

Screening of cognitive functions
Evaluation of methods and their applicability in neurological rehabilitation

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Gothenburg 2009



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ISBN: 978-91-628-7792-7

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Abstract

Assessment of cognitive functions is of great importance in neurological clinical settings as well as in rehabilitation. A cognitive screening test is short and comprehensive and can be used in various situations. The Barrow Neurological Institute Screen for Higher Cerebral Functions (BNIS) is a screening method developed for identifying cognitive dysfunction.

The aims of the thesis were (1) to evaluate the psychometric properties of the BNIS and (2) to explore similarities and differences between the BNIS and the Mini Mental State Examination (MMSE) and (3) to use the BNIS in a clinical context and examine patients with different diagnoses commonly seen in neurorehabilitation.

Material and Methods: The BNIS was used in patient populations and also in a control population of healthy adults. Parallel assessments with the BNIS and the MMSE were used and a linking of the BNIS and the MMSE to the WHO International Classification of Functioning, Disability and Health (ICF) was performed. In two follow-up studies the results from the cognitive screening (BNIS) were related to evaluations of neurological status, ADL ability, housing and return to work.

Results: BNIS showed good construct validity as a significant difference (total score and all subscales) between healthy controls and patients was found. A concordance between BNIS and MMSE was shown (Goodman-Kruskal gamma: 0.724, $p < 0.0005$), but also evidence that BNIS better discriminated patients who had high (≥ 27 p) scores on MMSE. BNIS was linked to 34 and MMSE to 26 categories of the ICF. Patients with stroke showed a recovery of cognition and ADL ability, but 83% still had cognitive dysfunction and 20% were dependent in personal ADL after one year. At three years after discharge 20% had returned to work. Among patients surviving a cardiac arrest 95% had evidence of cognitive dysfunction two years after onset. Sixty-four percent were living in their own home.

Conclusion: The BNIS significantly discriminated between neurological patients and controls. Patients who scored above cut-off on MMSE were better differentiated on BNIS. Cognitive function, assessed with BNIS, was related to ADL ability when stroke patients and patients with anoxic brain injury were assessed. Mostly an association between cognition and return to work also was found.

Keywords: cognition, cognitive screening, ADL, stroke, brain damage, ICF, return to work

ISBN 978-91-628-7792-7

LIST OF ORIGINAL PAPERS

This thesis is based on the following four papers referred to in the text by their Roman numerals:

- I. Hofgren C, Esbjörnsson E, Aniansson H, Sunnerhagen KS.** Application and validation of the Barrow Neurological Institute Screen for Higher Cerebral Functions in a control population and in patient groups commonly seen in neurorehabilitation.
J Rehab Med 2007;39: 547-553.

- II Hofgren C, Esbjörnsson E, Lundgren-Nilsson Å, Sunnerhagen KS.** A comparison between two screening instruments for cognitive function: parallel reliability and linking to the ICF of the Barrow Neurological Screen for Higher Cerebral Functions (BNIS) and the Mini Mental State Examination (MMSE).
Submitted.

- III Hofgren C, Björkdahl A, Esbjörnsson E, Sunnerhagen KS.** Recovery after stroke: cognition, ADL ability and return to work.
Acta Neurologica Scand 2007;115: 73-80.

- IV Hofgren C, Lundgren-Nilsson Å, Esbjörnsson E, Sunnerhagen KS.** Two years after cardiac arrest; cognitive status, ADL ability and living situation.
Brain Injury 2008; 22(12): 972-978.

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ABBREVIATIONS

ADL	Activities of Daily Living
BNIS	Barrow Neurological Institute Screen of Higher Cerebral Functions
CA	Cardiac Arrest
CI	Confidence Interval
Cognistat	Neurobehavioral Cognitive Status Examination
CT	Computer Tomography
FIM	Functional Independence Measure
I-ADL	Instrumental Activities of Daily Living
ICF	International Classification of Functioning, Disability and Health
ICDIH	International Classification of Disability Impairment and Handicap
LHD	Left hemisphere damage
MCI	Mild Cognitive Impairment
MMSE	Mini Mental State Examination
MRI	Magnetic Resonance Imaging
NIHSS	National Institute of Health Stroke Scale
OR	Odds ratio
OT	Occupational Therapist
P-ADL	Personal Activities of Daily Living
QoL	Quality of Life
RBANS	Repeatable Battery for the Assessment of Neuropsychological Status
RCT	Randomised Control Trial
RHD	Right hemisphere damage
ROC	Receiver Operating Characteristic
RTPA	Rank Transformable Pattern of Agreement
SSYK	Standard för Svensk Yrkesklassificering (Swedish Standard Classification of Occupations)
TBI	Traumatic Brain Injury
WHO	World Health Organization

INTRODUCTION

Cognition

The most fundamental elements of cognitive neuroscience were established in ancient Greece, where it was first determined that the brain was the physical seat of the mind (Farah 2000). Since then, the human brain has been the object of great interest and the focus of considerable research effort. In spite of this activity, the brain remains mysterious and difficult to understand fully. In his book *The Working Brain*, A.R. Luria writes: ‘The human brain, this most sophisticated of instruments, capable of reflecting the complexities and intricacies of the surrounding world – how is it built and what is the nature of its functional organization?’ (Luria 1973)

Cognitive science covers the different approaches to the study of intelligent information processing systems. Cognitive psychology and cognitive neuropsychology are two branches of cognitive science that focus on the study of the same intelligent system – the human brain. Cognitive psychology is interested in the normal function of the brain (Margolin 1992) while clinical neuropsychology investigates the interrelations between brain and behaviour on the basis of the alterations in brain function produced by injury or disease (Benton and Sivan 2007). Initially there was not much interchange between the two disciplines but in the 1970s they began to cooperate more successfully, with the result that, for example, the theories of cognitive psychology were used by neuropsychologists to ask questions about the localisation and organisation of cognitive functions that were more likely to produce generalisable findings (Farah 2000).

The dimensions of human behaviour can, according to Lezak (Lezak, Howieson et al.2004), correspond to three functional systems: (1) cognition; which concerns the information processing aspect of behaviour; (2) emotionality; that is, the feelings and the motivation connected with behaviour; and (3) executive functions, i.e. how behaviour is expressed. In neuropsychology, the cognitive functions have been given more attention and consideration than the emotional and executive control systems. This has happened partly because the deficits of cognitive functions are so prominent and may have consequences in daily life in various ways for many patients. Cognitive functions are also more readily conceptualised; they are measurable and possible to correlate with neuroanatomical systems.

All behaviour is determined by complex processes. A patient failure on a test of abstract reasoning may not be because of a specific impairment in conceptual thinking but because of attention disorder, verbal disability, or inability to discriminate the stimuli of the test.

Lezak (Lezak, Howieson et al.2004) further describes the four major classes of cognition corresponding to input, storage, processing and output. Thus (1) the receptive functions involve the ability to select, acquire, classify and integrate information; (2) the storage and retrieval functions include memory and learning, while (3) thinking corresponds to the mental organisation and reorganisation of information and (4) expressive functions are the means through which information is communicated or acted upon. These classes are integrated into each other and work together in complex ways that are very difficult to separate in assessment procedures. A division can be made within each class, however, between those functions that mediate verbal/symbolic information and those that cannot be communicated via symbols, e.g. complex visual and sound patterns. Lezak also points to the attentional functions, which

have a special position by virtue of being conceptualised within the frame of cognitive functions, but underlie and maintain cognitive functions (Lezak, Howieson et al.2004).

In order to understand how normal cognitive functions work and how they are restored after damage neuropsychologists have developed various assessment methods. These aim to provide information and understanding about the functioning level of several cognitive areas (e.g. attention, memory, visuospatial ability, etc.) and can be interpreted in both quantitative and qualitative terms.

General cognitive function

General cognitive function is most often described in terms of the concept of intelligence. The nature of intelligence is the subject of differing views. Initially the importance of a general factor, a 'g' factor was stressed which was believed to be reflected in assessment methods. Later on, the idea of multiple intelligences associated with different dimensions of cognitive ability was presented. A more recent theory, the Cattell-Horn-Carroll theory, includes a model, based on factor analyses, with several broad categories of abilities at a higher level e.g. fluid intelligence, crystallised intelligence, short-term memory, long-term storage and retrieval and processing speed (Carroll 1993). There are also primary factors at a lower level (e.g. quantitative reasoning, spelling, free recall and simple reaction time). This modern theory of cognitive functioning thus emphasises a structure of independent factors of intelligence. The first standardised tests, however, were constructed with clinical utility in mind and for solving problems initiated by school institutions and authorities. Later, however, these instruments and methods were criticised for being over-simplistic measures of cognitive capabilities.

Recently, test developers have begun to merge tests from different traditions; an example is the six-factor model which is used in the Wechsler Adult Intelligence Scale (WAIS-III) and the Wechsler Memory Scale (WMS-III). Tests based on empirical work, such as factor analysis, and the new conceptualisations of existing methods often assess a broader spectrum of abilities than previously represented and tend to harmonise more with the factor-based theories of cognitive functioning (Strauss, Sherman et al. 2006).

The following cognitive domains are usually assessed when neuropsychological tests are administered.

Attention

For the brain to function effectively there is a need for a selective process that helps the organism to focus on the most important information for further processing (Milham 2003). Attention is considered to comprise several distinct basic processes, including sensory selection, response selection, attentional capacity and sustained performance (Gunstad 2006) (Strauss 2006) Attention is often divided into the following components: alertness/arousal, focused attention, selective attention, divided attention and sustained attention (vigilance). Tests of attention usually measure more than one of these processes and many attention tests are multifactorial in themselves, as motor speed, speed of information processing, verbal ability, etc. are often required in the performance (Strauss, Sherman et al. 2006).

Memory

Memory refers to the processes of encoding, storing and retrieving information. Memory is regarded to consist of different forms, mediated by different processes associated with different underlying neural mechanisms (Buckner, Raichle et al. 1996; Lepage, Ghaffar et al. 2000; Cabeza 2008; Cabeza, Ciaramelli et al. 2008; Ciaramelli, Grady et al. 2008). Long-term memory refers to permanent storage; working memory (short-term, immediate memory) has a limited capacity to store information, commonly believed to range from seconds to one or two minutes. Working memory contains material both from sensory inputs and from long-term memory. It has been described as a limited-capacity attention control system that selects controls and coordinates processes involved in learning, comprehending and reasoning. Long-term memory is divided into explicit (conscious or declarative) and implicit (unconscious or procedural) memory. Explicit memory is the conscious recall of stored information and implicit memory refers to more heterogeneous abilities, such as priming, skill learning, procedural memory and habit formation (Strauss, Sherman et al. 2006).

Language

Numerous tests have been developed to assess speech and language functions. The ability to communicate verbally and through symbols is central in human societies and therefore deficits in speech and language utilisation are of great importance. There are comprehensive batteries, specific-function tests, tests for receptive and expressive language functions and tests directed at the functional ability to communicate in everyday life situations (Strauss, Sherman et al. 2006).

Visual perception and visuospatial ability

The two main goals of higher-level vision have been described as the identification and localisation of stimuli ('what and where'). Research indicates that there are two different cortical pathways for object and spatial vision, one in the ventral and one in the dorsal cortex. Disorders of object perception are observed when tasks are performed to manipulate the perceptual dimensions of objects, such as a fragmented version. In terms of spatial processing, two main pathways have been discussed (Strauss, Sherman et al. 2006). The first refers to difficulties in locating single objects in space (provided normal visual acuity) and the second refers to spatial analysis in more complex tasks. A faulty analysis of relative spatial information can be assessed with the help of measures of assembling and drawing.

Executive functions

Executive function is described by Strauss et al. (Strauss, Sherman et al. 2006) as a complex set of processes that have been rather vaguely defined. Generally, these processes are considered to belong to a system of supervisory capacity. Executive function is of importance for purposeful, goal-directed behaviour. In novel situations, where no previously learned routines are of use, executive functions contribute to the development of new strategies and monitor their effectiveness. Dysfunction can be manifested as inappropriate social behaviour, difficulties in decision-making, problems in showing good judgement when there is a need to change

plans, difficulties in initiation, organising and following plans, being easily distracted and limitations in the use of various aspects of memory (Strauss, Sherman et al. 2006). The structure and design of most medical and psychological examinations do not provide much opportunity for adequate assessment of the more subtle emotional and executive deficits (Lezak, Howieson et al.2004).The theoretical link between different areas of knowledge in social and cognitive science and also in neuroscience can contribute to a better understanding of executive functions. Integration of these factors is important for the development of new neuropsychological tests (Chan 2008). Executive dysfunction can also be reflected in the test performance of a patient through poor initiation, inflexibility, difficulties generating strategies and difficulties in correcting errors and using feedback.

Neuropsychology and neuropsychological assessment methods

The term neuropsychology is defined as the study of the relation between human brain function and behaviour (Kolb and Whishaw 2003). Clinical neuropsychology is the applied science studying the behavioural expression of brain dysfunction (Lezak, Howieson et al.2004). This author lists some common purposes of neuropsychological examinations: (1) diagnosis and patient care in terms of treatment management and planning; (2) identifying patient needs; e.g. when designing individualised treatment programmes; (3) evaluating treatment efficacy; and (4) in research. Neuropsychological assessment can help with the answers to diagnostic questions. For example, it can be used to discriminate between psychiatric and neurological patients, when distinguishing between different neurological disorders and when localising the site or brain hemisphere side of a lesion.

The development of new neurodiagnostics and neuroradiological methods has diminished the need for neuropsychological assessment for diagnostic purposes (Lezak, Howieson et al.2004). When the site and extent of a lesion have been identified with imaging methods, however, this will not show the behavioural consequences. A neuropsychological assessment can also be used as a predictive instrument, as a probability measure of a manifestation of a neuropathological condition or as a measure of the cognitive consequences of a particular brain disorder (Lezak, Howieson et al.2004). In the future, neuropsychologists should continue to develop assessment methods that focus on the diagnostic matters that are most clearly linked to treatment choice and outcome, identify conditions that are likely to result in cost savings and integrate treatment planning, process monitoring and outcome evaluation. The goal of clinical neuropsychology is to diagnose the presence of brain damage and dysfunction as well as the preserved cognitive and executive functions, emotion and motivation. Assessment is also often used to facilitate patient care and rehabilitation and is useful as a baseline for cognitive training. Neuropsychological assessment might also be the only way to document cognitive disturbances (Kolb and Whishaw 2003). Serial assessments can give information about the rate of the rate of progress or recovery and the potential for resuming a previous lifestyle. Neuropsychological assessment can identify mild disturbances in cases when other diagnostic tools have produced ambiguous results. Recovery of function after brain injury needs to be documented for rehabilitation planning but also to determine the effectiveness of medical treatment. Assessment results communicated to a patient and his/her family assists them in understanding the residual deficits and how these interfere with activity and participation so that realistic life goals and rehabilitation programmes can be planned (Kolb and Whishaw 2003).

An emphasis on greater consideration of the functional implications of neuropsychological test results has emerged. Referrals to neuropsychological assessments are now being made in order to establish the abilities of patients to perform activities of independent living or return to a previous occupation (Johnstone and Farmer 1997; Tröster 2000; Spooner and Pachana 2006).

Screening of cognitive functions

Initially neuropsychological test batteries were developed to assess several cognitive functions and in that way assess the presence, location and extent of brain injury. As modern neuroimaging techniques were established, other issues that needed to be addressed emerged, e.g. the nature of the cognitive deficit or estimating the potential for a successful cognitive rehabilitation.

In the case where a specific condition, illness or attribute may be either present or absent a screening test may be used. Screening has a place in neuropsychological assessment, e. g. when used to identify people most at risk of a specific condition or in need of further diagnostic study and also when brevity is required to preclude a lengthy assessment. There are tests constructed as brief screening instruments, which are often portable and can be administered at bedside. In a neurological and rehabilitation setting it can be of importance to establish whether the patient has a cognitive dysfunction depending on the medical status and clinical impression. In these instances a further step towards differentiation between medical diagnoses may be a central issue. Normally neuropsychological examination uses a comprehensive test battery to cover many different cognitive functions as well as to assess the severity or reduction of impacted abilities compared with reference norms and/or expected criteria. This is time-consuming and expensive. In an acute phase the patient may also be too ill and the impact of the disease or injury on regulation of mental energy too severe for the patient to be able to take part in the evaluation in a reliable way.. Possible confusion and a reduced ability to communicate and participate in the examination should be taken into account; they often prevent extensive examination. Thus there is a need for shorter cognitive screening tests to be used in these situations to obtain a cognitive baseline more easily and rapidly. To examine whether the disease or injury has affected neuropsychological functions or suggests a brain dysfunction behind the observed symptoms could also be of importance. In the neurological clinic, or when the diagnosis is known, the use of a cognitive screening test can be of value in following the restoration and recovery of the patient over time. In neurorehabilitation, for realistic goal formulation as well as for follow-up of rehabilitation outcome, cognitive screening can suffice until more comprehensive testing is needed. Different aims of cognitive screening also decide what conditions should be fulfilled by the test.

A common way to relate the test result to disease (or other condition or outcome) is to identify a cut-off score. A cut-off score is a single point along the continuum of possible scores and a result above the cut-off classifies subjects as belonging to one of two groups and scores below cut-off consign them to the other group.

During the last decades several cognitive screening tests have been developed of which the Mini Mental State Examination (MMSE) is one of the first and most well-known (Folstein, Folstein et al. 1975) Other somewhat more recently designed instruments are the Barrow Neurological Institute Screen for Higher Cerebral Functions (BNIS) (Prigatano 1995), Cognistat

(the Neurobehavioral Cognitive Status Examination) (Kiernan, Mueller et al. 1987), RBANS, (Repeatable Battery for the Assessment of Neuropsychological Status) (Randolph, Tierney et al. 1998), the Neuropsychological Screening Exam, the Adult Neuropsychological Questionnaire, the Neuropsychological Status Examination and the Neuropsychological Impairment Scale (Strub 1985). Some are based on interview questions or self-reports, and the time to perform the evaluation differs from 10 to about 60 minutes. The result is often presented as a total score, yielding a cut-off score to estimate the probability of dysfunction. To our knowledge, only a few of these screening tests have been translated into Swedish.

Psychometric concepts addressed in this thesis

Frequency distributions of many physical, biological and psychological attributes tend to be consistent with normal distribution. The normal curve is the basis of many commonly-used statistical and psychometric models within the classical test theory.

Reliability

Test reliability is connected with measurement precision. Results of neuropsychological tests, like other types of psychological assessment methods, are estimates of functions and abilities, where some level of measurement error exists. Reliability indicates the proportion of variance which is attributed to the variance in true scores. Test precision varies somewhat across the different populations and settings where the test is used. The reliability of a test can be defined as internal consistency, consistency over time, consistency over alternate forms and consistency across raters (Strauss, Sherman et al. 2006).

Validity

Test validity may be defined as the degree to which a test actually measures what it is intended to measure. As with reliability, a test cannot be said to have a single level of validity, but rather various types and levels across different populations and usages. Therefore, validity can be described as a property of the meaning that is attached to a test score. This means that interpretation of an individual test score in clinical practice must take into account the unique factors in the specific test situation.

There are three commonly-used components of validity: content validity, criterion-related validity and construct validity. These are ways of providing evidence of validity and are not themselves the equivalents of validity. Tests need to be continually re-evaluated for validity as populations and contexts change over time. Among the sources of evidence for content-related validity are a description of the theoretical model on which the test is based, reviews of the literature to find supporting evidence and selection of a panel for expert review. Construct-related validity can be defined by, for example, the gathering of empirical evidence of construct validation, demonstration of sensitivity to developmental changes, correlation with other tests and studies of group differences. The basis for evaluation of criterion-related validity can be identification of a relevant sample group reflecting the population of interest. If a subgroup is assessed, conclusions are restricted to that subgroup. The analysis of test-criterion relationships is also important and can be made through the use of contrasting groups, correla-

tion with previously available tests, use of accuracy statistics, outcome studies and meta-analysis (Strauss, Sherman et al. 2006).

More recently, the question of the so-called 'ecological validity' of neuropsychological assessments has been raised. 'Ecological validity' refers to how well the neuropsychological examination predicts behaviour or behavioural outcome. Among outcome evaluation, aspects of prediction of a person's ability to perform activities of daily living (ADL) have been accomplished (Cahn, Sullivan et al. 1998; Baird, Podell et al. 2001)

Test accuracy and efficiency

Test sensitivity is defined as the proportion of the examinees identified as having the condition of interest that is correctly identified. Specificity is defined as the proportion of examinees not having the condition of interest that is correctly identified by the test. The Positive Likelihood Ratio combines the sensitivity and the specificity into a single index, indicating the odds for a positive test result having come from a person with the condition of interest.

In clinical practice there is a need for test accuracy, for example when referring to diagnosis, for decision-making regarding the patient and for identifying need for assistance in daily living. Then the positive predictive power and the negative predictive power are of use. The positive predictive power is defined as the probability that a person with a positive test also has the condition of interest and the negative predictive power is the probability that a person with a negative test result does not have the condition of interest. When the predictive power approaches 0.5, examinees are approximately equally likely to have or not have the condition of interest, regardless of whether the test result is positive or negative. With a predictive power less than 0.5 the test classifications will be incorrect more often than they will be correct. Predictive power will vary between zero and one as a function of the prevalence (Strauss, Sherman et al. 2006).

ROC analysis

To present an optimum cut-off score the decision is often based on simultaneous evaluation of sensitivity and specificity or predictive power across a range of scores. A common method is the Receiver Operating Characteristics (ROC) Curve. A ROC plot is obtained by calculating the sensitivity and the specificity of all observed data and plotting sensitivity against 1-specificity, meaning that the proportion of true positives (y-axis) is plotted against the proportion of false positives (x-axis) in each specific score in the range of test scores. The area under the curve corresponds to the overall accuracy of the test. ROC analyses may be used to compare the diagnostic utility of two test instruments and thus be useful for test selection. A test that perfectly discriminates between two groups would be a curve that coincides with the left and top sides of the plot, while a test that has no discriminative ability would give a straight line from the bottom left corner to the top right corner (Strauss, Sherman et al 2006; Altman and Bland 1994).

Gender

Differences in performance on neuropsychological tests between men and women generally do not exceed half of a standard deviation and the overlap in distribution of scores for men and women is much greater than the distance between them. But there are studies which indicate that women, also in older age, perform better than men in tests involving verbal abilities and that men perform better than women in tests of visuospatial skills (Proust-Lima, Amieva et al. 2008). Although, results based on knowledge about cognitive differences between the sexes must be interpreted with caution (Lezak, Howieson et al.2004).

Age

There is debate about the impact of the nature of cognitive changes with increasing age, and divergent findings in various studies are also found. This may be because of differences in research methodology, and when effects of age are evaluated the impact of other variables must also be considered, such as different cultural settings, environment and medical status. Socioeconomic factors seem to have an impact in differences in cognitive function. Intelligence can be described as a complex hierarchy that reflects the interaction between the social context and the individual over the life course (Brunner 2005).

Great individual differences of the ageing process have been observed, making it very difficult to draw conclusions about the underlying variability. The concepts of crystallised and fluid intelligence have been used to distinguish more persistent abilities from those that decline faster (Lezak, Howieson et al.2004). Over-learned, well-practised and familiar skills, abilities and knowledge are ‘crystallised’. They continue to be fully operative, even showing gains up to the age of 60 years and remaining stable until the mid-seventies. Activities requiring ‘fluid’ intelligence, involving reasoning and problem-solving, typically decline slowly until the late 50s and early 60s, and then the decline proceeds faster

Slowing in psychomotor and information processing capacity may account for many of the measured changes in neuropsychological tests that decline with age. Others suggest that a visuospatial component or decline in frontal lobe dysfunction might explain the changes in performance (Lezak, Howieson et al.2004).

Cognitive decline in elderly people generally affects only some functions. Verbal abilities are more often well-preserved (Lezak, Howieson et al.2004). Older people perform less well on tests of visual perception, constructional tasks and memory (particularly visuospatial memory). Decline in test performance, however, does not usually indicate impairment in activities in daily living (Corey-Bloom, Wiederholt et al. 1996).

Longitudinal studies show fewer age changes. In a study from Denmark cognitive function was found to be relatively stable over an eleven-year interval for ages up to 70 years (Laursen 1997). The major change with ageing was slower processing speed and over time performance tended to decline somewhat in non-verbal learning and memory, retention of verbal material, psychomotor speed, visuospatial processing speed and concentration, most of the changes being without major practical significance (Lezak, Howieson et al.2004). People with better education and higher occupational status performed better than those less educated, but education has also shown no significant effect on cognitive change over time (van Dijk 2008). Elderly people were found to respond more slowly and made more errors on test of

divided attention (Lezak, Howieson et al.2004). Deficits in sustained and selective attention and increased distractibility also accompanied normal ageing (Klein, Ponds et al. 1997). Demographic and health factors can modify cognitive and sensory change in old age and the common patterns is a significant decline in speed and memory but not in verbal abilities (Anstey, Hofer et al. 2003). Demographic variables were found to have only minimal influence on episodic memory in healthy very old persons (Hassing 1998). Conflicting results may be discussed in terms of age range of the study group, definition and range of education, cognitive assessments methods, length of the study and confounding effects of other variables, such as health (van Dijk 2008).

Education

Effects of education on neuropsychological evaluations are persistently documented (Lezak, Howieson et al.2004). Education was found to have a substantial effect in test performance considering executive function, verbal fluency, verbal memory and cognitive speed as subjects with middle or higher level of education had better results than those with low-level of education (van Hooren 2007). In a community cohort study where both healthy and cognitively impaired persons were included, cognitive decline was slower in college-educated persons and also in women (Wiederholt 1993; van Hooren 2007). Education may protect against processes (other than dementia) that are involved in cognitive decline, also in younger persons, as measured by test performances (Farmer 1995). However, there are very recent results where education was not related to decline in cognitive performance in a population-based study of persons aged 75 years and above (Muniz-Terrera, Matthews et al. 2009).

Educational effects are manifested in most kinds of tests for cognitive abilities, and also in those believed to be reasonably unaffected by education. Because of low education cognitively intact people can get test scores in the range of ‘impairment’ based on healthy population reference scores (where the educational level approximates to the general level of education in a certain country).

It has even been recommended, in the case of dementia diagnostics, that behavioural data, such as activities of daily living (ADL) should be taken into account (Lezak, Howieson et al.2004).

A brain injury can enlarge education effects (Zillmer, Waechter et al. 1992) or education may have positive effects for only some people. Not only years of education may be taken into account, it would also be of importance to estimate the quality of the education (Lezak, Howieson et al.2004).

Brain disease

Several diseases and injuries in adult age affect the brain and its functions. It is of great importance to establish early diagnosis, treatment and rehabilitation. There are patients, however, who have to face the problem of living with long-lasting physical, cognitive, emotional and behavioural deficits.

Some of the diagnostic groups seen in neurological care are stroke, traumatic brain injury, Parkinson’s disease and anoxic brain injury because of cardiac arrest. Cognitive dysfunction

in the domains of memory, attention, visuoperception and speech and language are common in these diagnoses and also lack of self-awareness, problems with affect perception and behaviour as well as evidence of dementia (Kase, Wolf et al. 1998; Borgaro and Prigatano 2002; Patel, Coshall et al. 2002; Wilson, Harpur et al. 2003; Fernandez H 2005; Wood, Alderman et al. 2008). Patients with traumatic brain injuries often report physical difficulties as the greatest barrier to recovery, but over time concerns related to cognitive and emotional problems increase and become more prominent (Powell, Machamer et al. 2001; Emanuelson, Andersson Holmkvist et al. 2003).

Neurological diagnoses in the study groups

Stroke

Stroke is defined by the WHO as rapidly developing clinical signs of focal or global disturbance of cerebral function, with symptoms lasting more than 24 hours or leading to death and with no apparent non-vascular cause (WHO 1989).

A stroke can be classified as ischaemic or haemorrhagic depending on the underlying pathology. In the case of an ischaemic stroke the common underlying cause is an obstruction of the blood flow in a cerebral blood vessel, causing ischaemia and subsequent tissue damage. The obstruction is most often caused by atherosclerotic disease. In haemorrhagic stroke the most common cause is a rupture of a cerebral artery with intracranial bleeding and this in turn means distortion and compression of brain tissue. Ischaemic stroke accounts for about 80% and haemorrhagic stroke for around 20% of stroke patients (Barnes, Dobkin et al 2005). A reliable differentiation between these two main types depends on neuroimaging, either computer tomography (CT) or magnetic resonance imaging (MRI) of the brain. Ischaemic stroke may be further classified into three main subtypes: large vessel disease, small vessel disease and cardio-embolic stroke. Haemorrhagic stroke is categorised as either intracerebral or subarachnoidal haemorrhage.

Stroke is considered as a multifactorial disease in which genetic and environmental factors make about equal contributions (Hegele 2008). Around two-thirds of stroke patients have well-known risk factors for stroke (Barnes, Dobkin et al 2005). Stroke is the third major cause of death after ischaemic heart disease and cancer in the western world (Murray and Lopez 1997) and is also the commonest cause of disability in people of adult age.

Stroke incidence in Sweden is around 300 cases per 100 000 inhabitants a year, of whom 200 per 100 000 suffer a first incidence stroke leading to a total of about 25000 to 30000 people annually. Of these, about 20% will die within the first month and about a third of the survivors will remain significantly disabled after six to twelve months (Warlow 1998; Appelros, Nydevik et al. 2003).

Recent studies report a decline in stroke mortality, which may be a consequence of lowering case fatality rather than lowering the incidence rate (Sarti, Stegmayr et al. 2003; Sivenius, Tuomilehto et al. 2004). This, in turn, can be explained by better acute stroke care and/or a decline in stroke severity (Barnes, Dobkin et al 2005).

Although a tendency to a decrease in incidence has been observed in western countries over the last decades, an increasing stroke incidence in somewhat younger patients (<65-75 years)

has been reported in Sweden (Johansson, Norrving et al. 2000; Pessah-Rasmussen, Engstrom et al. 2003; Medin, Nordlund et al. 2004).

Under the age of 65 years there are twice as many men as women who suffer from stroke, while over the age of 85 the proportion of men and women with stroke is the reverse. Average age at stroke onset is 75.5 years. Around 20% are younger than 65 when they suffer a first stroke (Riks-stroke 2002).

Consequences of stroke

Impairments after stroke vary, depending on the site and extent of the lesion. Modern medical treatment in the acute phase can diminish the severity of impairment. Different degrees of hemiparesis and sensory deficits, hemianopsia, impairment of bowel and bladder control, dysarthria and dysphagia occur (Socialstyrelsen 2006). Fundamental cognitive functions such as attention, motivation, affect and emotion could be impaired, and also abilities vital for information retrieval, speed and ability of processing, i.e. perception (visuospatial difficulties such as visuospatial neglect), memory and executive functions. Language and communication abilities are often also impaired – after left hemisphere lesions as different kinds of aphasia and after right hemisphere lesions as pragmatic language disturbances (Kolb 2003). Costs are associated with cognitive impairment and ADL dependency (Claesson, Linden et al. 2005).

Prognostic factors for outcome of stroke

Several factors have a negative predictive value on functional outcome after stroke, such as severity of stroke, bilateral lesions, poor sitting balance, global aphasia, severe neglect, impaired cognition and depression (Flick 1999). Positive functional outcomes have been found to be related to absence of prior strokes, younger age, less severe neurological deficit, stroke involving cortical structures and left hemisphere lesions (Macciocchi, Diamond et al. 1998).

In a Dutch prospective study of stroke patients (mean age 58 years) following in-patient rehabilitation outcome of mobility one year after stroke was predicted by functional status; sitting balance, time between stroke onset and first assessment and age (van de Port, Kwakkel et al. 2006). Younger (<65 years of age) stroke patients, those with poor mobility and those unable to return to work report the most unmet needs and the youngest (<45 years) reported significantly more unmet needs than those in the older age group (Kersten, Low et al. 2002).

Cognitive impairment and depressive symptoms in the acute phase after stroke predicted long-term depressive symptoms and cognitive impairment. Increasing age, cognitive impairment and functional dependence predicted a reduced quality of life (QoL) (Nys, van Zandvoort et al. 2006). Unilateral neglect was the greatest risk factor for depressive symptoms at six months. The prognostic value of cognition suggested a reactive component in the development and continuation of long-term depressive symptoms.

Return to work after stroke seems to be a major factor for high subjective well-being and life satisfaction (Vestling, Ramel et al. 2005). Prognostic factors for returning to work are of both physical and psychosocial character. In one study, walking ability, white-collar work and preserved cognitive function had the greatest impact on work return, and a total of 41% had returned to work more than two years after stroke (Vestling, Tufvesson et al. 2003). In a retro-

spective study from Spain, of young adults (aged 15-45 years) with a first ischaemic stroke, 90% of the patients were independent and 53% had returned to work when followed-up after 12 years. Vocational adjustment was necessary, however, for 23% of those returning to work. For males of 35 years and over, the presence of cardiovascular risk factors and large artery atherosclerosis in the carotid territory were predictors of negative long-term outcome after the initial stroke (Varona, Bermejo et al. 2004). A higher level of function, as indicated by the Barthel Index, has also been shown to be associated with return to work (Wozniak, Kittner et al. 1999). Positive factors for returning to work reported in a study from 1985 were: age, type of occupation, degree of disability, race and also hemisphere injured (Howard, Till et al. 1985). Younger age, stroke severity, absence of cortical dysfunction and higher household income were factors associated with return to work and in this study there was no difference between left hemisphere and right hemisphere strokes or between cortical, infratentorial or lacunar strokes (Wozniak, Kittner et al. 1999). Fatigue was reported to be a problem (Lock, Bryan et al. 2005). In one study, absence of physical weakness and apraxia were identified as being predictive of return to work (Saeki, Ogata et al. 1995). Return to work was shown to be higher for people with white-collar jobs than for those with blue-collar jobs (Howard, Till et al. 1985; Saeki, Ogata et al. 1995; Vestling, Tufvesson et al. 2003). A stable pre-injury work history was a strong predictor of return to work (Keyser-Marcus, Bricout et al. 2002). Factors relating to dysfunctional interpersonal relationships and deficient social competence were reported to be the cause of many job separations after stroke. Work-related skills, such as inability to initiate a task, responding to non-verbal cues, observing safety requirements and using compensatory strategies consistently are important, as their absence makes it difficult for a person to contribute to work. Finally, strong family support seems to be a predictor of successful return to work (Barnes, Dobkin et al 2005).

Traumatic brain injury

Types of head injury can be divided into open-head injuries and closed-head injuries.

Open-head injuries are injuries in which the skull is penetrated. It will not always cause unconsciousness and often give rather distinct symptoms and often the patient will recover spontaneously. In closed-head injuries the brain is subject to mechanical forces, in terms of being pushed against the skull bone (coup-counter-coup injuries) and another mechanism causing injury is the shearing and twisting of neural fibres as a result of the movements of the brain (diffuse axonal injury). There is also the risk of haemorrhage, leading to haematoma which can cause increasing intra-cranial pressure. Closed-head injuries often lead to various lengths of coma. It can mean both the development of discrete symptoms, because of the damage of specific sites of the brain by the coup-counter-coup lesion, and more diffuse and generalised impairment from the more widespread type of damage caused by axonal tearing (Kolb 2003).

The incidence of traumatic brain injury (TBI) varies. In the western world estimates from population-based studies in the USA indicate around 180/ to 250/100 000 per year (Bruns and Hauser 2003). In Europe, the average incidence of hospitalised TBI according to results from 23 studies between the years 1980 and 2003 was 235/100 000 (Tagliaferri, Compagnone et al. 2006). Prevalence was not reported in the European studies, while there are approximately 2.5 to 6.5 million individuals in the US who have suffered from brain injury (NIH Consensus Development Panel 1999). In the European studies the ratio of hospitalised patients with severe,

moderate and mild brain injury was about 1:1.5:22. The commonest causes of brain injury were traffic accidents, falls, violence and sports injuries. There are groups at high risk: males were reported to have more than twice the risk of women. Adolescents and young adults (15-24 years) as well as people over 75 have the highest incidence ((NIH Consensus Development Panel 1999; Tagliaferri, Compagnone et al. 2006). In a Swedish study from 1992/3 incidence was reported to be higher, 546/100 000, in a population-based study of brain-injured patients registered at an emergency unit. Mortality was 0.7 % and 67% needed further admittance to hospital. Males had a 1.46 higher overall rate than females. The external causes were falls from the same level (31%), falls from a different level (27%) and traffic accidents (16%) (Andersson, Bjorklund et al. 2003). A more recent study from Norway for 2005/6 shows a considerably lower incidence of 83/100 000 patients hospital-treated for TBI. The result may indicate a decline in TBI incidence (Andelic, Sigurdardottir et al. 2008).

Consequences of TBI

TBI patients show a variety of cognitive dysfunctions but also behavioural, emotional and social problems are present and problems may be long-lasting. In a study of cognitive functioning ten years after brain injury, greater injury severity correlated significantly with poorer test performances in all cognitive domains assessed (processing speed, memory, and executive function), showing that many deficits persist over time (Draper and Ponsford 2008). Recovery after brain injury has been shown to be more noticeable during the first five to six months. In a study by Christensen and colleagues (Christensen, Colella et al.), this seemed to be a valid finding for most cognitive areas. Follow-up at one year, however, indicated that improvement had attenuated after the initial period, the exception being manual motor ability, the visuospatial domain and visual memory. The average level of function after the first year remained below the normal average, indicating that pre-morbid level of functioning was not reached. Severity of the TBI was not shown to affect functional outcome directly but rather through mediators, such as neuropsychological functioning, which significantly predicted functional outcome, as did occurrence of behavioural disturbances. Psychological and physical complaints were not predictive of functional outcome (Rassovsky 2006). Studies of patients with mild TBI, however, show somewhat varying results. At the early phase post-injury, mild TBI patients performed significantly worse than a control group of trauma patients without brain injury in cognitive tests on attention, processing speed, logical memory and vigilance (Landre 2006). In a group of mild but complicated TBI patients, remaining cognitive impairments were also found late post-injury but there were improvements according to neuropsychological assessments (Kashluba 2008). Single-incident mild TBI was recently reported, however, to have little clinical significance for long-term cognitive outcome or the occurrence of post-concussive symptoms and emotional or psychiatric dysfunction (Ettenhofer and Abeles 2009).

Deficit in self-awareness is common after acquired and traumatic brain injury and can predict behavioural disturbances (Bach and David 2006). Studies of quality of life achievements show that patients with TBI score lower than they did before injury and compared with reference groups. They also experience worse general health, depression, social isolation and lower labour force participation. Employment is an important factor for quality of life and many patients with TBI lose their jobs. Those who return to the labour market often work part-time and in a lower-level job than before (Dijkers 2004; Hawthorne, Kaye et al. 2009).

Prognostic factors for outcome of TBI

Outcomes after TBI have been described in terms of function, productivity, work return and/or return to pre-injury level and social reintegration. In a study of mainly mild brain-injured patients (n = 6783), it was found at one-year follow-up that only 4.9% had been subject to in-hospital neurorehabilitation. At the one-year follow-up 20.6% reported post-traumatic difficulties. One hundred and sixty patients could manage their life partly at follow-up and 116 people were unable to manage their activities in school or at work. TBI severity, age, concomitant organ lesions and other complications were associated with health-related quality of life and early social reintegration (von Wild 2008; Hukkelhoven, Steyerberg et al. 2003). In a mixed group of people with acquired brain injury, also including stroke, short length of stay in an acute hospital, high FIM™ score at admission and younger age were predictors of good functional outcome one year later (Blicher and Nielsen 2008). A very recent study concluded that presence of post-traumatic amnesia (PTA) for fewer than fourteen days was associated with a more favourable outcome in terms of productivity at one-year post-injury while the opposite was observed when PTA was longer than 28 days (Nakase-Richardson, Sepehri et al. 2009). In a study of moderate to severe TBI with follow-up after three and five years, significant functional limitations were observed. Recovery to pre-injury level was described, ranging from 65% of subjects concerning personal care to around 40% in cognitive competency, major activity and leisure and recreation. Severity of the TBI was related to functional status and to neuropsychological functioning, but not to emotional status or quality of life (QoL) assessment. It was noted that length of impaired consciousness contributed more to the outcome measures than did the anatomic lesions (Dikmen, Machamer et al. 2003).

A follow-up study of medical and functional status ten years after brain injury showed an epilepsy frequency of 19% and 31% were depressed. A majority (48%) had a good recovery or moderate disability (44%). Employment rate was 58%. There was an association between outcome variables and initial injury severity (Andelic, Hammergren et al. 2008). Neuropsychological assessment is often used in both the acute phase and during rehabilitation in order to evaluate cognitive abilities and possible dysfunction. Neuropsychological assessments have been shown to have good predictive value for the functional outcome in a shorter perspective (one-year follow-up) (Hanks, Millis et al. 2008).

Neuropsychological test batteries have also been used for evaluation of recovery over time and a considerable variability has been recorded ranging from no measurable impairment to very severe dysfunction. This finding indicates that neuropsychological recovery after TBI is not uniform as measured by conventional neuropsychological tests. In a study of neuropsychological performance five years after brain injury people with moderate to severe injuries were still found to recover several years post-injury, while for others significant impairment remains over time. In the study results showed that 22.2% improved, 15.2% declined and 62.6% remained at the same level (Millis, Rosenthal et al. 2001).

Anoxic brain injury

In the industrial part of the world the incidence of cardiac arrest is still growing. Sudden cardiac death is an important public health problem and 63% of all cardiac deaths in the US in 1989 to 1998 were defined as sudden (Zheng, Croft et al. 2001). A majority, almost 80%, of survivors remain in coma for varying lengths of time. The reason for this might be that after cardiac resuscitation, recirculation disturbances and complex metabolic post-reflow lead to neural cell death with deterioration of cerebral outcome (Madl and Holzer 2004).

In Europe the incidence of cardiac arrest outside hospital has been estimated at 37.7/100 000/year for all-rhythm cardiac arrest (CA) outside hospital. Survival was 10.7% for all-rhythm and 21.2% for ventricular fibrillation cardiac arrest (Atwood, Eisenberg et al. 2005). Around 15 000 die from heart disease in Sweden every year. Of these, around two-thirds die outside hospital. The proportion of those who survive the early phase and are admitted alive to hospital increased from 15% in 1992 to 22% in 2005. The proportion who survived the first month increased, from 4.2% in 2000 to 7.3% in 2005 (Swedish Resuscitation Council 2006).

Consequences of anoxic brain injury

Hypoxic-ischaemic brain damage owing to ceased or insufficient circulation can cause significant and long-term neurological and cognitive dysfunction. Neurological impairment is related to the extent of the brain injury and ranges from mild cognitive deficits to severe cognitive and motor deficits, preventing independence in activities of daily living (Khot and Tirschwell 2006).

Deficits of memory and also of executive function have been identified as common cognitive problems after hypoxic brain damage (Wilson 1996). An underlying cause of memory deficits has been associated with the negative impact of cerebral anoxia or hypoxia on the hippocampus region. In a small study of five anoxic brain-injury patients (with amnesic syndrome) a significant reduction of grey matter volume in the hippocampus bilaterally was noted when compared with healthy controls. The hippocampus was the only common atrophic region across the patients, indicating that the hippocampus is sensitive to ischemic damage to the brain (Di Paola, Caltagirone et al. 2008). Also the watershed cerebral cortex and the basal ganglia were more frequently damaged than the hippocampus (Caine and Watson 2000). There is also documentation supporting a more global nature of the brain damage from anoxia/hypoxia, affecting both memory systems and other cognitive functions (Grubb, Fox et al. 2000).

In a review paper of 58 studies memory difficulties were reported in 54% of the cases. These were most often combined with other neuropsychological deficits, such as visuospatial and/or visual recognition problems, noted in 31%. Changes in personality and/or behaviour were also described (Caine and Watson 2000).

Patients with anoxic brain injury had a shorter length of stay, better total FIM™ scores and they were discharged to rehabilitation facilities more often than TBI patients. It was concluded that also the anoxic damaged patient can benefit from in-patient rehabilitation with good functional recovery (Shah, Carayannopoulos et al. 2007).

Prognostic factors for outcome of anoxic brain injury

Long-term follow-up studies of outcome after anoxic/hypoxic brain damage are rather sparse and the results differ. In a small study of nineteen patients six months after cardiac arrest, eight (42 %) were working, six of them at previous levels. Of the eleven (58%) who were retired, seven returned to earlier levels of activity and four were neurologically impaired with mild to severe deficits (Granja, Cabral et al. 2002). In another follow-up study, two to seven years after CA, a significant relationship was found between the duration of coma and post-traumatic amnesia, complaints of cognitive functioning and quality of life. Duration of post-traumatic amnesia was associated with ability in daily functioning and quality of life. Experiencing cognitive difficulties was also associated with level of social participation and with quality of life (Middelkamp, Moulaert et al. 2007). In a Finnish study of outcome fifteen years after surviving pre-hospital CA, eleven of 59 subjects were alive at time of follow-up, and ten were eligible for neuropsychological examination. Five patients were considered cognitively intact; the others were diagnosed with mild cognitive problems. All except one were satisfied with their perceived quality of life (Harve, Tiainen et al. 2007).

Parkinson's disease

In Sweden, around 20 000 patients have the diagnosis, the incidence being in the area of 200/100 000. Most patients show the onset of Parkinson's disease between 50 and 60, and 25 to 30% are diagnosed before the age of 50 (Parkinsonförbundet 2009).

Cognitive impairments are common; 24% of newly-diagnosed patients were shown to have cognitive impairment in a study by Muslimovic and colleagues (Muslimovic, Post et al. 2005). The rate of annual cognitive decline in Parkinson's disease has been described as one point for the MMSE total score and 2.3 points for patients with Parkinson's disease with dementia (Aarsland, Andersen et al. 2004). A recent study is in agreement with these findings, as 31% of patients with newly-diagnosed Parkinson's disease were shown to have a decrease in MMSE total score with 2.39 points/year. The decline was associated with education, age of diagnosis, depression and diabetes mellitus (Kandiah, Narasimhalu et al. 2009)..

The incidence of dementia in patients with Parkinson's disease has been described as 95.3 per 1000 person-years and the relative risk of developing dementia as 5.9 (Aarsland, Andersen et al. 2001). The same author also found in another study that 78% of patients had developed dementia at the eight years' follow-up (Aarsland, Andersen et al. 2003). In a group of newly-diagnosed and drug-naïve patients with Parkinson's disease, most patients were cognitively impaired according to neuropsychological tests, compared to a healthy control group, but the effect size was small. Around 19% of patients in this group were considered to have mild cognitive impairment (MCI), relative risk for this was 2.1 compared with the control group (Aarsland, Bronnick et al. 2008).

Cognitive deficits associated with dementia in Parkinson's disease include deficits in attention, executive functions, visuospatial functions and memory. Core language functions are often preserved, but there are sometimes word-finding difficulties and problems in the comprehension of complex sentences (Merims and Freedman 2008). The most pronounced differences compared with controls have been found in executive functions and memory (Verbaan, Marinus et al. 2007). Impaired executive function may occur early in Parkinson's disease and

attention deficits in terms of prolonged reaction time, reduction in vigilance and fluctuating attention. Memory impairments are also frequent and are related to the development of dementia, as is executive function decline (Merims and Freedman 2008). Visual perception has been shown to be impaired and language problems that can occur are decreased phrase length, impaired speech melody, dysarthria and agraphia (Cummings, Darkins et al. 1988).

In a study of patients who had had Parkinson's disease for an average of three years, global cognitive function according to the MMSE was within normal range in 97% of the cases (Muslimovic, Post et al. 2008). There are some recently published studies indicating that the MMSE may be insensitive to more subtle changes in cognitive function in Parkinson's disease, when compared with a more recently-developed screening instrument, the Montreal Cognitive Assessment (MoCA) (Zadikoff, Fox et al. 2008; Nazem, Siderowf et al. 2009). In the latter study it was shown that 52% of patients with Parkinson's disease had a normal score on the MMSE but had cognitive impairment according to the MoCa.

Consequences of Parkinson's disease

Patients with Parkinson's disease have been shown to report lower health status than the general population. The diagnosis of Parkinson's disease was found to affect both physical and mental dimensions of health-related quality of life, that is. ambulation, dexterity, emotion, cognition and pain (Pohar and Allyson Jones 2009). Identification of the non-motor manifestations of Parkinson's disease is essential for ascertaining the functional status and for a better understanding of the neurodegenerative process (Simuni and Sethi 2008).

Physical disability, in terms of axial impairment, mood symptoms and co-morbidity contributes to disability and lower quality of life, while cognitive dysfunctions have only little impact according to one study (Muslimovic, Post et al. 2008). Other authors, however, have found that a mild cognitive decline contributed significantly to disability scores, independently of disease severity (Weintraub, Moberg et al. 2004). Visuospatial deficits are often present, the pattern of impairment being related to dementia and progression of the disease.(Levin, Llabre et al. 1991). This seems to be multidimensional, involving both functional ability and brain systems (Inzelberg, Schechtman et al. 2008).

Prognostic factors for outcome of Parkinson's disease

Parkinson's disease is progressive with an individual course. Motor ability deteriorates over time, there is development of levodopa-induced motor complications and poor levodopa responsiveness of motor signs like postural instability, freezing of gait and dysphagia and dysarthria. Many patients also suffer from non-motor symptoms, such as cognitive decline and dementia, autonomic failure, disordered sleep-wake regulation and sensory symptoms. The search for neuroprotective or restorative interventions is the primary goal of much research (Poewe 2006). Uncertainty about the prognostic importance of many baseline clinical features in Parkinson's disease remains. Greater baseline impairment, early onset of cognitive disturbance, older age, depression and lack of tremor at onset has been discussed as adverse prognostic factors (Marras 2002; Post, Merkus et al. 2007).

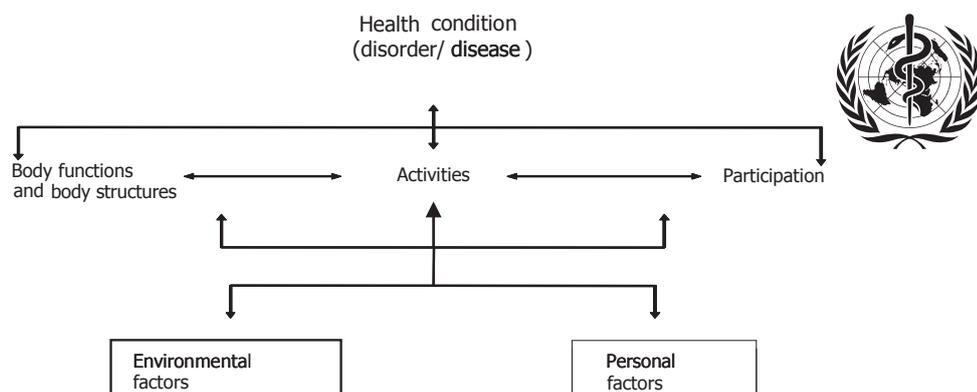
Rehabilitation

In stroke and other neurological diseases, rehabilitation is a process of interventions involving training to optimise functional motor control, cardiovascular fitness and muscular strength and endurance. The individual must try to learn again, with a damaged system, how to perform the activities of everyday life. Rehabilitation can be used as an assembly term for the interventions of medical, psychological, social and vocational character applied to facilitate the process (Höök 2001). This is largely based on the principles of education and relearning where it is necessary that the disabled person as well as his/her family is involved in the process for it to have a meaning and for stabilization over time. It deals not only with the physical disease but also with the psychological consequences of having a disease and with the environment in which the person lives and operates (Barnes, Dobkin et al 2000; Stucki, Reinhardt et al. 2008). Rehabilitation has been defined by the World Health Organisation (WHO) as a coordinated process that enhances 'activity' and 'participation'. In 2001 the International Classification of Functioning, Disability and Health (ICF) was published. It defines components of health and health related components of well-being (WHO 2001). The ICF can be used to assess the consequences of disorder and disease for an individual person as well as at population level.

The International Classification of Functioning, Disability and Health (ICF).

In the development of societies, the concept of health has been focus of a growing debate. Improving health status on individual as well as on societal level is not merely a matter of reducing disease and injury. Health deals with human functioning and the possibility for a person to live a full life. Thus, it is necessary to have relevant tools for the measurement of health and to assess which results that can be accomplished through interventions. This was the setting of the ICF (WHO, 2001). It includes a WHO mandate of the setting of norms and standards, encouraging global values of health, equity and inclusion in order to make it possible for nations to improve health policies and the structure of health systems. It was developed through a 10 year process, in which 65 member states took part. There was a broad-based consensus over terminology and classifications schemes and the model was subject of field-testing, ensuring cross-cultural comparability. The ICF is thus a proven international standard for functioning and disability classification. (Brundtland 2002) It was presented by the WHO in 2001 and is now accepted by 191 countries (Stineman, Ross et al. 2005) See Figure 1.

Figure 1. Components of ICF.



An individual's functioning in a specific domain can be seen as an interaction between the health condition and the contextual factors. There is a dynamic interaction between these units; interventions in one entity can modify the situation in the others. The interaction works in two directions and they are specific and do not necessarily have a one-to-one relationship.

The aims of rehabilitation are to guide the individual towards the best achievable function and possibility to regain prior life situation. Thus, rehabilitation has both a medical and a social goal, and the interventions aim to combine and coordinate these goals. In ICF(WHO 2001) terminology, there are three levels at which rehabilitation attempts to maximize function; impairment, activity and participation. Rehabilitation aims at alleviate impairment or actual loss of function. It also attempts to improve activity that has been restricted by the impairment and to enable participation in an unfulfilled social role which may have become a result of disability (Barnes, Dobkin et al 2005).

The focus on rehabilitation after brain injury has shifted during the last few decades. It used to be interventions concentrated on the restoration of body functions originally with focus on physical dysfunctions. Then followed also a focus on consequences of cognitive dysfunctions, and at the present time, the scope of rehabilitation has expanded to include community based interventions as well, concentrating on long term consequences such as restriction on participation (Mazaux and Richer 1998; Powell, Machamer et al. 2001).

The ICF provide a framework, which can be used for describing and measuring health and for classification of consequences of disease in terms of impairment on body structures and body functions, activity limitation and participation restriction (WHO 2001). The ICF is divided into two parts (Figure 1). The first part consists of the components Body functions (the physiological functions of body systems), Body structures (the anatomical parts of the body), Activity (the operation of a task or action) and Participation (involvement in a life situation). The second part is the environmental factors (physical, social and attitudinal milieu) and the personal factors (particular circumstances in a person's life and living). The last section is included in the ICF model not as a framework of items, because the attributes of a person are not altogether part of a health condition, but they influence how disability is perceived (Muo, Schindler et al. 2005). There are two important shifts in the ICF when compared to the previous model, the ICDIH; limitation in activity and restriction in participation are not seen as results of impairment, but there is a dynamic and multidirectional interaction between the components. The second change deals with the concepts of functioning and health which are not regarded as a consequence of disease or injury but are considered to represent the positive aspects between the person and the environment.

The ICF is also a classification system where the components in the model are divided into chapters including specific items or categories which are arranged hierarchically. There are two-, three- and four level categories and the ICF have a numbering system allowing for the coding according to the circumstances in an individual case (Muo, Schindler et al. 2005).

In the clinical context the ICF can be used to assess needs, when deciding interventions for specific health states, in rehabilitation and in outcome evaluation. In clinical practise, for making the use of the ICF more applicable and convenient it was decided that a linking of specific diseases and conditions to relevant ICF categories was of value. The aim was to create both Brief Core Sets allowing all patients with a specific clinical condition in a clinical study to be rated and Comprehensive Core Sets for the guidance of multidisciplinary assess-

ments in a patient with that specific condition. Initially, there were Core sets developed for 12 chronic conditions, among those a Core Set for Neurological Conditions in the acute hospital (Ewert, Grill et al. 2005) and in early post-acute rehabilitation facilities (Stier-Jarmer, Grill et al. 2005).

Different instruments used as outcome measurements can be linked to the categories of the ICF. Functional outcome scales are often chosen as endpoint measures in rehabilitation research, as they measure disability in terms of limitations in the activity level.

Activities of daily living

The lack of ability to perform daily occupations has become an important indicator of disability (Jette 1994; Verbrugge and Jette 1994). In daily occupations/activities of daily living (ADL) one can distinguish between personal daily life activities (P-ADL) (Law and Letts 1989) and instrumental activities, I-ADL (Wade, Legh-Smith et al. 1985). P-ADLs are intended to measure the basic daily activities that all people have to manage, regardless of sex, environment or culture. I – ADLs comprise the more complex activities that are essential for independent living in the society of today. The commonest sub-variables of P-ADL instruments are eating, grooming, dressing, bathing, toileting, transfers and mobility. Housekeeping, shopping and transportation are considered as instrumental activities (Avlund 1997).. The measurement of daily activities is complex and the result can be influenced by confounding factors (Feinstein, Josephy et al. 1986). It has been argued that functional scales are not able to describe the overall life situation of a patient recovering from a disease such as stroke. Changes in lifestyle, role fulfilment and goal achievement that often are consequences of neurological disorders are difficult to measure, however, in spite of their high relevance to outcome assessment. There is also an interest in Quality of Life scales (QoL) (Kaste, Fogelholm et al. 1998) and health-related quality of life (HRQL). HRQL is a multifactorial concept constructed to capture the aspects of self-perceived well-being that are related to or affected by the presence of disease or treatment (Ebrahim 1995). They measure physical function, psychological well-being, role limitations, pain and general health perceptions.

AIMS

The general aim of the present thesis was to:

evaluate a neuropsychological screening instrument, the Barrow Neurological Institute Screen for Higher Cerebral Functions (BNIS) for construct validity, discriminative ability with reference to occurrence of brain damage and dependency in ADL, and the applicability of the method in a clinical setting.

The specific aims were to:

- explore the construct validity and discriminative efficacy of the BNIS in a Swedish population of healthy subjects and patients with neurological diagnosis often associated with brain damage and cognitive dysfunction.
- compare the BNIS and the Mini Mental State Examination (MMSE) in order to gain a better understanding of the measuring qualities and type of information collected by the two scales.
- use the BNIS as an assessment method when studying recovery of cognitive function in stroke patients who had received in-patient rehabilitation and also describe the association between cognitive function, ADL ability and vocational status at one and three years post-stroke: use the BNIS when describing life situation for patients who had survived a cardiac arrest for two years with regard to cognitive function, ADL status, housing and return to work and assess the prognostic contribution of the early evaluations of neurological status, cognitive function and personal ADL and the association between cognition and performance in ADL activities.

METHODS

Study populations

Altogether, 172 patients and 92 controls took part in the studies. The study populations are presented in Table 1. All patients, except for the anoxic brain injured patients, were recruited from the Rehabilitation Clinic of Sahlgrenska Hospital in Gothenburg, Sweden. Gothenburg has a catchment area of around 600 000. It is mainly an urban environment, with a mixed population, as around 26% of the population is immigrants

{<http://www.immi.se/migration/statistik/folkmand-utlandskbakgrund2004.htm>}.

Table 1. Study populations; controls and patient groups in Study I-IV.

Study groups	Study I	Study II	Study III	Study IV
Control group n=92	Controls n=92			
Stroke n=82	Stroke n=48	Stroke n=16	Stroke n=58	
TBI n=36	TBI n=24	TBI n=12		
Anoxia n=25	Anoxia n=24	Anoxia n=16		Anoxia n=22
Parkinson's disease, n=29	Parkinson's disease n=24	Parkinson's disease n=5		

The Rehabilitation Clinic has both in-patient and out-patient facilities and receives patients in the sub-acute phase after neurological disease. The commonest diagnostic groups are stroke and traumatic brain injury. With few exceptions, patients are of working age, below the age of 65 years. The Rehabilitation Clinic has multidisciplinary rehabilitation teams consisting of the professions often seen in this setting; physicians, occupational therapists, physiotherapists, neuropsychologists, social workers and speech therapists.

The diagnostic group of Study I consisted of 120 patients where the stroke patients also participated in Study III and the anoxic brain-injured patients in Studies II and IV. Study I and Study II also included a clinical material, concerning the stroke, TBI and Parkinson's disease patients, where data were collected from medical records.

In Study III, all patients had had a first incidence of stroke and were below the age of 65 years. Patients with subarchnoidal bleeding were excluded.

In Study IV, a cohort of survivors of cardiac arrest outside hospital or at the emergency ward was examined at two weeks after cardiac arrest and followed-up at two years after onset.

The control group in Study I consisted of 92 people recruited as so-called healthy controls. For practical reasons they were mainly enrolled from hospital or university employees, and they had different vocational and educational backgrounds. They were approached by direct contact with the responsible research team member or by telephone or e-mail and/or through a direct contact with the workplace. The intention was to recruit control people younger than 65. All received oral and written information and gave their written informed consent. They were interviewed to ascertain that they had no history of brain disease or dysfunction, psychiatric illness or drug abuse, dyslexia or serious visual or hearing impairment and no ongoing somatic disease. The subjects were Swedish-speaking. The gathering of the control population was part of the data collection for establishing Swedish reference norms for the BNIS.

Approval of the Ethical Committee of the University of Gothenburg was given after consideration of the control subjects and patients taking part in the research studies (Studies I, II, III and IV). All patients in the studies, or in some cases, their next-of-kin gave their informed consent for participation. Demographic data of the study populations is presented in Table 2.

Table 2. Basic demographic data for the study populations, Study I-IV.

	Study I		Study II	Study III	Study IV
	Patients (n=120)	Controls (n=92)	Patients (n=52)	Patients (n=58)	Patients (n=22)
Men	86 (72 %)	41 (45%)	36 (69%)	44 (76%)	19 (86%)
Women	34 (28%)	51 (55%)	16 (31%)	14 (24%)	3 (14%)
Age, years mean, SD	51 (13.3)	43 (13.0)	50 (11.7)	52 (7.9)	59 (14.2)
Age, years range	18 - 74	19 - 69	22 - 71	28 - 64	22 - 74
Education, years ≤ 9	49 (41%)	14 (15%)	10 (19%)		
Education, years > 9	71 (59%)	78 (85%)	42 (81%)		

Assessment methods

The assessment methods used in the studies were all in general clinical use, with the exception of the Instrumental Activity Measure (IAM). The instruments represent methods to assess both the components of body functions and activities and participation of the ICF.

An overview of the assessment methods used in the studies is presented in Table 3.

Table 3. Systematic Assessment methods used in Study I-IV.

	Study I		Study II	Study III	Study IV
	Patients (n=120)	Controls (n=92)	Patients (n=52)	Patients (n=58)	Patients (n=22)
NIHSS				X	X
BNIS	X	X	X	X	X
MMSE			X		X
FIM™			X	X	X
IAM				X	

The data collection was performed by the author for the BNIS in Study III. Other data assessment was performed by members of the research team or professionals at the Rehabilitation Clinic (physicians, psychologists and occupational therapists).

Barrow Neurological Institute Screen for Higher Cerebral Functions (BNIS).

The Barrow Neurological Institute Screen for Higher Cerebral Functions (BNIS) is an instrument developed to assess cognitive function in a neurological setting. The rationale was to construct a method for a rapid, reliable and valid assessment and to address some limitations considered present in other screening instruments. First, it should provide an initial assessment to establish when a patient has the ability necessary to complete a neuropsychological test. Second, it should give information about the qualitative aspects of performance. The BNIS should also reflect the range of higher cerebral functions seen in patients who have focal, bilateral, diffuse or lateralised impairment. Finally, patients' self-perception or awareness vs. performance should be obtained (Prigatano 1991). The BNIS has been demonstrated to have good psychometric values and has been tested for reliability (initially both inter-rater and test-retest) (Rosenstein, Prigatano et al. 1992) and concurrent and construct validity in the US (Prigatano, Amin et al. 1993; Rosenstein, Prigatano et al. 1997) and in Sweden (Denvall, Elmstahl et al. 2002).

As described, the BNIS assesses different cognitive domains as well as affective and meta-cognitive aspects and also provides an index of overall cognitive function (Borgaro 2003). Test items are relatively simple to understand and are not considered intimidating for patients in the early stages after brain injury (Borgaro and Prigatano 2002). The test was designed to

take no more than 30 minutes to administer (Prigatano 1995). The test is presented in the form of a booklet, containing nineteen cards, with 37 items in all, including three initial pre-screen items.

Pre-assessment information is, if possible, systematically collected, such as age, educational level, socioeconomic status, estimated pre-morbid IQ, handedness, admission level of neurological functioning and time since onset of the injury (Prigatano 1995).

The three initial items are pre-screen items, where arousal level and alertness, basic communication skills and level of cooperation are assessed. The maximum score is nine points. To continue the assessment a score of at least two points on each item is required.

The BNIS consists of seven subscales. The following cognitive domains are assessed:

Speech and language (fluency, paraphasia, dysarthria, comprehension, naming, repetition, reading, writing, spelling, alexia and dyscalculia). The maximum score is fifteen points.

Orientation (right-left, place, date). The maximum score is three points.

Attention/concentration (arithmetic, memory and concentration, digits forward, digits reverse). The maximum score is three points.

Visuospatial and visual problem-solving (visual object recognition, constructional praxis, visual scanning, visual sequencing, pattern copying, pattern recognition). The maximum score is eight points.

Learning and memory (number-symbol, delayed recall). The maximum score is seven points.

Affect (expression, perception, control, spontaneity). The maximum score is four points.

Awareness (awareness vs. performance). The maximum score is one point.

For a description of the items of the BNIS, see Appendix 1.

In the validation procedure of the BNIS it was found that the average control subject had a mean score slightly over 46 points. Therefore a cut-off score for identifying brain dysfunctional patients as dysfunctional ('true positives') was set at 47 points. By means of this cut-off score a sensitivity of 92% was achieved, while the specificity was lower, 56%. The false positive ratio was 18% and the false negative ratio was 24% (Prigatano, Amin et al. 1993; Rosenstein, Prigatano et al. 1997). The BNIS also showed discriminative power to differentiate right hemisphere lesions from left hemisphere lesions. As predicted, the right hemisphere lesion patients performed worse than left hemisphere lesion patients on the visuospatial and affective subscales, while the left hemisphere damaged patients had significantly lower scores on the speech and language subscale (Prigatano, Amin et al. 1993).

Lezak (Lezak, Howieson et al. 2004) describes the test's psychometric properties: test-retest reliability showed a reliability coefficient of 0.94 and 0.97 for a subgroup examined by the same person at each time. Test-retest reliability for the subscales ranged from 0.31 (awareness) to 0.93 (speech and language). The inter-rater reliability coefficient was 0.998 for a small group of ten patients. Validation studies found an average difference between patients and controls of ten points ($p < .001$) (Prigatano, Amin et al. 1993). In this study, the BNIS correlated with the MMSE; correlation coefficient $r: 0.81$.

Mini Mental State Examination (MMSE)

The most well-known screening method used all over the world is probably the Mini Mental State Exam (MMSE) (Malloy 1997). It was essentially constructed for evaluating patients with depressive symptoms to establish whether cognitive impairment or dementia was likely (Folstein, Folstein et al. 1975). Many of the items were already used by neurologists when screening mental ability as part of the medical exam (Spreeen and Strauss 1998). The test has been mainly used for identification of dementia in geriatric populations, but also for purposes in other clinical and primary care settings. It has been criticised, for example, regarding its limited sensitivity in some items when correlated with neuropsychological tests and its inability to generate a cognitive profile (Feher, Mahurin et al. 1992). An expanded version of the MMSE, the Modified Mini Mental State Examination (3MS) has been developed (Teng 1987; Bland and Newman 2001), in order to increase the sensitivity. The MMSE has also been adopted for children and use in paediatric settings (Ouvrier 1993; Besson 1997). In a review article by Tombaugh and colleagues (Tombaugh and McIntyre 1992), good sensitivity and specificity are shown in the evaluation of psychiatric patients' relatively different criteria while the results were lower for assessed cognitive impairment. The content of the MMSE is highly verbal and therefore increases the risk of missing brain damage where visuoperceptual and/or visuoconstructional dysfunctions are most pronounced, as in certain focal lesions. The MMSE also has a limited way of assessing praxis and there is a risk that right-hemisphere disease will not be detected (Fillenbaum, Heyman et al. 1987). The MMSE has been said to have poor ability to detect cognitive impairment (not dementia) in a group of first-ever stroke patients (Srikanth 2006). A cut-off value of 23 or less has generally been accepted as indicating the presence of cognitive impairment. The lack of sensitivity has led to recommendations for using different cut-off levels: 0-17 = severe impairment, 18-23 = mild impairment and 24-30 = no cognitive impairment (Tombaugh and McIntyre 1992). Scores between 26 and 30 for normal cognitive functioning have been noted by other authors (Molloy, Standish et al. 2005). There are various normative data established. There are also normative data for a modified version of the MMSE, the 3MS, in groups aged 65 years and above (Tombaugh, McDowell et al. 1996). In the US, the test is available from a formal test publisher (www.parinc.com). In terms of demographic effects, age scores increase with age in children and decrease with older age in adults (Tombaugh and McIntyre 1992). Educational level is also defined as a factor affecting test scores. People with higher educational level tend to have higher scores than those with lower education (Crum, Anthony et al. 1993; Jones and Gallo 2001). There is evidence that low educational level increases the risk of misclassifying normal subjects as cognitively impaired and higher education may mask milder impairments (Spreeen and Strauss 1998). People with lower education often make errors on the items 'serial subtraction', backward spelling, repeating phrases, writing, naming and season and also on the copying item (Jones and Gallo 2000). Gender generally seems to have little impact on the score (Anstey 2000). Reliability estimates, such as internal consistency, have been shown to range from 0.31 in community-based samples to 0.96 for a mixed group of medical patients (Espino 2004; Foreman 1989; Tombaugh and McDowell et al. 1996). The lower reliability probably reflects the lower variability in healthy groups. Test-retest reliability for shorter intervals (under two months) generally falls between 0.80 and 0.95 (Folstein, Folstein et al. 1975) (Tombaugh and McIntyre 1992; Clark 1999). Inter-rater reliability has been reported to be marginal (above 0.65) (Folstein, Folstein et al. 1975). In a later study the overall inter-rater concordance was

good when used by general practitioners (Pezzotti, Scalmana et al. 2008). Ethnicity also affects MMSE performance (Espino, Lichtenstein et al. 2001).

As regards construct validity, the MMSE shows modest to high correlations with other brief screening instruments (such as the Blessed Test, the Dementia Rating Scale (DRS) and the Clock Drawing Task) (Fillenbaum, Heyman et al. 1987; Adunsky, Fleissig et al. 2002). This implies that various tests tap similar, but not identical, cognitive areas. Modest to high correlations have also been reported between MMSE total score and other cognitive tests (Feher, Mahurin et al. 1992; Tombaugh and McIntyre 1992; Giordani 1990) which support the idea that the MMSE total score measures some general cognitive ability (Spren and Strauss 1998). In the article by Folstein and colleagues (Folstein, Folstein et al. 1975) the items of the instrument were grouped into subscales of orientation, registration, attention and calculation, recall and language. According to Spren and Strauss (Spren and Strauss 1998), it is unclear whether the MMSE subscales can be viewed as measures of specific cognitive domains. For a description of the items of the MMSE, see Appendix 2. Studies using factor analysis have identified between two and five factor solutions (Giordani 1990; Mitrushina 1994). In the most recent studies, however, there is support for some of the original categories; orientation (time and place), attention (serial 7s) and memory (recall of three words), while there is less support for others such as registration, language and construction (Jones and Gallo 2000; Banos and Franklin 2002; Schultz-Larsen, Kreiner et al. 2007). The MMSE has been shown to have a modest relation with measures of everyday activities (Adunsky, Fleissig et al. 2002; Molloy, Standish et al. 2005). The MMSE has been described as most effective in distinguishing patients with moderate or severe deficits.

The National Institute of Health Stroke Scale (NIHSS)

The National Institute of Health Stroke Scale (NIHSS) (Brott, Adams et al. 1989) was used as an assessment of neurological damage before discharge. This is a quantitative measure of neurological deficits, where the presence of one or more deficits are identified and scored. It consists of fifteen items, e.g. level of consciousness, extra-ocular movements, visual fields, facial muscle function, extremity strength, sensory function, coordination (ataxia), language (aphasia), speech (dysarthria) and hemi-inattention (neglect) (Kasner 2006). The scores are summarised and a low score indicates fewer deficits. The maximum score is 36.

The NIHSS provides a measure of the key components of a standard neurological examination. It has established reliability and validity for use in prospective clinical research and predictive validity for long-term stroke outcome. The NIHSS was designed as an observational scale to assess differences in interventions in clinical trials, but its use in patient care is increasing as an initial assessment tool and in planning post-care disposition. The score is not directly and specifically associated with the ability to functionally compensate for a neurological deficit, however, and thus is not an ideal solitary measure of outcome after stroke. Often low scores occur in patients with disabling brain stem or cerebellum infarctions (Kasner 2006). In a post hoc analysis an excellent outcome was achieved by almost two-thirds of patients with a score of three or less at seven days after stroke onset. Few patients with baseline scores of fifteen or more had excellent outcomes after three months (Adams, Davis et al. 1999). More than 80% of patients whose score is five or less at time of admission will be discharged to home, whereas those with scores between six and thirteen will usually require

acute in-patient rehabilitation. Those with scores of fourteen or more frequently need long-term care in nursing facilities (Rundek, Mast et al. 2000; Schlegel, Kolb et al. 2003).

Functional Independence Measure (FIM™)

Assessments of personal ADL were made with the Functional Independence Measure (FIM™). This scale is an observational scale originally developed by a multidisciplinary team in 1984 (American Congress for Rehabilitation Medicine and the American Academy of Physical Medicine and Rehabilitation) to be used as a standard assessment tool. It is mainly a measure of activity limitations and reflects what a person actually does. FIM™ is used across a wide range of conditions and situations in rehabilitation settings (Haigh, Tennant et al. 2001). It is also intended to be discipline-and diagnosis-free. The use of FIM™ requires training by certified staff and a contract with the Uniform Data System for Medical Rehabilitation (UDS).

The FIM™ consists of eighteen items evaluated on a seven-category scale ranging from complete independence to needing total assistance, based on how much help a person requires in order to perform a given task. It is divided into two separate scales, a thirteen-item motor scale and a five-item Social-Cognitive scale (Linacre, Heinemann et al. 1994). A score of seven indicates complete independence, a score of six modified independence (e.g. the activity requires an assistive device), while a score of five includes supervision or set-up from a helper. A score of four refers to minimal contact assistance, subject requires no more help than touching, a score of three moderate assistance, subject needs more help than touching, two extensive assistance and a score of one indicates total assistance. It is summed up, resulting in a maximum score of 91 for the FIM™ Motor scale and a maximum of 35 for the FIM™ Social-Cognitive scale (Keith, Granger et al. 1987). In the present studies, II - IV, a score of ≤ 77 for the FIM™ Motor scale and ≤ 29 for the FIM™ Social-Cognitive scale were considered to indicate dependence in ADL, based on the need for modified assistance in all items except one, where supervision or more assistance was needed. The FIM™ is considered as the strongest scale for evaluating the need for assistance from another person to perform personal care activities (Granger, Divan et al. 1995).

The FIM™ is commonly used for in-patient rehabilitation (Dodds, Martin et al. 1993) but it is also recommended as a follow-up measure. The FIM™ has been translated into Swedish and validated on a Swedish population basis (Grimby, Gudjonsson et al. 1996). Data may be collected in the form of interviews or as self-reports. The validity and reliability of the FIM™ have been described in reports using different methods (Dodds, Martin et al. 1993; Stineman, Ross et al. 2003). Training of rehabilitation team members in using the FIM™ is an established area.

Instrumental Activity Measure (IAM)

Instrumental ADL was assessed with the Instrumental Activity Measure (IAM) (Grimby, Andrén et al 1996). This instrument contains eight items related to common activities and independent living. It is used in interviews with subjects, if possible in their ordinary environment. The scaling and method of assessment have been developed according to the format of the FIM™. Thus a score of seven indicates that the activity is independently performed while a score of one indicates total assistance (see FIM™). The IAM assesses the following areas: mobility outdoors, preparing a simple meal, cooking, public transportation, shopping (small-scale and large scale), cleaning and washing (Grimby, Andrén et al. 1998; Andrén and Grimby 2000). In Study III only the total score was used (maximum score is 56), as no cut-off limit is established for the IAM.

Return to work

Information on work content and vocational situation is of importance for goal-setting in rehabilitation. It has been shown that patients view return to work as an important indicator of recovery after stroke (Alaszewski, Alaszewski et al. 2007). Return to work is also used as an outcome measure of Activity and Participation after disease and injury. There are different definitions of the concept of work in different studies. There are also differences in the cultural settings and in the national welfare systems, which influence the degree of return to work in various ways.

Procedure

Studies I and II

The following applies to all cases in the control group and in the patient groups in Study I: the subjects were divided into age groups according to the BNIS manual (Prigatano 1995): 15-39 years, 40-59 years and 60-84 years. The level of education was defined in two groups. In accordance with the norms of the Swedish educational system, people with nine years of education ('compulsory school') or less were classified as low-level and those with more than nine years of education as high-level educated.

In study II data from clinical assessments with the BNIS and the MMSE as well as with the FIM™ were retrospectively collected from patients' medical charts and/or the quality register of the Rehabilitation Clinic. The sixteen patients who had an anoxic brain injury participated in a follow-up study of patients who had survived a cardiac arrest and where assessments with the two neuropsychological screening instruments were made at the most ten days apart. The patients with a stroke or TBI diagnosis were assessed during the in-patient period while the anoxic brain-injured were assessed as part of the follow-up study and the patients with Parkinson's disease were assessed when visiting the out-patient clinic of the Rehabilitation Clinic. The BNIS and the MMSE were linked to the ICF through a process including two separate pair of raters.

Studies III and IV

These studies were descriptive follow-up studies. As regards Study III the patients (diagnosed with a first-ever stroke) were assessed with the BNIS, the FIM™, the IAM and the NIHSS at discharge from the in-patient clinic. Patients with neglect and aphasia were identified according to their scores on the neglect item and best language item on the NIHSS. At the follow-up one year after discharge assessments were again made with the BNIS, the FIM™ and the IAM. Data regarding employment status and work content prior to the stroke were collected at admittance to the Rehabilitation Clinic. Vocational status before the stroke at one and three years after discharge was gathered. The patient was considered to be working if he/she worked or studied at least ten hours/week (40 hours/week is considered as full-time work in Sweden) at a workplace within the open labour market. The authors assessed work content and skill level according to the Swedish Standard Classification of Occupations 1996 (SSYK, 1996).

Patients in Study IV were all subjects in a longitudinal follow-up study of people who had survived a cardiac arrest (CA) out of hospital or at the emergency ward. Two years after the CA assessments with the BNIS and the FIM™ were performed and information about housing and work situation (if the patient was of working age) was retrieved. Data from examinations with the NIHSS and the MMSE and FIM™ at two weeks and with the BNIS between 45 to 90 days after cardiac arrest were gathered and analysed.

Data analysis

Descriptive statistics; frequencies, percentages, means, standard deviations (SD), medians and quartiles were used in all studies for describing demographic data and for data at ordinal level when not normally distributed. Non-parametric statistics were used for analysis of group differences, and a p-value of $\leq .05$ was considered significant. In some cases the confidence interval (CI) for 95% probability was presented. Calculation of difference between proportions was made according to Altman (Altman 1991). Hierarchical multiple regression and logistic regression were used for analysing the impact of certain variables. The logistic regression was performed with a forward stepwise procedure a (probabilities: entry 0.05 and removal 0.10). For the analysis of scale concordance between scales (BNIS and MMSE) the Rank Transformable Pattern of Agreement (RTPA) was used (Svensson 1993; Gosman-Hedstrom and Svensson 2000). The method describes the degree of agreement between two scales in ranking individuals. Goodman-Kruskal's gamma statistics was calculated for the two scales (BNIS and MMSE) when analysing concordance. The sensitivity and specificity of the BNIS and the MMSE with regard to personal ADL were calculated with Receiver Operating Characteristic (ROC) curves (Altman and Bland 1994).

All statistical calculations were performed with the Statistical Package SPSS: versions 12.0, 15.0 and were used. P-values are presented as in the SPSS output, where a value of 0.000 refers to a value < 0.0005 (Pallant 2007). An overview of the statistical methods is presented in Table 4.

Table 4. Statistical methods used in Study I-IV.

		Study I	Study II	Study III	Study IV
Descriptive statistics	Mean, sd				
	Median, quartiles	X	X	X	X
Group comparisons					
Non-parametric statistics	Mann-Whitney U test	X	X	X	
	Wilcoxon signed ranks test			X	X
	Chi2	X			
	Kruskal-Wallis test	X			X
Correlations					
Non-parametric statistics	Kendall-tau			X	
	Goodman-Kruskal's Gamma coefficient		X		
Regression analyses					
	Multiple regression	X	X		
	Logistic regression			X	
Other methods					
	RTPA		X		
	ROC-curves		X		

RESULTS

Study I and Study II can be regarded as method studies examining the validity discriminative qualities of the BNIS, while Studies III and IV both examine the applicability of the instru-

ment in clinical settings and in various patient groups where a neurological diagnosis is present.

Study I

Using the BNIS total scores we found no significant difference between men and women in the control population ($p=0.61$) or between the three age groups ($p=0.72$) but there was a significant difference ($p<0.0005$) with reference to educational level so that the low-educated (≤ 9 years) had lower total scores at the BNIS than those with education > 9 years. In the whole patient group there was no gender differences ($p=0.53$) or differences between the age groups ($p=0.72$). As in the control group, there was a significant difference between the high and the low educated also in the patient group ($p<0.0005$)

There was a significant difference between the BNIS total scores of the control group and the patient group ($p<0.0005$), as well as in all the subscales scores (see Table 5).

Table 5.

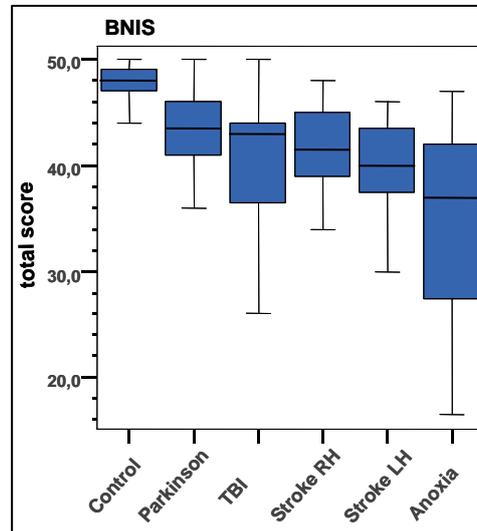
Mean values and SD of the BNIS total score and subscales in the control group and in the patient group (all diagnoses). *Mann Whitney U test, ** Difference between proportions (Altman 1991).

BNIS	Controls n=92		Patients groups n=120		p-value
	Mean	sd	Mean	sd	
Total score	47.5	2.0	39.8	6.8	<0.0005*
Speech and language	14.9	0.3	13.4	2.2	<0.0005*
Orientation	3.0	0	2.6	0.7	<0.0005*
Attention and concentration	2.5	0.7	2.0	0.9	<0.0005*
Visuospatial problemsolving	7.2	0.8	5.4	1.6	<0.0005*
Memory	6.5	1.1	3.9	2.2	<0.0005*
Affect	3.7	0.6	3.2	0.9	<0.0005*
Awareness v performance (proportion correct)	0.8		0.4		<0.00006**

There were also significant differences between the various diagnostic groups (BNIS total score: Kruskal-Wallis test χ^2 : 18.36, $p \leq 0.001$). The results of the control group and the diagnostic groups are presented as boxplots (median value and 25th-75th quartiles) in Figure 2. The hierarchical multiple regression analysis, where the 92 controls and the 120 patients were included, showed that the presence of neurological diagnosis had the most impact on the variance and together with educational level it significantly ($p < 0.0005$) explained 40.7 % of the variation in the BNIS total score.

Figure 2.

BNIS total score of the control group (n=92) and the diagnostic groups (n= 24 patients of each diagnosis). Boxplots are showing median value (line in the middle of the box) and 25th quartile (lower end of box) and 75th quartile (upper end of box).



Study II

There was a good concordance found between the BNIS and the MMSE (Goodman-Kruskal Gamma: 0.724, $p < 0.0005$). The RTPA showed that the eleven patients who reached the maximal score of 30 points at the MMSE, had a range of 42 to 49 points on the BNIS. No patient reached the maximal score, 50 points, on the BNIS. The subscales of visuospatial problem-solving and memory of the BNIS seemed to differentiate, as only one patient of those eleven scored the maximal eight points and four had the maximal seven points on the BNIS memory subscale. Corresponding total scores of the BNIS and the MMSE are shown in Table 6

Table 6.

Correspondance of total scores of the BNIS and the MMSE. Estimation according to RTPA; that is, differences in the marginal distributions are according to systematic differences.

BNIS, total score	MMSE, total score
44 - 50	30
43	29
41 - 42	28
39 - 40	27
38	26
34 - 36	24
32 - 33	23
30 - 31	22
28 - 29	21
26	18
24	12
22.5	10

On the subscales of the instruments, the lowest proportion of correct answers on the BNIS was found on the items ‘pattern recognition’ (17% correct), ‘awareness vs performance’ (27% correct) and ‘digits backward’ (38% correct). The corresponding items with the lowest frequency of correct answers on the MMSE were ‘recall of three words’ (42%) and ‘attention and calculation’ (58%).

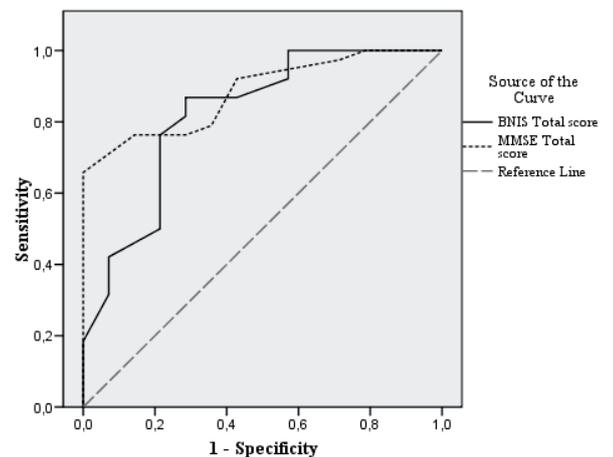
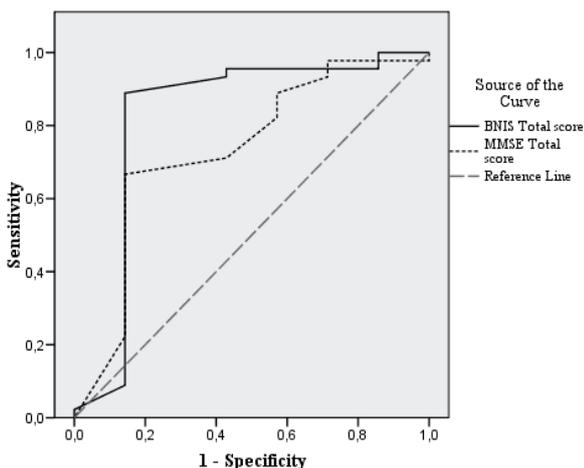
Use of ROC curves to estimate the sensitivity and specificity of the total scores of the two scales with respect to dependence in personal ADL (assessed by the FIM™) showed a sensitivity of 86% and a specificity of 89 % at the cut-off score < 34 points on the BNIS for FIM™ Motor scale; the corresponding cut-off for the MMSE was < 27 points (total score) with a sensitivity of 71% and a specificity of 69%. When associated with FIM™ Social-Cognitive scale the best cut-off value for BNIS was <38 points (sensitivity 79% and specificity 76%) and < 28 points at MMSE, giving a sensitivity of 86% and a specificity of 76%. Area under curve (AUC) showed that both instruments could discriminate ADL-dependent from ADL-independent with significant accuracy. ROC-curves for the BNIS and for the MMSE are presented in Figure 3a and 3b.

Fig.3a. Sensitivity and specificity of the BNIS and the MMSE for identifying ADL-dependence assessed with FIM™ Motor scale.

Fig.3b. Sensitivity and specificity of the BNIS and the MMSE for identifying ADL-dependence assessed with FIM™ Social-Cognitive scale.

AUC: BNIS: 0.821 (CI 0.583-1.058)
MMSE: 0.732 (CI 0.511-0.952)

AUC: BNIS: 0.820 (CI 0.683-0.958)
MMSE: 0.883 (CI 0.793-0.972)



BNIS cut-off score for identifying brain dysfunction (<47 points) gave a sensitivity of 86 % (FIM™ Motor Score) but a specificity of 9 % and the sensitivity when related to FIM™ Social-Cognitive score was 100 %, specificity 13 %.

The BNIS was linked to a total of 18 categories of Body functions of the ICF and MMSE was linked to 12. Both instruments were also linked to Activities and Participation; BNIS to 16 and MMSE to 14 categories within these components.

Study III

Follow-up from discharge to one year after discharge showed significant recovery in cognitive function and in ADL ability among first-ever stroke patients from a Rehabilitation Clinic.

This improvement in cognitive function, however, was noted only for the left hemisphere damaged (LHD) patients, not for the right hemisphere damaged (RHD). The RHD did not recover significantly in terms of personal ADL ability in the Social-Cognitive aspect. The RHD, however, appeared to have a somewhat higher level of functioning according to the results of both the cognitive screening and the ADL examinations. Still after one year, 83 % of the stroke patients had cognitive dysfunctions and 20 % were dependent in ADL. All patients, the LHD as well as the RHD, improved significantly in instrumental activities (see Table 7).

Table 7.

Results of cognitive screening (BNIS), personal ADL (FIM™) and instrumental ADL (IAM) (presented in terms of means and SD) at discharge from Rehabilitation Clinic and at 1 year after discharge. Patients with first-ever stroke. Mean values and SD are given.

	BNIS total score discharge (n=43)	BNIS total score 1 year follow-up (n=44)	p-value
All patients	40, 3 (5.3)	41.7 (5.4)	0.012
LDH	38.6 (6.0)	40.4 (5.7)	0.018
RHD	41.7 (4.7)	43.0 (4.4)	0.152
	FIM™ Motor score discharge (n=58)	FIM™ Motor score 1 year follow-up (n=56)	
All patients	78.2 (9.9)	82.3 (8.1)	<0.0005
LDH	75.5 (9.7)	82.8 (7.5)	<0.0005
RHD	80.3 (9.8)	82.3 (9.1)	0.004
	FIM™ Social-Cognitive score discharge (n=58)	FIM™ Social-Cognitive score 1 year follow-up (n=56)	
All patients	29.6 (4.8)	31.6 (3.5)	<0.0005
LDH	27.9 (5.2)	30.9 (3.8)	<0.0005
RHD	31.1 (3.9)	32.0 (3.3)	0.094
	IAM total score discharge (n=58)	IAM total score 1 year follow-up (n=56)	
All patients	25.3 (13.4)	38.1 (13.1)	<0.0005
LHD	22.2 (10.9)	36.9 (12.2)	<0.0005
RHD	28.7 (15.0)	38.4 (14.4)	<0.0005

Fifty-one people had worked before stroke onset and 4 were unemployed at the stroke onset. Four of these 55 people (7%) had returned to work one year later and eleven (20%) were working after three years. Patients with neglect and/or aphasia showed a lower rate of returning to work; two persons were back to work after three years and one person had worked at one year but not at three (11%). Of the 25 patients who did not have neglect or aphasia, nine (36%) returned to work.

Study IV

ADL ability and cognitive function in a group of 22 survivors of cardiac arrest (CA) were examined at two years post-cardiac incident. In personal ADL, FIM™ Motor scale showed a median of 86 (interquartile range 71-91) and FIM™ Social-Cognitive scale had a median value of 29 (interquartile range 21-34). The highest frequency of dependency among the items of FIM™ Motor scale was found in: 'shower' (38%), 'dressing of upper and lower body' and 'grooming' (33%). In the Social-Cognitive aspect dependency was noted in the items 'memory' (57%) and 'problem-solving' (52%).

Cognitive screening with the BNIS at two years after the cardiac incident showed that only one person had a result above the recommended cut-off score of 47 points. The subscales indicating most dysfunction; were 'memory' (median 1, interquartile range 0-4.5, maximal score 7), 'visuospatial problem-solving' (median 4, interquartile range 3-6, maximal score 8), 'attention and concentration' (median 1, interquartile range 1-2, maximal score 3) and 'awareness of own performance', 18 of 22 (86 %) people scored zero (incorrect estimation of own performance). Interquartile range here refers to the 25th and 75th quartile.

Fourteen people lived in their own home, two of these with assistance 16 to 24 hours/day. Eight (including the two living in their own home, but with extensive assistance) lived in sheltered accommodation. Seven of these were dependent both according to FIM™ Motor and Social-Cognitive scales. Four of fourteen people of working age (at onset of CA) had returned to work after two years (29%).

DISCUSSION

The purpose of this thesis was to examine the validity and clinical applicability of screening methods for the assessment of cognitive function in the neurological rehabilitation setting. One instrument, the Swedish version of the Barrow Neurological Institute Screen for Higher Cerebral Functions (BNIS), was more carefully evaluated. The results of Study I confirm earlier findings that this instrument has good discriminative ability with reference to brain diseases or injuries associated with cognitive dysfunctions.

Compared with the well-established MMSE, the BNIS appeared to discriminate better for the level corresponding to the maximal score of the MMSE. This implies that the BNIS might be used in circumstances where the patient seems to have relatively well-preserved cognitive functions and the instrument is still sensitive to detect subtle cognitive dysfunctions. Generally, cognitive screening examinations are of interest primarily in identifying dysfunctions related either to dementia or to other neurological diseases. In the case of the latter a short and comprehensive instrument is of conceivable use in many clinical circumstances, initially as a

baseline examination, during rehabilitation to follow progress or recovery and as a comprehensive examination when a conventional neuropsychological test battery is inappropriate.

There is some debate about the so-called ecological validity of neuropsychological assessment methods, and it is of importance to evaluate the assessment methods to ascertain good validity also in this respect. The term ecological validity refers to the degree to which a neuropsychological test can make an accurate prediction of behaviour in a real-world setting. Studies have reported moderate ecological validity (Chaytor and Schmitter-Edgecombe 2003) also in presumed healthy subjects (Van der Elst, Van Boxtel et al. 2008). Study II demonstrated cut-off scores for dependency in personal ADL for both the BNIS and the MMSE. We also performed a linking to the ICF of the BNIS and the MMSE where the BNIS was considered to cover a broader range of categories than the MMSE. The categories were mainly related to body functions, particularly within Chapter 1; Mental functions. It was also possible to link the BNIS to several categories within the components of activity and participation. The BNIS was found to be applicable in clinical use, since it is comprehensive and not time-consuming. Results from the clinical studies indicated a good correspondence with ability in everyday functioning and also concerning return to work, but both aspects need to be further explored, as there were some individuals with good results on the BNIS who did not perform as expected in activities of daily living or returning to work-life and examples of low scorers on the BNIS who did perform well in these two respects. Prediction of return to work is associated with degree of family support and with environmental and motivational factors. Employment status and the situation at the workplace, factors that are difficult to overview and assess, are also of importance. This might be part of the explanation why outcome in terms of return to work is difficult to predict, as it is related to several factors.

Validity and discriminative qualities

It was shown earlier that the BNIS can discriminate well between patients with neurological disease and healthy controls (Prigatano, Amin et al. 1993) and Study I confirmed this. Within the control group, there were no differences in the BNIS total scores that could be attributed to gender, but there was a significant difference with reference to level of education. Neuropsychological test results are often influenced by educational level; this is well-known and needs to be addressed when reference scores for the BNIS are developed, if possible. In the age groups included in the control group in the present study, no age effect could be identified; this, however, needs to be further investigated, particularly when the instrument is used with the older age-groups.

The evaluation of the BNIS subscales could be useful, as the results of the study showed that subscale scores contributed to the differentiation of diagnosis. This can be helpful in a clinical setting for planning the rehabilitation programme for a patient and detecting the cognitive areas of special interest for a more extensive neuropsychological examination. As recovery after acute brain injury or stroke is often faster during the first months, cognitive evaluation with a screening instrument, such as the BNIS, may initially be sufficient and can be completed after or during the rehabilitation period with a thorough neuropsychological examination. As the BNIS includes a few pre-screen items, the test can also be used very early in the acute phase, to obtain a baseline for cognitive status and also to make it possible to follow the first part of recovery and decide when the patient is ready for the full screen.

Unlike the often-used MMSE, the BNIS did not show a marked ceiling effect when used in the patient populations described. Otherwise there was good concordance between the BNIS and the MMSE and it was possible to identify cut-off scores for both instruments with respect to personal ADL ability as assessed with the FIM™. For the BNIS, the cut-off scores giving the optimal levels of sensitivity and specificity for identifying dependency were clearly below the recommended cut-off total score for diagnosis of brain dysfunction (47 points). This can be explained by the fact that the activities assessed in the evaluation of personal ADL ability are routinely performed tasks, maybe over-learned, where demands on cognitive function are not crucial and therefore a person with some cognitive dysfunction is also able to remain independent. For the MMSE the identified cut-off scores for ADL dependency were closer to the cut-off scores established for cognitive impairment and thus dysfunction.

The analysis of the Rank Transformable Pattern of Agreement performed for the scales indicated that though there was good correspondence between the scales they are not completely interchangeable. A suggestion from these findings is that the BNIS may be the method of choice for examining a patient with presumably minor cognitive deficits, while the MMSE may give sufficient information about a patient with more evident difficulties. Both instruments were linked to the ICF and were shown to assess categories at the level of both body functions and activities and participation. The BNIS generally covered more categories and included more detailed levels. This is of interest for future research, as the ICF provides a common terminology for health care professionals in different settings. The ICF model demonstrates the hypothesis of an integrative bio-psycho-social model for human functioning and there is a growing interest in interdisciplinary research on topics within the human functioning sciences (Stucki, Reinhardt et al. 2007) Classification and measurement of functioning are one of several research areas that are likely to develop as part of human functioning sciences, and linking existing instruments to the ICF will therefore be of importance.

Long-term follow-up with cognitive screening and ADL assessment

The BNIS was used in two clinical studies in which patients of different neurological diagnosis participated. Mean values of the BNIS total score indicated that a considerable proportion of patients also have cognitive difficulties from the long-term perspective. There was evidence of significant cognitive recovery in the group of stroke patients who were examined at discharge from Rehabilitation Clinic and at one year after, though primarily related to those with LHD rather than RHD. The majority of 88%, however, still had cognitive dysfunction at follow-up, according to the BNIS.

In the group of cardiac arrest survivors (n =22), only one person had a BNIS total score above the cut-off value of 47 at two years after the CA. In this group eight people (36%) needed sheltered accommodation and they initially had more neurological deficits, were ADL-dependent at hospital and also had cognitive dysfunction identified by the MMSE. The later assessments at follow-up performed with the BNIS showed memory difficulties and visuospatial dysfunction, attention dysfunction and reduced awareness of own performance as the most apparent areas of dysfunction according to the BNIS subscales. At individual level, the visuospatial difficulties were associated with the need for assistance in the self-care items such as dressing of lower and upper body, and memory dysfunction with dependency in the memory item of the FIM™ Social-Cognitive scale. This finding needs to be further explored, as cer-

tain cognitive dysfunctions may be more central in everyday functioning than others. To use a cognitive screening method that examines a range of cognitive functions is thus of interest. Depending on the problem, a cognitive screening needs to be followed by a more extensive neuropsychological testing in order to examine if, and which, cognitive functions could be associated with brain injury and thus have an impact on the patient's daily life.

Long-term follow-up and return to work

In the group of stroke patients presence of neurological deficits had a significant impact on vocational outcome. At the three-year follow-up, 11% of the patients with neglect or aphasia had returned to work, compared with 36% of those who did not have such deficits. Cognitive difficulties appeared to be an additional reason for the rather low level of return to work. Modern working life often requires good body functions, including cognitive functions such as speech and language function, visual acuity, attention capacity and executive functions. In the group of anoxic brain-injured, we found that four of the fourteen people of working age (29%) had returned to work. In total, therefore, around 10 to 35% of these two groups of patients with neurological diagnosis returned to work, deficits such as visuospatial neglect and aphasia apparently influencing the possibility of returning to work. Though the cognitive screen (BNIS) did not show clear discriminative power, analysis of the result on the subscales may be of interest. Besides the demands on cognitive function, in many work situations, social abilities are often necessary, and thus perception of social interactions and ability to regulate affective expressions and responses are important. In our studies, however, there were also examples of individuals who returned to work or maintained independency in ADL in spite of identified cognitive dysfunctions. They had, in most cases, been subject to rehabilitation efforts, including training of cognitive function and the adoption of learning strategies to compensate for and master their cognitive problems. Environmental factors vary and constitute different levels of demand on cognitive functioning.

There are also aspects of cognitive functions that are crucial in modern life – and thus in workplaces – that were not assessed by the screening methods used in these studies, e.g. affect expression and executive functions. The BNIS includes, unlike many other screening methods, items concerning affect, but further research about the significance of this field is needed and complementary and new methods must be developed for comprehensive assessment of these functions.

Limitations

The clinical studies are all based on small samples and reduce the impact of the results. To some degree the studies were also of a retrospective character, based on register data. There were also missing data in the prospective study of stroke patients (Study III), but we tried to analyse and describe this. The stroke and TBI patients had been in-patients and/or out-patients at the Rehabilitation Clinic. The patients with Parkinson's disease were attending a polyclinic reception at the Rehabilitation Clinic. The patients with anoxic brain injury were participants in a follow-up study connected with the Rehabilitation Clinic and inferences from the studies should be applied to these patient categories. There was no data collection on oc-

currence of psychiatric illness such as depression, medications or other conditions that could affect cognitive performance within the studies.

Future studies

There is of great interest to further explore the various neuropsychological screening instruments that have been developed. To have access to valid and reliable assessment methods is a professional demand and it is likely that these examinations are requested in the future, with an ageing population. Therefore it's necessary to continue the research considering the psychometric properties and qualities of these instruments. Neuropsychological screening can also contribute to clinical studies on different patient populations in both acute hospital setting as well as in long-term follow-up studies. Considering the BNIS, future work allowing for assessment of persons in the older age-groups would be of interest as well as of children.

Conclusions

- Screening methods are of value in neurological rehabilitation.
- The BNIS has good validity with respect to discriminative capacity between patients and controls and has good sensitivity and specificity with the recommended cut-off score of <47 (total score) for identifying brain dysfunction.
- The BNIS subscales can contribute significantly to the assessment with reference to identifying diagnosis associated with brain damage and also dependence in personal ADL ability.
- The BNIS and the MMSE are two screening instruments that are not interchangeable but rather complementary.
- Aspects of cognitive dysfunction were of significant importance for work return. Also, patients with aphasia and visuospatial neglect returned to work to a lesser extent.
- Vocational rehabilitation for stroke patients takes time; more people were working at three years post-stroke than at one year.

SAMMANFATTNING PÅ SVENSKA (SWEDISH SUMMARY).

Bakgrund

Bedömning av kognitiva funktioner är ett viktigt inslag i neurologisk sjukvård och rehabilitering. Neuropsykologiska bedömningar bidrar till diagnostik, behandlingsplanering och rehabiliteringsinsatser, inte minst vad gäller att fastställa rehabmål. Bedömningarna bidrar i hög utsträckning till identifikation av sjukdomens eller skadans konsekvenser och till en bättre förståelse av patientens behov, så att behandling och träning kan utformas utifrån den individuella situationen. Neuropsykologiska bedömningar är också betydelsefulla vid utvärdering av behandling och rehabilitering. Vid en neuropsykologisk bedömning utreds kognitiv dysfunktion men också vilka funktioner som är välbevarade och kan utgöra en resurs vid rehabiliteringen.

Många neuropsykologiska bedömningsmetoder är dock omfattande, tar lång tid att genomföra vilket är krävande för patienten. Därför har korta 'screening'-metoder utarbetats. Bakgrunden till detta var att öka möjligheten att identifiera patienter med ett specifikt tillstånd eller sjukdom, så att noggrannare utredning sedan kunde genomföras, om behov förelåg. Screening av kognitiv funktion är t ex vanlig då misstanke om demens föreligger. Det finns emellertid skäl att utnyttja möjligheten att få en snabb men tillförlitlig bedömning av kognitiv funktion även inom neurologi och neurologisk rehabilitering. Kognitiv screening är mindre krävande för patienten och möjliggör en bedömning redan i tidigt skede efter insjuknande eller skada, samt även uppföljning över tid för att följa förloppet. Vid en neuropsykologisk utredning görs oftast bedömningar av följande funktioner; uppmärksamhet, visuell perception och visuospatial förmåga, språklig förmåga, minne samt exekutiva funktioner. Även vid en screening är det huvudsakligen dessa funktioner som undersöks och kan beskrivas i form av subskalor.

Metoder

Neuropsykologiska bedömningar har som nämnts, oftast använts som ett underlag till diagnostik men i framtiden kommer fokus förmodligen mer och mer att betona beskrivningen av patientens kognitiva resurser i förhållande till förmåga att klara sitt dagliga liv och arbete.

Syftet med de arbeten som ingår i avhandlingen var att utvärdera ett neuropsykologiskt screeninginstrument, The Barrow Neurological Institute Screen for Higher Cerebral Functions (BNIS) beträffande validitet och användbarhet vid uppföljning av patientgrupper - ofta aktuella för neurologisk rehabilitering - samt samband med patientens förmåga att klara personliga aktiviteter i det dagliga livet (ADL). I de olika studierna har ett instrument för bedömning av självständighet i personlig ADL, the Functional Independence Measure (FIM™) använts. I studie III och IV har också en bedömningsmetod avseende neurologisk funktion (NIHSS) använts samt en metod att bedöma Instrumentell ADL-förmåga avseende mer komplexa vardagsaktiviteter som att tvätta, handla, laga mat etc (IAM).

Resultat

Resultatet av Studie I visade att BNIS hade god förmåga att diskriminera patienter neurologisk diagnos, där kognitiv dysfunktion är vanlig, från en kontrollgrupp med friska personer. Sensitivitet var 88 % och specificitet 78 %, vilket styrker instrumentets validitet.

I Studie II gjordes en jämförelse mellan BNIS och ett annat, ofta använt screeninginstrument; Mini Mental State Examination (MMSE). Resultaten här tyder på vissa olikheter mellan skolorna. På MMSE uppnådde 21 % maximal poäng (30 poäng), medan ingen patient hade maximal poäng på BNIS. BNIS uppfångade således variationen mellan individer som presterade väl på MMSE, medan det fanns en tendens till det motsatta så att MMSE bättre beskrev variationen bland dem som presterade på låg nivå på BNIS. Båda instrumenten hade god förmåga att identifiera de personer som ej klarade personlig ADL självständigt. BNIS var möjligt att koda till 34 och MMSE till 26 kategorier inom WHO's klassifikation av funktionshinder, funktionstillstånd och hälsa (ICF).

Studie III och IV visade att BNIS är en användbar metod för uppföljning av patientgrupper över tid. I en grupp strokepatienter (Studie III) sågs en förbättring av kognitiv funktion under perioden från utskrivning till bedömning vid ett år. En majoritet, 83 %, hade dock fortfarande kognitiv dysfunktion. Vid ett år fanns det en signifikant korrelation mellan resultaten på BNIS och självständighet i personlig ADL och patienterna hade förbättrats och uppnått ökad självständighet i ADL, med avseende på såväl personlig ADL som instrumentell ADL. Ett år efter utskrivning från Rehabiliteringsklinikens vårdavdelning var 80 % självständiga i personlig ADL. Återgång till arbete tog dock längre tid; efter ett år var 7 % och efter tre år var 20 % av patientgruppen åter i arbete.

I Studie IV följdes personer som överlevt hjärtstopp upp två år efter insjuknandet. Vid hjärtstopp kan hjärnskada uppstå på grund av att blodcirkulationen till hjärnan upphör under kortare eller längre tid, med syrebrist som följd. Det visade sig här att 95 % av patienterna hade kognitiv dysfunktion efter 2 år, enligt bedömning med BNIS. Minnesproblem och nedsättning av visuoperceptuell problemlösningsförmåga var vanligt, även om de flesta klarade av bo i sin egen bostad och 29 % av de patienter som var < 65 år återgick i arbete. Emellertid bodde 36 % på någon form av institution eller hade omfattande behov av assistans två efter insjuknandet.

Slutsats

Screeningförfarande för att bedöma kognitiva funktioner fungerar väl för patientgrupper aktuella inom neurologisk rehabilitering och kan bidra till såväl identifikation av kognitiv dysfunktion som bedömning och prediktion av förmåga att klara ett självständigt liv. Utvärdering av ett specifikt instrument, BNIS, visade att detta har god validitet i betydelsen att kunna diskriminera patienter med kognitiv dysfunktion från friska. Vid jämförelse med MMSE förelåg en relativt god överensstämmelse, dock ej fullständig, varför de två bedömningsmetoderna kan sägas komplettera varandra.

ACKNOWLEDGEMENTS

I would like to give my greatest thanks to all my colleagues and friends who have in different ways contributed to this work, especially:

Katharina Stibrant Sunnerhagen, my supervisor and friend, for never giving up, always having a positive attitude, being supportive and encouraging and for your firm belief in this project.

Eva Esbjörnsson, my co-supervisor, for your great concern, both for me personally and for the work, for the engagement and enthusiasm you have shown and for the fun we have had in spite of the many late hours spent.

All my fellow researchers at the Institution of Neuroscience and Physiology, Rehabilitation Medicine; for the encouragement and for many interesting discussions (about various topics) and for bringing about a supportive, pleasant and creative atmosphere: Ann Björkdahl, Åsa Lundgren-Nilsson, Beatrix Söhnel, Christiane Carvalho, Annika Dahlberg, Jerry Larsson, Jörgen Broeren, Ingrid Ahlgren-Morberg, Anna Danielsson, Yvonne Daving, Yolanda Santos-Tavares, Frida Källman, Carina Persson, Margit Alt-Murphy, Elisabeth Nordin and other co-workers.

Anna Ekman, statistician, for your knowledge and practical advices, and for your patience when guiding me through the world of statistics.

All my friends, colleagues and co-workers at the Clinic of Rehabilitation Medicine for support and understanding during the years and also more recent colleagues at Vuxenhabiliteringen, Göteborg och Södra Bohuslän and Handikappförvaltningen, Västra Götalandsregionen.

Karin Pettersson and Hans Aniansson, my colleagues, for your work with the clinical assessments and data collection and continued interest in the research.

Una Cunningham and Janet Westerlund for excellent revisions of the English text.

Ulla Ohlson and for administrative help.

My family; Kenth, Joel and Paul, for great patience, helping hands, good advices and various points of view and for being supportive in your own ways.

This research has been supported of grants from the VR-project (VR K2002-27-VX14318-01A), the Laerdahl Foundation, Västra Götaland Handicap Committee, The Swedish National Board of Health and Welfare Support for Rehabilitation, The Swedish Medical Society (the Olle Hööks Foundation), the Hjalmar Svensson Foundation and the Rune and Ulla Almlövs Foundation.

APPENDIX 1

BNIS Items:

	Score
A. Pre-screening.	
1. Level of consciousness/alertness	1
2. Basal Communication	1
3. Cooperation	1
B. Screening	
1. Fluency	1
2. Paraphasia	1
3. Dysarthria	1
4. Auditory Comprehension	2, 1, 0
5. Naming	1
6. Visual Object Recognition	
7. Repetition	2, 0.5, 0
8. Reading	
9. Writing (dysgraphia) – sentence copying	1
dictamen	1
10. Spelling (irregular) ‘diamon(d)’	1
(phonetic) triangle’	1
Awareness of memory deficits (see item 27)	
11. Left-right Orientation	1
12. Place Orientation	1
13. Time Orientation	1
14. Constructional Praxis dominant hand	1
non-dominant hand	1
15. Arithmetic Number/Symbol alexia	1
dyscalculia	1
memory/concentration	1
16. Digits forward	1
backward	1
17. Visual Scanning	2, 1, 0
18. Visual Sequencing	1
19. Pattern Copying	1
20. Pattern Recognition	1
21. Number/Symbol Test	4, 3, 2, 1, 0
22. Affect Expression	1
23. Affect Perception	1
24. Affect Control	1
25. Spontaneous Affect/Concept Comprehension	1
26. Delayed recall house	1
tree	1
flying	1
27. Awareness vs Performance	1

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