaeffer, we hear a melody, or a rhythm, rather than the actual

127. The original: "L'activité instrumentale, cause visible et premiere de tout phénomène musical, a ceci de particulier qu'elle tend avant tout á s'annuler comme cause materielle".

instrument that produces it. However, when playing a musical instrument it does not vanish completely; it also remains opaque and present since it offers resistance and surprises to its player, and therefore ceases to disappear completely; a notion that is further discussed in the next section.

Then, what is a musical instrument? A musical instrument is an object that is used to make music. For many people the word object, in this context, may connote all the wonderful man-made instrument that exist: flutes, saxophones, violins, etc. According to Grove Music Online, musical instruments are defined as: "Objects or devices for producing musical sound by mechanical energy or electrical impulses".

In the literature, there are two classical distinctions for classifying musical instruments. Both consider intentionality: either to *use*, or to *create* an object with the intention for music making. Both these distinctions depend on whether one accepts the audible outcome of the activity with those objects as musical. I will emphasize the word *musical* here, as it obviously is a decisive factor. However, if someone picks up a pair of stones and scratches them purposefully, another question might be raised: will this audible outcome be regarded as music, and consequently, can the stones be regarded as a musical instrument? The answer depends on who is responding. Nowadays most people probably agree that it is possible to make music with a pair of stones or other found objects. However, imagine that someone does not agree that the audible outcome of the scratched stones is music, then the pair of stones is no longer a musical instrument according to this determination. In the late '60s Christian Wolff did a series of pieces, called *Play*, for found objects, stones and sticks.[128] In Wolff's *Play* the distinction between music and instrument is blurred. The music directly comes out of the performers' activities with the stones.

It seems that the notion of a musical instrument and the music it may produce are interleaved, and the border between them is not clear. Imagine, on the one hand, an object that is used intentionally in order to produce sounds. If the audible outcome is agreed to be musical, then the object must be considered a musical instrument. However the object may not be considered an instrument if the outcome is not valued as music.

128. The instructions says: "Make sounds with stones; draw sounds out of stones, using a number of sizes and kinds (and colors); for the most part discreetly; sometimes in rapid sequences. For the most part striking stones with stones, but also stones on other surfaces (inside the open head of a drum, for instance) or other than struck (bowed for instance or amplified). Do not break anything". (in Nyman, 1999, p. 114).

On the other hand, all sounds that may be produced on traditional instruments, such as a violin, are not necessarily musical, but those objects will be categorized as musical instruments nevertheless. As long as we play on a traditional acoustic instrument, and occasionally use found objects in a widely accepted musical context, this blurriness does not cause much of a problem.

Problems arise with electronic musical instruments and the use of non-standard controllers and interfaces such as joysticks, gamepads, specially-made gloves, video motion tracking systems, etc. A user of such interfaces is likely to encounter suspicious judgments, ironic commentaries, indeed questioning whether it is musical at all. The arguments follow the logic of the intention of the construction: as the object is not intended for music, the output will not likely be music either. We have to find alternative ways of describing and categorizing musical instruments.

CLASSIFICATIONS AND NOTIONS OF THE MUSICAL INSTRUMENT

It is not my intention to make an in-depth description of classification systems of musical instruments, but rather to give an overview and point out some immanent problems. The standard classification of musical instrument (by Mahillon and Hornbostel/Sachs) traditionally classifies instruments in major groups such as wind instrument, string instrument and percussion instrument – with the electronic instrument as an optional category – and with further subdivision into subgroups and so on. According to the Grove Music Online, musical instruments can be classified as:

1. Strings (plucked or bowed).
2. Wind (played by blowing direct into the mouthpiece or through a reed).
3. Percussion (of determinate or indeterminate pitch).
4. Electronic.

The piano, for instance, is not easily classified, despite it has strings it is percussive in its mechanism. The standard classification was mainly designed for museums, as a vehicle to describe and compare musical instruments as objects with respect to material, construction, or sound producing technique. The advantage with such systems is that instruments from different cultures and historical periods will fit into one single system, but on the negative side, it does not consider the contextual or cultural aspects.

Kvifte (2007) gives a survey of a number of classification systems in addition to the systems of Mahillon and Hornbostel/Sachs. Notable examples are Schaeffner's system from 1932, that in accordance with Mahillon classifies an instrument with respect to sound production; in 1937 Galpin presented a system that was inspired by botanic classification that basically followed Horbostel/Sachs but, as mentioned above, added electrophones as a fifth category. One attempt to create a classification that was based on appearance and playing technique of an instrument was devised by Dräger. In order to achieve such a task, Dräger's system is divided in several areas as seen from a performer's point of view. In *Grundlagen des natürlichen System Der Musikinstrumente,*[129] the German researcher Heyde (1975) presents a somewhat different approach to the classification of musical instruments. He claims that his system shows objective relationships between instruments, based on natural properties. "Such systems are not man-made, but may be discovered" (Kvifte, 2007, p. 61). Lysloff and Matson (1985) presented an alternative instrument classification by grouping instruments according to shared observable characteristics. They claim: "Our first reconsideration focuses on the *sound-producing instrument*. This is defined as any device or human behavior constructed or carried out for the primary purpose of producing sound, whether musical or otherwise" (p. 217). However, they are keen to point out that items primarily intended for other purposes than sound making are not included.

In the article *What is a Musical Instrument?* Kvifte (2008) states that an instrument is "what is left behind when the performer is no longer present" (p. 48) and immediately argues that it is not that simple at all. He mentions whistling and singing as examples of instrument bound to the body of a human being. Furthermore, he clearly shows that it is almost impossible to define the border between a performer and an instrument. Wind instruments are good examples: the shapes of the oral cavity as well as the diaphragm are integral parts of the sound production system on such an instrument. The power of the diaphragm and the player's lung capacity are a consequence of the amount of practice undertaken, the food one eats, the metabolic system, etc. Obviously, such a distinction is very impractical in use. Kvifte asserts: "it is the playing technique and not the instrument itself which is the unit of analysis" (Kvifte, 2007, p. 92). Kvifte proposes using Heyde's vocabulary, that distinguish between *technomorphic* (mechanical) and *anthromorphic* (human) elements of

129. As described in Kvifte (2007).

an instrument, and makes a subdivision between *prototypical* instruments (entirely anthromorphic), *typical* instruments (both kinds of elements), and *exotypical* instruments (only technomorphic elements).

In a seminar for the Norwegian Society of Composers,[130] the British flute player and author David Toop (2006) suggests that a network of contextual connections appear when he is playing his flute:

> Now I mostly concentrate on playing my beautifully constructed if rather expensive Miyazawa flute, though the foundation of what I try to do is much the same. I breathe in air, then exhale through a technological system which embodies ergonomics, cultural history, aesthetic design, and a philosophy of art that entrains sonic phenomena through precise engineering. An admixture of air and sound waves is the result, and somehow this act of everyday survival is transmuted into the cultural act we describe as music. Once you become conscious of the process, then the notion of boundaries, whether framing the body or the space in which the body moves, becomes a zone of uncertainty (p. 3).

In Toop's point of view the concept and identity of a musical instrument is contextual. The concept "flute" is made up of different aspects: representation, the physical object, the sound, the space, the history and tradition, repertoire, flute players, etc.

Permanence – Variation

In an attempt to define the identity of the musical instrument, Schaeffer (1966) presents a theory: *the law of permanence – variation*. Permanence is the timbre of an instrument, whose definition initially is tautological: "Timbre is what enables us to identify one instrument rather than another", or "timbre is how we recognize that various sounds come from the same instrument" (Chion, 1983, p. 48). Furthermore, it is possible to attribute timbre to electronic sound treatments such as filtering and playing sounds backwards, and even a hi-fi system has a timbre. The physicists define timbre as the produced spectrum of frequencies, however, experiments[131] show that dynamics of a sound play an important role in the perception of timbre as well:

130. In Norwegian: Norsk komponistforening (www.komponist.no).
131. Chion refers to the so-called cut-bell experience, see footnote 123.

> So timbre is not a simple morphological criterion; with each instrument it defines itself as a particular structure of criteria which confers a particular 'genre' on the sound objects produced by that instrument (p. 49).

Instrumental timbre is not completely defined by the timbre of individual notes, "but by a *law of variation in the genre of these objects right across the register*" (p. 49). With the aid of this law, we can compare and identify sounds from different instruments with respect to pitch, as well as many other characteristics. Schaeffer goes as far as saying: "we must *give up the concept of timbre*, which is too vaguely defined, and stop re-enlisting it as a value [...]" (p. 52). Timbre may be replaced by more general concept of characteristic or *genre*, or more subtly, a *criterion*: "The concept of *timbre* is therefore a kind of *abstraction* sensed by the ear in all the potential sounds of a certain instrument" (p. 52). Within this pseudo-permanence, there are variations of two kinds: *abstract* variations that deal with values of register, mainly pitch and to a lesser extent intensity; and *concrete* variations, that are about characteristics in manner of playing. These concrete variations are mainly dependent on the potential given by the instrument with respect to an instrumentalist's playing style. Therefore, the three criteria for instrumental analysis *timbre*, *register,* and *playing potential* may be used to analyze an existing instrument, a new electronic instrument (sound-devices), or techniques that intend to go beyond the concept of instrument.[132]

An idiosyncrasy of musical instruments implies that they reveal musical structures with meaning,[133] starting with a range of concrete sounds, which establish an equilibrium between *abstract* capabilities and their *concrete* playing potential:

> The 'the instrumental fact', which is at the origin of all music as a 'precondition' (chap.1: *the instrumental precondition*, 41–50) respects this complementary duality, in traditional musics, by establishing the two 'correlative aspects' of the 'musical phenomenon': '*A tendency to abstraction, in so far as playing releases structures; the adherence to the concrete, in so far as it remains limited to the potential of the instrument*' (p. 53, italics in original).

132. Schaeffer furnishes the examples of musique concrète and electronic music. Since the time of the publication of *Traite des objet musicaux* a vast number of music genres that explore sound and noise has come to light.

133. See Kvifte's triangle on page 28.

Schaeffer regards "the instrumental fact" the concrete basis of all traditional music: "A precondition even to musical systems and languages" (p. 54). Schaeffer suggests a "*broadening of the notion of the instrument*" (p. 54, italics in original). By redefining the laws of the instrument, a music that articulates *suitable* sonic objects of the same *genre*, classified in *perceptual fields*, and *calibrations* of *criteria*, Schaeffer will state a law of all music: "Permanence of characteristics, variation of values" (p. 54), [Italics in original].

During the twentieth century, Schaeffer claims, three tendencies in modernistic composition have challenged the concept of the instrument. Firstly, the "excess" of abstraction in serial and algorithmic works, which strip instrumental structures off, and as a consequence regard all performances "contaminated" by instrumental insufficiencies. Secondly, the introduction of new "noisy" sounds in the orchestras, "false instrument" according to Schaeffer, such as various percussion, and so called extended techniques carried out on traditional instruments by which the permanence of the instrumental timbre is unclear and not guaranteed. Thirdly, the use of electronic devices in music making tends to go beyond the traditional notion of an instrument. At the beginning of the '50s the rivalry between *musique concrète* in Paris and *Electronische Musik* in Cologne, gave rise to a split in the notion of an instrument. On the one hand the "concrete instrument", and the "electronic instrument" on the other: "The two approaches apparently led, by two opposing routes, to the negation of the instrument as a vehicle for true musical expression" (p. 55). However, attempts were made to re-establish the instrument, such as Pierre Henry's piece from 1963, *Variations pour une porte est une soupir*, that explored playing possibilities of the employed objects, a door squeak, and a sigh.

A general concept for new instruments, or sound bodies, was formulated by defining new registers, "which will form a basis for a musical discourse, and not simply make sound effects" (p. 55). The *Traite des objet musicaux* stops here, but suggests *putting* certain sound criteria into *calibrations*, which would help to define *registers* and new scales.

Digital Musical Instruments

NOTIONS OF THE DIGITAL

This work deals with the designing and playing of digital musical instruments, and therefore some reflection about digital technology in general seems mandatory. Given the many books that explain and discuss digital techniques in minute detail, my intention here is merely to elucidate matters that have a bearing on instrument design and the music produced within the context of this work.

What makes a technology digital? Digital technique is about ordering, storing, and sorting data, makes use of logic, and deals with abstract code. The author and musician Aden Evens (2002), in his book *Sound Ideas* sheds light on this subject from a philosophic point of view. A computer is digital because everything that is accepted as input and output, and everything it stores, is actually numbers:

> Logically, the computer is a huge network of intersecting pipes, and each intersection either allows the electricity to pass or prevents it. It is this condition – this general principle of operation according to abstraction whose rules are immanent to its code – that defines a technology as digital (p. 65).

The binary number system is at the core of digital technology, which, as its name implies, deals with two numbers or states, zero and one, and nothing in between; it is either zero or one. Evans claims that the digital only deals with form, because it turns everything into information in order to operate. What does this mean? Digital technology transforms the actual into static pieces of information, which are stored and manipulated within a computer as numbers. In order to make those numbers meaningful, they must be decoded and presented in an appropriate form, such as images, texts, or diagrams on a display, or as sound from a loudspeaker. Likewise, we must enter information into the computer through an interface: a keyboard, or a mouse for instance, which translates human symbols and gestures into numbers. Therefore: "The digital is nothing but form, and form can always be perfectly reproduced with the right *formula*, anytime, anywhere" (p. 66). A digital copy is identical to the original, but the only thing copied is its form, while content is a matter of interpretation and translation of the copied numbers. This condition facilitates exchange and new interpretations of given information; it is possible to see a sound and to hear an image. In order to capture an object and transforming it into binary code, the computer must divide, and subdivide, the actual into discrete pieces, such as samples or pixels. Moreover, each part must contain at least two articulations, firstly one that describes its position relative to the context, and secondly its value. The coded color value of each pixel in an image is stored together with information regarding placement on the screen. Audio sampling is a series of measurements of a continuous audio stream done at the *analog-digital-converter* (ADC), where the value of each measurement is stored sequentially. In order to replay recorded audio, the stored values feed into a *digital-analog-converter* (DAC) in the same order and speed as recorded. The sample frequency and available dynamic values in each sample, or actual number of pixels per given area, and color nuances at each pixel, defines resolution. However, even at the highest resolution, small variations will fall between pixels and samples. It is the continuing variation that is filtered out, and not the lack of information that falls between that is of concern. Regardless content, digital technology treats everything in a similar fashion:

> The digital is able to accommodate a huge variety of different kinds of information, but in each case, it can store it on the same media, transfer it over the same lines, and manipulate it according to the same rules. The same analyses that reveal information about images also tell us about sounds and other data (p. 72).

A property of digital technology is that form and content are completely separated, and therefore content is a matter of the interpretation of information. Digital technology represents, but never presents the actual. Evans concludes by stating that digital technology does not offer new experiences each time, but rather a promise of the generic and repeatable, based on available bandwidth (p. 77). All these conditions may have an impact on musical instruments based on digital technology.

ACTION-SOUND LINKS

When someone pick a guitar string, the causality between the perceived sound and the player's action is clear, but when listening to a laptop musician, most of the time we do not understand the relation between physical actions and sound. In the thesis *Action-Sound, Developing Methods and Tools to Study Music-Related Body Movement*, Refsum Jensenius (2007) examines the perceived relations between physical actions and sounds. As a point of departure Refsum Jensenius refers to theories of ecological psychology by Gibson (1986), ecological listening by Clarke (2005), and Schaeffer's (1966) theories about listening. (See the Perception in Play chapter). There are two concepts of particular relevance for this work: *action-sound coupling*, and the *action-sound relationship*.

The term *Action-sound relationship* refers to contexts wherein we cannot be sure of the relation between action and sound. On the one hand, on an acoustic piano there is an action-sound coupling. A listener does not expect the piano to sound like anything else than a piano, and a flute-like sound is not a likely outcome. On a digital piano on the other hand, we cannot be absolutely sure of the audible outcome: the instrument may be silent if someone has unplugged the power cord, or, depending on the chosen sound, the instrument may sound like a different musical instrument, such as a vibraphone. Therefore, the action-sound link is much weaker (Refsum Jensenius, 2007, p. 23). Refsum Jensenius differentiates between *electronic devices* and *virtual devices*. The former includes, for example, doorbells, cell-phones, and musical instruments, while the latter refers to such things as television and computer games. To produce a sound on an electronic device, usually we are performing a direct interaction with some physical part of the device in question, like pushing a button. In a virtual device, we may trigger a sound in an action as well, but the sound is not under direct control; rather the device or software responds according to an designed and implemented virtual action-sound link.

Refsum Jensenius asserts that there is a significant difference between action-sound couplings and relations:

> […] knowledge of action-sound couplings is deeply rooted in our cognitive system, and that this knowledge guides the way we think about other types of action-sound relationships, for example in electronic and virtual realities. Similarly, I will also argue that knowledge of action-sound couplings is vital for the understanding of the creative use of action-sound relationships in music, film, and other multimedia arts (p. 23).

Furthermore, action-sound couplings comprise of an *action-sound palette* of conceivable audible outcomes from a certain object, depending on such properties as the material, the force of the impact, or the shape of the objects involved. Extended techniques, a common practice among experimental composers and performers – including improvisers – aim to expand and challenge the action-sound palette of conventional instruments in various ways. However the possible outcome from electronic and computer-based technologies are huge, and action-sound relationships are virtually infinite. It is quite possible to connect the doorbell button to a synthesizer or sample player; the bell may sound like an opera singer when the button is pressed. Probably most people will find this strange, and we can see that this indicates a weak action-sound relationship. Refsum Jensenius's concept of the action-sound palette shows similarities to Schaeffer's *law of permanence and variation* presented previously, were he defines the sonic identity of sounds produced from one musical instrument as a genre of sounds.

Gestural Surrogacy

A major presumption in *Spectromorphology* by Smalley (1997) is the need to distinguish between intrinsic and extrinsic features. The former deals with sound events and their relationships within a piece of music, whereas the latter refers to experiences outside the context of the work. Smalley asserts that the intrinsic and extrinsic are interactive. Spectromorphology defines action-sound links as *source bounding*, which points to our natural tendency to relate sounds to natural causes:

> Once we can grasp the relationship between the sounding body and the cause of the sound we feel we have captured a certain understanding: intuitive knowledge of the human physical gesture involved is inextricably bound up with our knowledge of music as an activity (p. 109).

One feature of acousmatic music is the tendency to fool the listener, or to create ambiguity in the perception of the cause of a particular sound. At one end of the spectrum there are anecdotic sounds, the replay of unprocessed recordings of well-known everyday sounds; Shaeffer's *Etude au chemin de fer*[134] is an example. At the other extreme there are sounds that go beyond imaginary physical boundaries. In order to categorizing imagined perceived sound bounding, Smalley has coined the concept *gestural surrogacy*, a classification that consists of five elements:

134. This piece consists of sounds taken from trains, and is regarded as one of the first acousmatic work composed. *Etude aux chemin de fer* was premiered in Paris in 1948.

- A *Primal gesture* is out outside of music actions, mostly referring to natural phenomena such as thunder and wind.
- *First-order surrogacy* is about intentional sound making that foregoes music making. One example is activity with sonic objects, with the aim of exploring sonic features, or to make recordings for further processing at the studio. Examples of compositions that start as first order surrogacy are Wolff's *Play*, discussed on page 154 and *Click Piece* by Stevens, presented on page 112.
- *Second-order surrogacy* is the playing of music on acoustic musical instruments, and here Smalley includes recordings of musicians playing identifiable instruments, as well as the playing of a synthesizer with sounds that emulate acoustic instruments. A significant difference from first order surrogacy is that a recognizable performance skill is required to achieve a particular outcome.
- *Third-order surrogacy* occurs when gestures are inferred or imagined in the music. One could say a particular gesture sounds "as if". For example, it may sound as if it were a huge violin with a resonance body made of water, played by a bow of steel wires; or it may sound as if an ant is playing a tiny violin.
- *Remote-surrogacy* is about the case where no sound bounding, real or imagined, can be perceived: "But some vestiges of gesture might still remain. To find them we must refer to tensile, proprioceptive properties, to those characteristics of effort and resistance perceived in the trajectory of gesture" (p. 112).

Smalley claims that too much use of remote surrogacy will make acousmatic music cold and sterile, since it is difficult for us to understand its meaning, whereas too much first and second-order surrogacy make a somewhat predictable and boring music. A good balance is advised.

Action-Sound Links in This Work

One could say that the instruments discussed in this work, being digital musical instruments, fall under the action-sound relationship, according to Refsum Jensenius's conception. This means that the perceived connection between sound and physical action is weak. In contrast to acoustic instruments, a digital musical instrument must be designed in minute detail: "With an acoustic instrument, one never knows what sonic possibilities will show themselves by accident in the course of free experimentation; a digital instrument, on the other hand, can do no more than it was created to do" (Evans, 2002, p. 90). An acoustic instrument is a unified whole, and integrated with its player, whereas the digital instrument, in line with digital technologies, is divided into parts. A digital musical instrument consists of a sound engine implemented in software, a controller that translates a player's physical gestures to messages which control the sound engine, and finally a sound reinforcement system consisting of amplifiers and loudspeakers. Digital technology implies that all information is perfectly clear; no fuzziness is allowed and it is either within threshold or not. Yet information must be interpreted and materialized, so where does the sound production take place? It is impossible to give a clear-cut answer. The sound engine produces and feeds information to the DAC, which in turn transforms the stream of numbers into analog voltage variations, and finally, those variations become sound when a loudspeaker cone start moving to and fro. The player of a digital instrument does not directly feels instrumental vibrations and physical resistance in her body; rather, the feeling of playing a digital musical instrument is somewhat detached. The player is physically integrated with an acoustic instrument, and since it offers perceptible physical resistance, it never disappears completely as a tool that get absorbed in its use. In contrast a digital instrument may be invisible in its use, and may be thought to mediate ideas ideas from the player as much as it responds to direct bodily expressions.

Digital musical instruments featuring third or remote order surrogacy, when perceived by listeners, can be experienced as cold and machine-like. I claim that this is not uncommon in connection to performances with so-called "e-mail musicians", musicians that operate their lap-top instruments from the computer keyboard and mouse, staring at the monitor, in whose playing no action-sound relation can be perceived. I do not deny that this kind of performances can produce astonishing music; however, it is difficult to perceive the interaction with musical output, which I value very highly. At the end, it is a matter of personal aesthetic choice. With computer technology, there are always choices.

A TAXONOMY FOR INTERACTIVE MUSIC SYSTEMS

During the course of the years, many interactive music systems have been made. The aim with such systems, most often, is to create virtual orchestras, and/or virtual co-musicians, rather than new musical instruments. A brief presentation that describes a number of historical and existing interactive music systems can be found in the Design Time Aesthetics chapter.

Nevertheless I have chosen to include a taxonomy of interactive music systems in this section, in order to introduce useful terms to the discussion of digital musical instruments here. In *Interactive Music Systems* Rowe (1993) describes and classifies interactive music systems: "Interactive computer music systems are those whose behavior changes in response to musical input" (p. 1). Most interactive music systems contain a listener section, which analysis the output of a human player with respect to pre-defined features, and an engine that produces new musical material based on analyzed features. The generation of material is either based on transformation of incoming data, or fetched from pre-defined and stored material. In both cases, the musical behavior of a human performer has a great impact on the outcome from the computer. Rowe distinguish between *score-driven* and *performance driven* concepts (pp. 7–8).

- Score-driven programs analyze and compare the input from a player with a score in order execute pre-stored events, or sequences of events, at pre-defined moments in the composition. This type of program often draws from a traditional notion of composition, based on meter, tempo, and beat, but offers flexibility to the performer, as the system allows interpretation of certain musical parameters – such as retardant/accelerando and fermata – at the performer's discretion.
- Performance driven programs do not use pre-defined scores and accordingly aim to create music that does not employ traditional metric concepts, but is more likely to base its behavior on parameters such as density and metric regularity.

Rowe makes a second distinction among whether the response of the computer-based instrument is *transformative*, *generative* or *sequential*.

- Transformative methods take all material from its input, apply transformations, and output the result according to pre-defined constraints. In this group "the source material is the complete musical input" (p. 7).
- Generative models utilize stored fragmentized material such as scales, sequences, and probabilities as its sources. "Generative methods use sets of rules to produce complete musical output" (p. 7).
- The sequential approach employs prerecorded pieces in response to real-time input. The playback of sequences may be varied with respect to tempo, transposition or other properties.

Thirdly, Rowe distinguishes between an *instrument* and a *player* paradigm.

- The instrument paradigm deals with an extended musical instrument: "Performance gestures from a human player are analyzed by the computer and guide an elaborated output exceeding normal instrumental response" (p. 8). 135
- A player is an artificial musician with a "personality and behavior of its own" (p. 8) and its output is most likely used in a duet with a human player.

MAPPING

The term *mapping* signifies a mathematical translation from one set of data into another set of data. Within the field of electronic music devices, mapping deals with connections between physical controllers, or a set of commands, to sound engine parameters. It is not my aim to discuss this topic thoroughly, but rather to give an overview and present a vocabulary of the subject matter. I restrict myself to using two main sources: The IRCAM CD-ROM *New Trends in Mapping* (2000) and the special mapping issue of *Organised Sound* (2002). Both these publications present works by leading researchers in this field such as Daniel Arfib, Claude Cadoz, Joel Chadabe, Camille Goudeseune, Andy Hunt, Daniel J. Levitin, Jean-Claude Risset, Marcelo M. Wanderley, David Wessel, and others.

Mapping is as old as musical instruments themselves; in traditional acoustic instruments, the mapping is integrated within the construction, while in electronic instruments the mapping is a matter of design and choice. It is claimed that one role of mapping is to define the limits of an instrument or a composition (Arfib et al. 2002, p. 140). Whether the instrument is acoustic or electronic, an important consequence of the mapping is "the feel of the instrument". Goudeseune (2002) states:

> If the performer can comprehend the mappings embedded in an instrument, obviously a more refined performance can result. This argues for static mapping over dynamic, and simple over complex […] Whatever decisions are made about mappings in an instrument, they result in what performers call the feel of the instrument (p. 85).

135. I assume Rowe thinks of acoustic instrument as the source, not as a silent controller.

Arfib et al. (2003, p. 127) argue that the use of perceptual layers in the mapping is important. They define three layers in the mapping chain: "From gesture data to gesture perceptual space, from sound perceptual space to synthesis model parameters, and between the two perceptual spaces" (p. 127). The first mapping layer transforms gestural data into *related-to-gesture* perception parameters, that is: "parameters that make sense to our perception" (p. 127). The second layer, *related-to-sound* perception parameters, differentiates between 1) physical parameters of a sounding object, such as volume, material, and elasticity; 2) signal parameters related to perception parameters like energy measure; and 3) the relation between these two. Meta-parameters and psychoacoustic parameters such as pitch, loudness, timbre and spatialization define a four-dimensional space.

Mapping Terminology

Goudeseaune proposes (2002, pp. 86–7) the following mapping terms: A *controller* is a complete physical interface or set of commands. A *control* is a single indivisible part of a controller. A *value* is the instantaneous state of a control. The *scalar* is a continuous control, and if the control is discrete, it is a *switch*. A *dimension* is a linear continuum and its *value* a scalar that realizes a dimension instantaneously. According to Goudeseune *parameter*, *dimension,* and *degree of freedom* are synonyms. Furthermore, a continuous control *drives* a dimension if a change on the control produces a corresponding change in the dimension's value.

Hunt et al. (2002) describe different mapping strategies as *one-to-one*, *one-to-many*, *many-to-one* and as a combination of the first three: *many-to-many*. An alternative notation is to categorize mapping strategies as *one-to-one*, *convergent* (one-to-many), and *divergent* (many-to-one) (p. 99). The left hand on a violin is a one-to-one mapping as it controls the pitch solely; the bow, however, is a one-to-many mapping as the speed and force simultaneously control amplitude, timbre, and pitch. Most acoustic instruments use one-to-one and one-to-many mappings and the latter has been proved intuitive and natural in electronic instruments as well (pp. 99–100). Goudeseune (2002, p. 86) also discusses the *order* of a scalar that describes how direct a mapping is between a control value and a dimensional value and is categorized with the integer −1, 0, and 1 respectively. Order 0 is a direct mapping where the control value is direct proportional to a dimension's value; in order 1 the degree of change of the control value is proportional to the dimensional value; and in order −1 a control value is proportional to a dimension's degree of change. Goudeseunse proposes an alternative notation borrowed from the field *proportional-integral-derivative* or PID control. In this notation, order 0 corresponds to linear relationship, order 1 to integral, and order –1 derivative. In order to exemplify the order 0: the left hand finger position on a violin string is directly proportional to the pitch; the control of amplitude on a violin is an example of a derivative –1 control, where the speed of the bow, and not the absolute position, determinates the amplitude. The jog shuttle on a video recorder is an example of an integral, order 1, type of control: the absolute position of the jog wheel controls the playback speed. Derivative controls show high agility but are poor at keeping a constant value while integral controls show opposite properties and are used when holding a constant value is of importance. It is also possible to describe derivative-integral controls in terms of transient response, how they handle sudden changes. Derivative controls have good response of transients while integral controls often goes beyond the desired output value.

Goudeseune (2002) proposes: on controllers with many controls, particular controls can be *selected*, *adjusted,* and *deselected*, and in addition the uses terms *primary* and *secondary* controls. A secondary control is used in order to change the behavior of a primary control. One example of a secondary control is the octave clef on woodwind instrument. The use of secondary controls reduces the numbers of controls needed and simplifies the controller, but it limits the number of simultaneously available controls. Goudeseune replaces continuous control with the term *slider* and categorizes them in one-dimensional *scalar-sliders* and higher-dimensional *multi-sliders*. Examples of scalar sliders are rotary knobs and linear sliders on physical controllers, sliders and scrollbars on computer displays and joysticks, as well as pressure-sensors, motion-tracking systems, etc. Multi-sliders can drive several dimensions at a time; the mouse can draw straight, horizontal, vertical, or diagonal lines. A slider can be either *absolute* or *relative*; the absolute slider has a one-to-one correspondence between a scalar's value and a dimensional value. A secondary control may change the resolution or offset the range of a scalar slider. It is possible to use one slider as a secondary control continuously varies the resolution of a primary slider. A relative slider is useful, for instance, when it is necessary to maintain fine-grained control of a large dimension when high resolution. "Pawing" with the mouse in order to control a large slider is one example of a relative slider application.

Arfib et al. (2002) define and distinguish mapping types according to *explicit/implicit*, *simple/complex,* and *dynamic/static* criteria. Explicit mapping deals with the case where a performer can describe precisely the links between input and output parameters. An implicit mapping "is considered a black box for which we define behavior rules but not precise value rules" (p. 130). *Complex* mappings are described as many-to-many and *simple* as one-to-one. *Dynamic* mappings adapt themselves and change accordingly during the course of a performance. Examples of dynamic mappings may be changing, or morphing from one timbre space to another, or changing resolution that allows a player to focus on specific details in one timbre space. Yet another example of dynamic mapping is the training phase in self-learning applications:

> In the case of implicit mappings such as artificial neural networks, such an adaption of the exploration domain can be achieved by minimizing the error between the perceptual parameter values to be reached and those predicted by the model. This is called the learning phase; it can be considered a preliminary task for the user – training before using the model – as well as the task going on while playing (p. 131).

There are different possible levels of learning, e.g. when a model is adapting itself to an instrument, or extracting general rules from the model, thereby enabling a performer to change the behavior or expressivity of an instrument. Input parameters define a *variation range* regarding both input and output parameters, a variation that defines the boundaries for a performer to explore. Limits are defined by two criteria, technical and aesthetic. The technical: "Convergence and stability of algorithms, physical limits of the synthesis model and of the gesture transducer" (p. 131), Aesthetic (or subjective): "It needs the judgment of the composer or the performer using the instrument, and also the judgment of the instrument's designer" (p. 131). The latter implies that matters such as personal knowledge, background, and taste play an important role when judging and selecting interesting perceptual zones in a synthesis model.

In order to facilitate comprehension of the mapping terms and functions presented above, I include below a list with short explanations of each term. This list is sorted according to order of appearance in the text, which also reflects a continuum from concrete to abstract concepts.

- *Controller* = a complete physical interface or set of commands.
- *Control* = a single indivisible part of a controller.
- Slider = see control.
- *Scalar-slider* = one-dimensional continuous control.
- *Multi-sliders* = higher-dimensional continuous control.
- V*alue* = the instantaneous state of a control.
- S*calar* = a continuous control that *drives* a dimension.
- *Switch* = a discrete control.
- D*imension* = a linear continuum.
- *Value* = a scalar that realizes a dimension instantaneously.
- *Parameter* = see dimension.
- *Degree of freedom* = see dimension.
- *PID* = proportional-integral-derivative control.
- *Order* = describes the relation between a control value and a dimensional value.
- *Proportional* = order 0, direct mapping where the control value is direct proportional to a dimension's value.
- *Derivative* = order −1, the degree of change of control value is proportional to the dimensional value.
- *Integral* = order 1, a dimension's degree of change is proportional to a control value.
- *One-to-one* = one control drives one dimension.
- *One-to-many* = one control drives many dimensions.
- *Many-to-one* = many controls drive one dimension.
- *Many-to-many* = many controls drive many dimensions.
- *Convergent* = see many-to-one.
- *Divergent* = see many-to-one.
- *Primary Control* = see control.
- *Secondary Control* = to change the behavior of a primary control.
- *Explicit mapping* = where a performer can precisely describe the links between input and output parameters.
- *Implicit mapping* = a black box for which we define behavior rules but not precise value rules.
- *Complex* mappings = many-to-many mapping.
- S*imple mapping* = one-to-one mapping.
- *Dynamic mapping* = self-adapting mapping.
- *Static mapping* = not self-adapting mapping.

Aspects of Mapping

As previously mentioned, one of the roles of mapping is to define the limits of an instrument and subsequently the feel of the instrument. One important aspect influencing the feel of the instrument is whether the mapping is dynamic or static. Goudeseunse (2002) states: "If the performer can comprehend the mappings embedded in an instrument, obviously a more refined performance can result. This argues for static mappings over dynamic, and simple over complex" (p. 99). A static and simple mapping does not imply that a dynamic and complex outcome is out of question: "Dynamism comes then from the gesture and not from the mapping" (Arfib et al., 2002, p. 141). It is a question of where or who generates the musical behavior, the mapping or the performer. A related issue is the question of virtuosity. With a highly dynamic and complex mapping, it is very difficult to learn to master an instrument. The extreme case might be a random dynamic mapping; in such a case, it is very difficult to learn an instrument because nothing is repeatable. "Some gesture devices constrain the gesture in such a way that virtuosity is impossible because no expert gesture can occur" (p. 142). Arfib et al. also claim that the difference between expressiveness and improvisation is very narrow where a good expressive instrument can replace or compensate for lack of virtuosity.[136] However: "Instruments, old and new, have to be evaluated on a musical and aesthetical basis, and not only on the basis of technological features" (p. 143).

LOUDSPEAKER SYSTEMS

The purpose of loudspeakers is to diffuse electronically amplified, processed, or synthesized sounds in a space. The reason I include a discussion of loud speakers in this work is that they constitute an integral part in all electronic instruments, including digital musical instruments. My aim is not to cover the full history and description of construction concepts of loudspeakers in this work as it is presented elsewhere, for instance in Emmerson (2007), Manning (2004), and Watkinson (1998). According to Emmerson (2007), in the field of acousmatic music, there are two different views regarding the role of the loudspeakers, the *idealist* and the *realist*:

136. I found this thought interesting, but a bit strange, although I understand it relates to the virtuoso ability to repeat gestures. While improvisation is not about repetition, nevertheless, an improvisation can be very expressive.

- First the composer's ideal soundfield as heard in the studio of creation. Some composers and performers (the "idealists") believe that this need no further interpretation, merely the optional adjustment of loudspeaker placement and setting the overall sound level.
- Second the composer's "musical intentions" for the listener. Recognising that the listening space may be radically different from the studio, some composers and performers (the "realists") believe this demands active interpretation i.e. "diffusion" (p. 148).

The realist approach is in my experience the most common, and from it follows the notion of regarding loudspeakers as instruments with their own individual character. In electroacoustic music, different sound diffusion concepts have been developed in parallel with the music, whereas the use of sound reinforcement systems in popular music genres has evolved under the guidance of different aesthetics and, I claim, more pragmatic needs.

Local and *field* are two terms that Emmerson (pp. 92–3) discusses in connection to the perceived causal relation of action and sound of a performer. A close perceptual relationship of action-sound, most often in the time span of our short time memory is characterized as *local*, whereas activities that cause events to happen in the medium to long-term time scale are regarded as *field* actions. Causality of the latter, the *field*, tend to be detectable through repeated listening only. The actual loudspeaker itself may influence the perceived distinction between local and field events. In order to maintain the sense that actions are local, a speaker in close vicinity of the performer is required. Furthermore, the directional characteristics of the speaker may also have an impact, where a more directed radiation reinforces the perceived connection. Emmerson defines the Local/Field distinction thus:

- Local controls and functions seek to extend (but not to break) the perceived relation of human performer action to sounding result.
- Field functions create a context, a landscape or an environment within which local activity may be found (p. 92).

Emmerson also discusses the idea of a space *frame*, a nested set of spaces from the *landscape,* constrained to the acoustic horizon, to the smaller *arena* that itself contains a *stage* upon which we frame an *event* (p. 97). The landscape and arena are part of the field, whereas stage and event constitute the local (Figure 21).

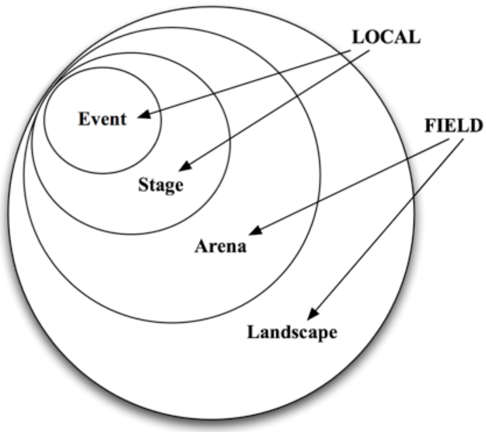

Figure 21: Local and Field frames, in (Emmerson 2007, p. 98)

When Schaeffer and his colleagues presented the result of their experiments in Paris in the late '40s and early '50s, they produced and performed in monophonic sound, and at the time, movement of sound in space was not yet an issue. However, with the premier of *Symphonie pour un homme seul*, by Henry and Schaeffer in 1951 they introduced the *Pupitre de relief*[137] (relief desk) in an early attempt to exploit real-time spatialization of sound. The system consisted of four loudspeakers, two in front, one behind, and one above the listeners suspended from the ceiling. Stockhausen's famous piece *Gesang der Jünglinge* from 1956 originally featured a five channel sound system that consisted of one speaker in each corner of the listening space and one mounted in the ceiling above the audience similar to the French pupitre arrangement. However, technical difficulties forced Stockhausen to omit the fifth channel and subsequently he re-mixed the piece into four channels, which eventually became the standard "WDR 4-channel" format (Emmerson, 2007, p. 156). In the booklet accompanying the CD release of *Gesang der Jünglinge* (Stockhausen, 1956), shows a diagram of the WDR 4-channel sound system (Figure 22). In addition, Stockhausen utilized an 8-track sound system in later pieces.

137. Also known as *Pupitre de d'espace* or the *Potentiomètre d'espace* (Emmerson, 2007, p. 150).

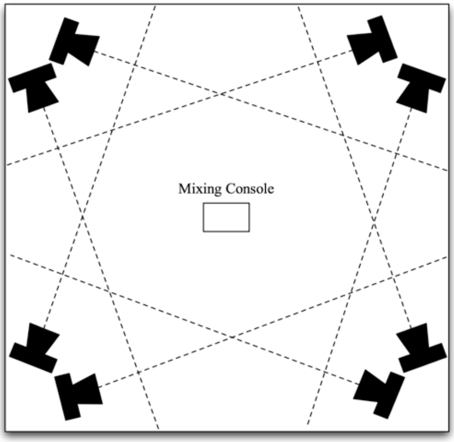

Figure 22: Four channel system, in the CD issue of Gesang der Jünglinge (Stockhausen, 1956, CD 3).

Four channel, or quadraphonic, sound systems eventually became a standard in the early '70s.[138]

One phenomenon that closely parallels French acousmatic music is the loudspeaker orchestra (*Orchestre de Haut-Parleurs*) and the "art of sound diffusion". The most well known are the *Gmebaphone* and the *Acousmonium*, which both emerged in the first half of the '70s and which were later followed by systems at other studios outside France. Common for all such orchestras is that the configuration calls for many speakers (up to a hundred), and it affords users the ability to spatialize sound in real-time. GRM's Acousmonium consists of roughly 80 speakers, divided in 16 channels. The concept is modeled after symphonic orchestras: the placement of loudspeakers in the hall takes its operative frequency range and sonic characteristic as point of departure. As a common practice, the original music is mixed in stereo in the studio, while the diffusion in the concert hall is regarded as an interpretation of the piece. The Gmebaphone was developed at GME[139] in Bourges under the guidance of Christian Clozier, and he puts emphasis on the notion that the sound diffusion system has to be regarded as an active interpretive tool:

138. I remember tape recorders that featured 4-channel operation from Sony and Akai was commercially available in Sweden in the mid '70s.
139. Groupe de Musique Expérimentale in Bourges.

> The Gmebaphone
> – is not: a loudspeaker orchestra
> – is: an orchestration generator (Clozier cited in Emmerson, 2007, p. 151).

The basic principle of the Gmebaphone is to perform spatialization by splitting a single sound source and distributing it in limited frequency bands. More recently, the Gmebaphone has evolved into a fully automated sound processor and diffusion system that enables pre-recorded interpretations to be performed, and in 1997, they changed the name to *Cybérnophone*. The BEAST[140] system a somewhat more flexible configuration and is often arranged to meet specific compositional demands. At the principal concert hall at SARC[141] in Belfast, the audience sits on a steel grill, which allows loudspeakers to be placed beneath the listeners as well.

Electrical sound reinforcement systems have been widely used since the '30s, which has had a major impact on the vast majority of music made after World War II. There is no such a thing as the perfect loudspeaker as all constructions are compromises, and therefore all loudspeakers have their own distinct sonic character that necessarily colors the material played through them.

Loudspeaker Systems in This Work

The digital musical instruments discussed in this work use loud speakers, as any electronic instruments do. At earlier stages in their development, notably with the improvisation groups Natural Artefacts (Lindeborg et al., 2003, and 2006) and Nilsson/Sandell Duo (Nilsson and Sandell, 2004) a quadraphonic set-up was used, similar in layout to Stockhausen's system. This implies a field function, which favors contextual and environmental types of textures. At the time, this sound reinforcement solution reflected the functionality, type, and musical roles of the instruments employed: they were simple sample-based instruments, which, in essence, produced sonic textures. Gradually, as my instruments developed and supported increased direct gestural play, the weak action-sound link in this field type of loudspeaker set-up proved inadequate. Eventually, an individual monophonic loudspeaker for the main sound source was chosen. This was a radical step that sacrificed one of the most widely embraced ideas in electroacoustic music: namely the ability to use

140. Birmingham Electro-Acoustic Sound Theatre.
141. Sonic Arts Research Centre.

spatial placement of sound as a dynamic dimension in music. In conjunction with a performance of Boulez's *Répons* (1984), Max Mathews[142] argues that the movement of sound in space is problematic, especially in contexts where electronic and acoustic sounds are mixed:

> Loudspeaker sounds always arrive later that direct sounds, but the listener is more attentive to the direct sound. For this reason, it's difficult to move the location of the sound source in a room. Although I don't know how Boulez felt about the performance of *Repons*, I never heard the sounds move to my satisfaction (Gayou, 2007, p. 17).

When using digital musical instruments in contexts where real-time interaction is at the forefront, such as improvisation, I assume it is more important to be able to identify the sound source, than to be able to make esoteric spatial sound movements. The reason is simple: the action-sound link in digital musical instruments is weaker than on acoustic instruments, and a multi-speaker set up will weaken it even more. The effect was immediate, for an exterior listener it was easier to hear and to identify me as one of the musicians in the group, and from my point of view, it facilitated interaction with fellow musicians.

142. See Computer-Based Composition Programs, starts on page 70.

The Hyper-Instrument

During the course of the years, I have designed and developed a hyper-instrument intended for ensemble improvisation: a collection of digital musical instrument modules that are interconnected and gathered within a common host application. A variety of theories and aesthetics imbue the design of these instruments, however, I am keen to point out that the multitude of influences does not make musical outcome eclectic. Rather, with respect to agreed-upon style and concepts in participating improvisation groups, I argue that music produced in this context is aesthetically coherent. The aim in designing these instruments is primarily personal: they are not intended for other users. This means that the design may show inconsistencies in certain respects, such as naming conventions, and usability. Despite this, there are parts in my system that may have potential for wider recognition: e.g. the modular thinking which enables exchanges of individual modules on the fly, and the ability to tailor-made set-ups for singular performances; global timing and synchronization; systemization and integration of hardware devices within the system; and finally musical features in singular modules.

The modules within the hyper-instrument show a huge variety with respect to pitch behavior, degrees of control, sound generation, etc. Furthermore, some modules are of original design, some are co-designed with others, while a third group deals with borrowed and applied technology. Inevitably, it is possible to classify the modules with respect to different criterion; however, I choose to make a categorization with respect to function and performance practice. The categories of choice are *main instruments*, *control instruments*, and *effects*.

In this work, no instrument is mainly designed with the aim to control generation of absolute chromatic pitches. Rather, my instruments deal with gestural control of sound processing and sound generation in the continuum. One exception is the Walker (see page 203), a jazz bass instrument that generates new events based on probability distributions of intervals and durations, and another instrument, the *exPressure Pad*, whose design, almost non-intentionally, allows for controlled chromatic play.

These chapter only shows grey-scale images, however a selection of colorized images appears in the Appendix.

GENERAL DESIGN OF THE HYPER-INSTRUMENT

The collection of modules and the structure of the hyper-instrument evolve and develop continuously. In order to facilitate exchange of modules and improvement of the entire system, a modular design is implemented. In practice, the hyper-instrument will not be the same on different occasions, depending on contextual matters such as co-musicians, repertoire, and venues. I discuss two generations of the system: the old 2003 system, and the revised 2009 system, restricted to principal features, leaving out specific details, unless they play an important musical role.

Due to modularity and flexibility, the OSC[143] protocol is used for communication. One important feature of OSC is its naming conventions, where all control parameters may have arbitrarily chosen names. All control values from the physical interfaces and inputs in instrument modules are normalized to 0–1 floating point numbers, and then assigned to selected musical parameters within the applications.

One important feature of the hyper-instrument is the global clock. All instruments that feature metric rhythmic behavior may be set in slave mode in order to synchronize with each other. The following instruments support synchronization:

- The Granular Machine
- The SyncLooper
- The Walking Machine
- The FourToThree
- Delays/Echoes

The global clock generator consists of a ramp generator that continuously generates a series of floating point numbers, from 0 to 1, during one cycle (Figure 23). By dividing the setting of global BPM with a suitable number,[144] one cycle of the clock generator equals the duration of four bars in 4/4 meter.

143. Open Sound Control is a standardized digital platform-independent communication protocol. www.cnmat.berkeley.edu.

144. Example: BPM 120 divided by 960 gives 0.125, which equals the current frequency of four bars in 4/4 in BPM 120.

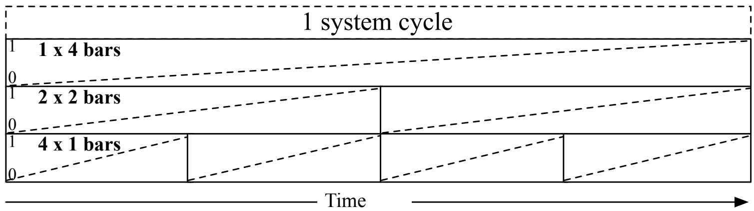

Figure 23: While global clock does one long cycle as master, slave modules can be set to play, one, two, or four bars.

Within each instrument module, the stream of floating point numbers from the global clock (0–1) is transformed in an integer counter, typically 1–96, which equates a resolution of 24 ticks/bar, permitting divisions by 3 and 4 in order to allow triplets as well. This design confines the possible maximum length of a repeating sequence to four bars, however, by applying a modulo operation on the output, it is possible to perform four one-bar, or two two-bar patterns within a long global clock cycle as well. The experiment *Davis Deconstructed*, (see page 314), demonstrates global clock and synchronization features of my system in a musical context.

Controllers

I employ three different physical controllers: *Evolution UC-33*, a MIDI-based fader, knob and button device; the Logitech *Gamepad* controller; and finally *Trigger Finger*, a 16-pad MIDI trigger device that transmits velocity and pressure data.

Evolution UC-33 is a compact and reliable unit equipped with nine faders, twenty-four knobs and ten buttons, in addition to transport and memory store/recall buttons. The UC-33 is utilized mostly for common tasks such as instrument output levels, master volume, aux levels, and transport control, in addition to control of certain parameters within particular modules. Figure 24 shows the common mapping in the 2003 system; note that only output levels from the first eight instruments are accessible from the UC-33, while additional instruments are controlled with the mouse.

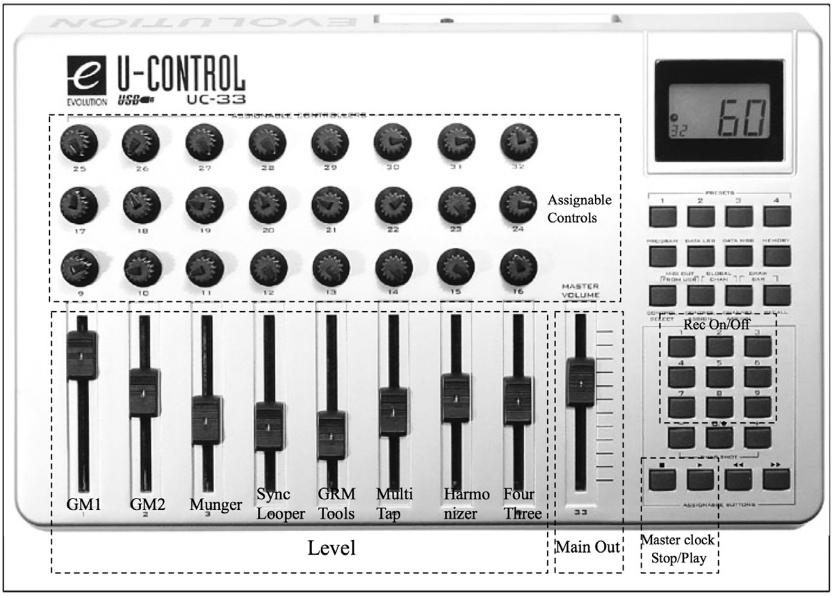

Figure 24: UC-33 as configured in the 2003 system.

Gamepad controllers are cheap, reliable and affordable and in addition it is easy to find a replacement if broken. The controller offers the performer direct access to a great number of parameters simultaneously, a feature that makes it superior to knobs and faders in many applications. There are 21 different controllers consisting of two joysticks for continuous control, plus a number triggers and toggles. Despite its limitations and imperfections, utilized controllers afford expressive musical control on applied instruments.

Figure 25: Rumblepad 2 from Logitech.

The current controller, Rumblepad 2[145] from Logitech (Figure 25), features two x-y continuous controllers, in addition to switches and toggles, in all more then twenty controls. The left thumb cross (up and down) is used to select one of four gamepad controlled instrument; an operation that is monitored on the general GUI, all other actions are mapped directly into selected instrument.

The other main interface, M-Audio's Trigger Finger (Figure 47), originally a drum/sample trigger, is an integrated part of the exPressure Pad instrument, and is presented in conjunction with the discussion of that particular instrument on page 215.

The choice of physical controllers is undoubtedly a source of debate and strong opinions, which I encounter in connection with performances and presentations of my music. My view of controllers is very pragmatic: as soon as a working solution is at hand, I prioritize spending my time refining and practicing my instrument, rather than looking for new hardware. However, new controllers and mapping approaches are subjects of much research activity, a field I follow very closely in pursuit of enhancing my music improvisation tools.

145. Other game controller models will work as well. Current mapping is discussed in conjunction to discussion of respective instrument.

THE 2003 SYSTEM

The top-level GUI features a number of differently colored squares, each one containing one instrument. It is possible to re-configure and accordingly change a single instrument while the top-level GUI remains, however not in real-time. Within each colored square a number of buttons and faders control mute, output volume, and aux-levels as well as open the GUI of the current instrument. Instruments supporting audio input display current sound source. In addition, the top level GUI shows current global tempo in BPM, a beat counter, and current selected instrument under gamepad control, etc.

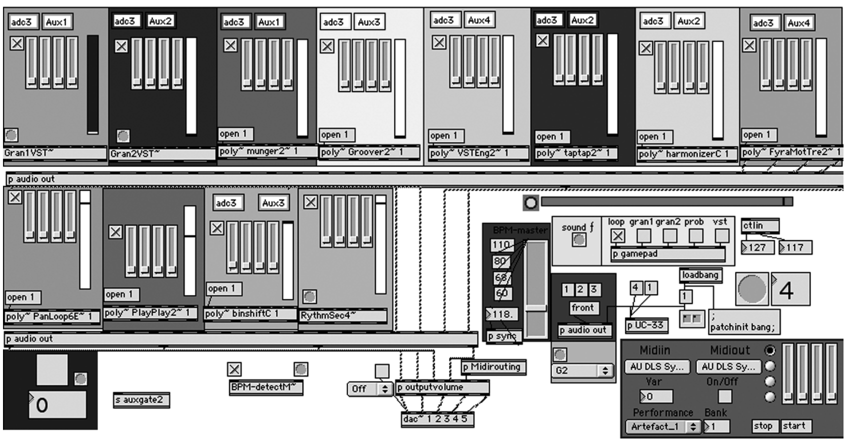

Figure 26: GUI of the 2003 system, actual set up used with Beam Stone in October 2007. Color image in the Appendix.

The general system supports quadraphonic output, however, only certain instruments feature such a set-up, and most performances utilize stereo, and more recently, monaural output.[146] The output from each instrument firstly passes an individual level control before passing the common volume control (only accessible from the controller).

146. A topic that is discussed on page 176.

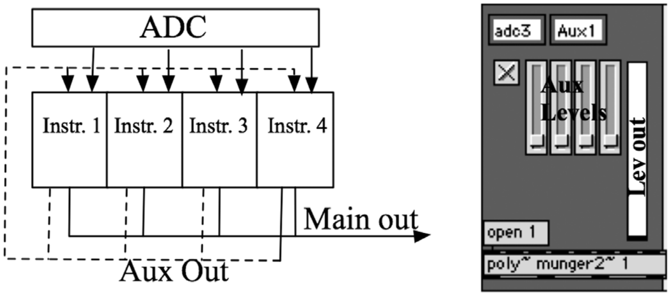

Figure 27: Signal flow of four instrument and GUI of one instrument container.

In Figure 27, the rightmost item shows one instrument module container: the four small auxiliary faders control internal aux output levels, an input source selector, and a level out. The two upper text squares indicate the selected sound source. Finally, the larger fader (Lev out) is controlled from a corresponding fader at the UC-33 controller (Figure 24), in this case channel three as seen on Figure 26. In all, there are four external inputs (analog-to-digital inputs, or ADCs) and four internal busses available. In this example, the left input is set to the external input nr three at the audio interface, and the right input is set to internal bus Aux 1. In this case, the leftmost small fader will send audio back to itself, which affords controlled feedback. Selected audio sources in individual modules are chosen and memorized inside a subpatch. The leftmost item in Figure 27 shows the audio signal flow principle, here exemplified with four instruments. External instruments, notably the Nord Modular G2 synthesizer are controlled within the green square positioned at the lower right corner of the top-level GUI, as seen in Figure 26.

THE 2009 SYSTEM

At the beginning of 2009, the structure of the hyper-instrument was completely redesigned due to tedious and slow real-time handling in the 2003 system. One major issue was to minimize mouse-operated actions as much as possible in addition to improve modularity and functionality. However, the instrument modules remain the same, except for an overhaul of inconsistencies in naming and labeling. The 2009 system design takes the UC-33 controller as a point of departure and subsequently only eight instruments are in use simultaneously, while the majority of controllers are hardwired to particular instruments. The first four channels offer audio input, channel 5 and 6 support only event-generating modules, and finally channel 7 and 8 contain effects. Figure 28 shows an example of a typical configuration.

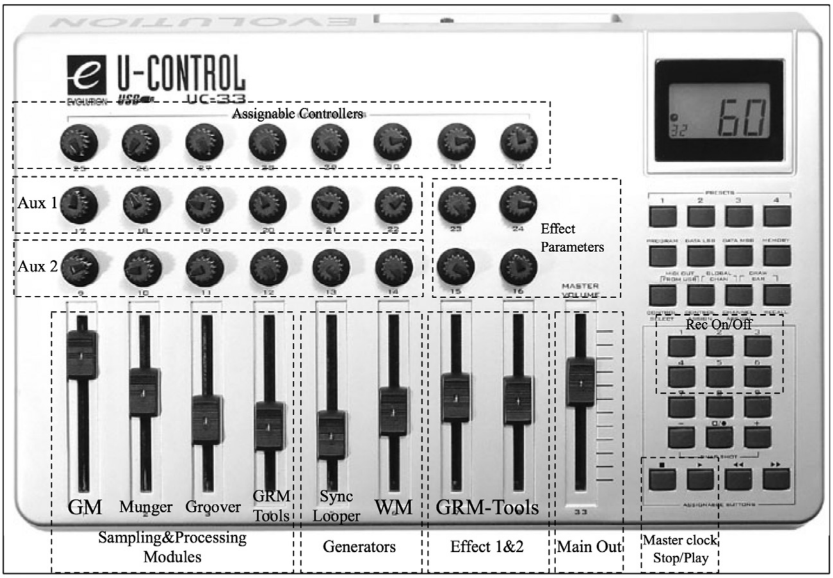

Figure 28: UC-33, the 2009 system, main mapping.

It is also noteworthy to point out that the auxiliary knobs (Aux 1 and 2) are hard wired from the instrument (channel 1–6) to effects 1 and 2 respectively.

In order to facilitate handling, the 2009 system features dynamic and memorized configurations of instruments, effects, and input filters. Figure 29 shows a schematic diagram of the signal flow in the 2009 system.

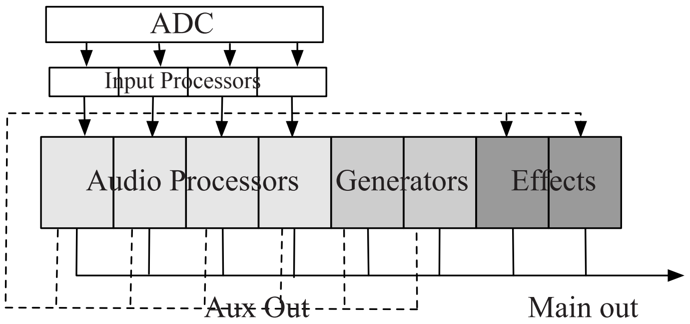

Figure 29: Signal flow in the 2009 system.

Figure 30 shows the 2009 system GUI; here the configuration used at the ISCM concert with Beam Stone in October 2009. The GUI (Figure 30) is divided into three horizontal areas that deal with audio input, instrument and general issues respectively.

The upper area features four different colored squares that contain two menus each, corresponding to input one and two at the audio interface. These are used to select an optional audio processor, or bypassing (IO-Dummy), to matching inputs of the first four instruments. In addition, the "open" button opens the GUI of a selected filter.

The middle section contains the selection and loading of instrument modules into all eight module containers, in addition to monitoring local DSP on/off plus a button that opens each module.

The bottom area handles general functions such as global tempo, beat counter, main level out, and chosen instrument to control.

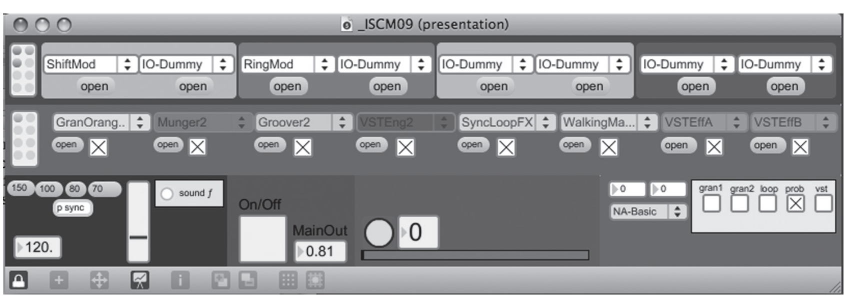

Figure 30: GUI of the 2009 system. Color image in the Appendix.

INSTRUMENT CLASSIFICATION IN THIS WORK

The library of available digital musical instruments consists of more then twenty different modules, but the number actually in use is approximately ten. The instruments show a great variety with respect to purpose, complexity, controllability, etc. Certain instruments have a broad range of applications, while others are small programs, aimed at specific purposes. The latter includes software specially developed for, and integrated in certain pieces of music. As discussed in connection to instrument classification, Kvifte (2007) argued for a musical instrument classification based on playing technique, which I find applicable in this work. I apply two categorization criteria for instruments in this work, one *functional*, and one *descriptive*. The former deals with functional playing modes on an instrument and distinguish between direct gestural control, *playing mode*, indirect control, *controlling mode*, and *effect mode*. The chosen descriptive instrument classification, divided into *main instrument*, *control instrument,* and *effects*, is based on available functional modes. A main instrument allows playing mode, while a control instrument only supports controlling mode, and the third, effects, are in principle simple effects such as reverb and delay/echo. It is worth noting that three of the four main instruments support controlling mode as well. There is no dichotomy between playing and controlling modes, rather, they exist a continuum, and the two extremes may mix. For instance, in a main instrument certain musical parameters may be under direct gestural control while others are not, and perhaps are only available from the mouse.

Playing mode refers to acoustic/mechanical instruments, which feature action-sound coupling, except in some rare cases such as piano rolls. This implies that a bodily action, a gesture, carried out by a player on such an instrument, is overt and directly and proportionally audible; its action-sound link is strong. For instance, when someone presses a piano key, the pitch, and relative dynamic of the resulting note is a direct response to the performer's action with respect to hand position relative to the keys and excitation force. Or, produced pitch and volume on a violin are proportional to finger position of the left hand, and employed force and speed with the right hand on the bow.

Controlling mode is primarily a phenomenon in conjunction with electronic instruments and devices, either analog or digital. Here, I refer to the discussion in the sub-section Compose, Control or Play on page 75 that treats early "music machines", which most often dealt with controlling processes rather than actually playing. In this group, a performing action is only indirectly audible; the action-sound-link is weak. With an electronic delay/echo device; when the operator changes the amount of feedback by turning a knob clockwise, it causes an increase in the number of repetitions; while the same action performed on a similar knob that controls delay time causes a slow down in the repetitive rhythm. Noteworthy to point out, the speed of the performed action does not significantly influence the audible result. Other examples of electronic instruments operating in this mode are drum machines, sequencers, and arpeggiators. This means that there is no direct causality between a bodily gesture performed on the interface, and audible output. It is necessary to make an additional distinction in this group, namely between *active control* and *active monitoring*. The first term entails a performance behavior that is close to playing, however carried out on a control instrument, whereas the latter deals with automatic generative processes where the instrument is left untouched, but monitored and adjusted if necessary.

Effect mode implies processing and coloring of incoming audio based on current parameter settings, and/or in controlling modes. Any instrument that features real-time recording can be set in effect mode.

An additional group is the *provider*: instruments that are integrated within the hyper-instrument, but played or controlled by someone else in the improvisational group. Typically, a delay based unit, whose audio input gate is controlled from a remote pedal. Additional concepts concern *primary gestures* and *secondary gestures*. The former is sonic gestures directly produced in playing mode, including acoustic instruments, whereas the latter refers to gestures that are created by effects out of primary gestures, notably delays and reverbs.

Main Instruments

In the following sections, I present four main instruments: *the Granular Machine*, *the SyncLooper*, *the Walking Machine*, and the *exPressure Pad* family. Within the Granular Machine, additional effects are integrated into the design, while the Walking Machine consists of two main instruments and three effects, which makes it a hyper-instrument in its own right. The four main instruments employ three basic techniques: audio sampling/processing, symbolic event-generation, and synthesis. However, all of the main instruments make use of all concepts in varying degrees. Firstly I present an overview of basic features and musical references, secondly a more in-depth discussion including design and mapping, while discussions and reflections about performance practices is undertaken in the concluding Analysis chapter.

THE GRANULAR MACHINE

The Granular Machine is a multifaceted and flexible instrument supporting playing mode, controlling mode, and effect mode, with the ability to record and process digital audio in real-time. Its most salient features are independent control of transposition, playback speed and direction of given sonic material, in addition to fragmentation/freezing. Integrated within the instrument are three effects, e.g. reverb, delay, and harmonizer, and due to its modular design, the effect configuration may be stored and recalled at the performer's discretion at any time. The Granular Machine has gradually developed from a sound processor and material generator aimed for acousmatic composition, into a playing mode instrument intended for live improvisation. The development of the Granular Machine has been driven by musical exploration of an existing sound processor, rather than conceptualizations of more general aspects of a given musical style or abstract ideas. It is worth noting that I do not intend to make a full presentation of granular concepts, but rather to pinpoint important matters that relate to the Granular Machine. Information about granular concepts and its history is mainly taken from (Roads 2002).

Playing techniques employed on the Granular Machine can be traced back to Schaeffer's pioneering works in the '40s, known as musique concrète. In order to carry out compositional ideas he utilized turntables, which offered transposition, repetition and fragmentation abilities. In the early '50s the turntables was replaced by tape recorders, which offered more precise control of sound manipulation while real-time abilities were somewhat lost. During the '50s a number of tape-recorders were developed, such as the basic workhorse *phonogène cromatique* and the *morphogènee*.[147]

The British inventor and Nobel price winner Denis Gabor presented in three seminal papers, 1946, 1947, and 1952, a theory that describes acoustic quanta. *The Gabor Matrix* states that "any sound may be decomposed into a family of functions obtained by time and frequency shifts of a single Gaussian particle" (Roads 2002, p. 57). One key issue in his theory connects the size of a sound particle with frequency and time resolution, and the more we fix one parameter, the less fixed is the other. In short, a sound particle is, with the language of today, windowed with a Gaussian function, and according to Roads: "Gabor recognized that every windowed analysis entails an uncertainty relation between time and frequency resolution" (p. 58). As an example, if the particle is 10 ms, the lower frequency limit is 100 Hz,[148] or: "to resolve frequencies to within a bandwidth of 100 Hz, we need a time window of at least 10 ms" (p. 58).

One of the first attempts to apply granular techniques in music is Xanakis's electro-acoustic piece *Concrete PH*, composed at GRM in Paris for the Philips pavilion at the Brussels World's Fair in 1958. Concrete PH was composed by cutting and slicing a great number of short tape pieces of recordings of burning wood in order to control the density of events. However: "This work was not the result of mathematical operations, but was approached by the composer intuitively, in the manner of sound sculpture" (Roads, 2002, p. 65). Eventually, Xenakis coined a new concept in music theory, namely *grains of sound*. Moreover, he utilized probability theory in order to control the distribution of grains with the aid of so-called Markov-chains of the first degree[149] (p. 66). In these early pieces Xenakis worked with grains with a constant duration and frame rate and according to Roads: "the idea that all grains have the same duration is aesthetically limiting" (p. 67). Despite this objection, the Granular Machine, by technical reasons, utilizes constant grain duration and frame rate. However, the control instrument the *Munger*, features dynamic grain sizes and frame rates.

147. "The *phonogène* brought Schaeffer's dream of the 'most general instrument imaginable' closer to realization. This modified tape recorder, operated by a small keyboard, allowed timbre transpositions within a two-octave range, through multiple playback heads operating at different speeds. Schaeffer patented the machine. [...] The *morphogène* allowed independent transformation of the various phases of the sonic object. Tape recorders ran at 76.2 cm/sec" (Gather, 2003, p. 271).

148. Gabor's formula: $\Delta t \times \Delta f \geq 1$ (Roads 2002, p. 58).

149. Markov chains are further discussed in connection to the Walking Machine.

The Design of the Granular Machine

According to Rowe's software classification system in *Interactive Music Systems,* the Granular Machine would be classified in the *performance-driven, instrument,* and *transformative* paradigms (Rowe, 1993). The Granular Machine, as its name alludes, is based around a granular engine, which originally was developed by the Japanese software developer Nobuyasu Sakonda[150] for the Max/MSP platform, which was published on the Internet as shareware in the late nineties. However, I have re-built and modified the software a number of times since then. In short, granular synthesis deals with the idea of chopping up a continuous sound into a stream of short fragments, grains. In order to handle digital audio data, a buffer is used, which may be filled with audio, either by loading an existing file from a hard disk, or through real-time recording via external audio inputs. When reading the buffer forward, a straight playback occurs, somewhat similar to playback of an analog magnetic tape on a tape recorder.[151] By controlling playback behavior within single grains and the stream of successive grains independent of each other, playback possibilities are very flexible, e.g. replay forward at half speed of the original; playing backwards at double speed and transposed down; or producing fragmentation and freezing effects.

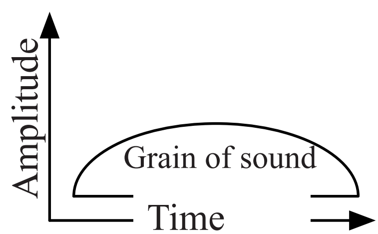

Figure 31: One grain.

150. Information of Sakonda: web.me.com/nsakonda/sakoweb/profile.html (September 2011).

151. Digital audio technique is discussed in a number of books. For instance Manning (2004), Roads (1996), and Watkinson (1994).

Figure 31 shows a schematic image of one single grain, and its idealized shape shows that each grain performs an in/out fade during playback, a.k.a. *windowing*; otherwise, audible clicks may appear. Noteworthy to point out, within each grain the relationship of speed/transposition is constant: doubling of speed always doubles the frequency. Playback speed is determined by means of current chosen hop distance (or process speed) of successive grains, while the playback speed within each grain controls pitch/transposition. Typically, each grain is 50–100 milliseconds long, and a common side-effect implies that a "grainy" quality most likely is audible. Grain lengths of 500 milliseconds and above, will produce an audible pulsating artifact, with a frequency directly related to current grain length. In order to minimize this problem, overlapping of grains is common, such that successive grains move forward only one eight of the entire length of a grain before the succeeding overlapping grain starts.

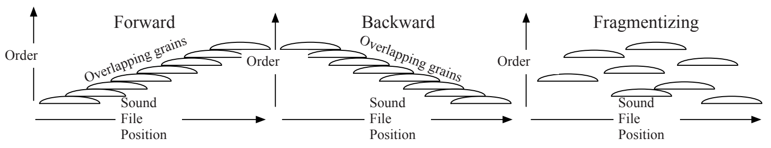

Figure 32: Streams of grains.Different orders of successive grains, gives different results.

Figure 32 shows that different orderings of successive grains will result in different audible results. By setting the hop size to zero, effectively playing back from the same position of the sound file, causes the sound to freeze. Assigning a random position to each new grain, either within a given selection, or the entire sound buffer, creates fragmentizing.

The Granular Machine features a number of musical parameters; some are accessible from both the GUI and the Gamepad controller; others are only accessible from the controller; and finally a group only accessible at the GUI. However, the design aims to gather control of playing dimensions at the Gamepad, whereas GUI-only parameters deal with setting and selection, and most often are not touched during performances. The GUI of the Granular Machine displays what I consider only necessary information to the performer.

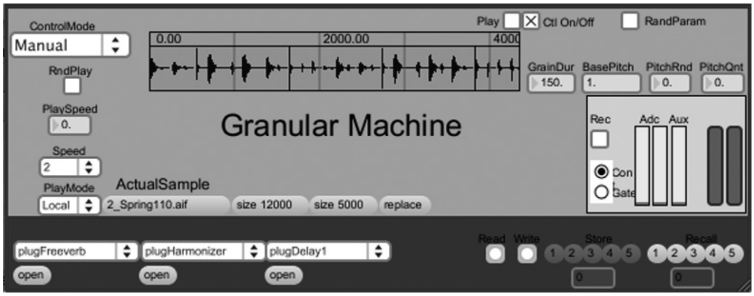

Figure 33: Top-level GUI of the Granular Machine. Color image in the Appendix.

The waveform display shows current sound in the buffer, which also continuously updates in the case of real-time sampling. The bottom, (blue), area deals with the selection, storage and recall of ancillary effects. The Granular Machine allows control of the following dimensions:

- *PlaySpeed* controls playback speed, where 1 is equal to forward at original speed; –1 backwards at original; while 0.5 and –0.5 denote half speed, forward and backward respectively. These parameters are only active in playing mode 2.
- *BasePitch* controls basic transposition.
- *PitchRnd* randomizes transposition of successive grains within a frequency band centered on the setting of BasePitch, the higher the value the broader the frequency band.
- *PitchQnt* works in parallel with *PitchRnd* and de-tunes grains on based on a pre-determined rhythmic lattice.
- *ControlMode* selects the source of grain hop size; manual denotes direct linear control from the interface; in automatic control mode playback speed and direction is controlled by a ramp generator, whose speed is controlled at the interface. Speed is only active when ControlMode is set to Global, and denotes a division by 1, 2 or 4 at the global clock.
- *ControlMode* selects ramp generator, local or global.
- *RandParam* randomizes a number of parameters.
- *RndPlay* performs automatic playing.
- *Play position* and *Selection size* are performed with the mouse directly at the waveform window, and are controllable from the interface as well.
- *Rec* controls and shows recording on/off.
- *ActualSample* shows current loaded sample from hard disk.

- *12 000*, *5 000* and *Replace* re-size the sound buffer (milliseconds), or manually load a sound file from a hard disk.
- *Cont* and *Gate* decide whether the recording will start immediately or wait for a sound loud enough to reach a predetermined threshold before recording.
- *Adc* controls level in from the audio interface channel one and two.
- *Aux* controls line level in from the audio interface channel three.
- *Play* indicates if the Granular Machine is playing.
- *Ctl On/Off* displays the status of a gate of incoming control data.
- *GrainDur* determines grain size, which may be changed during performances, but due to audible artifacts (abrupt change in pitch) operation while in silence is advised.

The Granular Machine is mainly played with the Gamepad controller, and features three modes of continuous gestural control: 1) *Manual mode*: pitch, playback position and selection of playing area; 2) *Playback mode*: pitch and playback speed/direction; 3) *Slave mode*: pitch. Four switches control on/off gating of outgoing audio from the main engine and three gates of incoming audio to sub processors respectively, and additional switch control and toggles record on/off as well as between randomized and straight pitch.

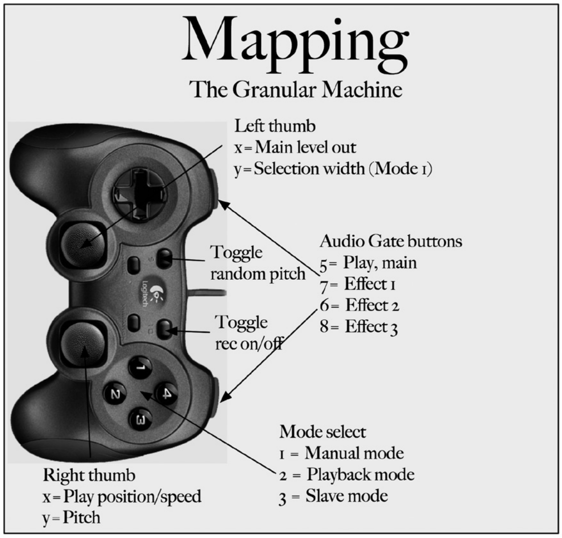

Figure 34: The Granular Machine, mapping from the Gamepad controller.

Figure 34 shows the mapping of the Granular Machine, as used in the 2007 GAS recordings and onwards. In *Manual mode* the right thumb joystick uses a *one-to-one* linear mapping for play back position and selection width on x and y axis respectively, whereas pitch control makes use of a non-linear scaling in order to preserve the plus/minus one octave transposition with respect to center position. A *derivative* mode is implemented in *Playback mode* in order to control speed and position of the playback, this is, data received from the interface controls direction and frequency of a ramp generator, which in turn controls playing speed and direction. In *slave mode* playback speed is synchronized to the global clock, while pitch control is accessible independently.

The internal effects are fed with audio when the corresponding button is pressed: button 6, 7, and 8 on the interface are assigned to Effect 1, 2 and 3 repectively (e.g. *AutomaticHarmonizer*, *BasicReverb* and *BasicTap*[152]). In order to allow quadraphonic audio, individual grains are routed cyclically into four-channels, but may be mixed down to stereo or monaural output, depending on the sound reinforcement system. Figure 35 shows the audio routing of the Granular Machine.

152. Effects are presented later in this chapter.

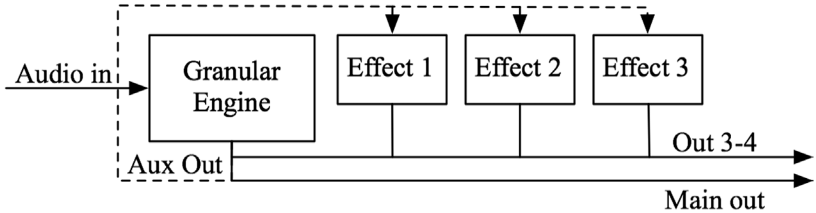

Figure 35: Audio routing in the Granular Machine.

The configuration and settings of internal effect parameters are individually accessible and possible to store and load dynamically.

Playing Modes of the Granular Machine

The Granular Machine supports three operating modes: *manual mode* allows playing mode and active controlling and monitoring; *playing* deals with playing mode only, and *playback mode* implies active monitoring. All three operating modes use content in the sound buffer, which consists of either prerecorded sound files or real-time recordings. In the latter case, the audio stream from an external source, microphone or line in, constantly replaces old material with new. As a result, the buffer is completely renewed at the length of the buffer, typically each five seconds. Record on/off control is directly accessible from the controller, which allows the performer to interrupt an ongoing recording, allowing exploration of buffer content. The waveform window that resides at the top-level GUI (Figure 33), visualizes the content of the sound buffer. In order to play the Granular Machine, the player monitors the waveform window, which shows current playing position and selection size superimposed over an image of the current waveform. One feature in the Granular Machine is randomization and quantization of pitch. These two parameters operate in a continuum, starting with no variation up to several octaves, and the latter from a pitch continuum to semi-tones. Both parameters are individually accessible via the mouse at the GUI. However, in recent mapping, both random pitch and pitch quantization are assigned a one-to-many mapping, the random pitch switch on the interface toggles between straight behavior and random setting of pitch and quantization simultaneously.

In manual mode, playback position, size of selection and pitch are under direct one-to-one control at the interface. Manual mode is best suited for exploration of timbral qualities, and to a certain extent gestures of given audio material. It is easy to park the "playing head" at one spot in the sound buffer in order to freeze a sound. With increased selection of audio, the output consists of a quasi-static timbre. Since the playback head (playback position) randomly jumps around within the selection, the output consists of a statistical timbral mean value of that particular selection. By closing the control signal gate on the interface, the current setting freezes and the Granular Machine turns into automatic playback. This feature is useful in order to create sonic textures, or ambiences, based on the contents of the sound buffer. It is noteworthy to point out that real-time recording may continue, while automatic playback goes on.

Playing mode differs from manual mode in playback control, which is implemented as a derivative control. Playback position is controlled from a ramp generator, whose speed and direction is controlled at the interface. This design facilitates exploration of gestural properties, and allows very precise playback control of fractions of a sound, for example, various parts of a percussive hit. According to Goudesaune: "Derivative controls shows high agility but is poor at keeping a constant value" (2002, p. 87). All other parameters are mapped identically as in manual mode, except that selection size is fixed to zero.

In playback mode the Granular Machine is synchronized to the global clock of the hyper-instrument. In this mode, the Granular Machine plays back its entire buffer one, two or four times during one global clock cycle, regardless length. As far as the sound buffer content is metrically even, such as a two bar drum loop, the output from the Granular Machine plays in perfect synch with other applications that feature metric behavior. However, and most likely when practicing real-time recording, neither the length of the buffer nor the content show integer relations with the global tempo. However, since the playback sequence always plays in sync, such that its start always coincides with the global "one", interesting polyrhythmic patterns may occur.

A special feature automatically sends audio into the first effect slot, and is used occasionally. When the main out is silenced (release of button 5 at the Gamepad), the last seconds of audio output is automatically routed into the first effect (e.g. Automatic Harmonizer) whose internal parameters randomly re-set at each new feed of audio.

THE SYNCLOOPER

The SyncLooper is a sample based loop player comprising four identical loop engines, which allows for four different loops (most likely drum loops) to play in sync with each other, subordinated to the global clock, regardless of tempo of origin. However, as a prerequisite in order to obtain tight synchronization, the sound files are required to be one, two, or four bars long. In parallel with most of my instruments, the SyncLooper has evolved from an instrument under GUI mouse-control, into a playing mode instrument.

The SyncLooper utilizes a simple granular technique. The reading of digital audio from a buffer is identical with the Granular Machine but it allows no real-time recording. At the core of the engine is a segmentation process: e.g., a two bar pattern is typically divided in 16 or 32 segments of equal length, which equals 8 ths and 16 ths respectively. Modus operandi implies that length/pitch of individual segments controls transposition, while the speed of successive grains affects playback tempo. Noteworthy, segment hop size is constant and defined by global tempo, with no overlapping; at slower tempi than original, a silent pause is audible between each segment; and in higher tempi the next segment cuts the end of the present segment.

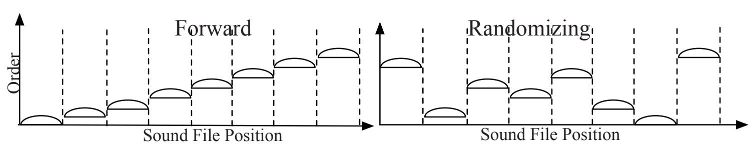

Figure 36: Segments in the SyncLooper. The left example shows a straight playback, while the right shows randomization of segments.

The SyncLooper's working mode is similar to REX-files,[153] however, in order to preserve natural attacks in a sound file, REX chops up a file according to discontinuities in the audio stream, a process that most often results in a number of segments of various lengths. While retaining original order, playback may vary with respect to tempo and transposition. A salient feature

153. REX is the native file format of ReCycle. A REX file contains the original audio of the loop, the spaces you have applied in ReCycle, and any effects or processing you have added in ReCycle. Taken from the website www.propellerhead.se (April 2010).

in the SyncLooper is to re-order segments arbitrarily, which stresses that each segment has to be of equal length in order to fit into the grid (Figure 36). Therefore, clicks and pops may occur, but a simple *windowing* function minimizes the problem.[154]

In essence, the SyncLooper consists of four loop engines, which are individually accessible from both the GUI, and the Gamepad interface. Audio out from the four engines of the SyncLooper is routed to left and right main audio out. Integrated into the design, in parallel to the Granular Machine, there are three effects available, which may contain any of the global effects. Furthermore, the separate effect output either merges into the main out, if mono or stereo sound diffusion is used, or goes to dedicated effect speakers.

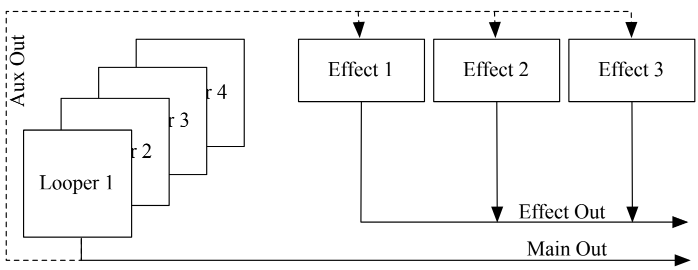

Figure 37: Audio routing in the SyncLooper. Four instances of the loop engine may play simultaneously, however, only one at the time is available for real-time control from the Gamepad interface. Active engine is brought to front at the GUI.

The top-level GUI of the SyncLooper deals with selection of sound files in addition to access a sub window that contains the three effects. In order to facilitate handling and fast changes of audio content in performance situations, it is possible to instantly recall five complete pre-stored configurations.

154. Synchronized fade in/out applied on each segment. See Figure 31.

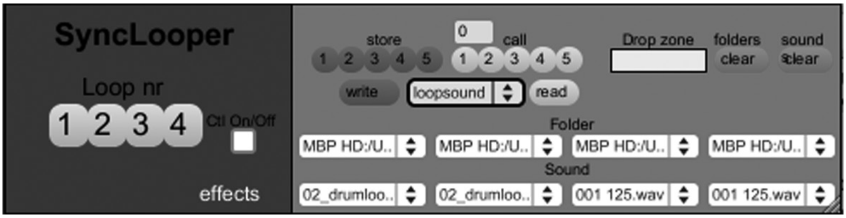

Figure 38: Top-level GUI in the SyncLooper. This window is mainly used for organization of sound files, and access to effects sub window. The four loop engines may be manually opened as well by clicking on respective loop number on the GUI. Color image in the Appendix.

A number of musical dimensions are accessible within each individual loop engine GUI in parallel with the Gamepad interface. Figure 39 shows the GUI of one loop engine.

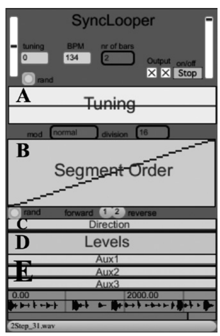

Figure 39: GUI in one SyncLooper engine.
Color image in the Appendix.

The following list presents available musical dimensions at the GUI:

- *Tuning* makes use of several GUI elements: the upper left fader controls global tuning; the number box shows actual tuning in semitones; the *rand* button applies randomization on individual segments (B), as showed in Figure 39; and finally the *Tuning* (A) window shows and sets tuning of individual segments.
- *BPM* displays original tempo of the loaded sound file.
- *nr of bars* shows the length of the loaded sound file, which is calculated on the basis of a simple algorithm, and manually changeable if necessary.

- *Output* shows status and sets open/close for an audio gate in the left and right channel.
- On/Off sets and displays play and stop.
- The upper right fader controls level out.
- *Mod* controls the four modes of playback with regards to segment order: *normal* plays back segments in the original order; *reverse* plays back the order of segments backwards, however each individual segment is played forward; *rand_once* randomizes segment order when executed; and *rand_auto* re-randomizes order of segments at each new repetition.
- *Division* displays the number of segments within one bar. Selectable between 8, 16 and 32.
- *Segment order* (B) displays and manually sets the playing position of each segment; a straight diagonal line from bottom left to top right indicates normal playback, whereas a line from top left to bottom right indicates backward playing; the rightmost window shows random order of segments.
- *Rand*, randomizes playback direction within single segments, as showed in the right window in Figure 39.
- *Direction* (C) sets and displays direction of individual segments.
- *Level* (D) sets and displays level of individual segments in five steps.
- *Aux* (E) 1, 2 and 3 sets and displays send open/close from individual segments to the three ancillary built-in effects.
- The bottom window shows the name of the loaded sound file; instant playing position and the waveform of the actual sound file.

The SyncLooper is primarily played with the Gamepad controller, while the GUI serves monitoring purposes. Certain parameters, such as tuning and randomization, work in parallel on the GUI and the Gamepad (Figure 40), while control of the order of playback, and gates to internal effects have different mappings. It is worth noting that only one loop engine is under active control at a time, the remaining three are either silent or perform automatic playback according to present setting.

The recent mapping of the SyncLooper was inspired by an idea from Gothenburg-based composer Åke Parmerud. Playback order is under real-time control, and allows the performer to play with the sound file in real-time. It is a variation of a many-to-many mapping, since two dimensions at the controller control the position of many sound segments (see Figure 73 in the Appendix). Moreover, tuning and duration of segments is controlled from the left thumb continuous controller. Three internal effects are integrated within the SyncLooper: a reverb of medium length, a delay, and a tap-delay. The mapping from the GamePad controller is as follows:

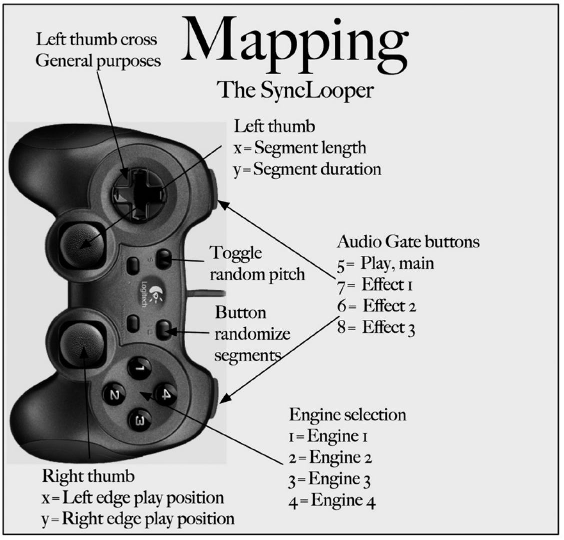

Figure 40: Mapping from the Gamepad controller to parameters in the SyncLooper.

- *Engine selection* activates and opens the adherent loop engine window. By double-clicking any button, all engines stop.
- *Audio gate* button 5 opens/closes main audio out.
- *Audio gate* buttons 6, 7 and 8 sends audio to one of the three internal effects when pressed.
- *Right thumb* continuously controls selection and playback order of segments; the x-axis controls the left edge (first audible segment) and the y-axis sets the right edge (last audible segment in the cycle), and interpolates a straight line in between. The mid window in Figure 73 shows examples of two possible momentarily settings; the darker line indicates forward playing, note that certain segments repeat because the selection does not include all segments, but played at the length of the entire sound file; and the grayed out line shows backward playing, also with repeating segments. If both left and right edges fall on the same segment, this particular segment

repeats throughout the cycle.

- *Left thumb* continuously controls pitch and duration of segments globally on x and y-axis respectively.
- *Left thumb cross* (left edge) may freeze the actual setting of segment playing order.

THE WALKING MACHINE

The Walking Machine is a dynamic, expressive, and highly idiomatic instrument, which aims to maintain the traditional role of a rhythm section in a free jazz context. The design of the Walking Machine is an original idea of mine and developed during an extended period, however, with extensive valuable feedback from fellow musicians. A key feature concerns real-time control of high-level parameters, that is, probability distribution of interval and duration, while underlying stochastic processes generate single musical events. The result is a continuous stream of events of various lengths. In addition, the integrated and synchronized drum loop engines can perform and superimpose consistent 4/4 meter. The intention is not to design an authentic rhythm section; rather to create an instrument that features selected practices from contemporary jazz such as gestural intervallic playing combined with a driving walking bass groove. It is worth noting that automatic generation of single events based on gestural description and/or list of probabilities is nothing new. Similar ideas have been realized in earlier music machines: e.g. the Belar and Olson machine and its predecessor the RCA synthesizer, the Raymond Scott system and POD by Barry Truax, which is discussed on page 71. However, those applications did not afford real-time playing and therefore were not playable in a live improvisation context.

The Walking Machine is an instrument that is able to provide an improvisational group a rhythmic and free-tonal platform as well as to allow its player "extra human" abilities, for instance performing drums and bass simultaneously, playing ultra fast walking bass accompaniment for an extended time, or to carry out big intervallic jumps at high speed. The sounds that the Walking Machine utilizes are close to its acoustic role models in order to maintain its traditional role. I claim that the Walking Machine, mirrors aesthetics gained through many years of musical activities as a saxophone player in performing, studying, and listening to music in the jazz vein.

Musical Influences

The musical inspiration to the Walking Machine is a free tonal walking style as heard on records such as Don Cherry's *Complete Communion* (1965), Ornette Coleman's *Change of the Century* (1959) and *Science Fiction* (1971), John Coltrane Quartet in *One Down, One Up* (Coltrane, 2006), *The Sorcerer* by Miles Davis Quintet (Davis, 1967), Wayne Shorter's *Super Nova* (Shorter 1970).

Modal jazz emerged in the late '50s. In essence, it was about a desire to reduce the underlying harmonic structure: functional harmony was replaced by a tonal frame that consisted of one or two modes or scales, such as the Dorian or Phrygian modes, imposed over a periodic schema, e.g. eight-bar modules ordered traditionally in a AABA form.[155] In *John Coltrane: His Life and Music* American musicologist Lewis Porter (1999) asserts: "Modal jazz offered freedom, but it also posed a challenge – to make coherent and interesting music with a minimum of harmonic guidelines. It might sound simple to play on one scale but it took great creativity" (p. 161).

Eventually the fixed bar structure vanished as well, to the benefit of more flexible forms. Therefore, the rhythm section gained freedom with respect to the soloists and vice versa. An improviser could no longer rely on the chord changes as the driving force, or *referent*, for the improvisation; therefore, a soloist must be able to create interest and drama by himself. One way of achieving interest was through "pattern playing", that is, patterns or sequences based on an intervallic approach that has the ability to create inherent interest, and subsequently juxtapose them with the rhythm section in performances. Porter quotes Coltrane; in 1961 he expressed this experience as:

> At first I wasn't sure, because I was delving into sequences, and I felt that I should have the rhythm play the sequences along with me, and we all go down this winding road. But after several tries and failures and failures at this, it seemed better to have them free to go – as free as possible. And then you superimpose whatever sequences you want to over them" (p. 166).

One common practice was to build patterns on fourths in contrast to the more third oriented be-bop. A plausible reason for the use of fourths has to do with the "open sounding nature" of that interval, in contrast to traditional

155. Such as *So What* by Miles Davis or *Impressions* by John Coltrane.

functional harmony that is based on thirds. In *Thinking in Jazz* by the American ethnomusicologist Paul Berliner (1994) saxophone player Benny Bailey reflects about interval playing as a vehicle that enabled musicians to "call up different sets of pitches having different harmonic relationships to the underlying chords" (p. 163). The well known jazz educator and piano player Walter Bishop Jr (1976) wrote in his practice book *A study of fourth*:

> While listening to some of the younger innovators in jazz, I became aware of the possibilities inherent in using an intervallic approach to improvisation. I decided to take the interval of the fourth and find as many ways I could to use it as linear device in combination with conventional chord changes and progression (preface).

Bishop summed up and formalized a common practice in contemporary jazz. It seems that the intervallic approach initially was developed as a means of expanding and developing the language of jazz improvisation inside the framework of functional harmony. Berliner (1994) discusses features of different intervals in intervallic playing:

> Emphasizing sequences of larger intervals, like fourths, distinguish melodies from those based on thirds, which more readily derive from chords, and from those based on seconds, which more readily derive from scales (p. 163).

The Swedish jazz saxophone player Lennart Åberg remembers: "All of a sudden patterns based on fourths appeared, you can almost date records from before or after, this way of playing affected mainly all jazz soloists at the beginning of the '60s".[156] During the course of the '60s, a number of jazz compositions, notably *Freedom Jazz Dance* featured an intervallic approach with an emphasis on fourths.

According to personal experiences, many jazz and improvising musicians spend a lot of time constructing and practicing different patterns in order to learn and internalizing them. In an interview in *Contemporary Music Review* Frances-Marie Uitti (2006) asked British sax player Evan Parker about his practicing habits. He mentioned the use of patterns based on intervals as central to his music: "Not really musical material, but more of a sort of proto material for what could become a study, mechanical exercise, or etude based on certain intervals or combination of intervals" (p. 2). In the same interview,

156. Personal conversation spring 2008.

Parker mentions Nicolas Slonimsky's book *A Thesaurus of Scales*[157] as an important source:

> What I do has a lot to do with Slonimsky but with the proviso that it isn't restricted to sub-divisions of octaves, although I think with those sort of patterns it can be done by additive or division processes if you allow for a large enough range… (p. 2).

Furthermore, Parker mentions that it is a kind of mathematical process that is about combining intervals in order to explore how far they would go, or number iterations before repetition, etc. (p. 2). Åberg also mentions that many improvisers used Slonimsky as a source of inspiration for the creation of new melodic material, aimed at improvisation.[158] The impact Slonimsky's work had on the jazz community may be attributed to Coltrane:

> Byrd[159] brought the book to the attention of John Coltrane, who… now found Slonimsky's material useful for his own music. As word spread within the jazz community that Coltrane was practicing from the book, performers from San Francisco to New York City experimented with its use (Berliner, 1994, p. 167).

One related, but somewhat different, approach to an intervallic approach is known as *motivic improvisation* and the undisputed father of this approach is Sonny Rollins. His method prescribes the use of all kinds of melodies, often borrowed from popular music, which he twists and turns inside out. Jost (1994) describes Rollins's style "[…] as were his willfully delayed rhythm and his habit of taking thematic motives apart and reassembling them with a persistence that sometimes made his improvisations into a musical jigsaw puzzle" (p. 138).

Another musician contemporary with the emergence of modal jazz was the saxophone player Ornette Coleman. The framework of Coleman's music consisted of the familiar jazz formula theme-improvisations-theme, where presented themes acted as a springboard for improvisation. However, instead of using the harmonic structure of the theme as the basis for improvisation,

157. Slonimsky's (1947) work is based on a concept that divides the octave in all possible ways, such as division in two, divisions in three, divisions in four and so on.
158. Personal conversation. As a newcomer in jazz at the beginning of the '70s, I was advised to use Slonimsky's book by the elder musicians.
159. Trumpeter Donald Byrd, my comment.

Coleman employed a *motivic chain-associations*[160] technique for improvisation, the theme is a point of departure, but eventually the connection vanishes. Melodic phrases are generated on a basis of free chain associations, where subsequent phrases evolve out of each other forming endless melodies. Unlike modal jazz, where the tonal reference relies on a scale, Coleman's playing relates to a single note that constitutes a tonal centre.[161]

The American trumpet player Don Cherry, member of Ornette Coleman's group 1957–1961 as well co-leader of a group together with Sonny Rollins 1962–1963, developed and employed another approach to motivic playing during the mid '60s and most likely both Coleman and Rollins have had a vital influence on Cherry's music. I refer to records such as *Complete Communion* (Cherry 1965) and *Symphony for improvisers* (Cherry 1965). In Jost (1994) Cherry asserts: "We improvise from the flavor of the tunes" (p. 144). According to Jost, this means that Cherry uses the intervallic and rhythmic properties of themes as a referent for his improvisational behavior: "[…] that what players primarily improvise on are not tonal centers, modes or even chord patterns, but the themes themselves and their motivic substance" (p. 144).

As showed, a number of improvisational concepts developed from an intervallic and/or motivic approach during the late '50s and '60s. I assume that a step toward a more abstract and autonomous use of interval structures, free from tonal, harmonic and melodic constraints and bindings, was not that far off. An intervallic approach is important with respect to my own improvising style on the saxophone.

It is claimed that the "classic"[162] rhythm section of Ornette Coleman, which consisted of Ed Blackwell on drums and Charlie Haden on double bass, did not play in 4/4-meter but employed a 1/4 meter, a pulse train with oddly placed accents. In an analysis of Don Cherry's solo on Ornette Coleman's (1959) *Face the Bass*, Jost (1994) shows that Cherry improvises "together with a rhythm, that suggests a straight 4/4 while at the same time contradicting it by off beat accents" (p. 136). Ornette Coleman's (1960) solo in *Forerunner* "[…] is based on a regular beat (here clearly tending toward 4/4), but Coleman's phrasing makes it difficult to determine 'one' in his melodic line" (Jost, 1994, p. 55). In the earlier mentioned Complete Communion record

160. A term coined by Jost (1994, p. 50).
161. For an in-depth analysis of Ornette Coleman's music, see Jost's (1994, pp. 44–65).
162. As heard on records such as *The Shape of Things to Come*, (Coleman 1969), *Science Fiction* (Coleman 1972).

by Cherry, Jost describes the drummer Ed Blackwell's improvising habits:

> Building on the rhythmic patterns of the tunes, he develops his solos into variations on those patterns by playing around them, breaking them up, putting them back together, superimposing others etc. (p. 144).

As we can see in both the examples, the 4/4 meter functions as a reference, favoring to a chain of patterns of varying length, derived from variations of the themes, are improvised. What was left was a basic unit pulse with arbitrarily placed accents. With this in mind it is plausible to claim that the bass player and the drummer perform a pulse train, which may be described as *one-one-one-One-one*, etc., with arbitrarily accents that "push" the rhythm by means of interaction with the other musicians.

This approach may be regarded as additive rhythm, that is, successive accents make up "bars" of different length additively on the basic unit pulse. We end up with an infinite non-cyclic chain of virtual bars of different meters. In *Math for Poets and Drummer* the mathematician Ruth Hall (2004)[163] defines additive rhythms as:

> Additive rhythm (also called durational rhythm) has an underlying unit pulse. Rhythm patterns are formed by combining unit pulses into notes. Plainchant, Indian, and Eastern European music is primarily additive. A note is the interval between successive attacks (p. 1).

Hall claims that additive rhythms have their counterpart, and origin, in poetic meters used by ancient poets such as *Pingala* and *Hemacandra*. Those meters were made up of combinations of long and short syllables forming rhythmic patterns (p. 1). Furthermore, Indian classical music utilizes additive concepts as well as many other eastern musical cultures. In the late '60s, influences from the orient were prominent in improvised music, e.g., in pieces where Don Cherry employed and developed material influenced from oriental origin, notably *Mu I* from 1968 and *Ethernal Rhythm* in 1969. This record features odd meters made up of additive rhythms, material influenced by the traditions of *Dhruphad* from the Dehli region and south Indian theatre music (Jost 1994, p. 156). Other noteworthy examples that explored additive rhythm concepts are guitarist John McLaughlin's *Shakti* (1977). One

163. www.sju.edu/~rhall/Rhythms/Poets/deanslides.pdf (February 2008).

composer who explored additive rhythm was Messiaen, and as Paul Griffith (1995) observes in his book *Modern Music*: "Let us not forget, he (Messiaen) once wrote, that the first, the essential element in music is Rhythm, and that Rhythm is first and foremost the change of number and duration" (p. 120, my bracket). In this context, Messiaen's piece *Mode de valeurs et d'intensités* is considered important. The key concept in this piece prescribes that each pitch has a fixed duration and dynamic. The tonal material consists of 36 chromatic notes, covering three octaves, where the highest note features a duration of 1/32 and on each descending note, 1/32 is added to the duration. Consequently, each new note, whatever rules its generation, adds its duration to the previous note/value, forming a chain of successive attacks/notes additively. In Nilsson (1993), I perform a "free jazz" variation on *Mode de valeurs et d'intensites* called *När jag kommer hem*.

The Design of the Walking Machine

One attempt in experimenting with an automatic modal jazz tune generator,[164] based on intervallic and additive rhythm approaches, was a predecessor to the Walking Machine. A probabilistic concept for generation of new intervals and durations was chosen; the method of choice was to control transition probabilities, also known as Markov chains of the first degree. The experiments were done in Max/MSP, where the *prob* object controls the creation of new events. One outcome was the composition *Probably Not* (Figure 41) that has been released on a CD (Lindeborg et al., 2001). The composition consists of two lines: melody and bass. The probability distribution was made up with a strong emphasis on the intervals fourths and seconds.[165] The bass line had a similar probability for intervals but a stronger weight for fourths and octaves and no long durations. Note that no editing was done after the

164. The Freedom Jazz Dance (Harris 1966) was used as inspiration.

165. The syntax of the employed *prob* object in Max/MSP prescribes chunks of three integer numbers, where the first two denote a transition from the first to the second (interpreted as negative and positive intervals), while the third is the probability weight (in percent) of that particular transition. The set of probability distributions that was used for the bass line in Probably Not: 1 5 11, 1 −5 11, −5 1 11, −5 −5 3, 5 5 3, 5 −5 11, 1 1 11, −1 −1 16, −1 1 22. The first chunk means a transition from a minor second to a fourth, both positive, with a weight of eleven. Rhythmically, the melody shows a strong probability for sequences of 8 s and 4 s with longer durations occasionally. The distribution looks as: 16 16 47, 16 8 7, 8 8 7, 8 16 23, 16 1 7, 1 16 0.5, 16 2 1, 2 8 0.5, (note that 16 is equal to 8 ths in the score).

computer generation of the material, just a straight transfer from the MIDI-file, which was created by Max/MSP, and exported into a score program.

Figure 41: Excerpt from Probably Not, bar 24–27.

Improvisation of the bass line was restricted to selection among a limited set of lists of probability distributions of intervals and duration. Although the musical result was satisfying the aim was to create an instrument that offered more directness and expressivity while retaining the sound and feeling of this implementation. One solution utilized interpolation between different probabilistic sets, and one attempt was made with an implementation of the *Space Master* concept by Ali Momeni and David Wessel (2003). This implementation was much more playable than its predecessor but was somewhat tedious to handle, which made it unpractical for live use on stage. With the introduction of the *Pattr* library in Max/MSP, finally a simple interpolator was at hand.

According to Rowe's (1993) software classification system in *Interactive Music Systems* presented on page 165, The Walking Machine is classified in the *performance-driven, instrument, generative/transformative* paradigm.

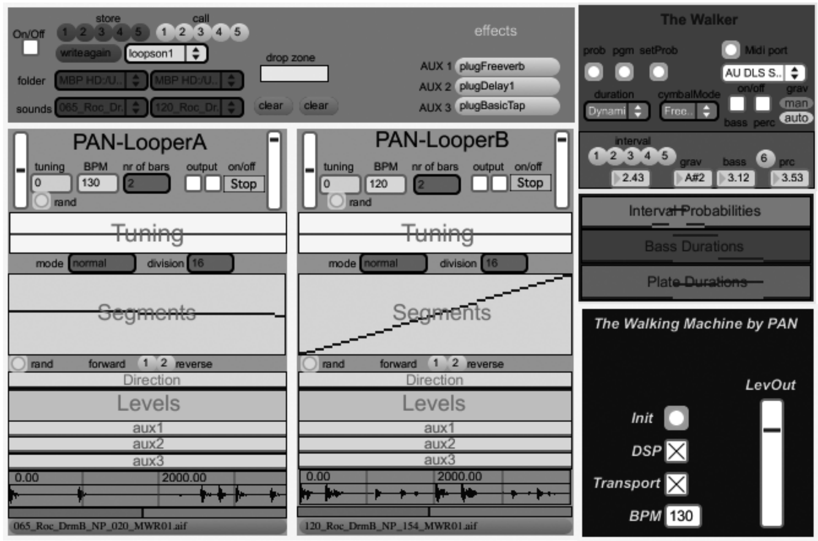

Figure 42: The Walking Machine GUI. Color image in the Appendix.

The Walking Machine consists of two parts: the Walker and the Looper, which play in sync with each other, subordinated to the global clock.

The Walker consists of an integrated bass and cymbal event generator; bass is generated by means of probability distribution of intervals and durations that combine unit pulses additively into MIDI events, which are played by a bass instrument on a synthesizer. The cymbal durations are controlled in the same way as the bass and the sounds are randomly distributed samples of four recordings of a 1 m^2 steel plate played from a custom made sampler within Max/MSP.

The drum engine, PAN-Looper A and B, is identical to the SyncLooper application inclusive the use of internal effects, except that it only makes use of two loop engines. The SyncLooper is described in an adjacent section. The visual part of the software contains windows needed for basic setting and visual feedback. The upper area displays monitoring and selection, as well as playback behavior with respect to duration. The middle area shows actual interpolation, while the bottom area shows actual probability distribution of bass, and cymbal (Plate) durations.

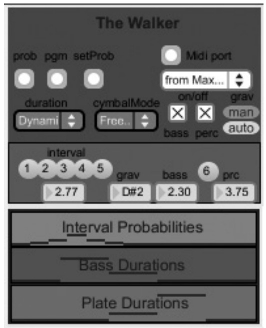

Figure 43: The Walker, Bass and Cymbal, of the Walking Machine. The upper area deals with access to sub-windows for editing purposes, as well as playback behavior with respect to duration. The middle area displays actual interpolation values in addition to manual selection, and at the bottom actual probability distribution for in turn, interval and duration for the bass, and cymbal (Plate) durations is showed. Image in color in the Appendix.

- *prob* opens a big sub-window that shows actual probability distribution, which is mainly used for editing purposes, similar to the three windows at the bottom.
- *pgm* handles program changes on utilized sound engine.
- *setProb* handles pre-sets of probability distribution lists.
- *duration* offers two choices: *dynamic* and *fixed*, where the former calculates each new event to 90% of its full duration, while the latter maintains a constant duration.
- *cymbalMode* controls whether the cymbal goes into off beat mode, or plays longer durations according to value (see at Durations and Accents further down).
- *Midi port* shows and selects among available MIDI instrument; *man* and *auto* concern gravitational note mode (see at Durations and Accents further down).
- *bass* and *perc* show if respective instruments are playing.

The bass pitches are generated by lists of probability distribution of intervals, and controlled in two different ways:

1. The player controls continuous linear interpolation between pairs of lists over an array of five lists. Figure 75 in the Appendix shows probability distribution of two interval lists, where blue and red are pre-defined, and the purple is the interpolation between the lists.
2. The player controls the centre position and skirt width of a bell-like peak of the probability list (Figure 44).

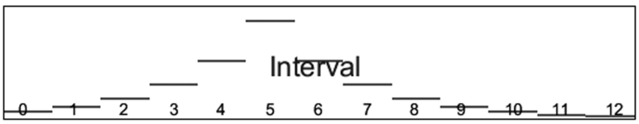

Figure 44: Group of intervals, this example shows a wide skirt width centered on the fourth.

An attractor note is used as a playing parameter. New events will "chase" a moving attractor: if the attractor note is higher than current note, next interval will be positive, and vice versa. This solution enables the player to create descending and ascending gestures, and if the attractor pitch does not move, new events oscillate around the attractor's present pitch. In order to insure that pitches are kept within the confined range of the instrument – e.g. low E on the bass – there is a controlling mechanism that checks, and if necessary, changes the direction and inverts the interval if the next event is predicted to fall outside the lower or upper limit.

The generation of duration on the bass and the cymbal – similar to interval generation – is done by means of interpolation between an array of five lists that contain probability distributions of five durations: sixteenth, eighth, quarter, half and whole notes. Probability lists may be arbitrary, however, most used is a set-up that stores 100% probability of one duration value at each of the five memory positions in increased order. A position between two values, e.g. eights and fourths, will result in a stream that statistically over time consists of 50% fourths and 50% eights. Durations greater than half notes force the cymbal into an offbeat mood; generation of new events is controlled randomly within defined durational limits, while manually controlled density changes those limits to shorter durations accordingly.

Accents[166] are generated such that between each one to each sixteenth event, a strong accent will be randomly generated and the rest of the events will have a slight variation of softer accent values. Those accents are created independently of the generation of durations. This concept was developed based on empirical knowledge.

The Walking Machine employs the Gamepad controller, and in playing mode no mouse operations are necessary, however the GUI is used for preparatory actions and visual monitoring. In practice, the mapping strategy allows the performer to focus on one particular sub-instrument at a time, which is the Walker or one of the two SyncLooper engines, while the others either continue to play with current settings, or are stopped. The mapping strategy in The Walking Machine is basically a static *one-to-one mapping* (Hunt and Wanderly 2002, p. 99) where the control of the probability distribution is considered an *implicit* (Goudeseune 2002, p. 85) mapping where the generation of events takes place in a black box.

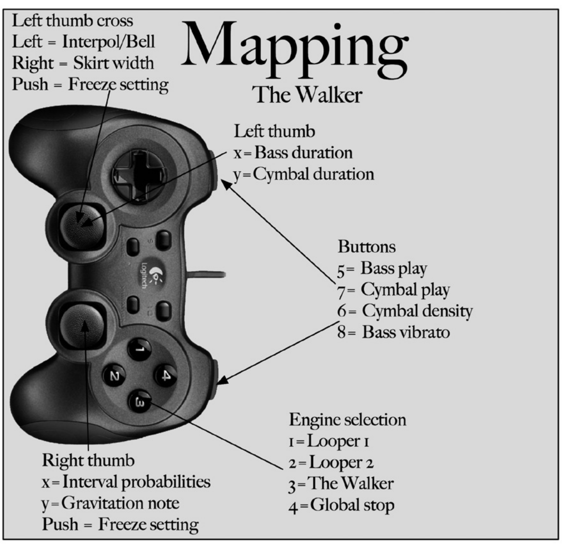

Figure 45: Mapping from the Gamepad controller to the Walker.

166. The Max/MSP patch that generates accents is shown and discussed on page 42.

Figure 45 shows the mapping of the Walker, and as the mapping to PAN-Looper A and B (See Figure 42) is identical with the mapping in the SyncLooper, it is not shown here.

THE EXPRESSURE PAD

The exPressure Pad family is a series of instruments co-developed with Palle Dahlstedt. To begin with, we posed the following question: How can we explore and control complex electronic sound spaces in improvisation, retaining the millisecond interaction that is taken for granted in acoustic improvisation, but has somehow gotten lost in electronic music? The exPressure Pad was presented at the EvoStar Workshop (Dahlstedt and Nilsson, 2008), and at the CMMR (Dahlstedt, 2008). Parallel to the development of the exPressure Pad, Dahlstedt and I formed duo pantoMorf to develop improvising instruments that fulfill the criterion:

> duo pantoMorf play electronic free impro. That is, we perform improvised electronic music as musicians, NOT looking like we check our email on stage. Our main rule is: if we take our hands away, the instrument goes quiet. We use no fancy sensors or esoteric gestural controllers, but very basic stuff that we know well how to play. But we develop new ways of playing them, and – most important – new ways of mapping them to sound, using carefully designed sound engines that allows fingertip control, while retaining a vast sonic potential. Every sound relates to and comes directly from a physical gesture by the player, which makes a huge difference for the audience. There are no ongoing pre-programmed processes, no overdubs, and everything is free improvisation.[167]

The Design of the exPressure Pad

This section presents an overview of designing principles at the exPressure Pad.[168] Principally, it is version 2 of our instrument I discuss; however, a predecessor is briefly presented as well, because it plays a vital role in one recording on the enclosed DVD. As a point of departure and inspiration, the

167. This is part of duo pantoMorf's public information text, published at Myspace in 2008. www.myspace.com/pantomorf.
168. Technical description and images is based on content in Dahlstedt and Nilsson (2008), and Dahlstedt (2008).

design of our instrument makes use of commercially available equipment that fits into our concept. The M-Audio Trigger Finger (Figure 47 on page 217)[169] is a MIDI controller, which consists of an array of sixteen pads that sends velocity and pressure data, in addition to a number of faders and knobs; moreover, mapping and sound generation take place within a Clavia Nord Modular G2.[170]

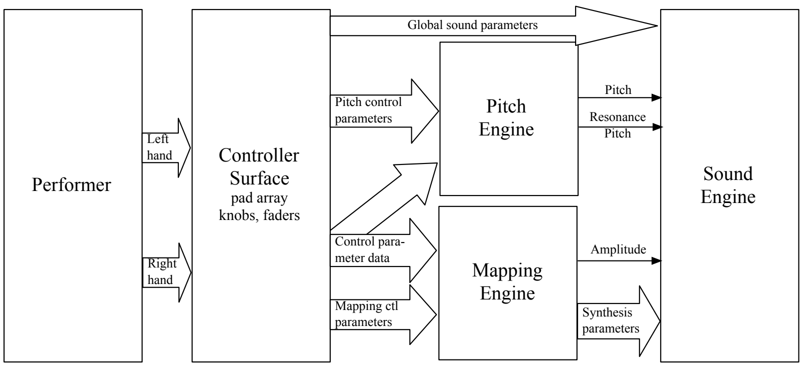

Figure 46: Schematic outline of exPressure Pad. Shaded arrows represent performance and synthesis data, while white arrows represent meta-parameters (pitch, mapping and sound engine).

Due to limitations in cognition and motor control, a human may only control a relatively small amount of simultaneous parameters. Therefore, we decided to develop a monophonic instrument, since it allows a performer to control more simultaneous expressive parameters than on a polyphonic instrument. As claimed by Levitin et al. (2002), no polyphonic acoustic instrument allows continuous control of pitch and timbre on single notes, most probably because of physical and cognitive limitations. One must assume that trained musicians fully exploit their expressive capacity regardless of instrument, the sum of information needed must be the same whether it concerns a monophonic or polyphonic instrument. Furthermore, we rejected a design that featured a simple one-to-one mapping strategy (Hunt et al. 2002), where one

169. www.m-audio.com.
170. www.nordkeyboards.com. The production of Nord Modular G2 synthesizers was defunct in 2008.

controller is assigned to one musical parameter, because such design either results in an instrument with severe expressive limitations, or most likely will end up with a large number of parameters that exceeds our simultaneous capacity to manage.

Figure 47: The exPressure Pad controller, Trigger Finger by M-Audio.

In order to design an exploratory instrument such as the exPressure Pad, one must think in potential, rather then to try to imagine all possible combinations of parameter values. Therefore, we implemented a vector design in order to control a high dimensional parameter space. Essentially, the design consists of a set of fifteen randomized vectors in a fourteen dimensional synthesis parameter space. Every individual controller (Pad 1–15) on the interface (Figure 47) is assigned a particular vector. The randomization does not change during performances, unless a performer changes it intentionally.

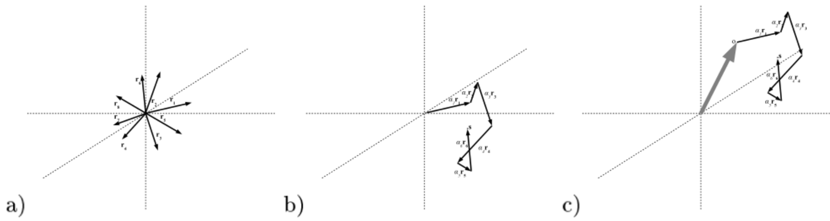

Figure 48: A schematic view of the mapping; a) a set of vectors of the synthesis parameter space, each corresponding to a control parameter; b) vectors from active pads arrives at a single sound; c) the origin o is shifted, which afford exploration of other subspaces. Image from Dahlstedt (2008).

Each vector is scaled by its controller and scaled globally. All vectors add up in order to arrive at a single point in the parameter space of a monophonic sound. Therefore, it is possible to explore a parameter space around the current point in all directions. Initially the vectors start at origin zero, but it is possible to shift origin intentionally by firmly pressing pad *reset* (Pad 16) at the interface while playing. Given its randomized vectors, implemented mapping is effectively *implicit*, as the instrument "is considered a black box for which we define behavior rules but not precise value rules" (Arfib et al. 2003, p. 132), and *complex*, which is equal to a *many-to-many* mapping. In addition, knobs and faders at the interface control deliberately selected parameters directly, notably assigned to pitch and morphology. In order to enhance direct control of the sound, fast attack and decay times are preferred over slow. This mapping concept is useful for other applications as well.

We perceive pitch differently in comparison with other musical parameters. At the very first vector mapping attempts, we mapped pitch from one vector component, which resulted in a lot of glissandi, and in addition to tiring the ear did not made musical sense. In order to get around this problem, we designed an additive pitch algorithm, and superimposed it on the mapping engine; consecutive pads are assigned a chromatic scale, which starts at the bottom left and increasing to the right and upwards. Simultaneously pressed pads (= intervals) add up and form a result interval, similar to the valves of a trumpet. This solution is compatible to our notion that higher pitches require more effort (engage more fingers), and the design of clavier instruments where low to high pitches goes from left to right. The interval sum is scaled by a secondary controller, fader (A), which allows a continuum from no pitch control, via micro tuning to chromatic pitch. In order to control pitch range, two designated faders control two intermodulating oscillators independently, within a range from 1 Hz to 10 kHz. Those faders may be used for gestural control as well as, for example, glissandi. The sound engine may produce noisy and chaotic sounds, with or without distinct pitch. In such cases, we use resonant filters in order to create a sense of pitch; a fader controls the pitch of the filters, while a vector component and the additive pitch mechanism may modulate it. The pitch mechanism allows a number of playing behaviors: on the one hand, with a low vector scaling, and pitch scaling set to maximum, chromatic melodies may be performed with a given timbre by either pressing single pads corresponding to intervals, or by engaging multiple pads, where the resulting interval is the sum of all pressed pads. On the other hand, if high vector scaling and low pitch scaling is employed, the instrument turns into a sound generator that produces noisy sounds with constant or no perceptible pitch variation.

The sound engine (Figure 49) is relatively simple and consists of two intermodulating oscillators, high and low pass filters, comb filter, amplitude control, and reverb. Important musical parameters are controlled by vector components, which sums up to approx 30 synthesis and control parameters respectively. However, some parameters are under direct control from assigned knobs and faders, such as oscillator waveforms.

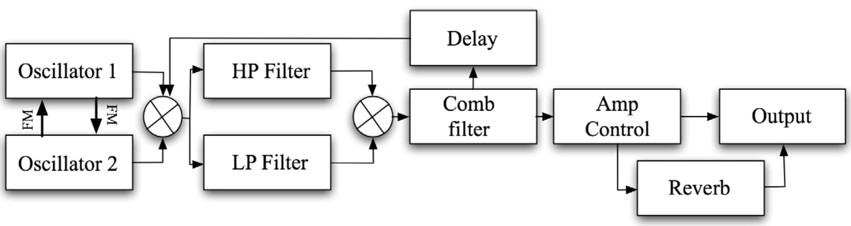

Figure 49: Schematic image of the sound engine.

Two intermodulating oscillators are mixed, and then pass to two parallel connected filters, one low-pass, and one high-ass, are mixed again, and then pass through a comb filter. From this filter the sound bifurcates, and one part passes through a delay, which feeds back into the mixer before the parallel filters, which make the sound more dirty, complex and organic; the other output from the comb filter passes through an amplitude control, and an optional reverb before amplification.

Parameters under vector control:

- FM amount.
- Oscillator cross fade amount.
- Filter cut off frequencies.
- Filter resonance amount.
- Comb filter feedback.
- Delay time.
- Panning.
- Reverb amount.

During the development of this instrument, it turned out that direct control of firstly morphology[171]; secondly pitch, and thirdly noisiness are very important in order to be able to play the instrument in a musically meaningful way. The following parameters are under direct control; letters refer to knobs and faders at the interface, see Figure 47 on page 217:

- Frequency modulation depth offset (G).
- Oscillator waveform (E, F).
- Oscillator pitch offset (B, C).
- Amplitude sustain (I).
- Amplitude decay (J).
- Velocity decay time (K).
- Pitch range (0–1 semi tone) between adjacent pads. (A)

There are three different ways to control sound morphology on the Trigger-Finger controller (Figure 47): one fader controls decay of velocity input (D), and two knobs deal with sustain (K) and decay of audio signals (L). Two faders (B and C) control pitch range, one for each oscillator, whereas intervals are played on the pads and scaled by a fader (A). At first, there was no way to tune the instrument to a certain pitch, either visually or via a "reset" procedure; but it has proven quite easy to "tune-on-the-fly" to an audible note/pitch from a co-player. However, in a more recent version, by setting faders A and B to the maximum position, the low-left pad corresponds to the note C, the next to C# etc in a chromatic fashion. This solution is further discussed at the experiment *My Funny Valentine* starts on page 318. One knob (G)

171. Referring to Schaeffer's cut-bell experience (see footnote 123).

controls noisiness by changing the amount of frequency cross modulation between oscillators, in addition to access to a changeable waveforms. At full frequency modulation, the instrument shows a quasi-chaotic behavior with respect to pitch and timbre, but is still under morphological control.

I used a predecessor to the exPressure Pad at the GAS performance of *Angle of Repose* with the group Beam Stone in 2007. In essence, the instrument is similar to the exPressure Pad, except reduced numbers of vectors, and most significantly, it did not have the additive pitch mechanism. Therefore, the instrument basically featured only two types of sounds with respect to pitch: one at mid-to-low register, with a morphology that may be described as "balloon-like"; and high sounds, which show a morphology similar to a "balloon fake-fart". One idiomatic feature is a low-pitched sound that sound like "ffrrr", which appears when a pad is released quickly. The synthesis engine is similar to the one used in version 2 of our instrument, and consists principally of two oscillators, two filters (low-pass and high-pass), amplitude control, and an additional reverb.

Control Instruments

This group comprises three instruments, the *Munger*, the *Groover2*, and the *FourToThree*. The former is built upon a granular application available as shareware, and the two latter are a design of mine. A control instrument, as I define it, displays no direct relation between performed physical action, and perceived audible result. Rather, these instruments perform automatic play, which means that they often are used in combination with a main instrument as creators of background layers, or creators of contrapunctual lines to either main digital musical instruments, or other participant musicians with the use of sampling. However, these instruments are occasionally the focused instruments in performances.

THE GROOVER2

The Groover2 is a four-engine loop player that, in contrast to the SyncLooper, performs asynchronous loops, and consequently is musically different. The Groover2 makes use of real-time recording from external, or internal sound sources, and its purpose is to create backgrounds and textures by combining loops. Its conceptual principle is simple and straightforward: record a sound source, select and transpose arbitrary sections of the resulting sound, and then repeat. With four independent loops, the result can be quite complex. Its name, Groover2, alludes to the fact that the application is build around the groover~ object in Max/MSP. I claim that the groover~ object, as well as this instrument, is very idiomatic given that it affords looping in this manner. Its main purpose is to create phasing effects. The design criterion of Groover2 is simple:

- Real time recording.
- Replay of multiple asynchronous loops.
- Arbitrary and random control of speed/transposition, and selection.

The top-level GUI consists of five areas: green, blue, yellow and red controls adherent loop engines, while the fifth purple section at the bottom deals with recording matters, such as selection of sound source and input levels. Certain actions, for instance manual selection of audio and transposition have to be done with the mouse, in addition there are automatic, randomly generated actions as well.

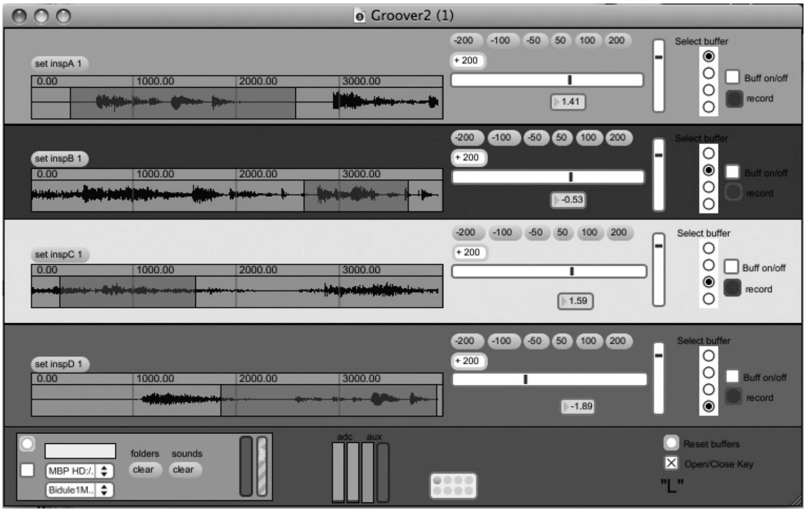

Figure 50: GUI of the Groover2.

Figure 50 shows the main GUI of the Groover2. Each loop section allows control of transposition, in octaves up/down or semitones,[172] playback direction, level out, selection of buffers, play/stop and record on/off. The waveform window displays audio content, which also serves as the graphical interface for manual audio selection. Furthermore, it is possible to assign sound buffers arbitrarily within each loop engine; a feature that enables all four engines to share the content from one buffer, which may be used to produce minimalistic phasing effects, as heard on Steve Reich's *It's Gonna Rain* (1964) and *Come Out to Show Them* (1965).

In order to avoid mouse operations, an automatic record/selection mode is mapped from the computer's keyboard: the enter key starts a recording that fills the first sound buffer, and at the same time selection of audio, transposition and playback direction changes randomly. Each time the enter key is pressed the next loop engine is activated in the same manner. When all four engines are full, the procedure starts over at the first engine. The space key re-randomizes all values without recording, and the a, b, c, and d keys re-randomize the setting in individual loop engines. In order to mix and balance audio output levels, separate assignable knobs at the UC-33 control level out from each loop engine individually. The length of sound buffers

172. Note that the relation pitch and playback speed is constant in Groover2.

is fixed to three seconds, a deliberate choice based on empirical tests with various lengths. It turned out that this length allows long enough samples to hold a gesture, and short enough to facilitate handling, and memorizing. Furthermore, by combining loops within given duration range making up musically meaningful textures.

THE FOURTOTHREE

The FourToThree instrument consists of two synchronized engines that generates polyrhythmic structures on behalf of a common sound source such as a drum hit, a single note or a piano chord. Each engine replays a common sample arbitrarily number of times during the duration of one, two, or four bars. It is possible to create polyrhythmic textures like five to four, or more complex such as 11 to 9. In parallel to other instrument in the hyper-instrument, like the Walking Machine and the SyncLooper, which feature metric rhythmic behavior, the FourToThree plays in sync with the global tempo generator. Originally, the aim with this instrument was to create polyrhythmic textures on real-time recordings, e.g. a piano or saxophone note, however it has mostly been used with prerecorded double bass and percussive sounds. Incidentally, I discovered that a similar instrument already exists, namely the *Rhythmicon*, a conception by Henry Cowell that Leon Theremin constructed at the beginning of the '30s.[173] The main GUI (Figure 51) displays and handles all vital information and interaction. In order to fill the audio buffer with sound, a real-time recording or prerecorded sound file, stored at a hard disk may be used.

173. The Rhythmicon is described in Roads (1996), and Manning (2004).

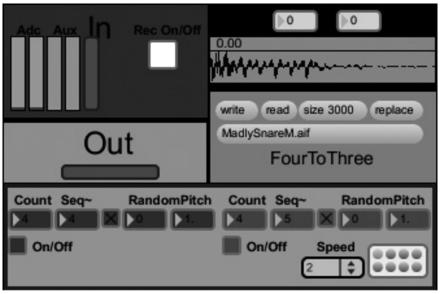

Figure 51: GUI of the FourToThree.

The FourToThree design criterion looks like:

- Creating polyrhythmic structures.
- Synchronization to global clock.
- Sample based.
- Allow real-time recording.

The upper left field deals with recording and selection of a sound source; the upper right window shows actual waveform and selection of recorded audio. The bottom window deals with settings of the polyrhythmic engine:

- *Count* connotes audible beats of the stream e.g.: 1, all beats are audible; 2, each second beat is audible; and 4, each fourth beat is audible, etc.
- *Seq~* sets number of replays during a period determined in Speed.
- *Random* detunes successive events randomly according to index.
- *Pitch* detunes with a fixed value.
- *Speed* sets loop length with regard to the global clock; one, two or four bars.

As an example: the setting at the displayed GUI (Figure 51) creates a "groovy" jazz cymbal texture; a sampled ride cymbal sound performs a 16 to 12 pattern over two bars, where all events of the 16 s are audible; while only each third event of the 12 s is heard. In addition, both streams are lightly detuned randomly, which simulates a doppler effect caused by movement, and the detuning caused by mechanical deformation of a real cymbal.

THE MUNGER

The Munger is a stereo granulator that behaves differently from the Granular Machine. Whereas the Granular Machine mainly is used for deliberately controlled playback with respect to pitch, playback direction and speed, the Munger mostly is used in situations that deal with various degrees of density, duration and relative pitch. At the core of the Munger is a custom made Max/MSP object, munger~, which is part of the *PeRColator,* a shareware library made by Dan Trueman at Princeton University.[174] I made the GUI design, mapping, buffer configuration, and audio in/out. In parallel to other instruments that use audio input, both real-time recording and pre-recorded samples are used. In the Munger, important parameters are accessible directly in the GUI (Figure 52).

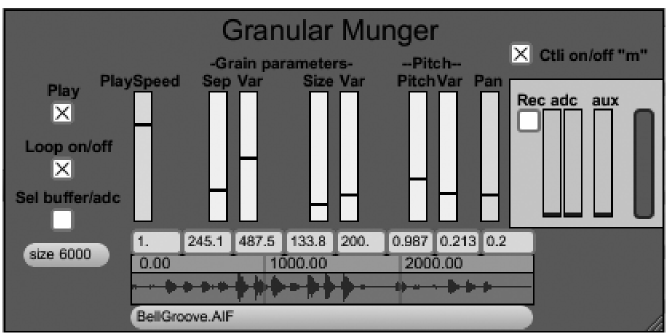

Figure 52: GUI of the Munger.

The majority of the faders are accessible from both the GUI and assigned knobs at the UC-33, while PlaySpeed, Pan, and toggles are GUI exclusive.

- *Play* start/stop replays from audio buffer.
- *Loop on/off* enables single or repetitive playback.
- *Set buffer/adc* selects between direct audio input, or reading from audio buffer.
- Size sets the size of the audio buffer.
- *PlaySpeed* sets playback speed from audio buffer.

174. Information and download: http://music.columbia.edu/PeRColate (March, 2010).

- *Sep* controls separation between successive grains, 10–1 000 milliseconds.
- *Var* applies random variation of grain separation according to index.
- *Size* sets grain duration, 10–1 000 milliseconds.
- *Var* applies random variation of grain duration according to index.
- *Pitch* sets transposition.
- *Var* controls random variation of pitch according to index.
- *Ctl* on/off, "m" on keyboard open/close control signal gate.

Effects

GRM TOOLS

GRM tools[175] are a commercialized collection of sound processors, so called plugins, that are available in common formats such as VST and TDM,[176] where the former is supported in Max/MSP. The software is developed at GRM in Paris and is based on a number of basic audio processing concepts that can be traced back to the early days of musique concrète in the late '40s.

In order to integrate GRM Tools within my hyper-instrument a shell, the *VST Engine*, handles audio in/out as well loading and opening the plugin GUI. GRM Tools allows mouse and keyboard control on its own GUI (Figure 53); however, it is also possible to access all parameters inside Max/MSP, which allows arbitrary mapping and selection of parameters. With the idea of increased playability, I have deliberately chosen two parameters in each plugin for real-time control. The 2009 system features two independent instances of GRM Tools which are active simultaneously, assigned to channel seven and eight at the UC-33 controller,[177] where two knobs on each channel are hardwired for control of selected parameters. In addition, it is also possible to load VST Engine in any of the first four channels as well.

175. www.grmtools.org.
176. VST are trademark of Steinberg, and TDM of Avid Corporation.
177. The design of signal flow is described in the section about the 2009 System.

Figure 53: Example of GUI in GRM Tools, here Delays.

The following list contains the basic library of plugins, brackets at the end of each description indicate the chosen parameters for real-time control.

- *BandPass* allows certain frequencies to pass or to be rejected, confined by low and high frequency settings (low frequency, high frequency).
- *Comb* is a comb filter that reinforces five arbitrarily selected frequencies of incoming audio (global delay, global resonance).
- *Delay* delays a signal and adds a selectable number of repetitions, feedback creates echo effects (first delay, last delay).
- *Doppler* creates the impression of spatial movement (circle amplitude, circle frequency).
- *Freeze* enables the performer to actually "freeze" a sound or fraction of a sound (left edge selection, right edge selection).
- *PitchAccum* applies transposition, delay and low frequency modulation on incoming audio (transpose 1, transpose 2).
- *Reson* creates an arbitrary number of resonance peaks within a chosen frequency range on incoming audio (low frequency, high frequency).
- *Shuffling* fragmentizes incoming audio and plays back fragments of arbitrary sizes, randomly chosen from a selection, or the complete sound file (fragment size, delay time).

TIMEFACTOR

TimeFactor by Eventide[178] is a so-called stomp-box, a stand-alone audio processor I use within my system occasionally. The TimeFactor is, as it name alludes, basically a classic stereo delay/echo box, which offers an extensive range of delay based algorithms: *Digital Delay*, *Vintage Delay*, *Tape Echo*, *Mod Delay*, *Ducked Delay*, *Band Delay*, *Filter Pong*, *Multi Tap*, *Reverse*, and *Looper*. Each and one of those algorithm features distinctive characteristics, noteworthy are the emulations of older analog applications such as Vintage Delay and Tape Echo. The user interface, as showed in Figure 54, shows main parameters; at the upper row there are delay time and feedback, in addition to dry/wet balance, and balance left/right channel. The lower button row features control of filter cut off, plus modulation depth and speed, whereas the Xknob is reserved for algorithm specific parameters.

Figure 54: Interface of the stomp box TimeFactor by Eventide.

178. Eventide is an American company that has made high-end audio processors since the '70s. Probably, they are most known for their harmonizer, which eventually become a generic name for that particular audio processing technique. For further information: www.eventide.com.

In addition to controlling the device with knobs and buttons at the interface, two foot pedals may be connected; one parallels the three buttons at the bottom, Active, Repeat, and Tap, whereas the other, a continuous expression pedal, is assignable to arbitrarily knobs such as delay time and feedback. I will not discuss further the function of this device here; according to my opinion this is widespread and well-known technology. There are several reasons I use this machine: it adds another timbre to my hyper-instrument; a stand-alone box is optimized and reliable; and it is sometimes used in a small set-up together with the exPressure Pad, which eliminates the need for a computer on stage.

INTERNAL EFFECTS

A majority of the instrument modules in my hyper-instrument make use of three internal effects and its audio routing is described in conjunction with each instrument. In order to allow easy handling, flexibility, and ease of upgrading and adding effects, a modular system is used. This means that all instruments share effect modules.

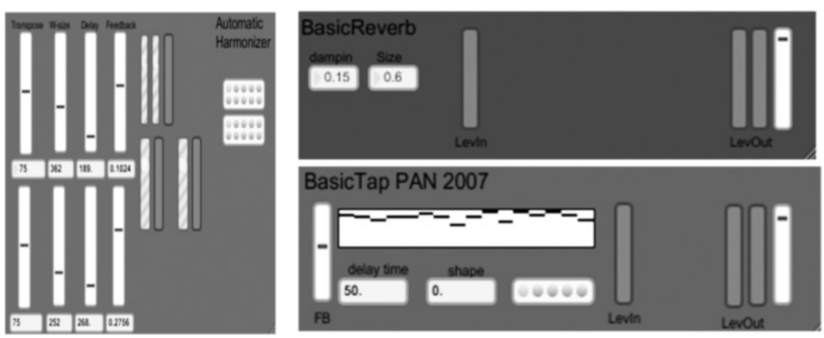

Figure 55: Three ancillary effects.

- At the moment, there are four effects available: Reverb, Delay, BasicTap and Harmonizer.
- Reverb is build around the shareware Freeverb
- Delay features a mono-reverb, where delay time is expressed as note values, and where global BPM is taken into account.
- BasicTap adds sixteen repetitions on incoming audio. Delay length and feedback may be changed and stored.
- Harmonizer is based upon an application that originally was developed and belonged to the IRCAM library *Jimmies*. The effect consists of two separate engines, left and right, which feature delay, feedback and transposition.

Setting

Next year we will be able to
improvise in a more controlled manner.

Jan Forsberg

Introduction

The digital musical instruments discussed in this work were made primarily for ensemble improvisation. To properly understand the meaning of these instruments, they must be understood in relation to this context, the improvisation ensembles that provide the playing field for this work. The enclosed DVD features recordings with two regular groups, Beam Stone and duo pantoMorf, one additional duo performance with bass player Peter Janson, (who is not specifically involved in this project), and two solo performances. But in this book I restrict myself to presenting Beam Stone, the key music group discussed in his work, which contributes the major part of the provided music material and experiences, and duo pantoMorf, the platform for the development of one of the featured instruments, the exPressure Pad. The second section of this chapter presents and discusses a number of terms that aim to further elucidate performance practices within groups in this work.

In order to describe the identity of a music group, band, or ensemble,[179] it is common to speak of its sound, which in this work signifies the *sonic identity* of a particular group. This notion of a distinctive sound is most often attributed to groups and artists within or stemming from the African-American

179. In this work I use the terms group, band, and ensemble alternately. According my opinion, the term ensemble is somewhat more connected to western classical music tradition, whereas group and band are more related to rock, pop, jazz, and related genres. By means of variation, I equally use those terms, and one reason is about that music produced within the realm of this work is a mix of elements from both contemporary art music, and African-American traditions.

music tradition. Since the beginning of the twentieth century many famous groups in the realm of jazz, rock, and pop have been identified with their unique sound: the big bands of Duke Ellington and Count Basie, the Benny Goodman sextet, Charlie Parker's groups, the Miles Davis Quintet, the John Coltrane Quartet, The Beatles, and The Jimi Hendrix Experience to mention a few. What constitutes the sound of a group? I will argue that it is the sum of its individual members' personal playing styles, chosen repertoire, and common performance practices. A closer look at famous big bands reveals that a number of high-profile individual members became very important for the band sound, such as Johnny Hodges, who played with Duke Ellington, and Ben Webster with Count Basie. The smaller groups that flourished in the '60s, Miles Davis Quintet, John Coltrane Quartet, and the Beatles, consisted of deliberately chosen superior musicians. Their repertoires most often was made up of compositions by the leader and/or members of the group, and performance practices were kept coherent. This means that: 1) the style of individual musicians are crucial, and no single individual is exchangeable without significant changes in group sound; 2) the repertoire is mostly stylistically coherent; 3) the playing behavior is limited, and/or constrained to a certain extent. In addition, a possible "hidden implicit agenda" constrains the musicians within certain limitations regarding permitted instrumentation, playing behavior, and so on.

BEAM STONE

Beam Stone is a trio that was founded in October 2006, and consists myself, digital musical instruments; Sten Sandell, piano, voice, electronics; and Raymond Strid, percussion. All three members have worked with each other in different constellations and circumstances since the late '70s. The trio started with at least two purposes in mind: to collectively create and develop improvised music, and to provide my research with empirical material. Let me stress that our artistic aims are the primary consideration: all concerts given by the trio have been done in public at regular clubs and/or music festivals. Enclosed recordings on the DVD may not be taken as demonstrations, but as examples of the trio's music, as performed in a public context.

The three musicians share a common background of working in rock, jazz, and free improvisation from the '60s and '70s, in addition to sharing influences from ethnic music that became well known at the same period, such as music from Middle East and Asia. Furthermore contemporary Western art music, chiefly from the period after World War II has also been important. It is important to point out that this research project is not about Beam Stone per se: rather, it is about the role Beam Stone plays in this work and my relation to it. Therefore it is beyond the scope in this work to present an in-depth portrait of Sandell and Strid. However, I will provide a short summary of Sandell's, and Strid's musical credentials.

Sten Sandell is one of the leading Swedish improvisers. Sandell has toured with musicians like Jon Rose, Sven Åke Johansson, Evan Parker, Barry Guy, and Mats Gustafsson to mention a few. Besides making his own music, Sandell has performed music by composers like Cage, Feldman, Nancarrow, and Sandberg. It is possible to hear Sandell's work in different contexts such as Gush, Low Dynamic Orchestra or in solo projects.

Raymond Strid started to play drum quite late in his life, in his twenties after finishing a career as an athlete and teacher in sports. Strid founded the well-known group *Gush* together with Sten Sandell and Mats Gustafsson. In addition, Raymond has performed with musicians like Anders Jormin, Barry Guy, Evan Parker, and Axel Dörner.

A predecessor to Beam Stone, Nilsson/Sandell Duo with myself on digital musical instruments, and Sandell on piano, practiced improvised musique concrète, restricting ourselves to exploring the sound of the piano through real-time sampling and processing. The music of Nilsson/Sandell duo can be heard on the CD *Strings and Objects* (Nilsson and Sandell 2004). Percussionist Raymond Strid was added as a third member in 2006, as his style of playing and musical ideas was seen to fit well into the context. Despite the fact that the three members had cooperated with each other in various circumstances earlier, Beam Stone became a new group, a completely different entity with a unique sound.

The musical concepts of Beam Stone were initially developed and settled upon during the course of a week-long "training camp" at VITC, (Visby Internationella TonsättarCentrum) in Gotland in October 2006. During that week, the trio experimented with a great number of improvisational concepts and approaches, from free improvisations to rigid constraints. As a result of this process, a number of fruitful musical concepts emerged, which later were applied during public concerts, and a recording of their first public concert at the 2007 *GAS*-festival in Gothenburg was released on CD in 2009 (Nilsson et al. 2009). In connection with the Swedish release of that CD, a tour with saxophonist and free improvisation pioneer Evan Parker was undertaken in Sweden in April 2009. Another concert held at the *World Music Days* (ISCM) in Gothenburg in October 2009 was recorded on video and supplies further material in this work.

During Beam Stone's inauguration week we agreed to record verbal reflections on our music. From the very beginning, in connection to single improvisations and experiments, spontaneous verbal commentaries and evaluation of the experiments were recorded, as well as personal experiences, tastes, influences, and ideas regarding style and genre was discussed in separate sessions.[180] Selected transcribed and translated material from these recorded reflections and discussions is interleaved at various places within this text, to further elucidate the subject matter of this work.

The Music of Beam Stone

What is the sound and music style of Beam Stone? First, it is important to mention that Beam Stone consists of three individuals, three experienced improvisers, each one with a highly developed and personal playing style. Consequently the music of Beam Stone relies on those three players. A music group, however, is more than the sum of its members. Beam Stone takes free improvisation as a point of departure, but incorporates influences from a great variety of genres, such as jazz and free jazz, contemporary art music, noise, ambient, as well as others. Pianist Sandell affirms:

> Well, in terms of style, for me, it is music that is based upon art music, and jazz, and rock music from the '60s and onwards, even though our attitude is somewhat different since we have a computer that is used as an instrument. But stylistically, I think that we are in that broad field [...] it is a broad field. [181] (Gotland 2006).

It is clear that our music shows influences from many sources, but at the same time I claim that our music is quite consistent with respect to performance practices and musical results. In essence, we are playing with sounds; that is, we explore and create sonic spaces by assembling, superimposing, and sequencing sonic objects.[182] Beam Stone's use of predetermined structures implies a departure from free improvisation practices, into the realm of contemporary art music. The appreciation of this fact is also evident in reviews of Beam Stone.

180. All translations labeled Gotland 2006 are made by the author.
181. The original: "Ja alltså rent stilistisk för mig så är det en musik som grundar sig i en konstmusikalisk och jazz- och rockhistorien från 60-talet och framåt sen att vi förhåller oss lite annorlunda därför att vi har en dator med som används som instrument, gör att det blir ett annat förhållningssätt. Men stilistiskt så tycker jag att vi är i det breda fältet,... det är ett brett fält."
182. See discussion about this matter at the section Playing with Sounds on page 51.

Here reviewer John Eyles emphasizes this tendency in Beam Stone's music:

> So it shouldn't be a surprise that, while a freely improvised recording, Beam Stone goes beyond the free jazz roots of improv with an impressionistic approach that shares more with ambient or contemporary composition (Dusted magazine).[183]

One essential feature in the music is the notion of the group as a collective sound body. Strid says: "Yes, we can, as three, become a unified sound body, but we can also, when we are a sound body, be much more than that. It is about complexity and simplicity" (Gotland, 2006).[184] A connected yet contrary feature is the ability to be three individuals. Within the group one is allowed to "do your own thing", that is, to lose the necessity of subordinating one's playing to the collective, in favor of exploring individual paths. By deliberately jumping between those two modes of playing – effectively a way of creating variation into the music – we reveal new meanings of the distinction between individual and collective, and this movement has turned out to be a distinctive feature of the group. Percussionist Strid summarizes the practices of Beam Stone quite well, and given that digital musical instruments is part of the instrument set-up, he also points out the links to electro-acoustic music:

> Yeaaah, it comes to mind that what we are doing is… working with sounds… sounds and rhythmics. Not in a conventional sense, but it is also improvisation. […] It is not harmony based, or melodically based, periodic or in any idiomatic style. Rather, it reminds me of electro-acoustic music, sometimes from the '60s, sometimes from 2000 s and also to a great extent European improvised music. It involves a lot of extended techniques, with piano, percussion, and electronics (Gotland 2006).[185]

Beam Stone's music does not rely on functional music systems wherein

183. www.dustedmagazine.com/reviews/4979 (June, 2009).
184. The original: "Ja, vi kan ju som tre bli en hel klangkropp, men vi kan också när vi är en klangkropp också vara mycket mer än så. Det är också komplexitet, enkelhet."
185. The original: "Jaaa, jag tänker närmast på att vad vi gör är… jobbar med ljud… ljud och rytmik. Inte i konventionell mening, men också att det är improvisation. Att man… dom kombinationerna. Det är ju inte stilistisk, det är ju inte harmonibaserat, eller melodiskt baserat, eller periodiserat. Utan eh… det påminner mycket om elektroakustisk musik, ibland från 60-talet, ibland från 2000-talet och mycket europeisk improvisationsmusik. Det är mycket ljud och extended techniques då det torde bli (Sten: hmmm), på svenska utökade instrumenttekniker med piano, slagverk och elektronik."

significant musical parameters are discrete and quantized with respect to a predefined lattice such as a chromatic scale system or rhythmic meter. Nor do the concepts of melody or accompaniment play any significant role either. Beam Stone emphasizes the gesture and the continuum, that is, the continuum of pitch, timbre, pulses, etc. It is a music of sound and gestures.[186] Despite that, occasionally within improvisational passages tonic centers, scales, steady pulses, and melodies can be identified, but they do not form a principal organizational principle. Wishart (1996) affirms there is a relationship between free improvisation and electro-acoustic music:

> Because of its essentially highly gestural basis, free improvisation need not to confine itself to the use of conventional sound sources. Any sound-producing object may be turned to musical advantage – an interesting parallel to musique concrète. The use of simple and non-prestructured sound-sources allows, in fact demands, strong gestural input from the performer. Experiences from the free improvisation forum can be extended into the electro-acoustic studio [...] (p. 37).

Wishart's quotation is an accurate description of the group's music, and I would add that in Beam Stone's music a contrary influence is possible as well: experiences from the electro-acoustic studio can be extended into free improvisation.

Beam Stone does not practice pure free improvisation, nor do we invent a new music. Rather, the group has developed and cultivated a unique style based on influences from preexisting music genres, and traditions. The repertoire of Beam Stone consists, in addition to free improvisations, of a number of pre-determined concepts, which act as referents during play, implying a certain playing behavior and interaction. For example, a jazz standard, music from the Western romantic era, or a march would all without question lie beyond the boundaries of possible and thinkable repertoire. But Beam Stone does methodically experiment and scrutinize concepts from other genres, such as free jazz, free improvisation, musique concrète, pointillist music, minimalism, noise and others. Strid reflects on this point:

186. See discussion about sonic objects regarding this matter, on page 139.

> Yes, hmmm, it is one, I wouldn't say we have done two different things, it emanates from one and the same thing. We work improvisationally to develop a material over the course of a couple of days, and… Then we have… not by random, exactly, but it turns out that in that time we would have worked with a number of musical, well not 'styles', but different expressions. And some of these, eh, expressions, you could say were influenced by certain different styles. From electro-acoustic music, or noise music, but changed, we have turned it, squeezed it. Say we try to do some kind of soft noise[187] … it ends up being a kind of drone. These are things we have cultivated, and now we have cultivated some more. … you could call them styles (Gotland 2006).[188]

Strid points out an important fact with regards to Beam Stone's working method: "we have worked improvisationally", which means that all concepts have been developed collectively by its members during play.[189] All members bring personal knowledge into the group, their experiences, instruments, expectations, ideas and so on, and during improvisation sessions a repertoire slowly evolves. An idea may emerges during play, and at other times someone may explicitly propose an idea. Successful ideas are memorized and named in order to be recognizable and repeatable in later performances. A promising and fruitful idea is explored, reflected upon, and refined stepwise: after each play session, we have discussions which leads to new playing attempts. In essence, it is a design process, which oscillates between discussions in design time, and attempts in play time, similar to the design process of the digital musical instruments discussed in this work.[190] After the week in Gotland

187. Strid refers to *Amalgamation*, which appear on two versions on the DVD, and is discussed in-depth on page 263.
188. The original: "Ja, hmmm. Det ju ett, vi har ju gjort två olika saker, det skall jag inte säga heller, det är sprunget ur en och samma sak. Vi har jobbat med att improvisera fram ett material kan man säga, under ett par dar och… Sen så har vi, ja…, inte slumpaktigt men det föll sig så att, det visade sig att ville jobba med ett antal musikaliska, ja inte stilismer men kanske olika uttryck. Och då var det ju, då har det blivit några sådana, eh, uttryck som, ja man kan beskriva, som influerat från vissa olika stilar. Från elektroakustisk musik, eller noisemusik, fast med en annan, vi har liksom skruvat, vridet på det. Vi gör ju någon bit där vi försöker göra nån sorts tyst noise, svag, som det är, men som egentligen blir någon sorts dron. Det har vi ju renodlat, nu har vi ju renodlat några till sådana här, man skulle kunna kalla för stilar då."
189. The discussion about the improvisation concept *Amalgamation*, presented further down in this chapter, provides examples of the development process of the group.
190. Discussions about design processes, including a definition of design time and play time starts on page 27.

2006, Beam Stone had developed a library of defined and named concepts, which have continued to provide substrates for improvisation in subsequent public concerts.

In a concert, some concepts are drawn from the repertoire of concepts agreed upon and determined before, whereas others emerge during the course of a concert. One example is the ISCM concert in Gothenburg in October 2009, included on the DVD. The first two pieces relied on predetermined concepts, while the concluding third piece was organized around rules about the order and formation of duos within the trio, the selection of digital musical instrument used and its playing mode.

So far I have laid out the influences and features of Beam Stone based on our own understanding of what we are doing. In connection to the release of the self-titled CD on the British label PSI, the CD got a number of reviews. I will here provide a few examples that further elucidate and frame what Beam Stone is all about. Eyles at Dusted Magazine continues:

> Across 12 pieces, ranging from under a minute to eight and a half, the three share equal responsibility for the music, which radiates taste and restraint. Strid's percussion is vital – he eschews the role of rhythmic powerhouse, opting for subtle interjections and textural punctuation. Of its working methods, the trio states, 'All kinds of sounds, 'musical' and 'non-musical' are used under the motto: Each sound has its own narrative!' Sandell's piano is central throughout, though it's hard to tell whether he's contributing live or via Nilsson's computer. The piano interacts and blends with the 'non-musical' sounds supplied by Nilsson, including washes of sound that could derive from natural phenomena. (Dusted Magazine).[191]

Eyles points out the collective nature of Beam Stone's music, and the use of "non-musical" sounds, whose origin is uncertain. One basic premise is to explore and investigate sounds, and a motto is: *each sound has its own narrative!* Ths statement clearly connects Beam Stone to the concept of *meta-music* as practiced by AMM, however, where the former group juxtaposes sounds based on a variety of ideas and concepts, in Beam Stone we interact and "just" play: with each other, with sounds, with the environment. This difference is also evident when listening to Beam Stone on record, which reviewer Bruce Russell from the British leading magazine in this field, The Wire, affirms:

191. www.dustedmagazine.com/reviews/4979 (June, 2009).

> It's hard to hear this without having AMM in the back of your mind, but they sound gloriously, and improbably, dissimilar. These guys aren't really manifesting meta-music, they just throw down and play, and it's a complete pleasure to hear (Russell, 2009, p. 48).

Another review is written by Glenn Astarta at Jazz Review, where he refers to minimalist music and drones:

> When performing on acoustic piano, Sandell dishes out flailing arpeggios yet steers the band into minimalist territory via trickling clusters and single note patterns. The artists navigate through nooks, crannies and dark caverns. They seemingly cover just about every possible angle throughout the preponderance of these mind-bending and largely, persuasive works. As these points are especially driven home during the album finale 'Angle of Response', featuring a pulse that mirrors an irregular heartbeat, coated with kooky electronics effects, droning notes and peppery beats among other essentials. There's a good chance that you haven't heard anything quite like it! (Astarta, 2009).[192]

Furthermore, Astarta also references geological ideas, which is certainly not surprising, given that all titles on the CD have names from this field. Yet another example comes from the review by Russell in The Wire:

> The three of them play a great three-way hand, giving each other space to go far out, before they all lock back together into some serious collective invention. They make this seem easy: but easy it assuredly is not. While the rhythm guys must know each other inside out, the trio are less than a year old, yet their attention to collective and individual texture is impeccable. (Russell, 2009, p. 48).

Russell emphasis our ability to deliberately oscillate between the collective and the individual, that is, to create collective textures, a sound body, or to behave as three individual voices, Yet another review, from Wyman Brantley, connects to matters that Russell touches upon: that is, relations between the individual and the collective but here, in terms of defining roles, or player types:

192. www.jazzreview.com/cd/print-20564.html (June, 2009).

> Fans of free improvisation may have noted a couple of common types of playing, no matter the instrument. One type – those you might call the 'springboard' players – seem to crave input from other players, sometimes to the point of being hesitant to play until hearing from the others. Another type – call them the 'wind-ups' – seem happy to rumble along in their own sonic universe to some extent, laying down textures that often heavily influence the overall shape of the music (especially when they play with springboards). If you imagine a third type of player, though, who manages to reflect the best elements of these other two types, you'll have some notion of much of the music to be heard on the excellent album *Beam Stone* (Brantley).[193]

To summarize: Beam Stone's music clearly shows influences from a variety of genres and styles, such as jazz, free improvisation, minimalism, etc. However, I claim that the most significant impression Beam Stone made on reviewers, at least when listening the CD, is the use of contrasts, the ability to explore and exploit the dynamics between the collective and the individual which is an essential part of the sound of Beam Stone. Additional quotes from reviews are also used later on in this chapter in the discussion of Beam Stone's improvisation concepts.

duo pantomorf

duo pantoMorf consists of myself and composer, musician and researcher Palle Dahlstedt. The immediate reason to form duo pantoMorf was to create a platform for development of new electronic instruments for improvisation. In order to evaluate those instruments it was considered to be of great importance that we encounter listeners in public concerts. However, I am keen to point out that the duo's aims are to a great extent artistic as well. At the core of duo pantoMorf, there is the exPressure Pad and its predecessors, the instruments developed by the duo. The design of the exPressure Pad is presented in the Instrument chapter, while performance practices are discussed on page 308. Properties and possibilities inherent in the exPressurePad are so intimately interleaved with the performance practices of duo pantoMorf that it is difficult to distinguish between external concepts and instrumental features. One could say that the instrument is the music. However some external constraints on playing and sonic behavior are used. This topic is discussed further down in this chapter.

193. Squidco: www.squidsear.com (August, 2009).

While the members of Beam Stone come from the same generation and to a certain extent share a similar background, duo pantoMorf exemplifies a different relationship. Dahlstedt was born in 1971, has a background as a classically trained pianist and composer of contemporary music, including electro-acoustic music. Moreover, at an early age he plunged into computer programming, as well as listening to various synthesizer bands of the '70s and '80s, like Front 242, Depeche Mode, and Kraftwerk. Dahlstedt and I met in the mid '90s; I was his teacher in studio techniques and electro-acoustic music at the School of Music at the University of Gothenburg. Eventually Palle became my assistant, and since then, we have cooperated in a number of different circumstances. One of Dahlstedt's main interests is generative and evolutionary music; that is, music based on generative algorithms and self-organizing rule systems rather than predetermined compositions, an interest I share. Furthermore, both of us are improvisers; Palle mostly as solo pianist, and I as a saxophone player in the jazz and free jazz traditions.

Initially duo pantoMorf started out by playing existing instruments of our own design, some of them presented in this work. However, it is with the creation of the exPressurePad that the identity of the duo was determined. The point of this instrument was to explore and exploit sounds and methods connected to electro-acoustic music practices, but with the same amount of direct and fast gestural control we take for granted in acoustic instruments.

The duo's music can be characterized as electronic free improvisation. The only sound sources employed are digitally produced synthesized sounds, and no sampling is involved. "Free" is a relative concept, and in this context refers to the traditions and practices of free improvisation as described previously, rather than implying no determinations at all.

In a group consisting of musicians playing traditional instruments, all members bring in personal skills and experiences previously acquired on their instrument. The individual styles of participating musicians are strong factors in determining the identity of a group, in addition to agreements about the area the group will explore. With duo pantoMorf, the aim was as much to develop an improvisation group, as it was to learn to play a new instrument. Dahlstedt and I brought into the duo our personal aesthetical preferences, knowledge, and skills acquired from being practicing musicians. Based on previous experiences from playing acoustic instruments, piano and saxophone respectively, one might ask: how did we profit from our embodied instrumental skills? At first we approached this new instrument from different angles. Dahlstedt comes from playing an instrument where practically everything is in the hands, whereas I am used to the saxophone, where one generates and controls notes with the mouth, and controls pitch with the hands. Presumably, given the nature of the new instrument's interface, a pianist would seem to profit more from previous instrumental skills than a saxophone player will, but I believe that in some ways the opposite might be the case as well.

On the one hand, a piano player is trained to perform complex synchronized movements with fingers and hands, and is possibly very well prepared to perform sequences of actions that might arise in playing the exPressure Pad, such as trills and patterns. On the other hand, the exPressure Pad is a monophonic instrument, like the saxophone, which means that a wind player may not feel constrained by its inability to play polyphonic voices. Nevertheless, every musician at a high level of achievement, regardless of instrument, has developed hand and finger control at levels far beyond non-practioners. I assume that in learning this new instrument, we both did profit from previous experiences and instrumental skills.

In order to develop the group, as in the early stages of Beam Stone, duo pantoMorf worked in private improvising sessions. During these sessions, in addition to free improvisations with no common agreed upon determinations, we made up a number of deliberate practicing concepts. Some of them are identical with Beam Stone concepts, such as "do your own thing" (see page 265), and creating a collective sound body "amalgamation" (see page 263). However, the uniqueness of duo pantoMorf is that both musicians utilize identical instruments, and as stated earlier, playing behavior and instrument properties are intimately connected to each other, and in practice inseparable. One fruitful way to increase playing skills and interaction is to find challenges in sound production, playing behavior and creativity. One example is to use only very short sounds, clicks, inspired by Stevens's *Click Piece* (see page 112); another is to play in turns, or to always create as much contrast with the other as possible. One method is to imitate each other, either deliberately with one designated leader, or following-the-leader type games, like in sessions where we challenge each other. One way to introduce variation in an improvisation is to momentarily change playing behavior: at a sign, like a nod, both players have to change playing behavior to something else, not specified as to content. Such a sign could occur each 30 seconds, and a session in this mode might continue for about ten minutes. I call this a *synchronized accident*, which is further discussed on page 260. To practice synchronized accidents is to practice a multifold of things: instrumental skills, listening abilities, and preparing for the unknown. It is a challenge for every instrumentalist to 1) come up with fresh new ideas twenty times in a row; 2) make a quick analysis of the emergent situation; and 3) adapt playing behavior in order to make something musically meaningful out of that situation. An example of unknown emerging textures can be heard at the beginning of *Shuffle* by duo pantoMorf on the DVD. Before the recording, we agreed to just start, without specifying what each of us was to play. I decided to start with the energetic repeated pattern that can be heard. As it turned out both of us started with repeated patterns, which turned to fit very well together, even though they were not synchronized.

The development of duo pantoMorf has been very similar to the way improvisation concepts were developed with Beam Stone. During the course of an improvisation, occasionally something worth further exploration emerges, which we eventually memorize and name, and repeat in public performances. One such example can be heard on the duo pantoMorf record *Antiforms* (Dahlstedt and Nilsson 2008). On the track *Eels*, we play two part atonal melodic lines, a kind of improvised counterpoint. This particular kind of interaction and output is not unique: a melodic duet between two players is a basic music interaction type. But in this case the intervallic identity is closely bound to the interface, mapping and tuning system of the exPressure Pad. On the DVD, at 2′32″ an example of this can be seen. It starts when I tweak parameters in silence, and at 2′43″ I start to play atonal melodic phrases. At this time Dahlstedt resists to join in, and continue playing. A minute later, at 3′46″, an example of imitation occurs, where both of us sync up in a fast pulse. Almost everything played on the exPressure Pad family of instruments in this work has its origin in duo pantoMorf practices: tracks from Beam Stone, particularly Amalgamation, My Funny Valentine, and Facing x with bass player Janson.

Controlling Improvisation

Freedom and Constraints

Is it possible to control improvisation?[194] From my experience I would say, yes we can. Is it desirable? I want to say yes and no. It is an aesthetic question.

In this section, I present a selection of guiding and controlling concepts applied to improvisation ensembles within the realm of this work. I emphasize that these concepts consist of a mélange of ideas taken from many fields, which means that the musical outcome, as it appears on the DVD, cannot be classified as belonging to any particular genre. We have invented our own style.

A basic assumption in this work is that our performance practices take free improvisation as a point of departure. Then, what is free improvisation? Bailey (1992) claims: "I think there is a type of playing which it is appropriate to describe as free improvisation. But it does seem difficult, firstly to get hold of it, and secondly, to keep hold of it" (p. 115). Apparently, there is something we may call free improvisation, but still, what is it?

Previously, I defined its sonic identity as a genre of playing techniques and sounds, but deliberately avoided discussing freedom, which I do now. In *Free Ensemble Improvisation* Swedish improvisation researcher Harald Stenström (2009) gives the following credo: "Free ensemble improvisation is musical real-time interaction between two or more musicians where nothing musical is predetermined or binding and where everything musical is allowed" (p. 108). However, within the realm of free improvisation, there are a number of high-profile and renowned practitioners, who obviously have made a great number of records and concerts over the years which together define a tradition. Therefore, one could say free improvisation is both a method of music making, and a tradition. Both perspectives are important in this work.

Since this project mainly deals with designing and playing digital musical instruments, it is beyond the scope of this work to thoroughly discuss the

194. "Next year we will be able to improvise in a more controlled manner" (Göteborgs Posten, Feb 22, 2010). The header quotation in this chapter was uttered in an interview by the head of the Swedish railway company SJ (Statens Järnvägar), Jan Forsberg, during the cold winter 2009–2010 in Sweden. A particularly heavy snowfall caused big problems, many trains totally ceased to function, which caused chaos and massive criticism in media. The original: "Nästa vinter skall vi kunna improvisera på ett mer kontrollerat sätt."

ontology of free improvisation per se. I allow myself to sum up a personal credo: I do not care the least whether an improvisation is regarded as free or not, as long as I *feel* free. I value perceived feeling of freedom invaluable in improvisation. Another major premise of this work is that improvising is like playing a game, and therefore applied controlling concepts are comparable to the goals and rules of a game. Before proceeding to discuss applied improvisation concepts in this work, I will discuss topics in improvisation that touch upon idiom, freedom, limitations, and referents.

As stated, free improvisation is music without any idiomatic constraints. It is non-idiomatic, which also raises questions about the predetermined vs. the natural, and emergent limitations in improvisation. Stenström (2009) reflects upon these issues:

> The statement that freely improvised music is idiomatic because it must be limited and systemized due to an unlimited number of musical options is the same as saying that non-idiomatic improvisation is idiomatic, which would be a paradox. However, whether the number of musical options are limited, or unlimited, I know of no free improvisor, my self included, who has any need to limit the number of options; on the contrary, the more he better. Since no human can handle an unlimited number of options, even if the will were there to do so, this limitation takes care of itself and probably varies from musician to musician from occasion to occasion (p. 319).

Apart from spontaneous and personally determined limitations, according to Stenström the presence of explicit predeterminations disqualifies any improvisation as being free and non-idiomatic, which, from a philosophical point of view, is a reasonable standpoint. However, I do not believe absolute freedom in improvisation is possible. A pragmatic point of view asserts that a particular player significantly influences any improvisation according to her own skills and playing style. In my opinion, the choice to play with a certain a player, or players, is an explicit predetermination by itself.

In *The Philosophy of Improvisation,* the British philosopher Gary Peters (2009) discusses freedom in improvisation from a philosophical point of view. He observes that at the very start of an improvisation, freedom exist. I pose the question: How do we start to play?[195] Playing starts when someone gives a sign that participant players understand and accept as the starting

195. I refer to playing in a broad sense, e.g. games, sports, and music.

sign. However, such a sign, such as yelling "play ball" in tennis, is not the real start of the play, rather it signifies that starting is now permitted. The real start occurs, most often, when a designated player makes the first move. An improvisation may start in silence, without any noticeable audible action and it is up to all participants, audience included, to understand and accept that.[196] (See discussion about rules on page 86). According to Peters, the first move will mark a space[197] – a previously unmarked space – that eventually establishes an identity for that particular play:

> The marking of a space – the tumbling contact of dancing bodies, a cluster of notes, the figuration of a page or a canvas – sets in train a movement, an emergence or occurrence that, while producing an artwork, is also the originary and originating gesture of the artist too (p. 13).

From this point of view, there is no essential difference between, say, playing tennis and free improvisation; rather, the difference lies in degrees of freedom, goals, and procedures. One salient feature and hallmark of free improvisation is staying clear of rules:

> The problem, however, is that once at play within the marked space, the improvisor or improvisors risk being enticed or indeed forced into the given structures of gameplay, thus posing a threat to the positive freedom desired and demanding, in turn, a liberation from the game. Squeezed from both sides, from the unmarked and the marked respectively, free-improvisation must either compromise and fall back on certain identifiable rules of gameplay or, conversely, devise strategies that allow vestigial productivity on the very edge of self-negation (p. 26).

196. At a concert at Mills Collage in Oakland, California, the British improvising group AMM once opened with 20 min of silence. As told in a personal conversation with John Bischoff, an electro acoustic composer and teacher at Mills College, Oakland, California.
197. As I see it, Peters presupposes that an ideal free improvisation starts in a void, and that the first move marks and establish a space accordingly. According to my presupposition, such a void is impossible, a space is already established whatever the intentions. Contextual factors such as the composition of the ensemble, possible agreements, the playing space and, subsequently, the opening gesture, all mark a sub-space or direction within an already constituted space.

This quote gives rise to a somewhat contradictory but nonetheless essential remark: At the moment the play starts, in freedom, freedom is challenged. By marking the unmarked space, a structure of game play may emerges. In Peters's view, the allowed freedom in free improvisation does not take away responsibility from the improviser, what happens is not haphazard:

> On the contrary, it is the improvisor who decides (or should decide) how to negotiate and manage the tropes and figures, codes and formulae within the contingency of any particular performance. Anything could happen but only certain things will, everything could be different but this time it will be like this (p. 109).

The task for the improvising musicians is to form and decide on the continuation of a particular improvisation based on the perceived direction and identity of the opening move, and also based on constraints and possibilities within the space that constitutes itself with this first event. Prévost (1995) makes a similar observation:

> Only at the point of making the first sound is the meta-musician free to determine the direction of the music. Once rolling, the only course is to give the performance coherence and develop a sharpened perspective on the nature of the ensuing work (p. 109).

There is always a fight to be free, which calls for actively forgetting what you just have experienced, in order to avoid to get caught in the emergent structure. To go with the perceived identity limits freedom in favor to subordination to the inherent rules emerging in the perceived structure. A completely free improvisation, idealistically, should be a series of openings, forgetting oneself by "emptying the memory buffer" in between.

In this work, I emphasize the freedom to make choices; even within the most rigorously controlled improvisation, there is freedom to do something else, or to do nothing. Sociologist Howard S. Becker (2006) recalls a teacher in photography that refused to regard anything beyond control:

> Instead, he pointed out we had always had the choice to do something differently: stand somewhere else, wait until another moment, use a different lens, a different aperture, a different shutter speed, to name just a few of the most obvious choices photographers make, wittingly or not, every time they make a picture (p. 25).

In music improvisation, in the same manner and regardless of genre, we are always free to make choices: play another note, stop playing, etc. Beam Stone's piano player Sandell argues that an improviser always has two choices at his disposal: maintain or change. Obviously, the former alternative gives us one choice:

- Maintain playing behavior.

While the change alternative gives us for instance the following choices:

- Stop playing, and remain silent.
- Create contrast.
- Try to destroy the current sonic identity.
- Change to another instrument.

Peters (2009) discusses positive and negative freedom, freedom to and freedom from (pp. 23–4). Seen in this light, explicitly premade constraints can be seen as freedom from freedom, which indeed can be very liberating and positive with respect to interaction and actual play. Furthermore, perceived freedom, according to game designer Schell, can be more important than real freedom (see page 84).

Dean (2003) states it may be useful to: "Distinguish improvisation based on a 'pre-arranged structure, procedure, theme, or objective' (a referent) from those not so based, while recognizing that total non-referentiallity is almost impossible" (p. xiv). In idiomatic genres of improvisation, notably jazz, the concept of *referent*, coined by Pressing (1984) is widespread:

> The referent is an underlying form scheme or guiding image specific to a given piece, used by the improviser to facilitate the generation and editing of improvised behaviour on an intermediate time scale. The generation of behaviour on a fast time scale is primarily determined by previous training and is not very piece-specific. If no referent is present, or if it is devised in real time, we speak of 'free' or 'absolute' improvisation. This is much rarer than referent-guided, or 'relative' improvisation (p. 346).

In jazz, the referent is most likely a song; its melodic, harmonic, and metrical structure constitutes a frame for improvisation. A referent can be abstract as well, such as rhythmic or melodic cells, intervallic structures, or perhaps verbal guiding instructions. One example is the working method of Miles Davis, who often provided referents to his bands as means of directing the music into certain modes. In an interview, drummer Billy Cobham recalls: "The very rare times he talked to me, it was something like: 'I need something from you. Give me something between the Latin and the jazz vein'".[198] Dean (2003) sees a parallel between biochemistry and the use of referents in improvisation:

> As a biochemist as well as musician, I am also tempted to think of the referent as 'substrate' for improvisation. This implies that, as a bodily metabolism, the substrate may undergo structural modifications that are functionally important, as well as simply providing a source of energy and material for the improvisation (p. xiii).

Dean suggests the existence of a dynamic type of referent whose function individual players may affect and significantly change during play. Examples of dynamic referents are Christian Wolff's[199] *Duo for Pianists (1958)*, and *For One, Two or Three People* (1964) where all instructions are derived from the players. Another example is Stockhausen's *Prozession*,[200] a score that only consists of three signs: plus, minus, and equal.[201] According to Dean (2003), referent based improvisation is often called *Comprovisation* (p. xiii), especially in American nomenclature, which emphasize the continuity between composition and improvisation. Borgo (2005) refers to a commonly used term for self-imposing constraints, namely *handicapping*:

> One common device used in both free and idiom-specific improvisation traditions is handicapping. Handicapping refers to a self-imposed challenge designed to limit material or techniques available to the performer (p. 24).

198. http://jazztimes.com/articles/20243-miles-davis-and-the-making-of-bitches-brew-sorcerer-s-brew (January, 2011).
199. Wolff's pieces are described in Nyman (1999, pp. 67–9).
200. Players are instructed to play fragments from other Stockhausen compositions according to those signs, where content is derived from previous events. With respect to immediate passed events, either heard or played, a plus sign prescribes more, longer, or stronger for instance, while a minus sign means less, shorter, or softer, and equal signifies continuation. This piece is discussed in *Stockhausen on Music*, a series of lectures by Stockhausen (1989, p. 113).
201. These referenced pieces contain complicated and complex rules, which cannot be framed in a single referent; my intention is only to exemplify the idea of creating self-organizing rule systems for playing.

Handicapping may be a constraint like limiting a player to use just one hand, for instance the left hand on a woodwind instrument, or allowing a player to play very few tones, or perhaps to play only on one string. The concept of handicapping mostly refers to playing techniques and material, as Borgo asserts, whereas the referent covers a broader range of constraints.

Ensembles in this work utilize controlling concepts,[202] as well as practicing improvisation without any explicit predeterminations. Applied prescriptive concepts in this work aim to either direct participant musician into certain types of playing behavior and interaction, or they merely function as a means of inspiration. As Dean (2003) points out, controlling concepts or referents can be seen as a substrate for improvisation providing energy and material, which may undergo significant functional modifications during the course of the improvisation. However, controlling concepts can also be used for analysis, for example in recorded improvisations. A predetermined concept or scheme applied to an improvisation is in practice an open composition, and in this case performers can, to a certain extent, be aware of the content or large form of an upcoming improvisation, or indeed of an entire concert. I claim the open nature of controlling concepts gives performers a great deal of freedom, especially on a gestural, meso time, level.

A controlling concept intentionally directs the musicians' attention, interaction, and playing behavior into a subspace within the larger possible space of playing behavior and interaction. Consequently, by using an identical controlling concept, it is possible to preserve sonic identity in consecutive performances. In improvisations of a regular group that do not have explicit predeterminations, previously rehearsed concepts may emerge spontaneously as the improvisation unfolds, giving an individual musician the choice to adapt to, or ignore the recognized concept.

Improvisation is a practice-based art. Probably the vast majority of playing behavior is made up of complex, multi-faceted interaction patterns that go on unconsciously and cannot be articulated verbally. Following are examples of explicit organizing principles that we use in order to control and inspire improvisations in various ways. The aim is to allow participant players a great deal of freedom, preserving for them openness to the emergent and unexpected. Interleaved within the text, there are excerpts from recorded

202. Applied concepts are compatible with Pressing's referent, but I have chosen to use the former term, given that referent most often is connected to a vocabulary bound to jazz practices.

conversations between participating musicians discussing these concepts. I have done the translation into English; the transcriptions of the Swedish original are in adjacent footnotes. Before proceeding with specific concepts, I present some general thoughts regarding form, plus handling and creation of the unforeseen.

MUSICAL FORM

A basic aesthetic standpoint in this work equates game playing and improvisation; therefore, I discuss form and narration in general within the Play Time Aesthetics chapter. Musical form may be regarded as a hierarchy of different time scales resembling a tree structure, discussed on page 132. The construction of musical form may follow two different paths: top-down or bottom-up. The traditional notion of musical form often follows the top-down path, where there is a readymade template, such as the sonata form, or a framework of the composer's devising which is populated with sonic material. From the turn of the twentieth century, Roads (2002) claims composers such as Debussy "discarded what he called 'administrative forms' and replaced them with fluctuating mesostructures through a chain of associated variations" (p. 12). Composers such as Varèse and Cage have clearly described the use of bottom-up strategies in their music. In Cage's music, form is often the consequence of a series of accidents and Roads claims: "For Cage form (and indeed sound) was a side effect of a conceptual strategy" (p. 13).

Here I briefly present some examples wherein we apply large form schemas; however large form control is not the norm in our work. One variety of controlling concept which we occasionally use is to determine the order of execution of sections before a performance, effectively making it a composition. One example of this "string of pearls" approach (see page 93) is *Facing x*, the duo with double bass player Peter Janson. One goal of this performance was to make a recording that presents some of my instruments in action, particularly the Walking Machine, which was not sufficiently covered in previous recordings. Therefore I made up a plan for the concert, including a rough description of interaction types, playing behavior, and instruments to use. In a mail to Janson the day before the concert, I give the following instructions:

1. You start alone. Eventually I enter and start to loop samples from you, and you play in dialogue with me, and against yourself. Successively move toward extended playing techniques.

2. I introduce electronic sounds; we will do a kind of sound improv, which eventually dissolves and decays.
3. I introduce my Walking Bass (the Walking Machine), at first "off time". Gradually we build a walking bass duel, as we did at Beche's (referring to a previous common concert).

This is the basic framework; other things may happen during the course of the improvisation. We should play for 15 to 20 minutes.

In addition I made up a "hidden agenda" defining the sequence of digital musical instruments to employ during the course of the concert: 1) the Groover2, 2) the Granular Machine, 3) the exPressure Pad, 4) the Walking Machine. In addition GRM tools were set up to provide sound effects. By listening to the recording and looking at the analysis of my playing behavior with employed instrument (see color images of my instruments GUI in the Appendix), it is evident that the musical form unfolds as planned. For the first three minutes the double bass interacts with the Groover2. The double bass is recorded in real-time into a sound buffer of three seconds length, and a semi-random mechanism controls selection, transposition/speed, and playback direction. Subsequently, created loops fall within meso time length. Theoretically, the longest possible duration is six seconds, in the case that the maximal buffer length is selected and the sound is transposed down one octave. In the concluding five minutes there is a gestural, meso level, duet between the double bass and the Walking Machine.

Another example is *Shadowing ISCM*, which was partly predetermined with respect to musical form. In this piece, it was agreed that the piece should start with a sequence of three duets: piano – digital musical instruments, piano – percussion, and percussion – digital musical instruments. Furthermore, we agreed to practice shadowing during duets where a digital musical instrument was participating. After the last duet the improvisation continued as a free improvisation.

Yet another example is *Amalgamation* with Beam Stone. In essence, the determination specifies that we should maintain similar playing behavior, forming a sound body, throughout the entire improvisation. In the ISCM version, we agreed to make two full stops during the entire improvisation, leaving silent areas, called *negative windows* in Stockhausen's nomenclature (see page 61). In order to synchronize our behavior, percussionist Strid was to cue the band with a nod of his head. The first pause occurs between 3′41″ and 3′50″, and the second between 4′54″ and 5′02″.

As a final note about musical form, I am keen to point out that I do not present complete form analyses of recorded improvisations in this work. The reason is simple: it would leave the impression that recorded improvisations on the DVD are thoroughly worked out compositions, and they are not. As previously stated, musical form is not a prioritized issue in these sections, and in most cases the form falls into place, organizing itself in real-time within the set conditions.

ACCIDENTS AND EMERGENCIES

One thing that has struck me in numerous improvisations over the years is a musician's ability to discover and take advantage of new things that may emerge during an improvisation. I call these new and unknown occurrences *emergent affordances*, and by this I mean the opportunity to make use of and exploit perceived qualitative changes in texture. In an ongoing improvisation, a change in behavior by individual players will cause a change in the sonic identity, which in turn affords new possibilities ad infinitum. Emergent affordances arise from many of the things a player can do: sudden changes in playing behavior; going silent; starting to play after being silent; changing to a new instrument and so on. A related concept is *contextualization*, that is, the process of taking advantage of and making use of seemingly mismatching actions.

Players may intentionally undertake accidental actions to bring surprise and variation into an improvisation. This strategy is about randomizing sound production, and/or to collectively changing playing behavior. An accident is a controlled and planned action, whose outcome is partly unknown, and, as in the case of normal mistakes, usually its consequences are taken care of by contextualization. Further down in this section, I present two kinds of accidents: the *controlled accident* and the *synchronized accident*. A controlled accident deals with individual behavior, while its sibling is about collectively coordinated behavior.

A closer listening to a recorded improvisation often reveals that improvisers directly react to, and take advantage of, emergent affordances. It seems that much of this kind of interaction goes on more or less unconsciously. In many cases, I cannot remember those moments of interaction that retrospect listening reveals. To me, it is obviously impossible to describe and analyze decisions made in these kinds of situations. Rather, as Schuback says on page 30, a musician thinks with the body. We react to different situations directly with our body according to pre-learned, trained behaviors. Moreover, Pressing's term *feedforward* can be applied here, by which he means our ability to "pre-hear" internally chosen actions without relying on either memory or auditory feedback (see page 131). One example is the opening in *Angle of Repose*, where I happen to make the first move with a member of the exPressure Pad family instruments. Since this was a free improvisation with no explicit common predeterminations, the first move decided to a great extent the identity of the first part of the piece. As can be easily heard, the first move was gestural in character, and the percussion player Strid picked up on this. Consequently, a gestural dialogue took place between the percussion and the digital musical instrument. An example of emergent affordances can be heard when a piano chord in high register appears at 01′21″, which triggers me to change my playing into a pedal point still playing the exPressure Pad instrument. Moreover, as part of my personal "secret" preparation for this particular improvisation, the FourToThree[203] module was pre-programmed to generate a polyrhythmic sequence that generates notes (a low C) according to a four against seven pattern played by a sampled double bass sound, forming a sort of irregular heartbeat.[204] At 4′16″, a percussive climax followed by a short break afforded a suitable moment to introduce the irregular heartbeat, which can be readily seen on the video. During the irregular heartbeat section, the FourToThree acted as an autonomous fourth virtual member of the group. This freed me to be able to play additional digital musical instrument modules, in this case the Granular Machine.

Contextualization

Is it possible to make mistakes in improvisation? After a concert jazz pianist Thelonius Monk looked worried, and when asked why, he answered "oh, I made the wrong mistake".[205] In a free improvisation usually it is not possible to make a "pure" mistake, such as playing a wrong note, since most actions are completely *contextualized*. Such a "mistake" will at best induce new energy and change the direction in an improvisation. Nunn (1998) describes contextualization:

203. See presentation on page 224.
204. The heartbeat refers to a review of Beam Stone by Glen Astarita: "[…] 'Angle of Response' (sic!), featuring a pulse that mirrors an irregular heartbeat, coated with kooky electronics effects, droning notes and peppery beats among other essentials", www.jazzreview.com/cd/print-20564.html (June 2009).
205. As told by David Wessel at CNMAT, UC-Berkeley.

> CONTEXTUALIZATION – By Improviser: Creation of musical context to imply meaning in retrospect (after the fact). By Audience Listener: Creation of musical meaning based on personal/cultural experience and preferences (p. 58).

A certain action from a participant player may sound out of context when it first appears, like a mistake. Nevertheless, seen in retrospect, it has acted as an impulse that changed the direction of the improvisation into a new identity, and therefore was meaningful. According to Nunn, one strategy to contextualize is to repeat the action, which may change a listener's impression that it was a mistake to hearing it as a new idea (p. 58). However, sometimes an action fits too badly within the current texture, or other musicians just ignore it, so that it comes across as a real mistake, a "wrong mistake". I claim that the risk of making wrong mistakes is potentially larger with digital musical instruments than acoustic instruments. Why? In general, many digital musical instruments only allow control of the generation engine, which sometimes makes them insensitive to context. On such an instrument it can be difficult to adapt behavior accordingly, to contextualize, if a certain action is perceived as wrong mistake.

I will provide two examples from *Angle of Repose* with Beam Stone: one of a wrong mistake, and one of contextualization. At 2′10″ a slow meditative bass figure, the irregular heartbeat, was introduced for the first time, but at that time it did not have any impact on the improvisation whatsoever. Fellow players completely ignored it, and therefore it sounds like a mistake. I remember that during that particular improvisation I was occupied with the *FourToThree* (page 225) module that generates the heartbeat, and felt disturbed at the unsuccessful first introduction, which in a way took some focus away from the collective activity. However, at 4′16″, which turned out to be a suitable moment in the improvisation to introduce the polyrhythmic pedal point, the irregular heartbeat completely changed the identity of the improvisation. Somewhat later in the same improvisation, another example of a mistake can be heard, but this time it is contextualized. At 5′24″ I start to play the Granular Machine, a processed piano sound, recorded previously during the improvisation. At first it appears strong and brutal, significantly different in character and too loud in relation to the current sonic texture. As far as I remember, I was very surprised with the sound and not very pleased either; however, the Granular Machine is a flexible instrument, and I was able to adapt my playing and kept on going. Seen in retrospect, this gesture re-directed the improvisation back to gestural interaction, which we did at the beginning of the piece. By means of *contextualization*, gradually the other players changed their behavior and began to interact with my playing, which eventually created a new identity in the forthcoming improvisation.

Controlled Accidents

In the essay *AMM and the Practice of Self-Invention* Prévost (1995) mentions *controlled accident* as a method to introduce surprises into an improvisation. At best, it can induce new energy to the entire group, but sometimes it aims at getting free of instrumental control in order to let the unexpected happen. Many improvisers have incorporated elements of controlled accident into their style of playing. Prévost refers to a practice commonplace in free improvisation: "[…] grasping a handful of drum sticks high above my head and then allowing them to fall onto the snare drum in some aural divinatory equivalence" (p. 20). His use of the word divinatory is important in this setting, since it emphasizes the idea of leaving event-making to a higher power, which might be chance. Obviously, this method relates to practices connected to Cage, as well as pioneer visual and conceptual artists like Marcel Duchamp, Robert Rauschenberg, and Jackson Pollock. It is about letting things happen, getting out of control. But sometimes this approach has been misinterpreted as "anything goes", which is not the case. In contrast, I claim that the condition where the controlled accident takes place has to be deliberately determined and framed, which Prevost's term also implies. This method can be traced back to ancient techniques practiced in the east, and Prévost mentions Chinese potters makers, and that Taoism deals with this subject matter. However, this topic goes beyond the scope of this work, and therefore I leave it.

In ensembles in this work, we frequently use controlled accidents, both as a means of inducing energy into the group, and as individual playing techniques. Controlled accidents in an ensemble setting are discussed in the next section. In this section I provide examples of accident practices used with the digital musical instruments discussed in this work.

With the exPressure Pad instrument, the controlled accident is a basic playing behavior, which presumed and planned for in the design process. In other words, Palle Dahlstedt and I deliberately designed an instrument with the ability to surprise its player during play. This behavior might be described as: "select and press an arbitrary number of pads and see what happens, and from there take advantage of the upcoming situation by applying control and contextualization". In practicing, I memorize the location of certain sonic subspaces, and together with vector scaling, morphology and pitch range control, I can control and nurture the emergent identity.

Another way of dealing with controlled accidents is in play with sample-based instruments, notably granular synthesis applications. One example is the SyncLooper, which allows simultaneous replay of four rhythmically synchronized loops; by selecting at random prerecorded loops from the internal sample library on the fly, unexpected combinations can happen, and surprising grooves can occur since all loops are still in sync.

In addition, controlled accident can be used within several other instruments of mine: the Granular Machine, the Munger, or the Groover2 for instance. When practicing controlled accident with the Granular Machine, it is mainly a means to introduce new sound material into the present context. While playing, I deliberately select a sample and load it into the instrument, and since I am familiar with all the samples in the internal library, I know what it will sound like. However, I may only have a vague idea whether this new sample will fit into the current situation or not. A variation of this technique is to put sample selection under random control, which will cause surprises even for me, even though I am supposed to be familiar with my own library. Nevertheless, my fellow players have no idea about the upcoming shift in output from my instrument, and therefore have no way to anticipate the effect of the action. At times, the introduced sound may have an impact on the interaction and musical outcome, and at other times, it just adds another layer to the context, while the other players don't respond by changing their playing. The Granular Machine has a number of sound manipulation processes, most of which are fully controlled actions such as play back speed, direction, and transposition. But it is also possible to randomly detune and quantize single grains, which cause a chord-like sequence to emerge in the sound stream. To a certain degree, it is possible to achieve the same effect of surprise as when anyone in the improvising ensemble deliberately introduces randomly selected material.

The second introduction of the irregular heartbeat at 4′16″ in *Angle of Repose* played by the FourToThree, described in the previous paragraph, can be regarded as a controlled accident. At its first occurrence, it passed unnoticed, and did not affect the current context at all, but the second time it completely changed the context and identity of the improvisation. It was not exactly a controlled accident, but still it was impossible to predict whether it would fit, and what its consequences in relation to the group context would be.

One salient feature of the Groover2 is its ability to perform controlled accident actions. The Groover2 is a control instrument that consists of four independent asynchronous loop engines, which means that the four loop engines do not play in sync with each other. This feature makes this machine an ideal vehicle for creating *phasing effects*, a common practice within minimalistic music (see processes in music on page 65). The idea is to create unexpected rhythmic patterns that are the combined sum of active loops. In order to do so, certain parameters of individual loop engines are under random control: selection of current sample, pitch/playback speed,[206] and playback direction. By pushing the enter key on the computer keyboard the first loop engine starts recording, and when finished, parameters on all engines are randomly re-set. A new tap on the enter key activates the next engine and so on, in a cyclic fashion. It is also possible to re-randomize loop engines without recording in order to change setting without changing content. This way of working has turned out to be very efficient as a way to create interesting layering of pre-recorded and/or live sonic material. Given that the Groover2 is a control instrument, it does not demand much of effort to use, which in turn makes it easy to combine with other modules during performances with my hyper-instrument. I have used this feature extensively on solo concerts, notably with the exPressure Pad as the exclusive sound source, but I also regularly use it in ensemble settings.

On the DVD the Groover2 can be heard at the beginning of *Facing x,* notably from 3′35″ to 5′00″. Peter Janson's double bass is sampled and played back using the features of the Groover2 described above. He interacts with a background made up of his own looped phrases, and since I merely trigger random parameter changes on the Groover2, effectively controlled accidents, each change forces a contextualization from Janson.

Synchronized Accidents

The concept *synchronized accident* is derived from Prévost's controlled accident concept, and has been elaborated within various groups during the course of the years without a dedicated name. We use the concept in order to create variation, to encourage awareness of the situation, and to keep players from falling into routine habitual playing. In essence, it is a method of performing synchronized changes of behavior, but changing into something new and unknown. It has proven an efficient way to avoid the dynamically bow-formed improvisations so common in free improvisation: an improvisation

206. Pitch and playback speed are coupled, so that halving the speed means the sound is transposed one octave down.

starts when someone makes the first move and slowly the other players join in, and after a while a certain identity is established, then the created identity slowly dissolves and after a period of transition a new identity is established.

The idea of synchronized accidents is not new. In *Cobra* (1984) by John Zorn (see page 119), synchronized changes of behavior play an important role. At a given hand-cue from the conductor – a triangle formed by both hands[207] – all or a designated group of players are required to instantly change their playing behavior. The California based percussionist and composer Gino Robair has further developed this concept. In his improvisation opera *I, Norton* (1998) he uses the triangle cue, as well as a cue which mimics a pair of scissors with both hands to cue a synchronized accident, both cues attributed to Zorn. Robair asserts that the synchronized accident may well be paired with musical content. As an example, Robair uses the term *Beefheart* to designate a cue wherein a group of players individually repeat a short arbitrarily chosen sequence. The resulting pattern[208] is reminiscent of the music of Captain Beefheart, as heard for instance on his seminal records *Trout Mask Replica* (1968), and *Lick My Decals Off Baby* (1970). At the scissor cue, combined with the Beefheart cue (point to heart), selected players start repeating an arbitrary phrase instantly.[209]

Within the ensembles discussed in this work, we experiment with synchronized accidents at rehearsals, especially in duo pantoMorf. At a given sign, perhaps a nod, or a certain sound/gesture from a designated player, after a predetermined length of time, or when someone in the group makes a surprising move, all players are required to immediately change behavior into something different. The content changed to, however, is not specified, and silence is also allowed. The task then is to figure out new affordances and contextualize musical roles and playing behavior within the new emergent identity.

I provide an example of synchronized accident from sports, however a more formalized procedure than those that appear in improvised music. A normal habit in ice hockey is that a player in the attacking team, seemingly at random, shoots the puck over the blue line into the opposing team's defending zone. This is done in order to set press by surprise and to avoid offside. The

207. By attaching thumb-to-thumb and index-to-index at chest height.
208. The resulting pattern is the perceived combined result of all active loops. See music processes on page 65.
209. This information was given by Gino Robair in a personal conversation in Gothenburg in April 2011. Further information about the opera I, Norton can be found at www.ginorobair.com.

outcome of such a shot is not always foreseeable; it might bounce weirdly, and a defender or the goalkeeper may take control of it. However, the attacking and defending teams have a number of pre-learned and embodied strategies to deal with a number of the possible outcomes of such a chance puck, and on seeing the effect of the shot, the players quickly adapt and take advantage of the emergent situation. In order to benefit from such a technique, the attacking team has to do it at times when the defenders are somewhat disorganized, or maybe is one player short.

Let us return to improvisation. The challenge in using the synchronized accident is not so much to instantly change behavior, that is easy. The difficulties come in trying to discover the emergent affordances in the new situation, in order to exploit it fully. What kind of sonic identity has emerged? What is my role? How can I proceed? Do I need to change or adjust my behavior? These and many more questions have to be solved on the spot, and decisions have to be made about how to continue.

One example of the synchronized accident can be heard at the very opening of *Shuffle* with duo pantoMorf on the DVD. In this particular improvisation I decided to start repeating a sequence played on arbitrarily selected pads on the interface (Figure 47 on page 217), and at the same time control parameters were set to produce relatively short sounds in mid register. The output from my instrument was not surprising, but whether the fast repeated sequence would fit in with fellow player Dahlstetd's actions was an open question. Incidentally, he chose to repeat a short sequence, and together our opening actions created an interesting texture. No contextualization was necessary and we continued without altering playing behavior for more than a minute. In essence, this opening created a Beefheart texture. A great deal of the entire improvisation can be seen as an example of practicing individual and collective accidents on the exPressure Pad.

Examples of Applied Controlling Concepts

In this section, I will present examples of prescriptive concepts that aim to control and direct interaction, individual behavior, and the musical outcome of an ensemble improvisation. I will discuss concepts that deal with the musical outcome, as well as functional relations between musicians. The concepts discussed can be used descriptively for analysis of already made and recorded improvisations as well. I emphasize that the concepts presented do not include all guiding principles that we use in the improvising groups discussed in his work. Nor do the applied concepts deal with large-scale musical form at the macro level; they apply to direct playing behavior, interaction, and musical output at the gestural meso level. In this regard, predeterminations may include prescription of duration. Selections from the DVD that exemplify the concepts discussed will be presented.

Amalgamation

Amalgamation is a procedure for creating a collective sound body, a soundscape, with no given explicit additional rules, such as defining specific properties of timbre, pitch range and morphology. Decisions about the properties of particular sounds to produce are left to participators previous experience and their own interpretation of the task. The given instruction directs participators' attention towards a general emergent sonic identity, that is a sound body, and each player adjusts their own playing behavior accordingly. The enclosed DVD includes two versions of *Amalgamation*, both performed by Beam Stone, one at GAS 2007, and the other at ISCM in 2009. In this section, I use material from remarks made by the members of Beam Stone. Therefore the text also elucidates the process of collective development in Beam Stone's music.

In essence, amalgamation is about creating a sound field without any particular form or development in mind. The sound content often consists of noise and sounds made by rubbing or friction, but other sounds are possible as well. In the 2009 version, two general pauses where agreed on in advance, and cued by percussionist Strid. One occurred between 3′41″ and 3′50″, and the other between 4′54″ and 5′02″. *Amalgamation* gets its inspiration mainly from two sources: one from the practice of mimicking external natural phenomenon such as the movement of wind and water, a procedure common in electro-acoustic music, and the other from practices in contemporary noise and drone music. In addition it also is reminiscent of John Stevens's *Sustain Piece*, which directs participating players to chose a note that feels comfortable, and sustain it for the length of a breath (Stevens, 1985, p. 65). In initial tests undertaken in Visby, Gotland 2006 Sandell asserts: "I thought about this… desert, for me it is something like that. We may find another name. It is a desert for me. Long, long, and nice, a kind of scrubby landscape" (Gotland 2006).[210] To create an amalgamated sound body is not a simple task. Strid comments:

210. The original: "Det var det jag tänkte… desert, för mig är det något sånt. Vi kan ju hitta något annat namn. Det är en öken för mig. Långa, långa fina sådana här risiga landskap".

"But, the fact that we create such superimpositions, with these three instruments, and then melt it together into a body […]" (Gotland 2006).[211]

After making further tests, our discussions focused on practicalities: how could we accomplish the task? The continuing conversation shows clearly that fulfillment of such a conception depends on many factors, on different levels. Strid states: "It was really hard for me. […]. If I am going to produce noisy sounds, I must be stronger. I cannot make it this soft" (Gotland 2006).[212] Sandell and I immediately protest, and tell Strid that it sounds good. He develops his thoughts: "No, it should melt together into one single noise body, and I cannot manage this, dynamically, not that if I play that softly" (Gotland 2006).[213] For Strid, there is a conflict between what it sounds like, and how it feels: "In reality I would like to play softer, I would rather play more softly but at the same time it loses something… I would like to have it this soft, but then it become too soft" (Gotland 2006).[214] Another issue is ergonomics:

> Strid: But, if I outline it, if I do it simple now. It is impossible for me to hold this position for a long time (playing a cymbal with a bow). This is some kind of noise sound. We may go on with this; we do not need to take it that seriously. We may find a way where it all fit together.
> Sandell: Yes. (Strid continue playing).
> Sandell: Sure, I can…
> Strid: I have to…, when we are ready, we have to check. I cannot stand like this for an unlimited amount of time, well maybe I an adjust myself into a more comfortable position.

211. The original: "Men just att man skulle få såna här lagringar, överlagringar, lagringar med dom här tre instrumentarierna och sedan att det skall smälta ihop som en kropp. Om man inte vet liksom".
212. The original: "Det var väldigt svårt för mig, jag märker jag har, jag har inte den här, alltså. Om jag skall ha brusklanger, det måste vara starkare. Jag klarar inte på så här svagt".
213. The original: "… att dom skall smälta ihop till slut som en enda bruskropp, och jag klarar inte det med, dynamiskt, alltså inte så svagt".
214. The original: "Egentligen vill jag spela svagare, men då tappar … egentligen så vill jag att det skall vara svagare men då tappar den… Jag vill ju ha det så där svagt. Men det är då det blir (för) svagt".

Sandell: It's hard on the back (Gotland 2006).[215]

This is a spatial piece of music, and the first tests we undertook were in a small acoustically dry studio at Tonsättarcentrum at Visby, Gotland. Did this affect our playing behavior?

Strid: The acoustics in here don't give me much in the way of a response I can work with. Obviously it would be different in another room.
Sandell: It must be fantastic in a room with a lot of overtones; it obvious would be much better. It asks for it! (Gotland 2006).[216]

Do your own thing

"Doing your own thing" is a special functional relation between musicians. In an interview, percussionist Tony Oxley (Watson, 2004, p. 64) said that he would rather play a musical than a functional role when improvising, a role which allows more freedom. This particular concept implies a further question: what happen if we consciously free ourselves from listening to each other, and concentrate our effort on playing and following individual paths? After initial tests with Beam Stone it turns out that it is very hard to do so. Analysis of recorded improvisations reveals interaction on different levels, a notion that is consistent with Cardew's notion of sound improvisation, previously quoted, "in that it acts subliminally rather than on cultural level". Furthermore, Prévost (1995) confirms our experiences: "As music evolves between listening musicians, dialogue determine direction even if the parties try hard to ignore each other" (p. 117). Our positive experiences of this concept makes us more confident, which in turn encourages exploration of individual paths now and then during the course of a free improvisation. For a listener, different and seemingly unrelated sounds that occur simultaneously

215. The original: "Strid: Men om jag lägger mig, om jag gör den här enkla bara nu. Nu kommer jag inte att kunna stå så här länge men. (Spelar på cymbal med stråken). Här är någon sorts brusklang. Vi kan bara liksom spåra på det här, vi behöver inte ta det så allvarligt. Om vi kan hitta. Om kanske kan hitta ett läge där vi sitter ihop med det här. Sandell: Jaa. Strid: (fortsätter spela). Sandell: Visst, jag kan…Strid: Jag måste… när vi är klara, vi får kolla. Jag kan inte stå obegränsad tid så här, det kanske jag kan göra om jag gör det bekvämt för mig. Sandell: Det är ansträngande för ryggen".

216. The original: "Strid: det är väl det att jag får inget svar från den här akustiken, hade det varit ett annat rum hade det säkert varit annorlunda. Sandell: "Det hade ju varit fantastiskt i ett övertonsrikt rum, det är ju självklart det skulle låta bättre. Det här kräver ju det".

makes up a structure and relations: "Musicians working on parallel lines may only meet on the aural plane of a third person" (p. 125). During the Gotland week, Beam Stone experimented with this concept repeatedly, and I will here reproduce some of the comments made in connection with those experiments. After the first try, Sandell said, half-ironically: "And we end up playing together anyway!" (Gotland 2006).[217] This comment, in essence, summarizes our experiences of the experiment. It turns out to be very difficult, almost impossible, to play without consciously listening to each other. The following conversation evolves around pros and cons of this concept.

Strid: You are not…
Nilsson: …forced to search…
Strid: Exactly!
Nilsson: …it may emerge in…
Strid: Very good concept I believe!
Sandell: Hmm.
Nilsson: It was much more together than we really…
Sandell: …than we really thought it would be, yes…
Nilsson: …from the beginning…
Sandel: …right from the start. (Gotland 2006)[218]

In essence, this conversation reveals that it may be easier, and perhaps more interesting, to play together if we intentionally avoid togetherness. It seems that this kind of "non-togetherness" liberates creativity, since the participant musicians are not forced to relate, synchronize, and adjust to each other. This short conversation between Strid and me exemplifies our notion, while both examples emphasize the difficulties of finding an appropriate vocabulary:

217. The original: "Så spelar vi ihop i alla fall!"
218. The original: "Strid: Man är ändå inte… Nilsson: … tvingad att söka… Strid: Precis! Nilsson: … det kan uppstå i… Strid: Väldigt bra ingång tror jag! Nilsson: Ja, det är det. Strid: Hmm, Jag tror att vi får resultatet lite grann, åt det vi vill. Sandell: Hm. Nilsson: Det är mycket mer ihop än vi egentligen… Sandell: … än vi egentligen tror, ja… Nilsson: … från början… Sandell: …även från början."

> Strid: Well, there will be good interplay, you must not search or work too hard, it just emerges. You have to really work hard in order to achieve… separate…
> Nilsson: …different paths, sure (Gotland 2006).[219]

Upon listening to recordings of the experiment, one can hear that the three of us use limited sound material, which we vary and combine in certain ways. It is obvious that the idea of non-togetherness is not fulfilled; almost as soon as we begin we start playing together. However, as is also implied in the spontaneous discussion, the idea of "doing your own thing" in itself brings in a feeling of freedom, which in turn stimulates creativity.

Improvisations where the "do your own thing" concept can be heard appear on track 4, *Threads*, and track 8, *Breccia* on the PSI CD Beam Stone (Nilsson et al. 2009). On the enclosed DVD, there are no examples where this concept is used explicitly. However, occasionally we do our own thing during the course of an improvisation, regardless of predeterminations.

Sounds and Silence

Cage has inspired this concept. It is about playing as sparsely and silently as possible. How much time can pass between consecutive sound events and still have the activity be perceived as coherent playing? In practice this is a difficult thing to do, since a tendency towards too much activity is always lurking around the corner. Mostly we have experimented with this concept in private rehearsals, and it has given us important inter-subjective experiences and collective knowledge among the players. Beam Stone did try this once in public at the GAS concert in 2007, but no one in the group is particularly happy with the result. On the DVD, on the track *Grey Zone ISCM*, from 6′28″ until 7′10″ the playing is indeed very sparse, even though this was not planned in advance, and is most likely influenced by the experience gained in our previous practice sessions in this realm.

219. The original: "Strid: Jamen det blir ju bra sampel då, då behöver man inte leta eller jobba så hårt. Det bara uppstår. Man får nästan verkligen jobba hårt om man verkligen skall försöka få det… separat va… Nilsson:… olika linjer, javisst!"

Analysis and Discussion

It's difficult, though,
to make interesting music with new instruments,
and learning to play an electronic instrument,
like acoustic instruments, can take years.

Max Mathews

Introduction

In this chapter, I present and discuss performance practices of the instruments discussed, including practicing and preparation. The designs of instruments I discuss in this work are foremost developed with an aim for ensemble improvisation, without excluding solo playing. Singular instrument modules are developed with a special musical purpose in mind – one instrument, one idea – which means that the implemented methods of event generation, sound processing, and control are unique for each particular instrument. Consequently, the instruments, discussed in this work show a great variety in choice of tools, controllers, aesthetics, design, mapping, and playing behavior. This research project aims to reveal relations between personal aesthetics, design decisions, performance practices, and their impact on musical output.

The research questions are:

- How do the aesthetic choices made during the process of designing my digital musical instruments relate to the particular structure and capabilities of those instruments?
- How may a personal aesthetic that shapes the design of digital musical instruments relate to playing behavior, interaction, and musical output in ensemble improvisation?
- How do these different connections, provided that they do occur, connect to each other?

In the Methodology chapter, I present four aesthetical dimensions: a) playing the instrument, b) interaction and musical roles, c) real and perceived degree of freedom, d) visual appearance. These dimensions constitute an analysis frame that aims to reveal possible connections between aesthetic choices at design time and perceived qualities at play time. Furthermore, I limit myself to discussing four main instruments: the Granular Machine, the SyncLooper, the Walking Machine, and the exPressure Pad; while I briefly touch upon two control instrument: the Groover2, and the FourToThree. The chosen analysis structure gives each instrument its own section heading, discussing the four dimensions in turn while referring to selected passages of the DVD. The instruments discussed are presented in-depth in the Instrument chapter.

PLAYING MUSICAL INSTRUMENTS

What role does a musical instrument play with respect to music character and outcome in improvised music? Possibly there is no clear-cut answer, but in my opinion, an instrument shapes playing behavior as much as the player shapes the music. As a point of departure, I refer to British saxophone player Evan Parker. Borgo (2005) cites Parker:

> The saxophone takes on a musical identity only in interaction with a performer. Parker's horn is not simply dependent on his playing, nor an extension of it, but in important ways his horn shapes his playing. As he uncovers new sounds, places other layers on hold, new combinations can emerge that were not predictable in their entirety. Just as it is valid from one perspective to say that Parker *plays* the saxophone, it is equally valid from another perspective to say that the saxophone *plays* Parker (p. 57).

Rather than saying the instrument plays Parker, I claim that, perceived affordances of the saxophone direct, shape, and to a certain extent confine his playing. Parker understands the musical world by means of his saxophone, is shaped by it, but he also acts within it, and shapes the world through the saxophone.

In *Phenomenology of Perception* philosopher Merleau-Ponty (2002) states that the human body is our viewpoint on the world, yet at the same time our body is in the world. Looking at Parker using Merleau-Ponty's vocabulary, playing a musical instrument is a way of understanding and experiencing the musical world, but at the same time a being-in-the-musical-world. Merleau-Ponty argues that a blind man's cane ceases to exist, it is rather an area of sensitivity (p. 165). Therefore, he claims, when getting used to an object, we are transplanted into it; we are incorporating it into our own body. By means of habit, we are dilating our being-in-the-world: "It is knowledge in the hands, which is forthcoming only when bodily effort is made and cannot be formulated in detachment from that effort" (p. 166). This statement is compatible with the remarks of Schuback (2010), quoted on page 31, where she asserts that musicians think with the hands, with the voice, and with the body. Practicing an instrument will make it a habit, and eventually when one is used to it, has been transplanted into it, has inhabited it, and gotten it into the body, the instrument in turn subsequently expands my being-in-the-musical-world. The instrument is the music, as Joel Chadabe states: "[…] the instrument is inseparable from the music it produces. As Yeats wrote, 'How can we know the dancer from the dance?'" (Chadabe, 2001).[220]

When I design a digital musical instrument, the intention is to realize a musical idea or theoretical concept into a playable instrument. During a stepwise design process of conceptualization, setting criteria, and implementation, the instrument takes shape. However, only in play, by playing and/or listening, are we able to experience and judge our implemented concepts. Most likely there is always a gap between aim and result, but after each iterative step in the playing-refinement-playing process, our understanding of the underlying theoretical concept increases. As Merleau-Ponty (2002) points out: "To understand is to experience the harmony between what we aim at and what is given, between the intention and the performance – and our body is the anchorage in a world" (p. 167). Furthermore, it is also possible to draw a parallel to the model Kvifte proposes in Figure 3 on page 28, which shows that music theory concepts only are meaningful in relation to an instrument, and can only be experienced and understood as music when someone plays it. This notion is compatible with Verplank's model of interaction presented on page 46 as well, where he uses *know*, *do* and *feel* as key concepts: to know is to understand the relation between doing and caused effect, to do is bodily activity, and to feel is to perceive the effects of doing.

What is the significant difference between a traditional instrument and a digital musical instrument at design time? I claim a freedom to implement whatever musical idea comes to mind, in contrast to being bound to given physical boundaries as is the case with traditional acoustic instruments. Norman (1998) asserts:

220. www.chadabe.com/statement (September, 2008).

> The computer is unusual among machines in that its shape, form, and appearance are not fixed: they can be anything the designer whishes them to be. The computer can be like a chameleon, changing shape and outward appearance to match the situation (p. 183).

However, this freedom is conditional. In order to develop a digital musical instrument, a designer uses many tools, and inherent within any tool, particularly digital tools, are aesthetical values that mirror aesthetics of its developer, or team of developers. The tools in question might be computers, music software, controllers, synthesizers, audio interfaces, and even high level programming languages like C++, and operating systems such as Linux. This means that all digital artifacts mediate aesthetics of many contributors to various extents. I do not consider this fact a drawback, but something to take into account when designing instruments. To paraphrase Marshal McLuhan, the tool is the message,[221] and the identity of a digital musical instrument is to great extent bound to and delimited by the hardware and software tools being used, which are in turn themselves made up of other tools. Moreover, digital technology can be ambiguous in that it affords exchangeability and arbitrary representation of data. Perhaps it is this doubleness of ambiguity and dependence that distinguishes the digital from the analog. At play time, affordances perceived in a digital musical instrument shapes one's playing, as any instrument will do.

IN DIALOGUE

Our traditional musical instruments have evolved over a long period of time, with contributions from many instrument makers and players in many genres; in fact, one could claim that a culture is embodied within any instrument. The perceived identity of these instruments is perhaps more determined by the history of the instrument's use, to its players and traditions, than it is by the aesthetics of the original designer, if this person is even known.[222] For example, some common preconceptions are that a saxophone brings in a flavor of jazz, and an oboe carries an air of classical music into any context. Toop (2006) asserts:

221. Paraphrasing the title of McLuhan's seminal book *The Medium is the Message* (McLuhan 1967).
222. Some instruments are intimately bounded to a particular inventor, such as the saxophone and the sousaphone, while the majority is not; if so, it rather refers to a particular brand among many, like Stradivarius, Steinway, or Gibson.

> I breathe in air, then exhale through a technological system which embodies ergonomics, cultural history, aesthetic design, and a philosophy of art that entrains sonic phenomena through precise engineering (p. 3).

On behalf of contextual associations a dialogical relation between a musician and an instrument occurs, which is as encouraging as it is demanding. I will give a personal example: one source of inspiration with respect to my choice of the baritone saxophone in my youth was the recording *Walking Shoes* by baritone saxophonist Gerry Mulligan. On the one hand, the sound of Mulligan inspired me to practice in order to learn to master the instrument, and on the other, it forced me to copy Mulligan's phrases as much as perceived affordances of properties at the instrument itself.

In the essay *Saxofonens röst, anteckningar om soloimprovisation*,[223] the Swedish literature scientists and connoisseur of free improvised music Ulf Olsson (2008) argues that jazz is a dictatorship[224] wherein the saxophone is the dictator that forces the musician to play. He refers to a rhetoric figure, *anaklasis*, which occurs when one participant in a dialogue situation "pulls words out of the other's mouth" and uses them with a different intention and meaning. *Anakrisis* is close to anaklasis, but signifies anticipation of the other's talk. Olsson argues that the saxophone anticipates and pulls phrases out of the saxophone player's mouth (p. 41).

According my point of view, the dialogue that occurs between a musician and an instrument constitutes a vital and important part of musicianship. Embodied contextual associations as well as the physical properties of an instrument have an impact on music produced. To reconnect to the beginning of this paragraph, one could say that Gerry Mulligan compelled me, he pulled phrases out of my baritone saxophone, and he anticipated my playing; a dialogue occurred between me and Mulligan, and the saxophone acted as the mediating medium.

A direct form of dialogue can occur between any instrument and electronic sound processors, notably delays, and reverb units. These devices process streaming audio from any sound source in real-time, generating a *secondary voice*, or a *sonic layer*. Depending on the current parameter settings in the sound processor, the new secondary voice may create background accompaniment,

223. *The Voice of the Saxophone, notes about solo improvisation*.

224. A term coined by Henry Parland, a finish modernistic writer who discussed "the dictatorship of jazz" in the '20s.

environmental textures, or constitute a dialogical counterpart. One example of the latter case is Miles Davis's playing in the introduction of Bitches Brew (Davis 1970), through a specially made echo device Teo One.[225]

What kind of dialogue occurs between the instruments in this work and their player? These instruments are not coherent physical objects of metal or wood, rather they reside in a computer, while an arbitrarily chosen controller controls it. Finally, a loudspeaker produces the sound, a device that may produces any sound. I claim that contextual associations are much weaker in this context than in playing the saxophone, my acoustic instrument of reference. I assume it has to do with the fact that my instruments are unique, no performance tradition exists except my own practice; there are no role models. It is possible to say that all features in the digital domain are made up, and dialogues are no exception. In the forthcoming Experiment section, I present two such dialogues.

PRACTICING

Through practicing, an instrument eventually become integrated within a player's body and nervous system; nothing stands between the instrument and its player. For the novice player, an instrument may offers resistance, and the only way to overcome this resistance is to practice. After enough time spent practicing, the instrument becomes more transparent and allows a player to play with others. However, as claimed previously, a musical instrument never completely ceases to exist independently of the player. The materiality of the particular instrument is always there; it is present as the buzzing sensation from the reed and mouthpiece on the lower lip and front teeth, the raw power needed to set a double bass string in motion, or the harsh response from a violin bow. Therefore, an acoustic instrument offers a player presence through resistance: "It offers to the musician a *resistance*; it pushes back […]. Paradoxically, the instrument cooperates by resisting" (Evens, 2002, p. 160).

A significant difference between everyday activities and, for example, music or sport activities has to do with purpose. Playing a musical instrument is a means in itself and not something we do in order to achieve something else.

225. From an article by Paul Tingen about Miles Davis's producer Teo Macero: "In addition, Macero expanded his tool kit with studio effects like echo, reverb and slap (tape) delay, the latter courtesy of a machine called the Teo One, made by technicians at Columbia. This effect can most clearly be heard on the trumpet in the beginning section of 'Bitches Brew' and 'Pharaoh's Dance' at 8:41" (http://jazztimes.com/articles/20243-miles-davis-and-the-making-of-bitches-brew-sorcerer-s-brew) Paul Tingen 2001.

In contrast, when using the vacuum cleaner the purpose is to clean the house, and not to "play" with the cleaner, and eventually such activities become habitual and the employed tools become invisible. Despite this, the activity in itself may be regarded as valuable. Expert skill researchers, such as Anders K. Ericsson (2002), show that everyday activities like driving a car become internalized and automated after an initial learning period of about 50 hours of practice. A hallmark among professionals of all kinds is to the ability to monitor oneself during practice and performance, and through such practicing methods avoid risks of *automatization* and *arrested development*.[226] A professional actively challenges his skills on an instrument by increasing the degree of difficulty of practice material, by looking for new sonic possibilities, and by varying practicing methods, for instance. According to Ericsson, it is about *deliberate practicing*:

> Expert performers counteract the arrested development associated with automaticity by deliberately acquiring and refining cognitive mechanisms to support continued learning and improvement. These mechanisms increase experts' control and ability to monitor performance. The expert has to continue to design training situations where the goal is to attain a level beyond their current performance in order to keep improving (p. 39).

In other words, an expert musician must constantly and deliberately challenge practice and performance habits, and actively seek resistance from the instrument, by means such as forcing a change in their own behavior, or by increasing the level of difficulty.

Is there any significant difference between practicing digital musical instruments and acoustic instruments? All musicians, regardless of genre and instrument, need to practice. For the improvising musician, practice consists of exploitation, exploration, and experimentation, which aims to develop, refine, and maintain improvising skills. In the essay *Shedding Culture* in the anthology *Art from Start to Finish*, sociologist and jazz trumpeter Robert A. Faulkner (2006) discusses the dichotomy of discipline and improvisation in jazz. Discipline, on the one hand, is exploitation of already-known routines, such as scales, templates, melodic/intervallic patterns, and chord progressions; on the other hand improvisation involves experimentation and

226. Arrested development is described as generalized automated behavior, a habit of only practicing and performing the already known.

exploration of the new and unknown. The former aims to be able to deliver musical ideas on an instrument, and the latter to challenge habits and clichés: "It means breaking loose from comfortable musical routines and established scripts. Oscillating between the two is a tense work" (p. 92). Jazz musicians often refer to practicing as *shedding* or *woodshedding*, which refers to the shed as a hidden space, a space where it is possible to practice privately without being overheard:

> Improvisation involves a 'perspective of practice' in its relation to creative work. The jazz musicians I work with call the former 'shedding'. They call the latter 'playing'. The shed is a place and an activity. It is a private place for practice. It is a solitary location for 'getting it together' (p. 93).

Faulkner emphasizes that the musical outcome of a particular improvisation, to a great extent, relies on short and long-term practice previously undertaken by participating players. In the longer perspective, an improviser's style mirrors her practice history. Exploitation of the known is most likely deliberately planned and structured, whereas experimentation and exploration may be more irrational and intuitive. A mistake can open a new perspective worth further investigation, something heard on a record or the radio can catch interest, one may read something, or discuss new possibilities with peers. In a public performance of improvised music, an improviser will quite likely test fresh material from recent shedding sessions, and therefore a concert is an occasion for evaluation. Since practicing goes on continuously, the cycle of experimentation at the shed, followed by tests and evaluation at concerts, is a never-ending process. Such process is compatible to design processes discussed on page 38. Prévost (1995) gives word of a similar notion: "The meta-musician is at the heart of an experiment. The audience checks the validity of the results" (p. 122).[227] Furthermore, the results of the private individual work done in the shed eventually become "cooperative behavior at work in a community of other musicians" (Faulkner, 2006, p. 94). Imitating one another and orally sharing findings and innovations made at the shed will distribute new habits and clichés within a community of improvisers.

To master a saxophone is to control a subtle sound production system: airflow, embouchure, lip pressure, and the shape of the mouth cavity are probably the most important variables. Until this day I cannot explicitly explain

227. Meta-music is discussed in-depth in Prévost (1995).

how to play the saxophone. It deals with processes that teach the body to do things, processes that, to a certain point, leaving out the conscious mind. It is embodied knowledge.[228]

One example of a learning process of exploitation of the already-known is learning to play high notes beyond the standard register on the saxophone. In my experience, even the best saxophone teacher cannot explicitly explain the techniques of playing high notes. A good teacher manages to explain the process, and suggests methods for achieving the goal. Nevertheless, the step-wise exercise process in learning to play high notes helped me understand the physics of the saxophone. Most saxophone method books show, in addition to standard fingerings, the fingerings for high notes. However, for most novice players those fingerings will not work, to the players' great confusion. It is necessary to learn and understand the nature of the instrument's acoustics before trying the high notes.

Before practicing the special fingerings, the novel saxophone player has to undertake preparatory exercises. For example, close all the keys and try to discover the harmonics for that particular tone, one by one. In the case of the tenor saxophone, start with the low B-flat: try to play the fundamental, the octave, the octave plus the fifth, the next octave, the major third and continue upwards in the overtone series. Then do the same on the next lowest note, the low B, and then the low C, etc. It will probably take an average player several weeks of daily practice to master this. When the harmonics can be performed fluently it will probably be quite easy to play the high notes with the special fingering suggested, and the pupil can start to practice the saxophone with an extended range.

As seen in this example, the way to achieve a certain goal can be difficult to understand initially. The young saxophone student simply has to trust mentors and instruction books regarding appropriate method. According to my personal experience, soon after learning to play saxophone high notes, a player will most likely over-use them in performance. Eventually they appear less often as they are incorporated into the player's style.

Practice consists of short-term and long-term goals. Mastering the high

228. Embodied knowledge, as I see it, is about things that a body can do, outside explicit verbal formulation. Cycling and swimming are two examples. It is impossible to explain how to do these things; intellectually it is possible to understand what goes on, but to really feel, comprehend, and to express what you are doing is another thing entirely. At least, I cannot do it. Everyone that has tried to teach a child these skills can bear witness about this.

notes takes long-term practice that must be maintained continuously. The high note example shows that typically long-term practice can temporarily have effects compatible with short-term practice. Short-term goals can be preparation for an upcoming concert, a new composition for instance, whereas long-term goals aim to develop and maintain skills in general. A particular free improvisation may show traces from recent practicing sessions at the shed, whereas long-term practice aims to build skills in order to interact with the unknown and unforeseen as best it can.

IN CONTEXT

A musical instrument is always played and heard in relation to a context, but at the same time is itself a constitutional part of that context. In Merleau-Ponty's terms, an improvisation ensemble can be regarded as a musical world, and a musical instrument allows a player to inhabit this world; it is her being-in-the-musical-world. Subsequently, in order to understand the meaning of the digital musical instruments presented here, it is mandatory that we consider their actual context.

Before proceeding, I would like to briefly recap what I consider actual context. Primarily, I regard the improvising ensemble as a salient contextual factor; it is here that play and interaction take place, and it is here that music making takes place. An improvisation group provides and constitutes a playground, it is a field of possibilities,[229] a field that is defined and confined both explicitly and implicitly. The creation of an improvisation group is a conscious and deliberate act; it is a voluntary and mutual agreement among a number of musicians to make music together in the future. The particular set of musicians involved is in itself a strong determination of the potential musical output. Individual players, by means of the background, formal training, experiences, playing style and instruments of the individual players has a strong impact on any performance, regardless of explicit agreements among them. Nunn (1998) asserts:

> There is no way to tell how much a given improviser calls upon Training, (instrumental music lessons) versus Experiences (practicing, 'jamming', 'rehearsing', performing, recording, promoting, producing, etc.). But both have a significant INFLUENCE upon any given performance (p. 43).

229. Field of possibilities is discussed on page 107.

A major tenet in this work claims that ensemble improvisation is compatible with game playing, which argues that gaming is a voluntary activity: it has rules, it has a goal, and it is a form of problem solving, to mention the most important factors. Setting up rules and goals that the participating members willingly accept defines and determines the musical direction of a group, and the achievement of those goals is problem solving. Similarly, the decision to play a game or sport implies acceptance of its rules and goals, in that case a fixed and pre-existing set of rules. But in a musical group, the rules and goals are not fixed, and are subject to negotiation. Among implicit factors in music-making, I emphasize the individual playing styles of participant players, which are most likely taken for granted, and are the foundation stone in many groups. In addition, agreements on what is not allowed are also commonplace; they might limit themselves a certain repertoire, or agree to avoid certain venues, for instance. Non-agreed upon matters can be a strong component as well.

The dialogical relation that occurs between a player and her instrument, which I discussed previously play a role in a group setting as well. I claim that the composition of instruments in a music group is significant in itself, regardless who are playing them. The very choice of instruments in an ensemble may set up a dialogue with tradition: e.g. "Coltrane quartet" of double bass, drums, piano, and tenor saxophone, or the "hard-bop setting" that adds a trumpet. With this said, the participating musicians' personal playing styles, aesthetic preferences, etc. are considered important factors regarding group identity. Other contextual factors are relations to a particular tradition, which are inherent to a group's identity. Moreover, venues are important contextual factors too; a big concert hall affords different modes of playing and interaction then the possibilities in a small club. Finally, we must not forget the audience, which plays an active role in improvised music performances.

Analysis

During the design process of the software instruments discussed here, I made an array of aesthetic decisions which resulted in a set of instruments with specific properties and functions. During play, all effort is focused on interaction with the environment, notably fellow players and if present, a referent. Presumably, the presence of any instrument in any context may influence interaction and musical output; it is impossible to distinguish the instrument from the music it may produce. Before continuing with my own reflections, I pose a question: how do digital musical instruments interact with acoustic instruments in improvisation? Beam Stone pianist Sten Sandell reflects:

> With our experiences of the tool, in this case a computer that generates sounds you are treating in different ways. It also becomes an instrument, a third instrument, which generates new timbres on behalf of us. But, it's an attempt to find alternative attitudes, and I think that's quite new. There is a one-dimensional way, what I mean is, the connection when working with laptops is often… there is no feedback in the process. You see what I mean? Of course, feedback between two instruments is obvious when playing with improvising musicians. The laptop thinking can be very one-dimensional. There is one output, but no input. This is something I find very important in this work. (Gotland 2006).[230]

Sandell points at a potential problem with contemporary laptop music: it produces its output blindly, insensitive to feedback from the environment, it is one-dimensional. We aim for interaction. One big challenge when designing a digital musical instrument is to make it flexible, quick, and intuitive to operate, in order to allow direct interaction with other musicians in

230. The original: "Med våra erfarenheter gentemot redskapet, en dator i det här fallet. Och som generar ljud och du påverkar på olika sett va. Och som också blir ett instrument, ett tredje instrument… istället för att… på så sett är det ett tredje instrument och på andra sett att du genererar nya klanger från oss va. Men, det är ett försök att hitta ett annat förhållningssätt. Och det tror jag är relativt nytt. Det finns en endimensionell väg, vad skall man säga, kopplingen när man jobbar med laptop är ofta väldigt… det är ingen återkoppling i processen. Om ni förstår vad jag menar? Alltså återkopplingen mellan två instrument är uppenbar om flera instrument, alltså…, när man spelar med improvisationsmusiker. Laptopstänkandet kan ofta bli väldigt, lite endimensionellt så där va. Man för ut, there is one output, det är ingen input va. Och det tycker jag är viktigt med det här arbetet".

real-time. With commercially available audio software today, it is possible to make astonishing music. However, the vast majority of such software and hardware systems either offer real-time control, in my opinion equal to real-time composition, or are merely acoustic instrument emulations, rather than being full-blown musical instruments in their own right.

In this work, I distinguish between *main* and *control* instruments, which correspond to available playing modes on a particular instrument, and consequently the possibilities available for interaction. In *playing mode*, a bodily action, a gesture, carried out by a player on a controller is overt and directly and proportionally audible; its *action-sound link* is strong (see page 161). In *controlling mode* the result of a bodily action is indirect, there is no direct perceptible relation between a physical gesture and audible output; the *action-sound-link* is weak. Direct gestural control in the playing mode allows and enhances the interaction possibilities with the musicians, while in the controlling mode an instrument performs a one-way communication, allowing no direct feedback. Consequently the quality of impact on a particular improvisation shows significant differences depending on the available playing modes in instrument employed. In general, the playing mode allows deep and subtle direct gestural interaction and is flexible and adaptive to current music context. The controlling mode turns out to be powerful in terms of directing musical outcome, compatible to performing an open composition.

A main instrument always supports the playing mode, and in most cases the controlling mode as well, whereas a control instrument only supports the controlling mode. This topic is further discussed on page 187. Two experiments exemplify these two modes of playing: *Davis Deconstructed* deals with control and real-time composition, whereas *My Funny Valentine* exemplifies playing. The four main instruments in this work are the Granular Machine, the SyncLooper, the Walking Machine, and the exPressure Pad, which I thoroughly analyze, while I limit myself to a brief discussion of two control instruments, the Groover2, and the FourToThree.

Practicing, Preparing, and Playing

How does one practice a digital musical instrument, and is it different from practicing a traditional instrument? With instruments in this work, there are certainly no established practice methods available, no tradition or mentors to consult. Rather, it is up to the designer/player to invent and discover ways of playing those instruments. Practicing a digital musical instrument is as much fine-tuning the software as actually playing them. Short-term practice may consist of adjusting a scaling component in the mapping engine, swapping the function of two buttons of the controller, adjusting the range of allowed values somewhere, or choosing a sample, to give some possibilities. Long-term practice, like practice on acoustic instruments, aims to develop and to maintain playing skills in order to be able to meet the demands of actual playing contexts.

As far as I remember, I have not performed a single concert without undertaking minor changes in the software in advance. In addition, it facilitates an upcoming performance to make some preparations, pre-setting parameters for instance. But the border between re-programming and pre-setting parameters is fuzzy; with software like Max/MSP it is easy to go into the code to make changes. In principle, preparation means to set parameters when the instrument is in the playing mode, while programming means to change its code. However, as a principle of mine, parameters which need to be changed frequently are made accessible through the GUI, or perhaps accessible from the controller, which make them "playing" parameters. Parameters which are rarely or never changed can be hidden, and are not accessible or visible from the top-level GUI.

In my personal experience, during conception and implemental stages of development, it is difficult to exactly figure out which parameters should be directly accessible, and which should not. However, the main principle must be to minimize the number of visible parameters as much as possible, since they can be a distraction during performances. In order to avoid the tedious work of initializing parameter settings in preparation for a concert, I prefer to automatically pre-load functions into my instruments. This means that the major part of the initializing work can be done privately in the studio ahead of time before the concert. For instance, a set of samples has to be loaded, and settings of resolution, density, tempo, and effects must be configured. This activity is akin to "warming up", or short-term practice on an acoustic instrument; it aims to meet anticipated demands from an upcoming event as best as possible. However, there is a risk of overdoing automation: after all the work is all about improvisation, and therefore an open architecture that allows changes on the spot is preferable. Norman (1998) asserts: "Automation has its virtues, but automation is dangerous when it takes too much control from the user" (p. 197).

Compared to acoustic instruments, my family of instruments demands a significantly lower amount of practice at design time, and possibly a lower cognitive load at play time.[231] Three factors may be discerned: First, I cannot think of any digital musical instrument where a player's body is directly involved in the sound production, like the lips and oral cavity on a saxophone, or the hands on a violin.[232] How could they be? This means that the generation of sonic events takes place within the instrument; the player merely controls the instrument, and consequently no practice is required for sound production. Secondly, behavior that requires skills on acoustic instruments may be implemented as properties within a digital musical instrument, a parallel to virtual skills in computer games (see page 90). Thirdly, most digital musical instruments, including mine, do not demand much physical effort to play, in comparison with acoustic instruments.

As discussed in Pressing (1984), one important purpose of practicing a musical instrument is to make lower-level tasks such as tone production and phrasing automatic behaviors by coding them into memory: "In other words, the ability to construct new, meaningful pathways in an abstract cognitive space must be cultivated" (p. 359). A pathway will either follow already existing hierarchical connections or end up in search of new ones. As a consequence, practicing increases the size of units used in perceptual coding, which in turn decrease the central processing load as a result of improved coding, because parts of the perceived aural data are "pre-processed" (p. 359). However, it is possible to implement such pathways in music or gaming software, which game designers designate as "virtual skills", see page 90, and according to Norman (1998): "Whenever information needed to do a task is readily available in the world, the need for us to learn it diminishes" (p. 56).[233] This means, rules of musical behavior reside in the computer instead of being knowledge in the head; it becomes knowledge in the world. Moreover, Norman distinguish between different layers of control:

231. In a personal conversation, Swedish saxophone player and fellow musician Ove Johansson asserts that the AKAI EWI, an electronic woodwind emulation controller, demands much less practice time compared to the saxophone; once learned it remains in the memory.
232. With reference for example to Yamaha's VL1 and successors, digital musical instruments relying on physical modeling may be comparable in complexity to controlling analog sound production.
233. Discussion about affordances starts onpage 125.

> All tasks have several layers of control. The lowest level is the details of the operation, the nimble finger work of sewing or playing the piano, the nimble work of arithmetic. Higher levels of control affect the overall task, the direction in which the work is going. Here we determine, supervise, and control the overall structure and goals (p. 197).

One example is the Walking Machine. Walking bass behavior is a built-in feature, while the task for the player is to deal with control of overall behavior, and leave event generation to the computer. During practice sessions I do not undertake much structured practice, the equivalent of practicing scales and patterns on a traditional instrument; rather practice time is merely spent with the aim of internalizing and feeling the mapping of the instrument. Furthermore, the GUI may display important musical information, such as current pitch and sound file selection, which reduces the need to learn as well. Even though a digital musical instrument seems less demanding than its acoustic counterparts, sustained deliberate practice is mandatory, as well being persistent in utilizing a new instrument. Finally, I recap with the heading quotation in this chapter by digital-music pioneer Max Mathews: "It's difficult, though, to make interesting music with new instruments, and learning to play an electronic instrument, like acoustic instruments, can take years" (in Risset, 2007, p. 19). It takes years to master a musical instrument, and digital musical instruments are not an exception in this respect.

I assume that a normal habit among digital musical instrumentalists is to look for and to test new ideas, either with the aim of improving or expanding possibilities in existing instruments, or to make up entirely new ones. This activity is referred to as *hunch* and *hack*[234] in the discussion regarding design processes on page 38. I can see that this activity is similar to practicing among jazz musicians, as discussed at the beginning of this section, and I would claim that exploration, in contrast to exploitation of the known, is about experimentation that may go on in an intuitive and unstructured way.

Practicing the hyper-instrument for instance, deals with experimentation with combinations of modules that reside within the system. One essential feature is the ability to synchronize different modules rhythmically with each other. It is difficult to determine whether certain pre-recorded loops will fit together during a performance, e.g. which application best suits a certain sample, whether individual components are complementary to each other,

234. Terms proposed by interaction designer Bill Verplank (2009).

and whether the combination will produce a result with an interesting character and consistency in some way. Therefore, practicing and preparation deals as much with experimentation in combining modules, and their preloaded sets of sound files, as it does with exploration of single sounds in order to know them "inside-out". A great amount of time is spent on looking for, examining, and testing samples.[235] The purpose is to explore and internalize inherent qualities and possibilities of individual samples in the sample-based main instruments. Over the course of years I have built a library that consists of a mix of sounds files: single percussive hits, instrumental notes, commercially available drum loops, instrumental gestures, loops selected from my personal record collection, shorter coherent pieces of music, and field recordings from various sources such as sounds from nature, and sounds from machines. As with the saxophone high notes I discussed earlier, new additions to the internal sample library may initially tend to be overused in a performance because of excitement with their novelty, which from time to time may overshadows musical considerations.

Selecting among all available samples within the global sound library requires a somewhat tedious mouse operation to load them into current instruments. Therefore, in order to prepare for an upcoming concert, sets of samples may be configured as presets, automatically loadable on the fly. In such cases, the player most likely knows the sound file, and has practiced with it in advance. In other words, inherent properties in such a sound file are thoroughly known and internalized during experimentation and practice at design time. This type of playing mode is appropriate when an particular anticipated sonic output is desirable, for instance in guided improvisations, or in bringing content into an improvisation when some perceived emergent identity calls for a certain material.

To sum up, there are significant differences between practicing, preparing, and playing traditional instruments and digital musical instruments in this work:

- Digital technology affords implementation of qualities beyond physical limitations.

235. A sample, in this work, is a digital sound file, a sonic object most likely at a length of approximately up to 3 seconds, compatible with notions of now, see page 130. Listening, examining and categorizing sounds is further discussed in listening in this work, starts on page 149.

- Digital instruments have an open design, which entails the necessity/possibility to constantly making small adjustments, overhaul, and perform adaptations of functionality and playability, the equivalent of practicing.
- Practice on tone production is not required.
- Musical behavior may be implemented in its design.
- Significant current musical information may be shown in the GUI.
- It is not limited to one particular instrument; rather it is a hyper-instrument where synergy effects of interacting multiple modules are essential.
- Necessary physical efforts are substantially low.

Faulkner (2006) asserts practicing aims at "getting it together", and in that respect acoustic and digital musical instruments are similar. However, practice methodology and habits must be adapted to meet these conditions. As a concluding remark, I will stress the importance of practicing. As with all musical instruments, a digital musical instrument requires and deserves deliberated and sustained practicing. The better the shedding, the better the performances.

Playing Sample Based Instruments

Two of the four main instruments in this work use samples as their sound source, while the other two utilizes sound synthesis. Before proceeding to discuss individual instruments, I aim to elucidate some features common to the Granular Machine and the SyncLooper, the two sample-based instruments. Neither the Walking Machine nor the synthesis-based instrument the exPressure Pad have many features in common with the other instruments, therefore I will discuss them individually.

Playing a sample-based instrument is somewhat similar to a technique visual artists employ. The material is somewhat like wax crayon on paper. Start by making an image, or taking an existing one; then cover the whole paper with black; then create new forms by scratching the black away, perhaps in the shape of a word, which enables the original image to become partly visible. The form of the upper layer consists of content of the underlying layer. The two layers may not have anything in particular to do with each other, but because they exist on the same surface, or at the same time, they form a relation. This kind of image is simple to create in a digital image-processing program such as Photoshop. Figure 56 shows an example of such an image.

Figure 56: Beam Stone on Beam Stone. The shape of the letters forming the word Beam Stone uncovers the underlying image of the members of Beam Stone. From left: Raymond Strid, Sten Sandell, and Per Anders Nilsson. Image: Ramon Altin. Montage: Per Anders Nilsson. We may only focus on one structure at a time, while the other constitutes the ground: either the underlying image is the intentional object, while the text is background, or vice versa.

A pre-loaded or real-time recorded sample is equivalent to the underlying image, the black can be seen as an intermediate layer that allows the performer to carry out gestures, whereas the scratching, or text, is comparable to gestures carried out on the controller. Figure 56 also illustrates that we are only able to focus on one structure at a time, with the other forming the background, either the underlying image is the intentional object, while the text is background, or vice versa. I claim a similar phenomenon occurs when playing with samples: attention willfully oscillates between sonic content and imposed gestures. The underlying sonic layer provides a basic sonic identity, a tint, a timbre, a pattern, while the current playing of the digital musical instrument allows certain portions of the underlying sample to get through, and became audible. As a player I play the sound file, through actions implemented within the digital musical instrument. Gestures undertaken as a player are superimposed on the original sample, which creates a kind of polyphony. Stockhausen (1989) casts some light on this subject with his piece for tam and live electronics from 1964, *Microphonie 1*. Microphonie 1 engages three participant players: one plays the tam, another moves the microphone, and the third controls the electronics, consisting of various filters. There is only one sound source but three players:

> This is a very strange situation, having three players working on the same sound. And there is an inner polyphony within each sound, a superimposition of different rhythms and dynamic curves (p. 82).

Most of the time the players behavior is not synchronized, which give rise to a kind of polyphony, and according to Stockhausen it was not possible to anticipate the audible outcome. One example that demonstrates this concept is presented on the DVD, the experiment *Davis Deconstructed*; see also the discussion on subject matter further down in this chapter. However, in this experiment both layers are rhythmically synchronized.

One feature implemented in many instruments deals with the ability to synchronize playback with the global clock of the hyper-instrument (see page 179). Regardless of its length, a sample is played back one, two, or four times during the course of one cycle of the global clock, which most often is interpreted as being four bars. In a playing situation, the Granular Machine, the SyncLooper and the Walking Machine, for example, may play in sync with each other, also forcing sound files of arbitrarily length and original tempi to play in sync with each other. Rhythmically interesting superimpositions may occur.

THE GRANULAR MACHINE

The Granular Machine is a sample-based instrument allowing real-time audio processing. In essence, it features transposition, playback direction, and fragmentation. In the mid nineties, while composing an acousmatic piece, *La Gamme Voiture XM* at GRM studios in Paris, I use granular processing as the event level generation method. At the time, real-time sound processing was only accessible on dedicated systems, in this case the *SYTER*, and GRM-tools, in-house audio processors at GRM.[236] However, studio access time was limited and in order to increase possible working time, a granular application in software intended for personal computers, *Csound*, was used. A significant property of Csound is the division between instrument and score, where the score is a list of commands that control the event generation in the specified instrument. In order to create a score, the graphical abilities in Max/MSP were used. By drawing curves defining time placement of values

236. GRM tools (www.inagrm.com/logiciels) is the successor of SYTER, and available as an audio library in popular plugin formats, such as VST, and TDM. Within the GRM library of sound processing tools, *Shuffling* is a granular synthesis implementation.

of selected parameters, Max/MSP produced score files, which subsequently drove the creation of Csound-generated sound files. The rendering of these files was very slow, however, and in order to be effective under such circumstances it was important to carefully and methodologically investigate the effects and impact of individual parameter settings on the sound produced. After repeated sessions with an identical sound source, only changing one parameter with each experiment, eventually I got granular synthesis "into my body". After this tedious work, I was able to simply figure out the parameter setting to produce an imagined sound gesture. Years later, when I started to experiment with granular applications operating in real-time, thanks to these deliberate experiments undertaken in Paris, the physical understanding of granular synthesis had already been established, and it was quite easy for me to create a real-time operated granular instrument. I already knew what I was searching for.

Playing the Instrument

The Granular Machine features three basic playing modes, each one entailing a different playing feel with specific playing behavior, which in turn give rise to different kinds of interaction and musical roles with respect to current musical output. In all modes, audio content resides within a sound buffer. The waveform window in the GUI (see Figure 72 in the Appendix) provides necessary visual information, which together with aural memory guides the subjective selection of arbitrarily parts of buffer content for further processing and playback. Buffer size may vary, but five seconds prove to be most useful: long enough to hold a phrase, and short enough to memorize. The Granular Machine's three basic modes of operation are manual mode, playing mode, and playback mode, and designated buttons at the gamepad controller allows switching in between; see page 191 for full mapping and further details.

In manual mode the right thumb controls playback position and selection size on the x and y axes, while the x-axis on the left thumb assigned to pitch. This mode suits exploration of timbral and statistical qualities of given material; especially interesting musically is the ability it provides to continuously vary the audio selection size and "freeze" sounds – that is, set very short audio selection sizes. An additional function randomizes and quantizes pitch; although available in all modes, it is best suited to manual mode. Since monitoring of current sonic content and playback position/selection in the waveform window is necessary, attention to fellow players may suffer. There is a potential risk for the player to be completely absorbed in the task of playing the instrument. The one-to-one mapping gives a feeling of working directly with the sonic material, compatible to scratching on an analog tape recorder or turntable. The potential for reacting to changes in musical context is good in this mode, and the waveform window supplies valuable information for finding suitable spots within the sound buffer. The possibility of momentarily freezing a section can free time for the player to play or prepare another instrument, while the Granular Machine continues to play. I highlight two examples of this behavior on the DVD. The first is on Shadowing with Beam Stone. From about 4′00″ to 6′20″ I perform a duet with percussionist Strid, practicing real-time sampling, using playing mode. At 6′20″, I set the instrument in automatic mode and at 6′27″, putting the controller on the table, and while it still plays, I continue with preparations for further activity. Another example can be heard on *Facing x*. From 6′25″ until 7′30″, with the Granular Machine also in manual mode. The random and quantization pitch function is clearly audible at 6′35″, creating an ambient background layer.

Playing mode features another type of mapping: an integral type 1 implementation on the x-axis of the right thumb controls playback position. This means that the absolute x-position of the right thumb controls playback speed, from zero at the middle position, to about ten times the original speed at the extreme left and right positions, which also signifies forward and backward direction. Note that no audio selection size is available in this mode; otherwise, the controller mapping is identical. The playback speed implementation adds juiciness to the instrument; a quick and subtle movement may give a huge audible response. Playing mode is good for controlled exploration of dynamic qualities in sounds, such as glissandi, growth and decay, attacks, etc.

Playback mode implies playback rather than playing. In this mode, the playback speed is synchronized to the global clock, which allows synchronization with other modules in the hyper-instrument. It is difficult to discuss the feeling of playing the instrument in such a mode; if playing mode is the equivalent of scratching a tape recorder, this mode is the equivalent of running it. However, in the experiment Davis Deconstructed, this mode is further demonstrated and discussed. In addition, and available in all modes, sound effects may add secondary gestures to performed gestures on the controller.

Interaction and Musical Roles

I identify four main musical approaches that the Granular Machine gives rise to, which link to available playing modes: shadowing and musique concrète in real-time[237] link to playing mode; the ambience generator links to manual mode, and accompaniment and complementary grooves link to playback mode.

Shadowing[238] means *direct gestural interaction* with a fellow player, and employs recording and live processing of fellow musicians in the midst of a performance. At the same time it is an instrument mediation concept, and a salient example of how instrument idiomatic properties may influence playing behavior, interaction, and music produced at play time. In this work, we use shadowing prescriptively for upcoming improvisations in various groups, notably Beam Stone. During a shadowing session, there is not much time to do an analysis of incoming sonic content; instantaneous response is mandatory. However, pre-performance practicing with various types of pre-recorded sound files is necessary in order to acquire the skill to handle all kinds of thinkable, but unknown situations. As its name implies it is about following and capturing a fellow musician's sound. The audible output from the instrumentalist of choice supplies the sound buffer with material, while gestures carried out on the Game Pad controller typically controls selection, dynamics, transposition, playback speed/direction, etc. A typical shadowing session may start by emptying the audio buffer. Consequently, with an empty audio buffer the shadowed musician necessarily must play the opening phrase. As soon as the sound buffer is partly filled, it is possible to start processing the recorded material. Produced sounds interact with the fellow musician, which allow her to play with her own sound, transformed however by the digital musical instrumentalist. At this moment, I may choose between manual mode and playing mode on the Granular Machine, which I do on the fly on the controller. Anticipating, and knowing something of the expected playing behavior of the fellow musician, the mode will be most likely decided beforehand; however, unexpected possibilities that arise in the actual situation may shape my selection as well. From a fellow musician's point of view, the output is without a doubt her own material, treated, however, by the Granular Machine.

237. Musique concrète in real-time is similar to shadowing, except that it utilizes pre recorded sound files rather than real-time recording.

238. The concept was coined by Beam Stone percussionist Strid as a way of describing his notion of the process in Gotland, Sweden, October 2006.

Shadowing affords dialogical playing in at least three simultaneous levels: 1) direct dialogue between digital musician and the fellow musician; 2) dialogue between the fellow musician and her own processed material; 3) dialogue between recorded material and the player of the digital musical instrument. Since no foreign sounds are introduced, the sound world within a shadowing session remains consistent. Do fellow musicians think I "steal" their sounds, and making profit of them? Strid reflects:

> Thus, it depends on the way you do it. I don't think you are doing it in such a way that you are stealing my sounds, and then get a free ride on them. Rather, you are quick, I really think so, and musically transforming those sounds, and making phrases quickly, then you don't think about it. You get loose of the feeling that this was my sound or phrase that comes back transformed. I don't think like that. Perhaps the first seconds, and if I know I am going to be processed in one or another way, then I try to work in a musical way, giving and taking. (Gotland 2006).[239]

Strid affirms that shadowing is not mere recording and playback in real-time. In order to make something musically meaningful out of it, the shadower must be able to make use of the recorded material in a musical way, as Strid pinpoints, the ability to react quickly is essential. One could think of this as composing musique concrète in real-time with a dynamic sound source. It is about acousmatic listening, as discussed on page 145 and onwards, but is also about interaction with a fellow player. To be in the midst of a shadowing session requires making instant analyses of the incoming sound, and at the same time to act, actively transforming and playing in dialogue with those sounds.

Shadowing can be heard on various tracks on the DVD, one obvious example is on Shadowing ISCM. This piece was designed to feature three duos in sequence, and that the duos with digital musical instruments should involve shadowing. The piece starts with the piano alone. Obviously, I have to

239. The original: "Alltså, det beror på hur man gör det, nu tycker jag inte du gör det på ett sådant sett så att jag upplever det att du tar mina ljud och sedan glider du, öh… åker gratis på dom. Utan du är såpas snabb så att, och tycker jag att du är… musikaliskt förvandlar, tranformerar dom här ljuden och fraserar väldigt snabbt så att man, man tänker inte på det, det går väldigt fort när man släppt tanken att där var mitt slag eller där var den klangen du gjorde eller den lilla frasen och nu kommer den transformerad. Så tänker jag nog inte då, Bara kanske de första sekundrarna (sic) och vet jag att, att jag, att bli bearbetat på ett eller annat sätt. Då försöker jag bara jobba musikaliskt, ge och ta mot det här".

wait for some material from the piano before going into action. During the first duo (0′00″–2′25″) with Sandell, who mainly utilizes the piano, the control instrument the Munger is used. In addition, the piano sound is run through a ring-modulator effect in order to add color before going into the Munger. Given that the Munger is controlled from the MIDI mixer, I create more of a secondary voice to Sandell's playing, rather than performing direct gestural interaction with him. The duo with the percussion starts at 4.00, now with the Granular Machine, which allows direct gestural interaction. Another example of shadowing can be heard at Angle of Repose with Beam Stone. From 5′25″ until the end the Granular Machine is used. At this occasion I introduce a gesture consisting of a piano sound, previously recorded during the same session. Note that I am not in the picture until 5′34″. I continue to play with content in the sound buffer until approximately 7′50″ when I start to record the percussion, which gradually replaces the buffer with cymbal sounds. From ca 8′00″ until the end, the Granular Machine is in manual mode and produces an ambience type of texture. Shadowing occurs at Facing x as well. At 4′15″, I pick up the gamepad controller and start to shadow bass player Janson. Initially, I utilize playing mode, and from 4′40″ to ca 5′00″, a fast glissandi is audible.

Ambiences are stable or semi-stable sound masses generated based on prerecorded material, from either the internal library, or from real-time sampling. When used as an ambience generator, the Granular Machine can be set either in automatic play or manual play, which is considered *indirect interaction*. In manual mode, it is possible to select the entire sound buffer, or a portion of it, with the controller. In such a case (see Figure 72 in the Appendix), playback position of successive grains is evenly distributed throughout the buffer selection. This means that the sonic output is stripped of morphological properties of the original sample, emphasizing timbre. An additional feature allows random de-tuning of individual grains, which is good for "cloud-like" textures, and furthermore an available pitch quantization effect allows chord-like structures to be generated. At the end of the percussion – the Granular Machine duet in Shadowing, direct interaction with Strid effectively stops at 6′28″. This is clearly visible on the DVD when I put the Gamepad interface on the table. The Granular Machine becomes a static ambience generator, which creates sonic ambience based on percussive sounds.

Real and Perceived Degree of Freedom

When playing the Granular Machine, particularly during shadowing sessions, I usually depend on sonic output from a fellow player, which obviously limits the available choices. On the other hand, the internal sample library allows this instrument to utilize any available pre-recorded sound. Although the previous case may seem severely limited, I do not feel constrained; rather the perceived feeling of freedom is big, while in the latter situation sometimes there is the frustration of having too many choices, which limit the perceived feeling of freedom. In a shadowing session, the perceived feeling of freedom may be described as a freedom from freedom. By this I mean that it frees me from the duty to come up with new interesting sounds; rather I have to make something musically meaningful of available and given sounds. Consequently it also sharpens my attention to the current situation, to the interaction with my fellow musician. In contrast, when employing pre-recorded samples the number of choices increases; it offers a different kind of freedom. For example, during the course of an improvisation the current texture may seem to call for a particular sample I know is available. This kind of situation\ gives real freedom and many sonic choices. However, there is the potential risk that the process of finding and loading the sample takes attention away from the actual playing, and that the moment is gone by the time the "right" sound file is loaded. One could say that searching for sound files in the midst of a performance forces a player to jump into design time activity. This means that the conscious mind gets involved in decision-making temporarily, but as soon as the sample is in the buffer, it is possible to jump back to "play time mood" again. To oscillate between design time and play time is not unique with my instruments; in my experience playing the saxophone there are moments of consciously searching for suitable things to bring into an improvisation as well. The difference lies in storage of memory; an acoustic player searches within her memory for playing choices, while on my instruments I search in the computer. This is compatible to Norman's distinction between knowledge in the head and knowledge in the world. This leads to considering the graphic user interface, or GUI.

Visual Appearance

The GUI of the Granular Machine[240] displays only information I judge important at play time. Its most important window is the waveform window (see Figure 72 in the Appendix), which displays current content in sound buffer, plus information of playback position and sample selection size. Additional information shows current play mode transposition, and playback speed/direction. This means that my playing depends largely on looking at the GUI, which is evident in the DVD, for instance in the shadowing examples above. This mode of operation has both positive and negative implications. Since the current state of musical parameters is visible, silent preparation for future activity is possible. On the negative side, dependence on visual information may take attention away from direct interaction with players and the current musical situation.

THE SYNCLOOPER

The SyncLooper is a sample-based instrument that does not feature real-time recording. The output from the instrument relies on the content and identity of the current sample in the buffer, but on the other hand the inherent idiomatic nature of the instrument itself characterizes its output to a high degree. The SyncLooper aims to play with sound files, particularly loops containing rhythmic material, rather than controlling playback, a situation common in many loop-based software programs, and corresponding to Chadabe's fly-by-wire model discussed on page 75. Initially, the inspiration comes from *ReCycle* by Propellerhead, and *Ableton Live*, two software systems that allow synchronized play back of multiple loops regardless of the tempo of the original material. The SyncLooper is the featured instrument in the experiment *Davis Deconstructed*, included on the DVD and discussed on page 314. Note that the following section merely discusses playing mode, while the experiment Davis Deconstructed explores controlling mode.

Playing the Instrument

The SyncLooper's modus operandi is to chop a sound file into 8, 16 or 32 segments of equal length at duration of one, two, or four bars, while a global clock determines tempo. Playing the SyncLooper is a matter of reordering

240. The Granular Machine mapping and GUI is presented on page 191.

and de-tuning segments in real-time. However, the segmentation mechanism generates artifacts: that is, an audible pulsation is present in all audio material to some extent, in addition to pops and clicks that occur now and then. Those artifacts appear most often in non-rhythmic material such as single notes, sustained chords, or even bass lines, and may not be noticed at all in rhythmic material such as drum loops. This is not surprising, since the SyncLooper primarily aims to handle short, rhythmic percussion loops. Available parameters are: segment position, playback order, individual tuning, direction, and effect send. The SyncLooper supports the controlling mode and the playing mode: in the controlling mode all operations are carried out with the mouse in the GUI (Figure 57), while playing mode employs the gamepad controller. The implemented control mappings work in parallel, and both support a mix of control and randomization. Three integrated effects play an essential part as well: *delay*, *reverb*, and *multitap*, which create secondary gestures based on primary gestures, and are mostly used in order to enhance timbral qualities. Note that the SyncLooper is capable of playing back four different synchronized loops simultaneously, however only one of the four loop engines may be actively played at a time. This means that the other three are either silent, or automatically playing back based on an individual parameter setting, which in turn leads to special playing approaches that have consequences for both interaction and the music produced.

In controlling mode, the segment order window (B) consists of an array of sliders whose horizontal position corresponds to metric position in the sequence, e.g. the first slider is equal to the first sixteenth, second slider to the second sixteenth, etc. The vertical position of a particular fader controls which part of the sound file plays at the corresponding metric position in the sequence. Tuning (A) and level (D) of individual segments operates in the same fashion; tuning offers 25 vertical positions, plus or minus one octave in semitone steps, while level affords control over five levels of volume. The effects are controlled from Aux 1, 2, and 3 at the GUI (E), and can be either in open or close position; in the open, up position, audio feeds to the adjacent effect at the corresponding metric position in the sequence. Controlling mode is well suited to real-time composition; that is, to consciously and methodically building music structures in real-time. Nevertheless, mouse operation is a tedious way of playing, more suited to the studio than to real-time performances. I discuss performing in controlling mode in-depth in the discussion of the Davis Deconstructed experiment further down in this chapter.

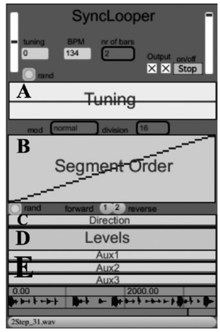

Figure 57: GUI of one SyncLooper engine.

In playing mode, a number of musical parameters are under direct gestural control by the gamepad: x and y axis under the right thumb continuously controls selection of segment, while the left thumb continuous control is assigned to global segment length and transposition. Other designated buttons may randomize pitch (A) and direction (C) of individual segments. The implemented mapping gives the feeling of direct gestural control, similar to that of the Granular Machine, while the ability to control randomization of certain parameters introduce surprises and new affordances during the course of a performance. The latter feature connects to Chadabe's sailing model where known forces such as wind and current may influence the music in an unpredictable way (see page 75). During play, control of detuning and duration are extensively used; for example, an extremely short duration value produces a stream of clicks, while long durations in combination with down tuning create dark noises. Effects are directly accessible with the left and right index on the controller, which opens a gate to respective effect. This control feels rather like "shooting" audio into the effects, which contributes to the perceived feeling of juiciness in the instrument. For example, it is simple to create outbursts of sounds to enhance dynamic high points in an improvisation. Another peculiarity of the SyncLooper is that it constantly moves forward, synchronized with the global clock, which means that a groove is always present, either explicitly or implicitly. One could say that the SyncLooper creates a basic pulse, and at the same time is subordinate to it. This is due to the design of the instrument, such that the speed of event generation depends on global tempo, and in principle is beyond performance control. The physical effort it takes to maintain a fast groove for an extended period is demanding when performed manually on an acoustic instrument such as a double bass, but with the SyncLooper it is almost physically effortless. My role as a player is to monitor, actively respond to and interact with fellow musicians, by imposing gestures on top of, but still depending on, the fixed subdivision of the given global tempo.

Interaction and Musical Roles

In performance, the SyncLooper allows *direct gestural interaction* with fellow players, in addition to *indirect interaction* such as providing a groove, which constitutes a rhythmic ground for the entire ensemble. Examples of direct gestural interaction are two tracks with Beam Stone entitled Grey Zone, (GAS 2007 and ISCM 2009), which rely on a quality descriptor in analysis of soundscapes, that is, *metabolic effect*. The salient property of metabolic effect is a sound mass that can be perceived in two ways. On the one hand, the immediate aural impression is of a quasi-static sound field, but a closer listening focusing on details reveals a huge and varied activity on mesa- and micro- time scales. In this setting metabolic effect is a prescriptive tool, giving participating musicians a task: to collectively create a sonic texture, consisting of single events, with such density that the perceived texture could be viewed either as a swarm, or as single events. The Grey Zone improvisations included on the DVD rely largely on the inherent and ubiquitous pulsating effect that the SyncLooper produces, and by speeding up the BPM to 160, the basic pulse of eights is fast indeed. In practice, it constitutes a time reference for the piece, and an example of instrument meditation and indirect interaction. All four engines are used. Two of them contain jazz whisper loops, and the two others contain conventional drums. These samples are never audible in their original form, however. It is striking how well the SyncLooper blends with Strid's percussion, in both behavior and timbre. In the Internet magazine Zidco, reviewer Bruce Russell writes:

> Both Sandell and Nilsson use electronic devices to create many of the chirps, rumbles, and buzzes heard on the CD, including the sampling and retooling of the sounds of the instruments themselves. 'Grey Zone' provides a great example of the latter approach. Nilsson processes Strid's skittering percussion lines, apparently, expanding their palette and increasing their velocity, the effect sounding something like a superhuman John Stevens playing a kit the size of a small house (Scidco 2009).[241]

241. www.squidsear.com/cgi-bin/news/newsView.cgi?newsID=975 (Aug. 2009).

Metabolic effect, as a prescriptive concept, provides the group a task that offers both challenge and inspiration. On both recordings the musical outcome falls within our expectations, however whether we succeeded to achieve the desired effect or not is a matter of discussion, and I will argue, not the point. To my point of view, Grey Zone has the distinctive flavor of free jazz, and the presence of a steady fast pulse, which creates a groove, plays an important role in establishing this feeling. My notion jibes well with Jost's (1994) analysis of Cecil Taylor's music (pp. 72–3). In essence, Jost states that as long as Taylor and his fellow musicians play with a steady fast beat, it is jazz, but as soon as the tempo drops or loosens up, the music becomes contemporary music. At some points with the SyncLooper, the basic groove seemingly disappears and/or dissolves as well, however time keeping continues within the machine. One example of this playing behavior occurs between 3′40″ and 4′15″ in Grey Zone GAS, where the ubiquitous fast unit pulse is merely implied, while in Grey Zone ISCM we go in and out of tempo during the entire piece.

Grey Zone turns out to be an exploration of the possibilities inherent in this digital musical instrument. I play the SyncLooper actively in both recordings, providing the trio with an underlying fast pulse, which is an idiomatic artifact of the instrument. A couple of months after the recording, the group watched the DVD, and I recorded our comments. A propos the ubiquitous fast mechanic pulse from the SyncLooper, I claim that my instrument keeps up the tempo continuously, but it is clearly a machine thing. The interest lies in the contrast between the machine-like and the human. Strid states that it reminds him of a pinball game, but the interest presupposes that the tempo remains constant even if we slow down and play more sparsely:

> Nilsson: Apparently, much of what I'm doing is a kind of engine, somewhat special
> Strid: It might be, I don't know how, we have this basic tempo, and works with contrasts. It is fast, the 'scratch', the metabolically. Intersecting moments of contrasts, well I don't know.
> Nilsson: But retaining the flow, yes. We have touched upon it, to make 'holes' in it, but still maintaining the tempo.
> Sandell: Sure, we can punctuate it more, making more holes, while keeping the tempo. (Stockholm 2007).[242]

Although the basic idea is keeping the groove going, in both recordings there are moments when the underlying pulse vanishes and is merely implied. One example from the GAS version is a 30 second passage that starts at 03′30″. Primarily I exploit the SyncLooper's ability to maintain an ultra fast tempo for long stretches of time. Beyond that, the recordings show a great variety of different roles in terms of instrumental and personal impact. For most of both improvisations, the SyncLooper maintains the underlying fast pulse, working together with the percussion, but never takes a soloist role. Nor does any other musician. I claim that the special color the SyncLooper adds to an improvising ensemble has to do with its design as much as with my own playing and selection of sonic material. In the provided examples the pulsating effect, which began as a non-intentional artifact of the system, proves to actually be an important component of the music. Therefore, the output from the instrument is a product where impact from three different sources are apparent: firstly timbres and structure from employed sound files, and secondly gestures performed by the player, and both these sources are imposed on the third, which is the regular pulsating effect that act as a metronome. The two recordings of Grey Zone exemplify mediation: idiomatic features of, in this case, the SyncLooper have a profound effect on the improvisation, coloring and controlling it to a great extent. Given that there is nothing in the Metabolic Effect prescription that would explicitly create a steady fast pulse, an all-acoustic improvisation

242. The original: "Nilsson: Sedan är det klart att mycket av det jag gör är väl någon slags motor… på ett sätt här så. Som kanske är lite speciellt då. Strid: De skulle ju, jag vet inte om man då… man har det här grundtempot och jobbar mer med kontraster? Det är snabbt, det är plottret, det här metabolistiska. Man lägger in moment av kontraster. Ja vet inte. Nilsson: Men ändå behåller flödet ja. Vi var ju inne där när vi går ner, så är ju det kvar i så att säga… Sandell: Visst kunde man punktera det mer, man skulle kunna göra mer hål i det. Och även om dom behåller tempot […]".

that utilizes this concept, or one based on a different digital instrument, would certainly have unfolded differently.

Real and Perceived Degree of Freedom

In play and interaction with fellow musicians, I do not feel particularly constrained, despite the fact that the instrument only allows a limited set of behaviors. This means that the perceived feeling of freedom is greater than real freedom, which is merely a freedom to choose sound content from available sample library. However, as Grey Zone shows, it is possible to successfully play the SyncLooper in non-groo ve based contexts as well. The SyncLooper is best suited for situations in which it act as a referent, where a preset, or a set of presets, of sound files (typically loops) are prepared in advance, but most often one preset is used throughout a particular section. One particular feature of the SyncLooper is the capability to pre-load presets from the sound library into the four playback engines. It is possible to compose presets supporting different musical approaches, which also reflect different musical roles:

- *Complementary preset* can be interpreted in different ways. It can serve a rhythmic function, where different samples may take care of different parts in the sequence, or it can specify an arrangement where different layers assigns to different frequency bands.
- *Theme preset* may consists of elements from a common sound source or a coherent group, such as bird sounds, a certain kind of percussive instrument, and a set of different sampled loops taken from one track of a record. This type of preset can be heard on both versions of Grey Zone. The SyncLooper is loaded with four different drum loops, one in each engine, and consists of basic rhythmic patterns performed on traditional drum-sets, the first two played with whispers, and the others with sticks.
- *Contrast preset* deals with grouped or single sound files that differ considerably in sonic character. A special character emerges by only playing one at time, and by shifting between them.
- *Imposed rhythmic behavior* on non-rhythmic sounds: on a sustained or decaying sound, such as a cymbal hit, a guitar chord, or a sung note, the segmentation and windowing mechanisms impose an even pulse. Furthermore, by applying random variation to playback order, tuning, and direction, an interesting rhythmic object may be heard.

- *Coloring* deals with elements of all kinds, where the effects play an important role. In this approach the player explores timbral qualities through extreme variations of pitch and duration.
- *Function and color* prescribe the use, for instance, of two basic groove elements that make up the character and basic rhythm, and two ancillary engines based on "noise", which add color.

Visual Appearance

The main window GUI of the SyncLooper provides controls for sample library operation, with links to sub windows containing individual loop engines and effects. Loop engine sub windows (see Figure 73 in the Appendix) show and allow simultaneous mouse control of available parameters. Each engine looks identical, but each controls its own set of parameters. Only one engine is active and controllable at a time, while passive engines are still visible. In play, it is only necessary to view and touch the main GUI when dealing with the sound library and effects settings; all other control is done through the gamepad controller. This means that all attention can be focused on interaction with fellow players and musical content.

THE WALKING MACHINE

The most idiomatic instrument in this work is the Walking Machine. Whenever present, a free jazz flavor pervades the entire improvisation. The Walking Machine started out as a push-button MIDI event generator, but has been further developed to use a probability distribution of intervals and durations for event generation. The design criterion for the Walking Machine describes a virtual rhythm section, consisting of double bass and ride cymbal. However, it is impossible to clarify what comes first, the musical idea or the tools itself. Experiments with Max/MSP, particularly the *prob* object, provided inspiration for this software. As discussed on page 191, the very first idea was to create a modal jazz melody generator,[243] but by mapping the MIDI stream to a bass sound, and with slight changes in the probability distribution setting, a walking bass line emerged. Through earlier extensive experimentation with various probability distributions, I was able to acquire a physical knowledge of the relation between different distributions and their musical outcome. When it came time to develop the Walking Machine, with its capability for real-time control of probability distributions, I already had a good habitual understanding of these relationships, which guided the design process and quickly gave me the ability to perform with this new instrument.

It is worth pointing out that I am neither a bass player, nor a drummer, despite some experience of playing the double bass in my youth. However, to be a saxophone player in a jazz context implies that I have cooperated with

243. *Probably Not* is presented on page 210.

many rhythm sections in a number of occasions over the course of years. This means that I have gained experience and knowledge, in how rhythm sections behave musically in different situations, insights into how they think and what they are doing. I have also encountered many rhythm sections by listening to records and attending concerts. With all this experience, I have developed a rhythm section aesthetic. Therefore my notion about playing the rhythm section relies on what I *think* they do as well as what I *like* them to do.

Playing the Instrument

The Walking Machine has three instrument modules: a walking bass generator, the Walker, and two SyncLooper engines. In playing the Walker one controls only the higher-level probability distribution of intervals and durations, while the software takes care of generation of single events. The Walker on its own does not produce a perceptible fixed meter, but rather a pulse train with randomly generated accents. Due to design considerations, only one of three modules of the Walking Machine can be actively played at a time, while the two other are either monitored or silent. This means that during a performance I intentionally shift focus between being a bass player and being a drummer, also keeping an eye on the two monitored instruments, if they are playing. At the moment the player switches to a different active event generator, e.g. from the Walker to a loop engine, the bass and the cymbal continue to play based on current settings. While the Walker plays automatically, it is possible to activate additional drums in the loop engines, either by introducing a distinctive groove and/or imposing percussive gestures and accents. One efficient way to create grooves with the SyncLooper is to select a noisy sound segment such as a hi-hat hit to be played throughout, and mix it together with a randomized drum loop in another loop engine. Once such a rhythmic platform is established, one can turn back to the Walker, and continue active interaction with the ensemble or perform a bass solo. An example of this feature can be heard on *Facing x*, at the start of the jazz walking section at 14′12″. A hi-hat segment of sampled loop is chosen to achieve this effect.

In real life, playing any instrument in a traditional rhythm section of bass and drums requires a great deal of physical effort from the players. In contrast neither the Walker nor the SyncLooper demand much physical effort at all, and the effort that is carried out is not proportional to the playing behavior elicited. The perceived connection between imagined and actual physical effort required to produce audible results is weak. This gap creates a feeling of uncertainty and "un-realness" that is an essential feature of the Walking

Machine. The instrument features an *action-sound connection* designed according to Jensenius (2007), that is, the mapping between the interface and the sound engine emulate no "natural" relations. As a consequence there is no significant difference with regards to physical effort whether I play sparsely rubato gestures or perform ultra fast steady walking bass grooves.

One of the great advantages, and a characteristic property of the Walking Machine, is that low-level event generation takes place within the instrument based on the performer's gestural behavior carried out on the controller, the Gamepad. By employing only four continuous controllers and two switches at a Gamepad controller, a rudimentary but functional jazz rhythm section is at the hands of one performer. The bass demands three high level parameters that control generation of new events: interval size, gravitation or central note, and duration, in addition to vibrato; the cymbal demands only one parameter, which is duration, and degree of density is controlled in off beat mode.

Therefore the feeling of performing with Walking Machine can be described as remote[244] or automatic; the lack of direct physical contact with the sounding body of the instrument results in no haptic feedback. Altogether, this means that the Walking Machine entails a more distant instrumental relation, and I claim that the process of controlling it is as much conceptualizing as playing. A factor that reinforces this tendency is the fact that one player may play and control the entire rhythm section simultaneously, and therefore is forced to be aware of the effect of the sum of all three instruments. At the same time, there is the feeling that one is fully in control of the instrument's behavior, which enhances direct interaction with fellow players.

Our traditional acoustic instruments, such as a saxophone, give a clear signal to the audience what to expect in terms of musical role and sound produced. In some sense, I also used to hide behind the saxophone! In comparison, the tiny little Gamepad controller feels a bit toyish. But during the course of a performance, as my involvement in the music deepens, such feelings disappear in favor of integration and assimilation that is comparable to performing on a saxophone, as described in the section of relations to the instrument (see page 11).

244. I will here refer to Smalley's (1997, p. 112) concept of surrogacy, which deals with perceived connection between a sound and its physical cause.

Interaction and Musical Roles

The Walking Machine affords a number of different playing behaviors and musical roles, providing grooves, gestural playing, and bass or drum solos, to mention the most important ones. It is possible to use the Walker alone, with or without the cymbal, together with the integrated SyncLooper, or playing the SyncLooper alone. The Walker features two aspects of walking bass, namely groove and gestures: groove is the steady stream of notes that makes up a rhythmic foundation, while direct gestures control generation of duration, intervals and pitches of successive events by means of selected probability distributions. The Walker does not allow its player to carry out chord changes, and therefore playing conventional jazz standards are not an option. Furthermore, it does not operate within metric boundaries; instead it produces an endless stream of events of different durations, with randomly generated accents, imposing additive rhythm. But when overlaid with output from one of the loop engines, this stream is likely to be perceived as an articulated 4/4-meter.

As soon as the Walking Machine is present it mediates and imposes a free jazz flavor, and regardless of context becomes a rhythmic touchstone. Listen to two short passages in Shadowing from ISCM with Beam Stone. The first starts at 3′39″, and the second at 4′32″. The Walking Machine performs a fast walking type of accompaniment, which undoubtedly conveys a free jazz flavor. A more elaborated example can be heard on Facing x. From 12′40″ until the end of the recording the Walking Machine makes up the basic identity of the piece, including providing the groove. I assert that the Walking Machine constructs a well-defined structural section in Facing x. When describing the predetermined form of the performance to bass player Janson, the last section was referred to as The Walking Machine section (regarding form matters see page 253).

As referred to in the discussion of inherent structures in pattern playing on page 204, the Walking Machine operates largely in its own musical space, free of absolute pitch control or fixed meter, wherein interaction is more about juxtaposition than integration. The shared context between co-musicians and the Walking Machine is mediated through a common basic pulse as well as through interaction based on gestural actions. It is also useful in the context of a common referent, such as a predetermined theme or a formal constraint such as a specified number of bars. Figure 58 shows the interaction flow where each musician behaves based on their individual knowledge base, their "secrets" so to speak, subordinated to the possible common referent and the unit pulse.

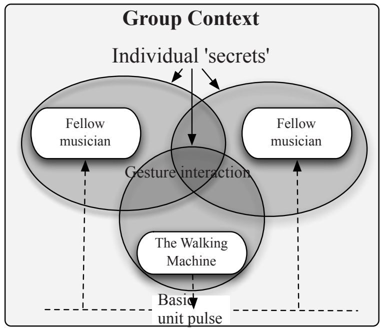

Figure 58: Interaction in an ensemble where the Walking Machine is used. It resembles the concepts of secrets in games and music presented on page 105.

The Walking Machine operates at the *mesa* level of music, that is, the gestural level.[245] A gesture, or phrase, that consists of several events is generated with one stroke of action on the interface. In this instrument the performer's discretion is focused on dealing with larger form structures; lower-level tasks such as producing single notes and keeping time is left to the machine.

Real and Perceived Degree of Freedom

The Walker features two modes for pitch generation, interval group, and preset distribution. (see further details on page 209). In most situations, when playing the Walker actively, the interval group probability distribution mode with variable skirt width (See Figure 44 on page 213) has turned out to work well. A relatively small skirt width facilitates more precise control of interval generation, while a wide skirt width affords a more general behavior as interval size only is only broadly specified, such as small or big. If skirt width is narrow, or a single interval is chosen, it allows more exact control such as chromatic runs and octave playing.[246]

245. Further discussed in Timescales in Music on page 132.
246. Octave bass is an idiomatic playing technique at the double bass. It is about to execute two notes one octave apart: the left index is placed on an arbitrarily note on one of the two lowest strings, E or A, and the little finger two steps up on the D or G string respectively, which gives a one octave interval. In this position it is facile to jump between octaves, and to sustain notes, and by moving the whole hand while keeping relative finger position, it is easy to change pitch while retaining identical playing behavior. A bass player that practices this technique is Charlie Haden, for instance heard on the record *Science Fiction* (Coleman, 1971).

The other mode, which deals with interpolation between presets of probability lists (see Figure 75 in the Appendix), is best suited to the situation where the Walker performs automatically based on the current setting. A preset list may be tailor made in advance in improvisations containing pre-determined references, and/or compositional elements. The Walking Machine is a highly idiomatic instrument, designed for a special sub-genre of jazz improvisation, and as long as an improvisation evolves within these constraints, the Walking Machine performs very well, and allows its player to interact dynamically with a good degree of expressivity with fellow musicians. In essence, outside of playing free jazz style walking bass, the available perceived or real degrees of freedom are quite restricted. In principle, choices are confined to selection of probability distribution mode.

Visual Appearance

The GUI of the Walking Machine contains three small windows that display the current distribution of bass intervals and durations, as well as the cymbal durations. The GUI also displays information about the current playing mode, and the current value of the gravitation note. In order to create and store new probability lists two different sub windows must be opened, one for each function. During play, it is not necessary to monitor the GUI, but the probability distribution windows do give feedback that the instrument is functioning properly, a valuable feature when silently preparing or checking the instrument before playing.

THE EXPRESSUREPAD

The ExpressurePad[247] family of instrument is used for sound improvisation and exploration of sonic spaces where control of exact musical pitch is a secondary consideration. It is possibly the most flexible instrument in this work; it offers a comprehensive dynamic mapping together with vector control of a high dimensional parameter space that offers seemingly unlimited possibilities to explore sonic spaces. Our main design rule states: "If we take our hands away, the instrument goes quiet", which implies that the audible output is a direct result of performed bodily gestures. This means that a rhythm, or pulse, has to be performed manually, and a dense texture takes real physical effort to achieve. In principle, a similar bodily action will give similar audible result,

247. exPressure Pad is designed and developed in cooperation with Palle Dahlstedt.

given that the position of controllers such as pressure and velocity scaling are similar. This means, in the short time scale, it is possible to repeat an action almost exactly, but there is no way to exactly recreate a sound arbitrarily. I do not consider this condition a drawback, rather the contrary, since our instrument offers challenge, surprise, and a sense of control at the same time. After several years of experience in various improvisational contexts with essentially the same instrumental design, from solo playing to larger ensembles, we have not yet "hit a wall" and gotten bored. On the one hand, it is a rich and full-blown musical instrument compatible in complexity and expressivity with a traditional acoustic instrument, at least within a musical context that can take advantage of its features. On the other hand, though, it is a highly limited instrument, particularly in pitch-based contexts, or even when repeatability or full control is required. It is a demanding instrument, and regular practice is required to maintain playing skills, and to develop its expressive capabilities. A performer does not always know exactly what to expect from a particular action, and therefore aural feedback plays an important role in getting a handle on its responsive behavior and audible result.[248] This means that proportionally huge amount of attention must be paid to aural feedback, sometimes to the extent that it might overshadow interaction with other players. Further down in this chapter I present and discuss solo playing with the exPressure Pad in conjunction to an experiment on the DVD, My Funny Valentine.

Playing the Instrument

Playing the exPressure Pad is easy: press arbitrarily a number of pads, listen to the result, and from there explore the surroundings by further "kneading" the pads being pressed. By scaling the sensitivity with designated knobs, the size of the searchable space of timbre modification is controlled. Another noteworthy feature is the possibility to intentionally shift the origin of the vector space: when encountering an interesting area in the sonic space, worth deeper exploration, tap on pad no. sixteen (reset in Figure 60) on the interface, and from then on the selected point defines a new origin. By pressing the same button, to its full value, the origin resets to zero.

The implemented mapping allows control and exploration of timbre in a number of ways: if vector scaling is high, it affords exploration of a high

248. Audible feedback is important on all instruments, but most likely basic pitch and dynamic are anticipated and pre-determined by position of engaged fingers and planned physical effort.

dimensional parameter space, leading to highly dynamic gestures. The player can play one controller pad alone, or play different ones simultaneously with all ten fingers.

Downscaling of vectors allows more subtle timbral control, such as carrying out rhythmic figures on a single pad, while pressing additional controllers to add timbral variation. By engaging, or overlapping, two groups of controllers crosswise, complex trajectories may occur. Vectors can be negative as well, and as a consequence some pads may work in opposition to others, damping or even muting timbral components increased by others. This creates a rich array of timbral possibilities that can be explored musically. One important feature in the design is the ability to re-randomize all vectors. The result is similar to re-arranging the furniture in an apartment: the contents are still the same but all the spatial relations are different. In such a case subspaces previously positioned far from each other may appear in close proximity, or vice versa, which results in an instrument that feels new, fresh, and familiar all at the same time.

A number of designated knobs and faders directly control parameters that deal with sound morphology, which allows the performer to operate in a continuum from very short un-pitched clicks, to plucked string-type of sounds and sounds with a long decay. Combined with direct control of noise content and oscillator waveform, which also are affected by the vector mapping, the performer has a huge variety of playing behaviors at his disposal. The velocity decay control, if set to a long value, affords a dialogue with itself: first building up a sound by the playing of the pads, and secondly, when the hands are lifted off the control surface, the slow decay of the sound can be heard. Direct control parameters turn out to be very important with respect to playability and instrumental fitness in various contexts.

The direct mapping of effort to sound production means that it require a proportionally great amount of physical effort to perform a full concert on the exPressure Pad, which, in my opinion is one of the best qualities of the instrument. On the track *Shuffle* on the DVD, duo pantoMorf demonstrates a variety of playing techniques I will discuss below.

Interaction and Musical Roles

In many ways, the exPressure Pad is comparable to an acoustic instrument since it supports similar types of interaction and musical roles, such as direct gestural interaction, soloist – accompaniment and others. Direct gestural interaction can be heard on Angle of Repose with Beam Stone. At the opening, I first play a phrase on the exPressure Pad, then go silent for about 15 seconds, and then percussionist Strid makes his first move at 0′16″. From there, we perform in dialogue until 1′21″ when I switch to an accompaniment role by playing a semi stable drone that lasts until 2′51″. In another example, in Facing x, a "blip" at 7′40″ marks the start of a dialogue with bass player Janson, while some other instruments, notably the Granular Machine and the Groover2, generate an ambient layer with sounds derived from Janson's bass.

The exPressure Pad is good at imitating sounds. During a duo improvisation, for example, the fellow player may suddenly change what they're doing, from, say, long and low pitched notes into outbursts of noisy clicks. If I decide to mimic or track what they are doing, I make an estimation of the most salient sonic characteristics and adjust parameters accordingly. I may set the morphology parameters to produce a short click sound; then set pitch offset to a suitable value, adjust the amount of frequency modulation to set the degree of noisiness in my voice, and finally adapt my manner of playing on the pads to be appropriate for all these new settings.

Another set of roles is the soloing/accompaniment relation. Two examples occur in Shuffle with duo pantoMorf. The first occasion is at 2′41″ where I start to play atonal melodies, while Dahlstedt performs a shuffle like accompaniment, and at 6′00″, where I start a groove, a rhythmic pattern that may function as an accompaniment figure to Dahlstedt's playing, and eventually sets up the transition to the end of the section.

An alternative solution is to create contrast with respect to the other musician's activity. One example on the DVD appears at 3′42″, when I start a fast pulse, and eventually Dahlstedt hook up with a similar sonic identity and behavior. It is feasible to say that the music of duo pantoMorf is as much about exploring possibilities of the instrument itself, the instrument as a field of possibilities, as it is about the composition and the interaction between participating musicians.

Real and Perceived Degree of Freedom

The aim of the design of the exPressure Pad is primarily as a tool for sound improvisation, and in such contexts it gives the performer many possibilities to meet emerging situations, and offers a great deal of freedom to its player. I claim that possible choices in a given situation depend as much on a player's skill as upon features of the instrument. Its huge sonic palette runs a spectrum from noisy explosive outbursts, to plastic timbres, to subtle blips and clicks. This means that both the perceived degree of freedom, and real freedom is big. Not surprisingly, in contexts where subtle control of absolute pitches is mandatory it performs less well; e.g. idiomatic jazz type improvisation over an advanced functional harmony framework is not in the range of possibilities.

However, during the course of the years I have participated in many situations where tonal improvisation was at the forefront, and most often there have always been meaningful choices available. In such situations, the instrument's capability for rudimentary control of pitches has turned out to be a valuable feature. This has meant that I could chose to join fellow musicians deliberately, and not restrict myself to producing contrasting material, which often is the limited case available when laptop and jazz musicians meet. For instance, it is feasible to hook up with a bass figure, playing simple melodies, producing a tonal drone, or creating a second contrasting melody line. Despite the fact that tonal playing is not a main feature of the exPressure Pad, it can play a role in such musical contexts. The exPressure Pad is the featured instrument in an experiment where I perform the jazz standard My Funny Valentine, which I present further down in this chapter.

Visual Appearance

In contrast to other instruments in this work, the exPressure Pad engine resides within a designated synthesizer module, the Nord Modular by Clavia. Therefore during performances there is no GUI available; the only thing to see is the Trigger Finger controller. This means that the need for the player to do any visual monitoring is small, in principle limited to occasionally checking on current global values, such as pitch offset and modulation.

CONTROL INSTRUMENTS

In this section, I briefly pinpoint examples involving two additional instruments, the Groover2 and the FourToThree. Since these instruments operate solely in *controlling mode*, they fall under the *control instrument* category. In controlling mode, the instrument generates its output independent of context; it performs blindly, despite the fact that it provides real-time control of musical parameters. Such an instrument may influence musical output of the entire group largely. This is not surprising; given that controlling mode does not feature direct gestural control, and therefore does not allows direct gestural interaction with fellow players.

One such an example can be heard on *Facing x*, from the start until 5′00″. During this part of the performance, the instrument of choice is the Groover2, the asynchronous loop player. The Groover2 is designed primarily to create minimalist inspired repetitive structures (see page 65) based on live sampling. In this passage, bass player Peter Janson adapts his playing to the sonic textures the Groover2 generates, all of which are based on samples of Janson's own playing, previously recorded on the spot during the course of the improvisation. A special function on the Groover2 allows its player to instantaneously alters the setting of all or an individual loop, while the new parameter settings are randomly generated at each new change command. This means that neither the fellow player nor I are in full control of emergent sonic textures, which indeed is a main aesthetic idea of this instrument. A similar function is at work in the FourToThree module. This instrument can have different functions depending on the sonic content and parameter settings. Listening to Facing x again, in the last three minutes FoutToThree generates the ubiquitous ride cymbal, which creates a jazz flavor; a steady up beat groove that have a significant impact on the musical output.

Another example with the FourToThree can be heard on Angle of Repos with Beam Stone, from 4′16″to ca. 6′00″. A low irregular bassline changes the mood of the improvisation entirely. Consequently, the FourToThree creates an independent sonic layer, insensitive to the current identity. In this case, the instrument performs automatically; I do not tweak any parameters. Sonic content and parameter settings were prepared privately in advance before the concert, comparable to having a secret in a game (see page 105). This means that I knew what might happen, but fellow players did not. I argue that the irregular bassline has the same impact as performing a composition of mine, that for a while it defines the identity of the musical output. Since the current parameter setting and sample is memorized at the instrument, it is also possible to repeat this behavior at another performance.

Both these examples emphasize the idea that computer technology provides an empty structure, and that just by changing sonic content and parameter settings, the musical function and meaning of this particular instrument changes significantly.

Experiments

BACKGROUND TO THE EXPERIMENTS

In this section, I present two experiments; two solo pieces that make use of material related to the jazz tradition. The pieces are *Davis Deconstructed* and *My Funny Valentine*. A common denominator for both experiments is the music of Miles Davis; it is a personal tribute and homage, and in the case of Davis Deconstructed, an homage to drummer Al Foster as well. Both pieces have been performed in public concerts,[249] but the materials presented here are recorded live in the studio. What are these experiments about? In both cases, the task undertaken is to explore and present familiar musical material, performed with a selected number of the instruments under discussion in this work. One hypothesis in these experiments is that the musical impact and identity of the employed digital musical instruments can be heard and revealed clearly in relation to existing and familiar material. Another is to make up a contextual dialogical space between an instrument and its player by utilizing well-known material as a referent. The first experiment utilizes a pre-existing sound file, a two bar excerpt that is de-constructed and subsequently re-constructed. The second experiment takes the standard jazz tune My Funny Valentine by Richard Rogers and Lorenz Hart in Miles Davis's (1965) version as a point of departure, on an instrument originally not intended for tonal melodic playing.

DAVIS DECONSTRUCTED

In this experiment, an excerpt from the Miles Davis record *Get Up With It* (Davis 1974) provides sonic content.[250] A two bar sample is taken from the piece *I Love Him Madly*, which is reported to be a tribute to Duke Ellington, who died shortly before the actual recording session, which took place in June 1974. This particular recording is more than thirty minutes long, and stands out in relation to the often highly energetic music of Miles in this period, since its mood is sparse, meditative, and laid back. The recording features

249. Davis Deconstructed was premiered at the ICMC (International Computer Music Conference) in Miami in November 2004. (www.computermusic.org). My Funny Valentine was performed at the Academy of Music and Drama at University of Gothenburg in March 2009.

250. Also included on the enclosed DVD is a demonstration of Davis Deconstructed, where I present the software that was used and guide the viewer through the piece.

an alto flute solo by Dave Liedman with extensive use of delay/echo, the Teo One device mentioned previously, in addition to solos by Davis. However, what intrigues me the most in this recording is the interplay in the rhythm section, that is, bass player Michael Henderson, drummer Al Foster, percussionist James Mtume, and guitar players Peter Cosey, Dominque Gaumont, and Reggie Lucas. Therefore, the two bar sample I used consists only of the rhythm section, which is basically made up of three distinctive layers of timbres, electric bass, drums, and guitar. The main driving force in I Love Him Madly is without doubt the drum work of Foster, particularly the snare drum, which he plays very sparsely. By means of time displacements of individual hits and accents at the snare drum, Foster continuously varies the rhythmic weight of the basic groove, which induces energy to the piece. Henderson's bass mostly marks down beats and making up a tonic center, while the guitar, I believe Gaumont, mostly adds color as well as creating complementary melodic lines. The sample is taken approximately 10 minutes into the piece, and consists of a straight ahead drum pattern, a C in the bass, a C minor chord, and a gesture on the guitar (Figure 59).

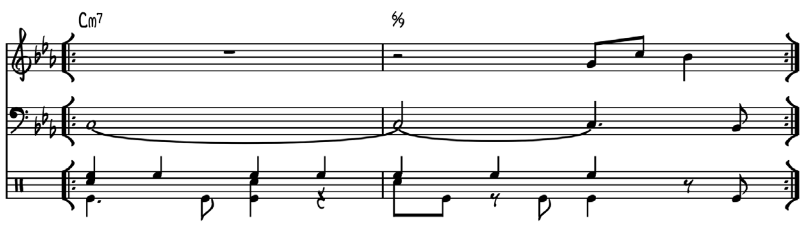

Figure 59: The principal basic groove of the sample utilized in Davis Deconstructed. Staves shown, from top, are guitar, bass and drums (hi-hat, snare drum, and bass drum).

In Davis Deconstructed principally three instrument modules are used: the SyncLooper, the FourToThree, and the Granular Machine, in addition, audio effects such as echo and reverb play a decisive role as well.[251] The driving rhythmic force in Davis Deconstructed is carried out with the SyncLooper and the FourToThree in parallel, while the Granular Machine adds color and to a certain extent emphasizes down beats, which were important in Davis's music at the time.

251. An in-depth presentation of the instrument utilized can be found in the Instrument chapter.

Davis Deconstructed is built upon and relies on the SyncLooper's modus operandi of chopping a sound file in segments of equal length to be tuned individually and re-ordered arbitrarily. All operations were carried out with the mouse in the GUI. The reverb is set to medium length, approximately 1.5 seconds, the delay is set to produce quarter notes triplets with respect to global tempo, and the multitap produces sixteen evenly distributed taps, approximately 100 ms apart, in order to emulate a drum roll.

The FourToThree module is used entirely as a snare drum emulation, in an attempt to emulate Foster's playing. From the principal sonic object, the two bar loop, one single hit from Foster's snare drum is cut out by practicing *stress-articulation*, which in turn constitutes a new sonic object.[252] Basically, ThreeToFour uses two engines that may arbitrarily divide a measure from one to sixteen events of equal length utilizing a common sonic object. In Davis Deconstructed, one fundamental rhythmic relation, two against three, is used in various preset variations on the FourToThree instrument. In order to create variation, each third event of the triplet stream is omitted; in addition the *veladd* application (see page 43) creates randomly generated accents in the event stream.

Finally, the Granular Machine utilizes the snare drum sample as well, but it merely adds sonic color. One of the Granular Machine's features is to vary playback speed and pitch transposition independent of each other. In this particular setting, the snare drum sample is slightly down-transposed and time stretched to fit the length of the two bar cycle, and it aims to put emphasizes on the one-beat in addition to providing color. According to Schaffer's typology (see page 145), a percussive hit is classified as impulsive, a short burst of energy that quickly decays. When stretched in time it is still very strong initially, and then slowly decays. The windowing function in the Granular Machine causes a buzzing sound,[253] particularly in time stretching settings. I do not regard this a major drawback, however: this coloring is part of the sonic identity of my instrument.

252. Stress-articulation takes natural discontinuities into account when cutting out a new sonic object. Sonic objects are discussed on page 139.

253. Windowing is used in conjunction to sound processing techniques based on overlapping successive short segments, e.g. granular synthesis, in order to avoid clicks. Discussed further on page 191.

Practicing, Preparing, and Playing

As I discuss previously (see page 281), scrutinizing and experimenting with samples is an essential part of the practice routines for many of the instruments discussed in this work. My personal sample library comprises a jazz archive consisting of samples taken from different jazz records, and since I like *I Love Him Madly*, probably because its meditative and ambiguous character, I started to investigate the chosen sample more carefully. Practicing Davis Deconstructed consists of playing the chosen sound file with the available instruments, as a means to internalize its inherent properties. In a piece like this that employs controlling mode, practicing involves memorizing the sequence of all necessary actions to undertake. In addition to the SyncLooper, the FourToThree plays a central role in groove building, but this instrument is semi-automatic in operation, and performing with it means dealing with the selection of presets from pre-stored lists of parameter settings. Therefore, I spent a large amount of practice time in experimenting with different samples and combinations of samples. Before a live performance a great deal of technical preparation has to be undertaken: loading samples, "zeroing" the SyncLooper, manually setting playback parameters on the Granular Machine, and selecting preset numbers on the FourToThree. Generally speaking, it is more about being mentally prepared than physically fit.

A performance of Davis Deconstructed, in essence, means engaging in a predetermined sequence of actions. Davis Deconstructed starts in a void, and gradually the piece builds up in a stepwise fashion. The first sound we hear is a hit from the bass drum that repeats at the one-beat of each second bar, and after a couple of bars an echo effect adds quarter note triplets to the bass drum, which results in a two against three pattern. Gradually, more sound segments add in, with additional effects, notably reverb and more delays. Eventually, the FourToThree enters, first with straight quarter notes that contrast with the triplets caused by the integrated delay effect within the SyncLooper. Eventually a secondary loop engine is activated, which adds contrast in color and groove, another preset on the FourToThree adds triplets, and the Granular Machine addes the time stretched snare drum. In a real-time performance situation, after performing the composed opening, it becomes about playing[254] with the digital musical instruments, like a painter that picks colors from a palette in order to create a image; in this case, an aural image.

254. In the sense of playing with toys.

Conclusion of the Experiment

As the instrument designer and sound provider, at design time I determine a field of possibilities, which confines possible output. In performance, I actualize the possibilities by exploring both the instruments and sonic object of choice. Several musical structures superimpose: the sound file and the note-to-note procedures implemented in instruments employed. A digital musical instruments can be regarded an empty frame, or an empty structure, while chosen sonic objects contain another structure, as seen on the provided note example for instance. One essential feature in the SyncLooper may be described as deconstruction – reconstruction: it is feasible to state that simply by loading a file into the software it is deconstructed, whereas playback is an act of reconstruction. With another sample, while retaining identical processing, the musical outcome would certainly be different, but a great deal of identity would probably remains. The situation also implies a dialogical relation between, on the one hand instrument properties, and on the other utilized sonic material. As performer, I can only do what my instrument allows me to, while the sonic output of any action consists of material from the sample, however deconstructed, and reconstructed based on structural properties in my instruments.

MY FUNNY VALENTINE

In this experiment, I perform the jazz standard *My Funny Valentine* with the exPressure Pad, and in addition utilize the effect processor TimeFactor (see page 230) to generate secondary voices. I undertook this experiment to satisfy my curiosity and to challenge myself to perform a jazz standard using the exPressure Pad's built-in abilities to play chromatic scales. My Funny Valentine was chosen deliberately and for several reasons. First, I have played it numerous of times on the saxophone, and therefore know it quite well. Secondly, the mood of the song is quite open and ambiguous, almost modal, which allows a great deal of freedom in relation to the underlying harmonic structure. Thirdly, the range of the melody is not particularly great, which was necessary for a tune to be playable on the exPressure Pad. Initially, this instrument was not intended for tonal playing; rather it aims to explore and control complex electronic sound spaces in improvisation.[255]

255. This sentence is taken from the design criteria that Palle Dahlstedt and I specified for the exPressure Pad.

The additive pitch system, discussed on page 215, was added at a relatively late stage in the design process, after we realized that pitch had to be treated differently than the timbral parameters, such as the filter coefficients and frequency modulation index. In duo pantoMorf performances preceding this experiment, we explored tonal elements occasionally, such as repeating short melodic sequences, bass figures, or atonal pseudo-serial melody lines, but without control over the absolute pitches (meaning that this was not repeatable in subsequent performances). Some of these explorations can be seen and heard on the duo pantoMorf track *Shuffle* included on the DVD.

In private rehearsals we used to challenge each other by playing diatonic scales, little melodies, and tonal sequences. Although none of this work made its way outside the practice room, still the idea to perform a well-known piece of music started to grow. The version included on the DVD was recorded live in the studio, and is somewhat shorter than the first concert performance, but the musical form and instruments utilized in these two performances are identical.

Practicing, Preparing, and Playing

The lowest note of My Funny Valentine is its first note; therefore, it seems obvious to start at the pad situated at lower left bottom, which would allow the greatest possible pitch range. In order to perform in a particular key, and given that the exPressure Pad originally only supported relative pitches, it was necessary to define a fixed mapping between pads and MIDI note numbers. The key of choice became C minor/Eb major, despite that fact that A minor/C major is a possibly more common key, at least among female singers, probably because A minor lies in a more comfortable tessitura for many of them. Figure 60 shows the current mapping of pitches at the Trigger Finger interface.

Figure **60**: Trigger Finger, the exPressure Pad interface with My Funny Valentine mapping.

The highest note on My Funny Valentine is Eb/D#, which seems to exceed the possible pitch range on the instrument, but the implemented additive pitch system overrides this limitation. Pressing low C, transposes all pitches one semitone up, and pressing C# transposes all pitches two semitones, etc. In order to reach the high Eb, one must press both low C and the high D simultaneously. This can be seen on the video at 1′31″. Two mid-placed sliders (B, C) control tuning of oscillator one and two respectively. The leftmost slider (A) re-scales the interval between adjacent pads: the maximum position sets the interval to one semitone, a mid-position to one quartertone, while at the lowest position all pads give the same pitch. In order to make the instrument to support simple and reliable absolute tuning as shown at Figure 60, the pitch mechanism is slightly modified compared to the previous design: when pitch control of oscillator one (B) is set to the maximum position, and slider (A) to maximum as well, the instrument is chromatic and automatically tuned "in C". Slider (C), the pitch control of oscillator two, allows chromatic transposition, which affords experimentation with voicing, such as playing in parallel thirds or fourths.

In order to expand the sonic palette and to allow interaction with a virtual secondary voice (see page 272) I used an external effect processor, the TimeFactor (see page 230). In this context, the effect performs three tasks: providing a dialogical partner, producing complementary sonic layers, and creating an accompaniment. The virtual dialogical partner operates on a gestural time level, processing and playing back sonic material continuously, based on the instrument's algorithm and current settings. The "complementary sonic layers" are textures that are relatively static and independent from the main voice, even though they too were originally created using the ex-Pressure Pad. Finally, the built-in looper function within TimeFactor can create accompaniment sequences on the spot. The planned performance of My Funny Valentine demanded deliberate practice controlling particular effect algorithms, and, given that TimeFactor allows only one effect program to be active at a time, the sequence of employed effect programs had to be tested out as well.

In contrast to other recent performances, I made up a pre-determined musical form, although leaving a lot of room for freedom in the form. I rejected the idea of improvising within the jazz idiom, however I did follow the traditional jazz format of starting with the melody, following with an improvised solo, and ending by repeating the melody. During the straightforward melody presentation, the *duck delay* of the TimeFactor instrument is employed. In essence, this is a stereo echo effect where the output from the effect is muted as long as audio is present on its input. This means that during the melody presentation, we hear the effect only in the pauses between phrases, when the main instrument is silent. This effect aims to reinforce sonic identity and acts contrapuntally to the melody. Occasionally, the effect works in freeze mode, which turns it into a quasi-static sonic layer, ignoring the signal at its input. Listen at 0′29″, at the beginning of the second A section, where the effect makes up a sonic layer in parallel to the melody. Another example can be heard at the end of the second A section, starting at 0′44″, where the high C from the melody sustains throughout the bridge.

The improvisation section did not have a predefined content or form; rather, I allow myself the freedom to do whatever comes to mind during the course of the performance. The sequence of effect algorithms used in the TimeFactor, as I have already touched upon are determined beforehand, framing the improvisation. After the initial ducked delay effect during the melody presentation, I utilize the *multi tap* effect during the improvisation. The multi tap affords generation of ambient, almost reverb type textures, one example of which appears in the section with short, click-type sounds, starting approximately at 2′22″. In the DVD version, I do not completely leave the realm of My Funny Valentine during the improvisation, but at times, no direct reference to it can be heard. At the end of the improvisation, a long sustained note is held on the interface, the low C, a pre-determined action. Its purpose is to "mask out" or mark time, allowing the music to continue while I change effect program into the looper program (done at 3′03″). At 3′16″ the loop recording starts, and I perform a short sequence based on the three first notes of the melody, C, D, Eb with octaves added in between.[256] After finishing the recording, the sequence starts to repeat itself, transposed one octave down, and subsequently is played back at half the original speed. From here on throughout the piece, the loop is unchanged, and functions as a rhythmically independent, but tonally related accompaniment.

Conclusion of the Experiment

How did this experiment turn out? What did I learn? On a personal aesthetic level I am satisfied with this performance, despite that fact that the exPressure Pad design does not particularly suit this kind of music making. Indeed, I believe this limitation contributes to making the recording interesting. One factor is resistance: at a physical level this instrument requires a relatively small amount of effort to play, since it does not involves tone production, just control. On many digital musical instruments, the physical effort required is similar, whether playing soft harmonic sounds or high energetic noisy sounds, while on acoustic instruments this is never the case. I regard the exPressure Pad as a middle way in this respect: strong and complex sounds require increased pressure, and sometimes the engagement of more pads. Still, the physical effort needed to play this instrument is by no means comparable to that required on the saxophone, for instance. As far as instrumental technique goes, saxophone skills are not directly transferable to the exPressure Pad. Figuring out and playing a straight scale or any other predetermined tonal pattern requires a great deal of conscious thinking and resistance. It feels very awkward and clumsy, like being a beginner. Playing a melody is one thing; another, and much more demanding one, is idiomatic jazz improvisation. It may be possible to learn to master the exPressure Pad instrument at such a level of tonal control, but I can see no use in doing so, since it would be much more convenient to use a normal keyboard, or, in my case, a digital wind controller to play the instrument in this manner. In fact, Palle Dahlstedt has made versions for this purpose for keyboard and mallet instruments, and a wind controller is on its way. At the beginning of the improvisation, I try out some tonal playing, but very early on I make a "wrong mistake", which

256. I made a mistake in the last note of the sequence, adding an unwanted lower extra note which became part of the accompaniment.

is difficult to mask out and contextualize, and therefore I quickly move into non-idiomatic sound improvisation. Towards the end of the improvisation I do "things I usually do" on my instrument, in this case electronic sound improvisation. (I assume many jazz solos are played the same way, with the soloists playing what they are accustomed to playing).

After doing this experiment, I have retained the absolute tuning feature, and at times, when performing with acoustic musicians, it has turned out to be valuable to be able to produce a particular pitch at will. This ability increases the number of possible contexts in which one can fit in with acoustic instruments. Furthermore, the discovery of playing melodies on this instrument has given birth to new experiments in this direction. One example is a performance in Lisbon in 2010, where I played Joe Zawinul's piece *In a Silent Way* accompanying a silent movie projection. The recorded performance of My Funny Valentine is an experimental fusion of jazz, free improvisation, and electronic music practices. Miles Davis's music, both his ballad playing in his version of this song, (Davis 1964), and his use of delay devices, for instance in Bitches Brew (Davis 1970) have been direct influences on this work. One particular influence from experimental music is the Click Piece by John Stevens, presented on page 112, and electronic music practices discovered within the exPressure Pad itself.

Concluding Discussion

In this concluding section I will present, recapitulate, and reflect upon my findings in this research project, while the closing paragraphs summarize my contribution to the research field of interaction design, and some suggestions for further research based on this project. In this work, I demonstrate that a specially-designed digital musical instrument can direct and influence the outcome of a musical improvisation to various degrees depending on the context. I see a parallel in this regard to the impact of the individual members in improvising groups in general: sometimes one individual has a significant influence, whereas at other times their work recedes into the background.

In the instruments discussed in this work, I have implemented musical concepts and ideas I find interesting and important. One could say that these instruments mirror and mediate my taste. Undoubtedly, the designs aim to create instruments suitable for ensemble, and occasionally, solo improvisation. The work is concerned with expanding the field of musical possibilities through the exploitation and exploration of digital technology, rather than mimicking existing musical instruments. Almost incidentally, designing and playing my own instruments has helped me to discover, understand, and conceptualize my own musical knowledge and taste as well.

I want to emphasize the difference between *design time* and *play time* activities (see page 27). My digital musical instruments are the fruit of efforts made at design time. Activities at design time are processes wherein the conscious mind articulates, monitors and evaluates. Design time work includes tedious design/development process, the stepwise process that includes the expression of ideas and criteria descriptions, conceptualizing functional modules, implementation into code, and the testing, evaluation, adjustment, and refinement of this code. Composing music is another example of activity at design time, work which aims to control others' future activities at play time. In practicing a musical instrument, another design time activity, intentional focus is directed towards different aspects such as tuning, scales and pattern playing, and sound production, rather than producing artistic output. And for the improvising musician, practicing "in the shed" is about achieving the playing skills needed for improvisation. In essence, all activity during design time aims to prepare for future activity in play time.

Play time is to be in the moment, the now, to be in the midst of the flux of time, to act and re-act with the body, and to think with the body. One major point of this work, which aims to frame play, equates music improvisation with playing games and doing sports. Accordingly, I do not regard music experiences as aesthetically superior to games and sports. Rather, with support from Gadamer, Huizinga, and various game designers, I claim that play in all forms mirrors aspects of being a human, and of relations in life. From this point of view, a cycle race may offer as much aesthetic values as a concert, despite the fact that they offer different experiences, and subsequently have to be judged differently. To be a competitive cyclist, in addition to building necessary physical strength, one must accumulate knowledge to handle emergent situations that might occur within the framework of the sport. I here refer to the Swiss bicycle road-racing champion Fabian Cancellara, the favorite in *De Ronde van Vlaanderen* in 2011,[257] which is one of the five big one-day races in the sport. In an interview two days before the race, a journalist proposed to Cancellara that he has demonstrated his improvisational skills by winning in a number of different situations:

> For me, it's however it comes, I know what it is to jump from the front, or from behind, step by step like last week. I know how it is when you're alone in front, or when there are two of you. I know a lot of different scenarios. I think I can say that maybe I could have a perfect scenario with whatever comes my way because I know how to handle all situations. But still, it's one day that's going to decide this race and nothing else. What you've done before is important but now it's 260 km that are going to decide the race (Cancellara, 2011).[258]

As Cancellara states: it is one day that matters and nothing else, what has been before is only important in terms of experience and acquired knowledge. A bicycle race is an event with an unpredictable outcome that takes place within the frame of a fixed set of predetermined rules and a particular goal, which makes up its set of initial conditions. Cancellara points out a number of different thinkable scenarios he must prepare for: to go alone, to attack from the front or from the back, to be two cyclists in an escape, etc. In addition to fixed factors such as the racecourse, there are many random factors

257. The Tour of Flanders is considered one of the five so-called monuments in road cycling, and is held the first Sunday of April each year. In the 2011 edition the major pre-race favorite Fabian Cancellara did not manage to win, however he did finish third, behind the Belgian rider Nick Nuyens, and Sylvain Chavanell of France.
258. By Barry Ryan Published: April 1, 20:47, Updated: April 1, 23:49 Edition: First Edition Cycling News, Saturday, April 2, 2011. Race: Tour of Flanders. www.cyclingnews.com (April 2011).

that may influence the outcome as well, the weather, a puncture, or a crash, which altogether make it impossible to predict the outcome of a race in advance. Rather, the athlete who has the greatest improvising skills to meet and handle emerging obstacles and possibilities will have the greatest chances to win.[259] I claim that a winner has embodied this kind of knowledge, that there is no time to think, and one has to react and act with the body. Despite their unpredictability, most things that actually happen will be within a frame of possible outcomes, in cycling as well as in music improvisation. A be-bop musician has to know a great number of tunes and how to improvise in functional harmony, while a free improviser must be able to deal with extended playing techniques, noise, silences or whatever else might appear during the course of an improvisation. As I see it, a genre or a musical tradition provides a general framework to operate within, while the identity of a particular improvising ensemble, as discussed previously, is the result of negotiations between participating members, culminating in a set of rules and a desired music behavior and outcome.

As I have previously stated, musical instrument shapes playing as much as its player plays it. However, in my instruments, qualities are deliberately created at design time according to my personal taste. Therefore, one could say that my influence is two-fold, as instrument designer and as participating musician on that particular instrument. In a solo situation the instrument constitutes the context as well as completely delimiting the possible musical outcome. As a performer in such a situation, what I do is to interact with the instrument alone, while at the same time the perceived affordances of the instrument direct and guide the playing to a great extent. Figure 61 shows that personal aesthetics influence the musical output in many ways; most notably the choice of instruments, playing behavior, and context.

259. It is worth noting that: in reality, very few cyclists have the physical and mental capacity to win those great races.

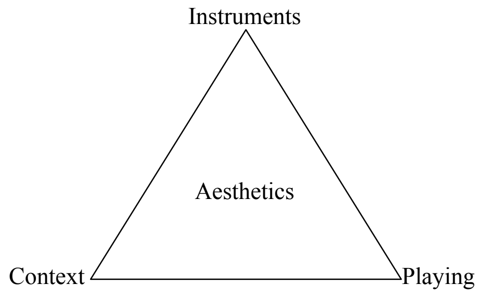

Figure 61: I assume aesthetic influence is multifold. My research shows that subjective aesthetics can be realized in the design of digital instruments, and I claim that the mere presence of such instruments may have impact on playing behavior, interaction, and musical output when used in context.

A cornerstone of this work is the idea of self-organizational music making: the music forms itself as a consequence of initial conditions, applied rules, and goals. At play time, however, what actually happens is not haphazard; rather, it depends on deliberate choices and efforts made at design time, which directly and indirectly guide the playing behavior and interaction within an ensemble. This point of view relates to concepts about chaotic dynamic systems, wherein a small change in initial conditions may have big consequences in output.[260] However, the main interest and focus of this work is on looking at the affordances available in actual conditions, rather than mere systems theory. Perceived affordances of the instrument employed direct playing behavior and the quality of interaction. Similarly, perceived affordances in applied music rules shape the play and interaction between participant players in an improvisation as well. With all acoustic instrument improvisations the hardware is fixed, since those instruments are locked by design. In situations where digital musical instruments are involved, there is one additional open factor: a digital musical instrument might change in

260. Borgo (2007) discusses chaotic and dynamic systems in *Sync or Swarm*. Furthermore, Marcel Cobussen, Henrik Frisk, and Bart Weijland (2010) touch upon similar ideas in their common paper *The Field of Musical Improvisation*. http://musicalimprovisation.free.fr (October 2011). However, it is beyond the scope in this work to make an in-depth investigation in subject matter.

design, or new ones might be invented. By developing new instruments, and by deliberately implementing desired aesthetic qualities at design time, it is possible to direct and guide the musical outcome in subsequent improvisations at play time. It is possible to customize an instrument to have a certain behavior that is unavailable on an acoustic instrument.

Contribution and Further Research

MY CONTRIBUTION

What is my contribution to the field of research in this work? I show that concepts from the field of interaction design applied to music open up new possibilities for analysis and music making. First, it allows analysis of music from the players' point of view, rather than taking a composition as point of departure. Secondly, it shows alternative ways of controlling the musical result. Any design time determinations, such as notated compositions, open scores, melodic/harmonic structures, verbal and tacit agreements, instrument design, etc. give rise in play time to certain behavior and interaction patterns between participating musicians. My research shows examples of the implementation of subjective aesthetics within the design of digital instruments, and I argue that the presence of such instruments in improvisation may have an impact on playing behavior, interaction, and musical output. One could say that designing instruments is similar to composing music at the meso time level, since this process is concerned with creating short-term musical structures and note-to-note-procedures. However, larger musical forms, partly or completely unknown at first, emerge and organize themselves during the course of playing. In the midst of an improvisation, all the attention of a player is on interacting with fellow players and on musical output, with and through the instrument. Nevertheless, inherent properties in the chosen instrument delimit what I can and cannot do, and these properties significantly influence the possible interactions, and consequently, the musical result. Since I am both designer *and* player of the employed instrument, I assume my influence is multifold. My notion also implies that the conception of the musical work vanishes, since the music emerges out of given conditions in real-time rather than interpreting and giving life to a preformed idea.[261] These conditions are a field of possibilities that are actualized at a singular performance.

The field of interaction design is a new discipline that combines concepts from traditional industrial design and architecture with methods for observation and analysis from the field of Human Computer Interaction and experimental psychology. In her thesis *Teaching and Learning Aesthetics of Interaction*, interaction designer Lundgren (2010) frames interaction design:

261. In Swedish I would have say to "gestalt" a preformed idea.

> Being the art of inventing, and designing the interaction of and with interactive artifacts (such as computers, cellphones, interactive toys, computer games, etc.) its focus lies upon design, design processes and rationales for design, however utilizing methods for observation and analysis, as well as design guidelines firstly developed and used by the Human Computer Interaction-community. As such, it is an interdisciplinary subject, drawing from computer science, information technology, electronics, informatics, cognitive science, psychology, graphic design, industrial design and a handful other subjects. (p. 15).

Interaction design deals with the interaction between a user and computer-based artifacts that aims to solve well-defined problems or tasks. Examples of such tasks might be printing from the desktop, making telephone calls, selecting and storing channels on the TV set, etc. Furthermore, its interdisciplinary nature entails influences, sometimes contradictory, from involved disciplines.

One related field is Sonic Interaction Design (SID), a project financed by the European union,[262] which was running from 2006 to 2011, and gathered about forty European researchers in this field:

> Sonic Interaction Design explores ways in which sound can be used to convey information, meaning, aesthetic and emotional qualities in interactive contexts. It is a discipline that emerges from contributions coming from different directions, such as auditory display and sonification, sound and music computing, perception and action (Rocchesso 2011, p. 3).

Within the SID umbrella, a huge amount of sub themes reside: sound analysis, spatial sonic interaction, sketching and prototyping, sonification, human gestures, etc. Without a doubt these themes closely relate to this work. Most efforts within SID deal with solving technical issues in order to create products and/or software that involve sound interaction.

My first research question: How do the aesthetic choices made during the process of designing my digital musical instruments relate to the particular structure and capabilities of those instruments? The design and development

262. SID was a project within COST – the acronym for European COoperation in Science and Technology – is the oldest and widest European intergovernmental network for cooperation in research. Established by the Ministerial Conference in November 1971, COST is presently used by the scientific communities of 36 European countries to cooperate in common research projects supported by national funds www.cost.eu, (August, 2011).

of instruments in this work, after initial conceptualization, proceeds in a spiral-like iterative process in three phases, which I may describe as implementation, test, and evaluation phases. In this respect, my work connects to design work in general, since this is a common notion of work processes within the design research community.

The second research question: How may a personal aesthetic that shapes the design of digital musical instruments relate to playing behavior, interaction, and musical output in ensemble improvisation? How do we measure design?

Lundgren et al. (2009) bring aesthetics into game design, a subfield of interaction design, by showing that different games give rise to a number of distinctive aesthetic ideals regarding interaction, both between participating players as well as between a player and a game. A topic further discussed in the Play Time Aesthetics chapter. Lundgren's (2010) thesis scrutinized aesthetics in interaction design, in a personal mail correspondence she claims however:

> [...] my thesis was partly to summarize the importance of aesthetics in interaction design, which crystallized into about five different main ideas, and then to look at how to investigate and teach them. But the whole point of this work was to talk about aesthetics in an objective manner, rather than subjectively (My translation).[263]

Moreover, Swedish design researchers Hallnäs and Redström (2006) point to two important factors, the potential user, and evaluation of the design:

> Evaluation means that we let the given someone 'use' the design to do that something given at some stages in the design process in order to see to in what sense the design meet usability criteria and requirements. Ideally we would like to prove that the design defines things like an efficient work method, an informative and intuitive interface, etc (p. 54).

However, in my opinion there are possible applications of technology that are not covered well by this model; in particular, research into computer technology as a means for personal artistic output. First, Hallnäs and Redström imply an imagined and anonymous "someone", but in this work designer and user are

263. The original: "[...] min avhandling handlade delvis om att summera synen på estetik inom interaktionsdesign, vilket utkristalliserade sig till ungefär fem olika huvudidéer, och sedan om hur man kan utforksa och lära ut dem. Men hela grejen med det handlade om att prata om estetik på ett objektivt sätt, snarare än subjektivt."

identical. This means, from a designer's point of view, I do not have to deal with possible misinterpretations of the design by future unknown users; as user/designer, I know the artifact inside out, and anyway the design is always open for changes and improvement. Secondly, while evaluation in interaction design practices aim to reveal whether an artifact meets specified criteria and requirements, the evaluation of instruments in this work relies on artistic practices. The artistic qualities of my instruments with regard to interaction and musical outcome are perceived in "real-life" contexts, such as concerts and CDs. These situations serve as the frameworks for measurement. From a subjective point of view, it is the perceived feeling of playing these instruments that counts, and from a inter-subjective point of view, it is what we, the participating musicians, feel, experience and produce when playing together that is important. Of course, in addition, reviewers and listeners add valuable notions as well.

To summarize: this research demonstrates and discusses examples of designing *and* using digital artifacts as a means of artistic expression, rather than merely seeking to invent and scrutinize new techniques, or engage in product development. The driving force during design processes in this work is to implement subjective aesthetical values in the design of digital musical instruments as personal and creative tools for music making. Moreover, I show and emphasize that sustained practice and use in context, in parallel with the design work, is mandatory in order to fully realize and exploit the artistic potential of new technologies. This explains why I am not primarily interested in designing for other users. I consider my instruments personal artworks, and as such they are too bound to my personal aesthetic, and too limited and idiosyncratic in their use to attract other users. I rather encourage other art creators to take the methods and implementations discussed here as role models, and to make their own tools based on their own aesthetics.

Further Research

The point of departure in this research project is a number of digital musical instruments aimed for improvisation. At first, my research interest was to scrutinize their use and musical roles in the particular context of ensemble improvisation. One presumption was to take verbal communication between participating musicians as a starting point, with the aim to build a list of concepts that could serve prescriptively, as well as descriptively for analysis. However, during the course of the process, a research project may go in new directions, unforeseen initially, and leave certain earlier presumptions behind. My focal point has moved slightly to study design decisions in relation to playing behavior, interaction, and musical output. In this work, I give examples of a limited number of descriptive concepts, but do not present a comprehensive vocabulary. A possible future research project may be to thoroughly investigate one or several music groups' internal communication vocabulary in terms of tradition, genre/style, gender, age, social context, musical output, etc. One suggestion is to do a comparative study between different genres. Such a project could reveal and increase our understanding of musicians' professional language and their means of communicating practical knowledge.

A key concept in this work equates play, game, and music improvisation, and above all aims to describe and outline a frame wherein my instruments operate. I claim that an improvisation group provides such a frame of activity and interaction for participant musicians, with their own explicit and implicit confining rules of behavior. I am keen to point out that this is a personal aesthetic standpoint, and not commonplace within the community of improvisation, even though similar concepts have been exploited as organizing principles in game-like compositions. In order to investigate and deepen my understanding of play and game, on the one hand, I turned to philosophy, and particularly the valuable contributions of Gadamer and Huizinga with respect to the ontology of play and game. On the other hand, I have encountered game designers and researchers whose work within the field of interaction design has provided significant research concepts. From initially being a vague idea about applying concepts from game design to music improvisation, this thinking has turned out to be an aesthetic cornerstone in this work that has revealed new perspectives and insights. One idea deals with player's attitudes toward different games. In order to apply this idea to music, I present a selection of music pieces as if in a game, and in analysis, one could discover different player types and relate these types to their personal attitudes and preferences for different types of music. In this work, the selection of pieces is made arbitrarily and almost coincidentally; I happen to know and like the music selected. However, a further systemized research may be valuable, which would include a number of deliberately selected musicians and music works. Such a project will shed light and increase our understanding of why certain musicians prefer certain pieces of music, while others have other preferences. Selection of musicians may take age, instruments, gender, genre and other variables into account, whereas the selection of music may include a multitude of genres.

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Appendix

Analysis of DVD Content

In order to facilitate viewing and orientation I am providing graphical analysis with respect to the employed instruments and controlling concepts on DVD content. Table 1 displays which instruments are active in individual tracks and where.

		Instrument	Main Instruments				Controlled Instruments			Effect Processors	
			Granular Machine	SyncLooper	Walking Machine	exPressure Pad Family	Looper2	FourToThree	Munger	GRM Tools	TimeFactor
DVD-Item	Beam Stone	Grey Zone GAS		x							
		Grey Zone ISCM		x							
		Amalgamatation GAS				x				x	
		Amalgamatation ISCM				x					x
		Angle of Repos	x			x		x	x		
		Shadowing	x		x	x					x
	PJ	Facing x	x		x	x	x	x		x	
	pM	Shuffle				x					
	Solo	My Funny Valentine				x					x
		Davis Decontructed	x	x				x			

Table 1: Employed instruments on the various DVD tracks.

The following analyses[264] serve as an orientation of singular improvisations on the DVD. The background graphic displays a waveform of present sound file, which in conjunction with the time line at the bottom facilitates navigation in the different tracks. The upper grey bar shows the controlling concept applied, if any, or my type of playing behavior, while the lower bars show instruments employed in order of attention during play: playing mode comes before controlling mode. Note that each analysis window shows the entire improvisation, which implies variable time resolution. Table 2 shows instrument color-codes in analysis:

	Granular Machine
	SyncLooper
	Walking Machine
	exPressurePad
	FourToThree
	Groover2
	Munger
	Time Factor
	GRM Tools

Table 2: Color codes of employed instruments.

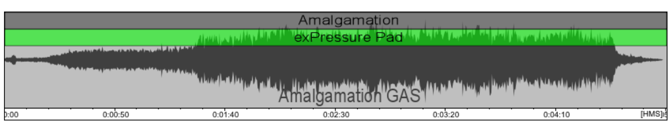


Figure 62: Amalgamation GAS

264. Analyses made with Acousmograph analyzing software, a shareware available at www.ina.fr/grm.

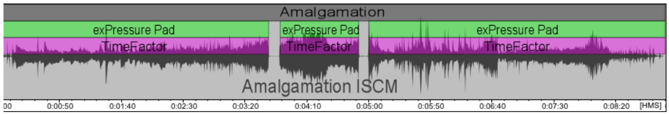


Figure 63: Amalgamation ISCM

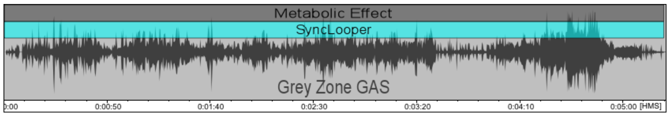


Figure 64: Grey Zone GAS

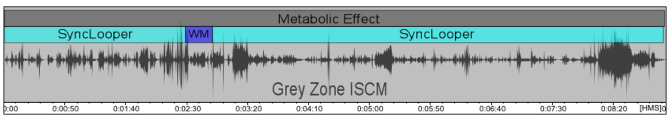


Figure 65: Grey Zone ISCM

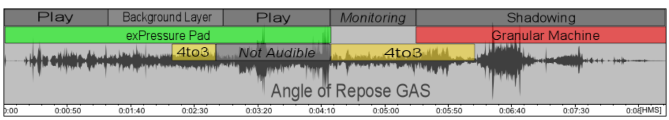


Figure 66: Angle of Repose

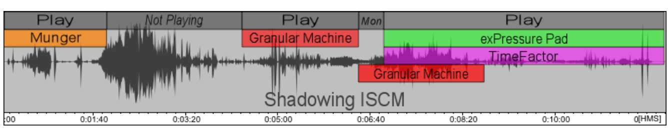


Figure 67: Shadowing ISCM

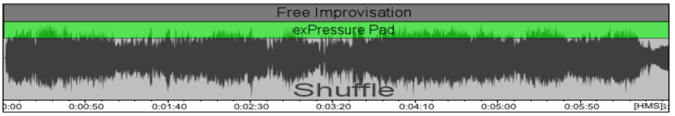


Figure 68: Shuffle with duo pantoMorf

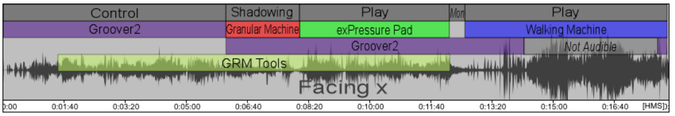


Figure 69: Facing x with Peter Janson

Instrument GUI

The Instrument chapter comprised of a number of images showing examples of the GUI of my instruments, however, for practical reasons they appear in grey scale, while their color equivalents appear in the following section.

GENERAL GUI IMAGES

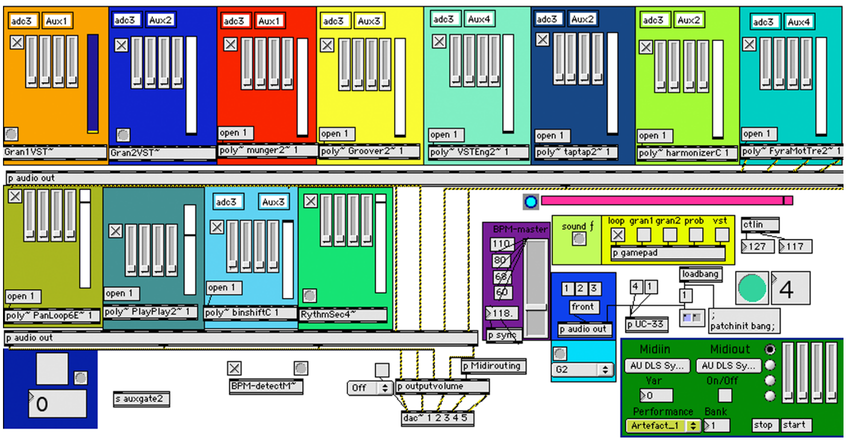


Figure 70: GUI of 2003 system

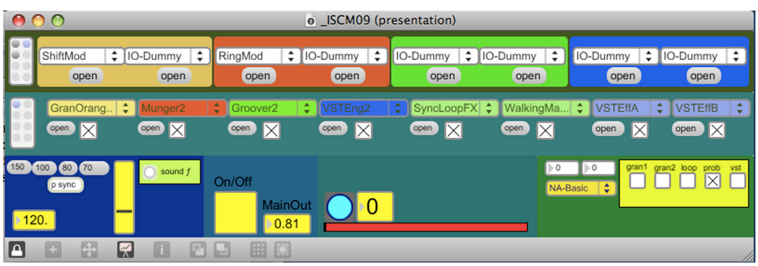


Figure 71: GUI of 2009 system

INSTRUMENT GUI

Figure 72: GUI of the Granular Machine

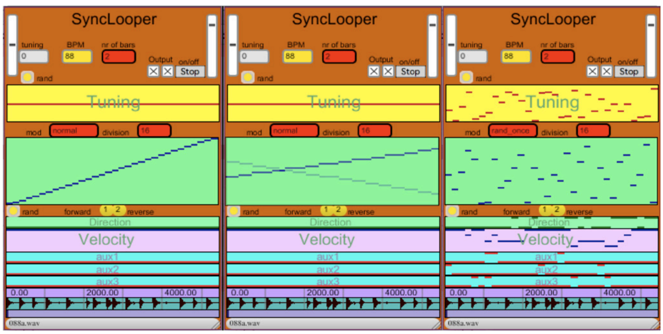


Figure 73: Example of different playback settings at the SyncLooper. 1) Straight playback; 2) Sound file position at left and right edges are controlled from the Gamepad interface, values in between are interpolated as a straight line; 3) Random order of playback, tuning and segment direction is under interface control, while velocity values and effect sends from individual segments are manually set at the GUI.

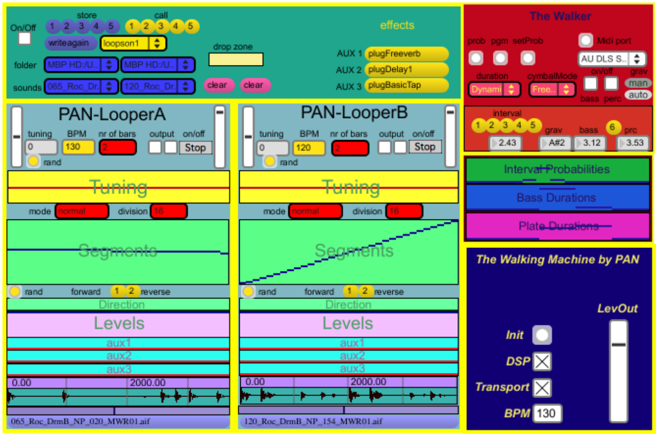


Figure 74: GUI of the Walking Machine

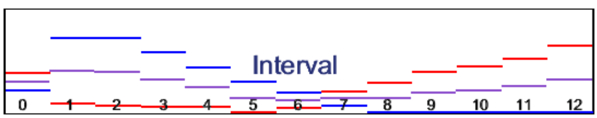


Figure 75: Probabilities of bass intervals of the Walking Machine. The red and blue are examples of different presets, while the purple is an interpolation between the two.

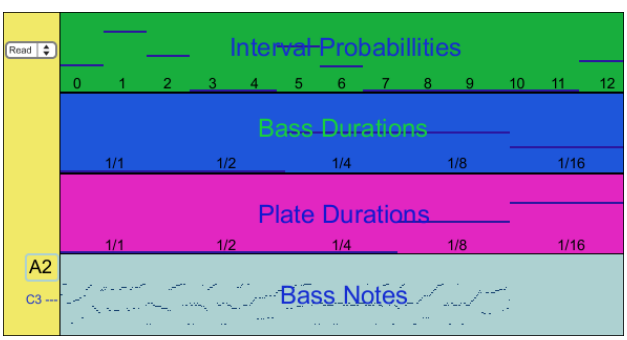
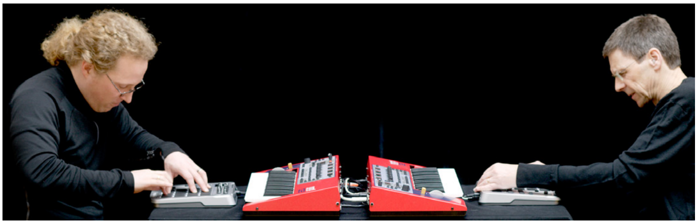


Figure 76: Examples of probability distribution settings of the Walking Machine. From top: bass intervals, bass durations, cymbal/plate durations, and history of played bass pitches.



duo pantoMorf: Palle Dahlstedt and Per Anders Nilsson. Photo: Anders Bryngel.