APRAXIA IN STROKE PATIENTS:
assessment and treatment

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ISBN 90-6905-384-5

"Words are too solid
They don't move fast enough
To catch the blur in the brain
That flies by and is gone

I'd like to meet you
in a timeless
Placeless place
Somewhere out of context
And beyond all consequences..."

(Suzanne Vega, 1988)

Ter herinnering aan mijn moeder

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Part I

INTRODUCTION

"Education is an admirable thing, but it is well to remember from time to time that nothing that is worth knowing can be taught"
[Oscar Wilde, 1854 - 1900, Ib.]

chapter 1

INTRODUCTION

Introduction

Stroke is one of the major causes of disability and handicap. In the Netherlands there are almost 30.000 cases of stroke per year (Wilken & Kessels-Buikhuizen, 1994). Many stroke survivors experience serious problems during the execution of activities in daily life: as a result these patients remain dependent upon some form of care (Van Crevel, 1991; Limburg, van der Meer, Schade & van Crevel, 1992).

A considerable number of stroke patients have significant persisting neurologic impairments (Brandstater, 1990). Cognitive impairments are present in most of the cases and should be recognized in an early stage for the benefit of rehabilitation. When these neuropsychological deficits cause restrictions in the ability to carry out purposeful and learned activities, the patient may be apractic. Apraxia refers to a spectrum of disorders affecting the purposeful execution of learned skills. De Renzi (1989) has described apraxia as follows: a patient with apraxia does not know what to do, because the plan of action is disrupted (ideational apraxia); or, in other cases, the patient does know what to do, but not how to do it (ideomotor apraxia).

Apraxia is a source of problems for the patients and their families: the consequences of the disorder are experienced during the execution of activities of daily life, but these consequences are hard to understand or interpret. Unfortunately, the consequences of apraxia are also difficult to understand for clinicians and researchers. The consequences of the disorder are sometimes underestimated, especially in those cases where test performance and everyday behaviour are dissociated and errors occur when the patient is asked to perform on demand (De Renzi, 1989). Moreover, observing an absence of, or disturbance in the plan of action is almost impossible. Identifying apraxia can be difficult since the clinician is confronted with definitions based on exclusion (Lezak, 1995): apraxia is operationally defined as problems in functioning in daily life which are not the result of primary motor or sensory impairments, nor of deficits of comprehension, motivation or memory. The literature on apraxia is inconsistent and confusing, and the diagnosis is often made on the basis of personal experience, clinical impression and intuition (Poeck, 1985). Also, patients with apraxia may show several other cognitive deficits (e.g. aphasia, motor or perceptual impairments) which have a confounding effect on the dia-

gnosis. In the next chapter, a more detailed review of the literature on apraxia is presented.
Besides being difficult to diagnose, apraxia is hard to treat as well. Not much is known about both the principles and the effects of treatment. In a recent meta-analysis on stroke rehabilitation, outcome studies concerning the treatment of apraxia were not reported (Ottenbacher & Jannell, 1993). Single-case studies concerning the rehabilitation of apraxia have occasionally been published (e.g. Pilgrim & Humpreys, 1994). The study in question, however, was directed towards understanding the nature of apraxia rather than enhancing the quality of care for apractic patients in general. The rehabilitation of patients with apraxia will be discussed in the review presented in chapter 2.

In conclusion, diagnosis and treatment of apraxia in stroke patients have as yet not been structured systematically nor investigated properly. Elaboration on, and further research in this field of rehabilitation is therefore necessary. In the present study we have developed and evaluated a program for assessment and treatment of apraxia in stroke patients. In this thesis the results of the study are reported and consequences for future research and implications for clinical practice are discussed. In this chapter a general overview of the study is presented.

Content of the study

The purpose of the study is twofold: first, development of a diagnostic procedure and examination of the quality of the diagnostic instruments; and, second, development of a treatment program and evaluation of the effects of treatment.
Apraxia is one of the neuropsychological deficits following stroke which causes severe disabilities in daily life. In order to successfully treat the consequences of apraxia it is important to assess the problems experienced by the patients in their daily activities. We have developed the following diagnostic procedure for the assessment of apraxia and its consequences for daily life. First, a neuropsychological apraxia test is conducted, based on tests from De Renzi and colleagues. Our test offers a differentiation between patients with apraxia and patients without apraxia. Second, this apraxia test has been complemented with a more ecological procedure. The consequences of the impairment observed in

every day life should be disentangled as well. For this reason an observational procedure has been developed by which the nature and the severity of the restrictions in daily performance can be made explicit. For both the apraxia test and the ADL-observations, aspects of the reliability and validity have been investigated.
A main focus of the therapy program was to enhance the quality of life of stroke patients with apraxia by improving their independence in performing daily activities. In order to ascertain whether this goal had been met, the level of independent functioning was assessed before and after the patients had received treatment. In addition, individual factors possibly predicting the outcome of the therapy program were examined.
The research questions concerning the diagnostic procedure and the effects of treatment of apraxia are presented in chapter 3.

Structure of the thesis

This thesis consists of three parts. In Part I the setup of the study is explained. First, the aim of the study is outlined (chapter 1). In chapter 2 a review of the literature on apraxia is presented. Chapter 3 deals with issues in rehabilitation. In this chapter the step from theory to practice is made by introducing the main principles of assessment and treatment that have been elaborated upon in our therapy program.

In Part II the scene shifts to the results of the study. This part consists of three papers dealing with the assessment of apraxia and its consequences (chapter 4 through 6) and two papers discussing treatment outcome (chapters 7 and 8).

Part III contains the general discussion (chapter 9) where the main conclusions and implications of the study are sketched. Finally, possibilities for further research and the implications for clinical practice in general are discussed.

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chapter 2

APRAXIA IN STROKE PATIENTS:

a review of the literature

Stroke: the clinical picture

Cerebro vascular accidents (CVA) - also known as stroke - are the most common form of cardio-vascular diseases, next to coronary heart failure. Many different types of cerebro vascular accidents can be distinguished; for instance, subarachnoid, intracerebral haemorrhage or other cerebral haemorrhages, occlusion and stenosis of precerebral or cerebral arteries, and acute and other, non-strictly defined cerebro vascular disorders. A major distinction is between a 'bloody stroke' due to vascular rupture (cerebral haemorrhage) and 'non-bloody stroke' due to vascular blockage (cerebral infarction) (Jansen, Keli & Kromhout, 1994).

CVA can be described as an acute occurrence of clinical symptoms and signs of a focal dysfunction of the brain, lasting longer than 24 hours or resulting in death, with no other than a vascular origin (Van Crevel, 1991).

In most of the patients a cerebral infarction is caused by an arterial blockage due to coagulation in the carotid artery. Cerebral haemorrhage is caused by rupture of a bloodvessel. It is estimated that 80 % of the CVAs is due to cerebral infarctions and 20 % to cerebral haemorrhages (10 % to intracerebral haemorrhages and 10 % to subarachnoid haemorrhages).

The most important determinant of stroke is high bloodpressure. Advanced age, smoking, obesitas and diabetes are also associated with an increased risk. Extensive long-term alcohol consumption seems to be another important determinant of stroke (Jansen et al, 1994).

The prevalence of stroke - standardised for the Dutch population in 1990 - is 9,84 per 1000 men and 9,93 per 1000 women. In absolute terms, this amounts to 72.700 men and 75.100 women having had a CVA. For both sexes the prevalence rate shows a strong increase in people aged over 60 (Jansen et al ,1994).

The incidence rate is an indication of all new cases of stroke per year. Wilken and Kessels-Buikhuizen (1994) estimate the total number of patients suffering a stroke in the Netherlands at 26.000 a year. Each year 2,2 per 1000 men and 2,0 per 1000 women are registered as new cases of stroke. These rates are based on registration in general practice. The Dutch National Survey (Van der Velden, De Bakker, Claessens & Schellevis, 1992) shows a lower incidence rate of 1,3 per 1000 persons per year. Stroke mostly affects older people: in 9 out of 10 cases in which stroke leads to death, the patient is older than 65 years.

Stroke is the third major cause of death, after heart disease and cancer. The

average life expectancy after stroke is five years. Some 20 to 25% of the patients do not survive the acute stage (3 to 4 weeks after stroke). The chance of survival differs per type of stroke: 80 % for cerebral infarctions, 50 % for subarachnoid haemorrhages and about 20 % for intracerebral haemorrhages (Jansen et al, 1994). The most important prognostic factors are high bloodpressure, previous history of CVA or TIA, loss of consciousness and cardiac failure (Limburg, van der Meer, Schade & van Crevel, 1992). The prognosis of functional recovery after stroke is related to variables such as ADL-dependency at admission, age, status after recidive CVA, severity of hemiplegia, severity of somatosensory loss of arm function and trunk balance (Jongbloed, 1986, 1990; Hier & Edelstein, 1991; Gladman, Harwood & Barer, 1992).

Stroke is one of the major causes of disability and handicap. The sequelae of stroke present themselves in the form of neurologic, cognitive and behavioural disorders. The size and the site of the brain lesion are the most important determinants of both the nature and the severity of functional defects as well as of the probability of functional recovery (WHO, 1989). Frequently occurring consequences of stroke are hemiplegia (paresis of one side or part of the body), spasticity, problems concerning sensory loss, perceptual deficits, cognitive and emotional impairments. Among the cognitive and neuropsychological disorders, problems in language, memory, perception and action are the most common. When these cognitive deficits cause problems in the execution of activities of daily life, the patient may be apractic. Unfortunately, in most cases cognitive deficits do not occur in isolation: a patient with apraxia may experience problems in more domains; for instance, aphasia and apraxia are often associated. In the following sections, a review of the literature on apraxia is presented.

A review of apraxia

Definition

The term apraxia covers a spectrum of disorders affecting the purposeful execution of learned and meaningful skills (De Renzi, 1989). Apraxia is one of the classic neuropsychological syndromes, along with aphasia, agnosia and amnesia (Tate & McDonald, 1995). A patient with apraxia has difficulty with, or is not able to perform learned and purposeful activities. By definition, these

disturbances in the organisation of voluntary actions are not due to primary motor or sensory impairments. Neither are these difficulties the result of lack of motivation, attention, memory or comprehension. Other impairments may be present in the stroke patient, but these deficits are not the main cause of the inability to perform purposeful acts (Geschwind, 1975; De Renzi, 1989; Kolb & Whishaw, 1990).

Forms, occurrence and mechanisms

Forms of apraxia

Many different classifications, taxonomies and forms of apraxia are described in the literature. However, an accepted taxonomy for the apraxias is not available (Tate & McDonald, 1995). The term apraxia was introduced by Steinthal (1871), but Liepmann (1920) formulated the first, now classic theory of apraxia in which he proposed three different types: ideational apraxia, motor apraxia, and limb-kinetic apraxia. Ideational and motor apraxia were characterized by impairments in the proper sequencing of intact movements, while in limb-kinetic apraxia the movements as such are impaired without disturbances in the sequence. Luria (1966) discussed three forms of apraxia: frontal, premotor and kinesthetic apraxia. In the first two types described by Luria, the sequencing of movements is improper. In kinesthetic apraxia the sequencing remains intact, but the kinesthetic sensitivity disappears. The forms of apraxia just described are all associated with the limbs.

Apraxia is also classified in terms of the body-part that is affected, for instance buccofacial or oral apraxia. In these cases, the voluntary movements of the face, mouth, lips, larynx or tongue are impaired (Heilman & Gonzalez Rothi, 1985). In addition, many forms of apraxia are described in relation to the activity that is disturbed, for instance constructional apraxia (Kleist, 1934), dressing apraxia (Brain, 1941) and walking apraxia (Gerstman & Schilder, 1926).

Most types of apraxia have been the object of research studies, and some forms of apraxia, for instance dressing apraxia, have been dismissed (Arnadottir, 1990) or at least disputed (Schellekens, 1989) as a separate form of apraxia. Using the term dressing apraxia suggests that there is a type of apraxia for every activity that can be disturbed (for instance washing apraxia, sitting apraxia, eating apraxia). This would lead to an endless list of apraxia types and would not contribute to the understanding of the phenomenon.

In the present study the focus will be on ideomotor apraxia and ideational

apraxia. These two types of apraxia have been the object of most studies in recent years and are sometimes labeled the two classic forms of apraxia (Tate & McDonald, 1995), although this label is somewhat arbitrary. In the following sections ideomotor apraxia and ideational apraxia will be discussed in more detail.

Ideomotor apraxia

In ideomotor apraxia (IMA) the idea or plan of action is not impaired (i.e. the patient does know what to do), but the implementation of the movement sequence into a proper mode of action is disrupted (i.e. the patient does not know how to do it; De Renzi, 1989). Patients with ideomotor apraxia have "difficulty with the selection, sequencing and spatial orientation of movements involved in gestures including emblems and pantomimes" (p. 134, Heilman & Gonzalez Rothi, 1985). The most frequent errors in IMA patients are the use of body-parts as objects, spatial orientation problems, inappropriate hand postures (e.g. holding an object with an awkward grasp), perseverative errors, and content errors (e.g. the movement was not appropriate for the tool or gesture requested; Van Rossum, 1990; Miller, 1986; Shelton & Knopman, 1991). The movements are generally regarded as clumsy and inflexible (Arnadottir, 1990).

Heilman, Rothi and Valenstein (1982) claim that there are two types of ideomotor apraxia: they observed a difference between errors made by patients with lesions of the supramarginal or angular gyrus and errors made by patients with lesions anterior to the supramarginal gyrus that disconnect the visuokinesthetic motor engram from the premotor and motor areas important in programming movements. Both kinds of patients perform poorly to command and imitation, but the first type of patients is also unable to discriminate between well-performed and poorly performed acts. The second type, disconnection ideomotor apraxia, can further be subdivided in a form induced by callosal lesions and a form induced by lesion of the hemisphere containing the visuokinesthetic engram.

A most striking observation is the fact that a patient with ideomotor apraxia may not be able to perform on demand whereas exactly the same activity may be executed perfectly in a natural setting (De Renzi, Motti & Nichelli, 1980). This would imply that ideomotor apraxia is not a matter of the gestures themselves, but of the circumstances under which the gestures are made. Apparently, the motor program does exist but cannot be retrieved from memory under certain

circumstances (De Renzi, Motti & Nichelli, 1980). According to Faglioni and Basso (1985) IMA seems to be apparent in situations of testing and not affecting everyday life. The determination of a movement seems to be disrupted, while automatic movements are not affected (Tate & McDonald, 1995). The claim that IMA is merely an artefact in testing performance has been challenged in several studies in which disturbances in everyday activities following IMA were demonstrated (De Renzi & Lucchelli, 1988; Bjorneby & Reinvang, 1985; Sundet, Finset & Reinvang, 1988). Sundet et al (1988) demonstrated that, while several neuropsychological variables were considered, ADL-dependency was influenced most by ideomotor apraxia.

Ideational apraxia

A patient with ideational apraxia (IA) does not know what to do: the very concept or idea of the motor act is lacking or not accessible from memory (De Renzi & Lucchelli, 1988; De Renzi, 1989). These patients are seriously disabled because the execution of movements towards a specific goal requiring the use of objects is not possible (De Renzi & Lucchelli, 1988; Poeck, 1983). Since the plan or idea of the act is missing the patient does not know what to do with the objects: he might brush his teeth with a spoon and comb his hair with a toothbrush (Singu, Cohen, Duhamel, Pillon, Dubois & Agid, 1995). A patient with ideomotor apraxia would use the comb to comb his hair, but he might place the comb upside down on his head. A patient with ideational apraxia having problems organizing performance will for instance first put on the shoes and then try putting on the socks, or keep putting food in his mouth without swallowing (Arnadottir, 1990). Performance is poor when an activity consists of a series of movements (Welman, 1979).

Tate and McDonald (1995) state that among the various definitions of IA, two trends can be identified: both camps acknowledge the disruption of the serial ordening of movements, but only one camp emphasizes that IA can be interpreted as 'agnosia of usage' specifically affecting the use of objects.

At times there is discussion about the autonomy of IA: the claim was made that IA was only a severe form of ideomotor apraxia (IMA) (Liepmann, 1920; Sittig, 1931; Zangwill, 1960; Heilman, 1973). Moreover, IA and IMA frequently coexist in the same patient. De Renzi and Lucchelli (1988) claimed, however, that the analysis of errors in apractic patients has established the autonomy of IA being a distinct form of apraxia. Tests requiring the demonstration of object use

(multiple object use as well as single object use) were not significantly correlated with an ideomotor apraxia test involving the imitation of movements. The type of errors one can observe in IA patients are omissions, mislocation or misuse of objects, and sequence errors (De Renzi & Lucchelli, 1988; van Rossum, 1990). Compare the type of errors in IMA noted earlier: the use of body-parts as objects, spatial orientation errors, inappropriate hand postures and content errors.

Occurrence of apraxia

Apraxia is one of the more frequent sequelae of brain damage. It is usually found in stroke patients, but the deficit is also seen in patients with Alzheimer's disease (Taylor, 1994; Ochipa, Gonzalez Rothi & Heilman, 1992). In addition, apraxia is one of the symptoms of cortico-basal degeneration (Leiguarda, Lees, Merello, Starkstein & Marsden, 1994) and is reported in individuals with Huntington's disease as well (Shelton & Knopman, 1991).

Apraxia usually occurs following left hemispheric lesions. It has also been reported to follow right hemisphere lesions, but this occurs considerably less frequently. This was noticed first by Liepmann (1908), who found approximately 50 % of the left hemispheric patients in his study to be apractic, while none of the right hemispheric patients was found to be apractic. Liepmann concluded that the left hemisphere is dominant for the organization of motor control. Later studies have supported this claim (e.g. Pieczuro & Vignolo, 1967; De Renzi, Pieczuro & Vignolo, 1968; Basso, Luzzatti & Spinnler, 1980; Kertesz & Ferro, 1984; Heilman & Gonzalez, 1985). In a study conducted by De Renzi and his colleagues (De Renzi, Motti and Nichelli, 1980) 20 % of the right-brain damaged patients and 50 % of the left-brain damaged patients were classified as apractic. Constructional apraxia - the inability to correctly draw or assemble parts to form a unitary structure - seems to be a more common and more severe consequence of right-sided lesions, but there is some debate on the incidence of this form of apraxia after right and left hemisphere lesions (Sunderland, Tinson and Bradley, 1994).

Apraxia and aphasia

Apraxia can be associated with aphasia, for which the left hemisphere is dominant as well. A correlation of 0.40 between apraxia and aphasia has been reported (De Renzi, Pieczuro & Vignolo, 1986; Kertesz & Ferro, 1984). Although

these deficits frequently coexist, by now it is acknowledged that their relationship is not causal. Aphasia has been found in non-apractic patients (De Renzi, Motti & Nichelli, 1980), and the opposite pattern (apraxia without aphasia) has also been reported (Papagno, Della Sala & Basso, 1993). In a sample of 699 patients, Papagno, Della Sala and Basso (1993) found 10 patients to be apractic but not aphasic, and 149 aphasic patients to be not apractic. A few single case studies support the independence of apraxia from aphasia: for instance Selnes, Pestronk, Hart & Gordon (1991) studied a right-handed man with a left-sided stroke showing a marked apraxia, but no aphasia. The association between apraxia and aphasia is likely due to the fact that contiguous structures are involved (De Renzi, 1989; Tate & McDonald, 1995).

Neuroanatomical mechanisms underlying apraxia

Many studies have investigated where in the left hemisphere the lesions are located that result in apraxia. Originally, Liepmann (1905 /1980) postulated that ideomotor apraxia results from isolation of the primary motor cortex. Liepmann distinguished three types of ideomotor apraxia, based on the site of the lesion: parietal apraxia, in which the associative sensory areas are disconnected, frontal apraxia, caused by damage to the left premotor cortex, and callosal apraxia, resulting from the disconnection of the two sides of the brain. In the literature evidence is found for the existence of apraxia resulting from parietal as well as frontal lesions (e.g. Kolb & Milner, 1981; Kimura, 1982; De Renzi, Faglioni, Lodesani & Vecchi, 1983; Faglioni & Basso, 1985). Faglioni and Basso (1985) reviewed numerous cases in which the disruption of the callosal pathways resulted in apraxia in a left limb.

Geschwind (1965) proposed that apraxia is the result of a disconnection between the language area of Wernicke and the premotor cortex, the area involved in the execution of movements on demand. Heilman and Rothi (1985) criticized Geschwind's idea of the language area being involved in the existence of apraxia, and claim, like Liepmann, that motor-engrams in the parietal lobes are responsible for the production of movements. Clark, Merians, Kothari, Poizner, Macauley, Rothi and Heilman (1994) conducted a study to determine whether the original model of Liepmann or the model of Geschwind could be supported. They found that apractic patients also make errors when contextual cues are present; this finding supports Liepmann's idea that apraxia is a deficit of the visuokinesthetic representations of learned movements. Liepmann (see

Faglioni & Basso, 1985), De Renzi (1989), and Clark et al (1994) describe ideational apraxia as a deficit of the visuokinesthetic representation of learned movements, ideomotor apraxia as a result of the disconnection of these representations of the premotor and motor area's. Heilman and colleagues (e.g. Heilman, 1973), however, deny the existence of ideational apraxia, and distinguish between two forms of ideomotor apraxia, stating that ideational apraxia is only a severe form of ideomotor apraxia.

Summary and conclusions

Apraxia is a disorder affecting the purposeful execution of learned and meaningful skills. Apraxia is frequently found in stroke patients, and occurs mostly following left hemispheric lesions. The deficit can be associated with aphasia, because of involvement of contiguous structures. Many different classifications, taxonomies and forms of apraxia are described in the literature; however, an accepted taxonomy for the apraxias is not available. Two forms of apraxia that were the object of many studies have been described in more detail: ideational apraxia and ideomotor apraxia. A patient with ideational apraxia does not know what to do, because the idea or plan of action is not available; a patient with ideomotor apraxia does know what to do, but not how to do it, because the ability to turn the plan into a mode of action is disrupted. Distinction between the two forms has been defended on the basis of many theoretical claims and neuroanatomical and neuropsychological models. Some authors (e.g. Arnadottir, 1990; Lezak, 1995) conclude, however, that it is not recommendable to differentiate between forms of apraxia on the basis of abstract theoretical claims; instead, one should focus on the specific observable problems in daily functioning, using descriptive terminology.

In the present study no attempt will be made to make yet another theoretical claim or to again put forward a new neuroanatomical model of apraxia. Instead, the observable problems in ADL-functioning probably caused by ideational or ideomotor apraxia will be the object of study. Taking the consequences of apraxia as the point of departure, the autonomy of the two forms of apraxia will be discussed. In the following sections the literature on assessment and rehabilitation of apraxia will be presented.

Assessment and testing procedures

Concerning testing procedures for apraxia, a large number of studies have

reported many different tasks. Task demands vary depending on the part of the movement system involved (limb versus axial movements), the type of movement (dynamic versus posture), the type of limb gesture (transitive versus intransitive; symbolic versus non-symbolic; meaningful versus meaningless), the input modality (command versus imitation; verbal versus visual versus tactile), and the complexity of the movement (single versus complex gestures; single object use versus multiple object use) (Roy, Square-Storer, Hogg and Adams, 1991; Tate and McDonald, 1995).

As noted earlier, in our study we focus on two forms of apraxia. Ideomotor apraxia is most commonly tested by asking the patient to imitate gestures; these gestures can be either symbolic or nonsymbolic, involving the fingers, hand and/or arm, or be a posture or a sequence of movements. In a study by De Renzi, Motti and Nichelli (1980) a 24-item test was administered assessing the ability to carry out movements on imitation. In this test, finger movements and whole arm movements were required, half of which were meaningful and the other half meaningless.

Typically, ideational apraxia is examined in tests requiring the use of objects. They may involve either single objects or multiple objects, either the actual use of objects or pantomime, and they may require several input modalities as well (verbal, visual, tactile or combinations). De Renzi, Faglioni and Sorgato (1982) investigated the performance with respect to the use of objects presented in the verbal, visual and tactile modalities. A higher percentage of patients failed when the verbal and visual modalities were used than when the tactile modality was used. De Renzi and colleagues concluded that these findings support the hypothesis that apraxia results from the disconnection of information processing and movement programming. Subsequently, De Renzi and Lucchelli (1988) conducted a study in which patients were required to demonstrate the use of single and multiple objects. The tests were not significantly correlated with tests involving the imitation of movements (for determining ideomotor apraxia), which led to the idea of ideational apraxia being an autonomous syndrome.

Besides numerous different task demands, many different quantitative and qualitative scoring methods have been applied to measure the extent to which apraxia is present (Tate and McDonald, 1995). Quantitative scoring methods are mainly applied for research purposes. In many studies, scales are used to label the performance; for instance a scale ranging from 3 (correct) to 0 (incorrect)

(Kertesz and Ferro, 1984; De Renzi and Lucchelli, 1988). The problem with these scoring methods is that no information is acquired concerning the nature of the problems. Qualitative scoring methods can offer more information to this end, but are, in general, less reliable. These methods are used to characterize the behaviour of the patient with apraxia by means of errors in performance. Error analyses have provided some insight into apractic performance. McDonald, Tate and Rigby (1994) performed a qualitative analysis of error types in ideomotor apraxia; when subjects were asked to make gestures, movement-related errors were made, body-parts were used as objects, and substituted movements and perseverative errors occurred. Assessment of apraxia remains however difficult, since the results in these qualitative studies are often ambiguous.

In summary, numerous testing procedures and scoring methods are found in the literature but results are often inconsistent and confusing. Concerning the reliability and validity of the instruments no information is reported. An estimate of interrater reliability is found only in one of the many studies cited (Goodglas and Kaplan, 1963): the inter-judge agreement was found to be acceptable. To our knowledge, the diagnostic value of clinical tests for apraxia has not been studied.

Unfortunately, clinicians attempting to diagnose apraxia are confronted with additional problems. The majority of the testing procedures are often merely part of a neuropsychological battery examining for a heterogeneous group of functions, or they are supplementary examinations in an extensive aphasia battery (e.g. the Luria-Nebraska Neuropsychological Battery, Golden, Hammeke & Purisch, 1980; the Boston Diagnostic Aphasia Examination, Goodglass & Kaplan, 1983). So, these examinations are not specifically aimed at apraxia. Clinicians attempting to diagnose apraxia mainly by relying on personal experience, clinical impression and intuition (Poeck, 1986) cannot really be blamed in this respect.
The problems clinicians face in exploring the phenomena associated with apraxia are complicated even more by other issues. Firstly, apraxia is frequently accompanied by several other cognitive deficits. As noted earlier, apraxia is often associated with aphasia, but also with visual and visuospatial deficits. Secondly, patients with apraxia often fail when performance is requested (i.e

performance on command during examination), but act correctly in spontaneous behaviour. This dissociation between test performance and spontaneous behaviour often leads to an underestimation of the deficit by the patient and even by the caregivers. Finally, as noted earlier, apraxia is often defined by what it is not. This means that all other explanations for the problems in the execution of purposeful learned skills should be excluded. Ideally then, apraxia can only be diagnosed if a full battery of neuropsychological tests is presented.
In the present study an attempt is made to solve part of this problem by developing a diagnostic procedure for apraxia and its consequences for daily life and by investigating the reliability and validity of the diagnostic instruments.

Recovery, prognosis and rehabilitation

Treatment of apraxia has not been the subject of many research studies, and neither has much attention been paid to the identification of prognostic factors. Basso, Capitani, Della Sala, Laiacona and Spinnler (1987) investigated the recovery from ideomotor apraxia in acute stroke patients and assessed variables capable of predicting the evolution of ideomotor apraxia. They found that improvement is not related to age, sex, education, type of aphasia, initial severity or the size of the lesion. Recovery did seem to be related to the site of the lesion: patients with anterior lesions have a better chance of recovery.
In a study by Bjorneby and Reinvang (1985) the degree of self-care in patients who had suffered a stroke was assessed at different stages of recovery. All apraxia variables appeared to be significant predictors of subsequent dependency: in untreated patients the relationship between initial neuropsychological tests of apraxia and ADL function on admission is moderate, while the relationship between initial apraxia measures and longterm dependency after rehabilitation (4-6 months post stroke) is strong. The authors concluded that more attention should be given to the effect of apraxia on ADL in the domestic situation. Skills learned in the hospital are difficult for patients to perform and maintain in the home situation. Similar results were reported by Sundet, Finset and Reinvang (1988): variables related to apraxia at the start of rehabilitation correlated significantly with the level of ADL-dependency after discharge (the presence of apraxia on admission predicted a higher use of aids and persons in order to manage alone).
At present hardly any information is available on methods and efficacy of rehabilitation of apraxia. This was observed earlier by Heilman and Gonzalez Rothi in

1985, but in a more recent meta-analysis on stroke rehabilitation studies evaluating treatment of apraxia are not even mentioned (Ottenbacher & Jannell, 1993). In a recent review of the empirical literature on apraxia (Tate & McDonald, 1995), definitions, taxonomies and examination procedures are presented, but recovery or treatment is hardly discussed. These authors do, however, mention that apraxia is said to disappear rapidly, but this statement is easily refuted by referring to the study of Basso et al (1987), in which apraxia was observed in stroke patients five or more months post-stroke.
Occasionally, the results of the rehabilitation of a single case of apraxia are reported. Pilgrim and Humphreys (1994) presented the case of a left-handed head injured patient with ideomotor apraxia of his left upper limb. The purpose of the study was to present an analysis of the nature of the apraxia and the results of a rehabilitation strategy. The method of treatment was a modified form of Conductive Education (CE) which is an educational approach for the attainment of functional motor goals in the rehabilitation of brain damaged children and adults (Cotton & Sutton, 1986). The principle of this treatment was to restore performance through a restructuring of the functional system by incorporating the role of speech in the regulation of motor acts. The therapy showed a positive effect, but little carry-over to everyday life.
Sunderland, Tinson and Bradley (1994) report preliminary findings on stroke patients in a physical rehabilitation trial. In this study the main focus was on recovery from constructional apraxia. Five months after stroke, significant differences in recovery were found in a left hemisphere and a right hemisphere group. It appeared that the patients with left hemisphere damage showed more improvement, and also a greater variability in recovery was found within this group.

In conclusion, in spite of the disabling consequences of apraxia for ADL-functioning, there is little information on prognosis and treatment of the disorder. In the present study a therapy program for apractic patients is developed and evaluated. The goal of rehabilitation in general, and of rehabilitation of apractic patients in particular, is to enable the patient to reach and maintain an optimal level of independent functioning. In this study it will be investigated whether changes in independent functioning occur in patients treated according to the guidelines of a therapy program for apractic patients. The therapy program will be discussed in detail in the next chapter.

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chapter 3

REHABILITATION OF APRAXIA IN STROKE PATIENTS:

theory and practice

The ICIDH as a framework for studying apraxia

Rehabilitation of stroke patients in general is concerned with the consequences of stroke and the implications for a patient's daily life. These consequences can be numerous and complex. Describing the consequences of stroke in terms of death or complete recovery is far from sufficient. In order to specify the consequences of stroke, a conceptual frame of reference is needed. In other words, management of these consequences demands a practical classification scheme (Bennekom & Jelles, 1995).

In 1980 the World Health Organization (WHO, 1980) published the International Classification of Impairments, Disabilities and Handicaps (ICIDH). The ICIDH classifies the consequences of diseases at three levels of health experience: impairments, disabilities and handicaps. The ICIDH includes the implications of a person's health problems for daily life. Moreover, the ICIDH classifies health problems in terms of medical as well as social problems and thereby exceeds the field of medical science. The framework offers a description of the person's health problems instead of an explanation; it describes a person's health status at a particular point in time and not in terms of a disease process (Halbertsma, 1995)*.

The first level of the ICIDH is concerned with impairments: 'in the context of health experience, an impairment is any loss or abnormality of psychological, physiological or anatomical structure or function' (WHO, pg 27). Impairment refer to organs or the level of functions. The second level of the ICIDH is the level of the disabilities: 'in the context of health experience, a disability is any restriction or lack (resulting from an impairment) of ability to perform an activity in the manner or within the range considered normal for a human being' (WHO, pg 28). Disabilities refer to the level of individual action. Handicaps are the third level of the ICIDH: 'in the context of health experience, a handicap is a disadvantage for a given individual, resulting from an impairment or a disability, that limits or prevents the fulfillment of a role that is normal (depending on age, sex, and social and cultural factors) for that individual' (WHO, pg 29). Handicaps refer to the level of social interaction.

*) A new version of the ICIDH has been developed: the ICIDH-2. At the moment this version has not yet been published officially; only a draft version is available.

The following could be an example of the application of the concepts of the ICIDH: a person has had a stroke (disease), as a consequence this person has a hemiplegic bodyside (impairment: hemiplegia), which leads to problems in self-care (disabilities: basic ADL-activities are difficult to perform), and this person is not able to drive his bus (handicap: the old job has become impossible to fulfill). In the ICIDH-model a disease manifests itself in the form of impairments, which in turn can lead to disabilities, while disabilities can lead to handicaps. In clinical reality these relationships are less linear: a neurological deficit, for instance, does not necessarily lead to physical disabilities.

In the present study apraxia is conceptualized in terms of the ICIDH. In figure 3.1 a schematic presentation is given of the framework which is applied to apraxia and its consequences.

Figure 3.1. Schematic presentation of apraxia in terms of the ICIDH

pathology	impairment	disabilities
stroke	apraxia	restrictions in the ability to carry out purposeful ADL-activities

In terms of the ICIDH apraxia can be defined at two conceptual levels. At the level of the impairment, apraxia can be defined as the breakdown of the concept or plan of action (i.e. ideational apraxia) or of the implementation of the concept into a motor program (i.e. ideomotor apraxia). At the level of the disabilities, a patient with apraxia experiences restrictions in the ability to carry out purposeful ADL-activities. However, in dealing with psychological consequences of disease - such as apraxia - some limitations have to be considered (Deelman, Eling, de Haan, Jennekens-Schinkel & van Zomeren, 1997). The ICIDH-model does not completely fit the area of psychology. Testscores that are obtained by the use of a neuropsychological test are based on behavioral performance. Neuropsycho-

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logical impairments can only be measured by means of behavioral performance and should therefore, in terms of the ICIDH, be labeled as disabilities. However, there is a clear distinction between the behavioral performance in a neuropsychological testsituation and the behavioral performance in daily life. Neuropsychological tests are used to measure the level of the function/impairment and thereby expected to represent performance in daily life. In addition, it is important to gain an insight into daily life itself. This is necessary because it is extremely difficult to generalize the results of a neuropsychological test to performance on activities in daily life. Incompetent behavior in a testsituation does not mean that incompetent behavior will occur in one's own environment (Smith & Clark, 1995; Roorda, Roebroeck, Lankhorst, van Tilburg & Bouter, 1996). In the present thesis we therefore make a distinction between the neuropsychological impairment apraxia and its consequences for daily life (disabilities related to the presence of apraxia). Assessing apraxia and its consequences can thus be done by studying behavioral performance in a neuropsychological apraxia test which is conducted in a (highly) standardized context in order to try to capture the praxis function as closely as possible; while the consequences of apraxia for every day life can be assessed by observation of ADL-activities which are conducted in a more ecologically valid context, resembling the real life stuation as much as possible. Both forms of testing do, however, yield only a partial representation of the patient's behavior in daily life.

Take for example a patient with ideational apraxia. On the level of the impairment, the breakdown of the plan of action is assessed by asking this patient to demonstrate the use of an object. These assessments usually take place in a highly artificial testing environment in the form of a standardized neuropsychological apraxia test. However, witnessing a patient experiencing problems in such a setting does not justify the conclusion that this particular patient will also experience problems in daily life. Generalizing the results of these tests to ADL-performance is difficult. For the purpose of rehabilitation, assessment of disability in daily life is a necessary complement to the neuropsychological apraxia test. The development of a therapy program for patients with apraxia can be based on these considerations. Before describing the treatment methods underlying the therapy program, current methods in cognitive rehabilitation will be discussed.

Chapter 3

Cognitive rehabilitation

The psychological consequences of acquired brain-damage, such as stroke, can be tackled by different treatment methods. The following treatment methods can be distinguished in the field of cognitive rehabilitation.

Cognitive retraining (drill and practice)
Cognitive retraining is aimed at recovery of distorted functions (i.e. reducing impairments), such as attention, memory and visual perception. The idea is to improve the function by means of repeated practice. This method is also known as drill and practice or repetitive practice. In memory and attention rehabilitation, the cognitive function is sometimes viewed as a 'mental muscle' which can be strengthened by simply exercising repeatedly, as in normal muscles (Harris & Sunderland, 1981). Some authors labeled this method as 'mental body building' (Van Zomeren, Brouwer, Saan, Deelman & Minderhoud, 1984). The underlying idea of this therapy is that repeated stimulation of brain structures supposedly facilitates neuronal growth, regeneration or sprouting within brain structures (Berg, 1993). By improving basic cognitive functions, generalization is aimed for by means of repetitious drills based on a restorative model, a process of trying to reverse an underlying cognitive deficit (Gordon & Hibbard, 1991; Radomski, 1994).

Stimulation therapy
Methods of activation and stimulation are also based on the idea that the neural substrate can be influenced (Deelman et al, 1997). In stimulation therapy the patient with a hemiplegic body-side is stimulated to use the paretic arm as much as possible. A similar form of treatment was proposed by Buffery (1976) in treating patients with aphasia: verbal information was presented to the left visual area in order to stimulate the right hemisphere to process verbal information. Sparks and Holland (1976) stimulated the language function of the right hemisphere (through melody and rhythm) in order to let the language production be taken over by this part of the brain (Melodic Intonation Therapy). Scherder (1995) investigated the effect of stimulation therapy in patients with dementia. Improvements in cognitive, emotional and physical functioning were found after electrical stimulation of peripheral nerves and massage of the back. A final example of sensory stimulation is coma arousal, but studies investigating this

method have led to some contradictory results (Deelman et al, 1997).

Skill training

Basic skills can be lost as a result of brain damage. Skill training is aimed at the patient regaining the ability to perform certain activities. In this case the training consists of repetitive training of daily activities, such as preparing a meal (i.e. aimed at disabilities). The training aims at one specific skill at a time. The procedure to be followed is basically the same in every training. The mode of instruction depends on the possibilities of the patient as well as the complexity of the activity (De Moor et al, 1990). Skill training thus resembles cognitive retraining by using repetitious drills. Effects of generalization are not aimed at in this method of treatment. But skill training is directed more to problems in actual behaviour because the unit of practice is daily activities.

Strategy training

The aim of strategy training is to teach the patient strategies to compensate for the impairments by executing daily activities differently. Improved independence in daily functioning is expected to be reached this way. This method is not aimed at recovery of the function, but at improved functioning despite the presence of impairments. Compensatory techniques are designed to help patients effectively use residual skills by teaching them ways to minimize the extent to which problems impinge on daily activities (Radomski, 1994). Strategy training is based on the assumption that patients can be helped by providing them with compensatory strategies in the form of either external aids (checklist, diary, alarm clock, etc.), or internal procedures (self-instruction, association, visualization, etc.). The exercises can be aimed directly towards the problems in actual behaviour (Van Zomeren & Brouwer, 1994). In this kind of training patients can be taught to use cognitive 'protheses' and to modify the demands of the task or environment in order to bring it into the person's competence level (Prigatano, 1987). In memory rehabilitation for instance, strategy training does not teach the patient how to perform a certain task, but helps him find a method for remembering and retrieving information (Berg, 1993). Strategy training has been applied with some success in the areas of memory and problem solving, while training of attentional strategies is evolving (Van Zomeren & Brouwer, 1994; Deelman et al, 1997).

Behavioral modification

Behavioral modification techniques are aimed at both decreasing undesirable behavior and increasing desirable behavior. Behavioral modification can take place by interfering in the situation or by changing the consequences of the behavior in question. Wood (1987) describes examples of techniques that were successfully used in teaching ADL-abilities (e.g. self-care skills). Wood applied contingent reinforcement in the form of tokens to improve attention during therapy tasks. A commonly applied technique in the field of behavioral modification is operant conditioning: desirable behavior is systematically and consequently encouraged. The use of 'punishment' to decourage undesirable behavior is not recommended in the rehabilitation process; although in some cases, such as undesirable verbal or sexual utterances or aggressive behavior, this form of therapy can be a prerequisite because provocative behavior can be an impediment as regards the actual therapeutic goals. Van Zomeren and Brouwer (1994) state that behavioural conditioning techniques will probably be most appropriate for patients suffering extensive cognitive problems which impede the application of teaching strategies.

Counseling

In some cases it is not expected that any further improvement in functions or abilities can or will take place. These instances demand that the patient and his or her social environment accept the fact that the patient has to live with the lasting presence of cognitive impairments and its consequences for daily functioning. Counseling can then be offered by means of (social) support and patient education. Evidently, it is important in every therapeutic situation to offer the patient and his/her family the necessary information about and insight into the disease, its consequences, the assessment procedures and treatment programs. Fear, tension and uncertainty have to be minimized. For patients whith no chance of recovery, information and solace are the most essential elements of treatment.

In the present study we have chosen one of these methods for the rehabilitation of stroke patients with apraxia. In the following section this choice will be explained and motivated, but first the assessment procedure for apraxia will be presented.

From theory to practice

Assessment of apraxia

The clinician needs a clear overview of the consequences of the disease on different levels of health experience. Assessing a patient with apraxia, the neuropsychological impairment apraxia as well as the disabilities resulting from apraxia should be made explicit. The following procedure was developed in our study.

The first part of the assessment procedure consists of a neuropsychological test for apraxia, as close to the impairment level as possible. The test is based on studies by De Renzi and colleagues (De Renzi et al, 1980, 1982, 1988). The procedure involves tasks for demonstration of object use and imitation of gestures. Using this test should facilitate the differentiation between patients with apraxia and patients without apraxia.

The apraxia test consists of two subtests, which are widely acknowledged as being tasks to test for ideational apraxia (i.e. demonstration of object use) and ideomotor apraxia (i.e. imitation of gestures). The use of objects is tested in three conditions (De Renzi et al, 1982). Three sets of objects are presented to the patient with the same instruction 'show me how you would use .... (this object)'. Each set consists of three objects frequently used in everyday life. The first set of objects (key, hammer, and toothbrush) is presented verbally, without the object being present. The second set of objects is presented visually (spoon, hammer, and scissors); the objects are present, but the patient is not allowed to touch them. With the third set of objects actual use is tested (eraser, comb, and screwdriver). Imitation of gestures is tested by asking the patient to imitate the following six gestures immediately upon demonstration by the researcher: sticking out one's tongue, blowing out a candle, closing one's eyes, waving goodbye, saluting, and making a fist (De Renzi et al, 1980). In both subtests, the patient is asked to use the hand ipsilateral to the side of the brain lesion, which in our study is the left hand. This instruction is given to avoid interference of motor or sensory impairments (De Renzi et al, 1980). The scoring method is based on the one used by De Renzi and Lucchelli (1988): the performance is correct, adequate and appropriate (3 points); the performance resembles the correct one, but is executed somewhat imprecise, or a body part is used as object (2 points); the performance only weakly resembles the correct one, but is

carried out in the correct place, or the performance is correct, but executed in a wrong place, for instance moving the spoon to the nose instead of to the mouth (1 point); and finally, the performance is completely wrong or not recognizable as such (0 points). The patients are asked to carry out the performance; if at first attempt the performance is completely correct, a score of 6 is given. A second attempt is made if the execution was not quite correct or even totally wrong. The scores of both attempts are added up to arrive at the score per item. The maximum score for demonstration of object use is 54 and the maximum score for imitation of gestures is 36; together the subtests add up to a score of 90. The apraxia test is conducted with the patient sitting facing the researcher in a quiet room suitable for testing.

The second part of the procedure involves the observation of ADL-activities focussing on disabilities resulting from apraxia. A specific procedure to serve this purpose was not yet available, which led us to develop a set of standardized ADL-observations. This observational method can be used in combination with the apraxia test in order to assess the level of independence and the nature of the deficit reflected in the patient's performance.
The observational method is based on a method developed by Arnadottir (1990). After consulting experts in the field of stroke rehabilitation, Arnadottir's functional independence measure was adapted in order to generate more detail. The resulting independence scale consists of 4 levels ranging from 'the patient is totally independent and does not need assistance' (0), to 'the patient is totally dependent upon full assistance from the therapist' (3). In addition, three scales were developed to measure the more qualitative aspects observed in the performance. Three aspects of an activity are distinguished, according to the framework of information processing: initiation, execution, and control of an activity. Following rather classic concepts (Donders, 1868/1969), contemporary cognitive psychologists distinguish various stages in the processing of information, being either serial or parallel in nature (e.g. Sanders, 1980; Schmidt, 1988). Apractic patients may have problems with any one of the stages of which an activity consists. The three aspects can be conceptualized as follows. Firstly, in order to initiate an activity, a patient has to understand the request of the therapist (for instance to get dressed), construct a plan of action accordingly and subsequently activate a command for actual motor performance, selecting the correct objects. Secondly, the execution has to be

performed correctly, using the adequate objects, in the proper sequence of steps, and finishing the performance when appropriate. Finally, the performance has to be controlled and corrected if necessary. For each aspect an observational scale was developed to assess the problems. On the basis of error analyses in the literature three scales were developed, as in Arnadottir's procedure (1990). Each scale consists of different levels, ranging from 'there are no observable problems, the patient performs well without help' to 'the therapist has to take over in order to get action or result'. Four everyday life activities are observed: personal hygiene (washing the face and upper body), dressing (putting on a shirt or blouse), preparing food (preparing and eating a sandwich), and a fourth activity which could be chosen by the therapist (following the institution's standard observation procedures, or an activity appropriate to the patient's needs). The three activities which were prescribed are considered to be standard in occupational therapy departments; the fourth activity could for instance be preparing coffee or tea. The occupational therapist observes the patient executing the four activities, and scores the findings on a standardized form. By assessing these aspects, problems in functioning are identified and plans for treatment can be formulated accordingly.
Concerning both instruments, the apraxia test as well as the ADL-observations, various clinimetrical properties will be examined in the present study (chapters 4 through 6).

Strategy training for patients with apraxia

Given the positive results of strategy training programs for memory and attention deficits, we have chosen this approach for the treatment of apraxia in stroke patients in the present study. The drill and practice method was found to be ineffective in various studies (e.g. Prigatano, Fordyce, Zeiner, Roueche, Pepping and Wood, 1984; Godfrey and Knight, 1985; Schachter, Rich and Stampp, 1985). Ericsson and Chase (1982) and Berg (1993) showed that the drill and practice approach does not generalize to other problem areas; there is no general increase in memory capacity. The effect of stimulation therapy on attentional behavior in daily life remains unconvincing because of limited evidence (Van Zomeren and Brouwer, 1994). The efficacy of stimulation training in attention deficits is questionable: generalization of the training effect decreases when the resemblance between training methods and the evaluation method decreases. This problem of generalization also shows up in skill training

and behavioral conditioning techniques. Strategy training, however, helps the patient to master a method instead of a specific task (Berg, 1993); a strategy mastered ought to generalize to other tasks besides the training task. Some case studies describe the positive effects of verbal mediation on cognition (Van Zomeren and Brouwer, 1994). For a broad review on single strategy studies in memory rehabilitation one could consult Berg (1993). Berg, Koning-Haanstra and Deelman (1991) showed that objective improvement in memory tasks was established by strategy training only, while subjective improvement was rather easy to achieve and could even be established by using drill and practice.
The choice for teaching patients strategies to compensate for the impairment in voluntary action was motivated by one other issue. This concerns the recovery of higher cognitive functions. By now it is widely acknowledged that it is impossible to completely restore memory capacity lost by neurological damage or normal ageing (Miller, 1984; Moffat, 1984) since it is unlikely that the central nervous system possesses sufficient plasticity for such restoration of higher cognitive functions. Moreover, in those patients for whom the time elapsed since stroke is considerable, spontaneous recovery is not expected. Spontaneous reversal of neurologic symptoms, partial or occasionally complete, can take place within a few hours to a few months after stroke (WHO, 1989). In many cases the chance of recovery is minimal: apraxia is frequently irreversible. As noted earlier, in a study by Basso et al (1987) the presence of apraxia was observed five months post stroke. It is, therefore, not realistic to expect recovery from apraxia, neither through spontaneous recovery of the impairment, nor through repeatedly stimulating brain structures in order to restore functions. Thus, the ultimate treatment aim should not be reduction of or restoration from the impairment apraxia. Instead, the aim of rehabilitation should be for the patient to learn to deal with the existing impairment more efficiently in order to obtain improved ADL-functioning.

In summary, the method of rehabilitation which was chosen for the treatment of apraxia in stroke patients is strategy training. The therapy program is aimed at improving the performance of patients with apraxia by teaching them strategies - ways to compensate for the apraxia. The program is, therefore, focused on improvement in ADL-functioning. The central aim is to enable patients to function more independently, despite the probably persisting presence of the apractic impairment. Patients are expected to improve in ADL-functioning, with

no or only small changes in the severity of apraxia.

A therapy program for apraxia

Applying the principles of strategy training, we have generated a therapy program for stroke patients with apraxia. In this section the content of the therapy program is elaborated.

The therapy program has been developed for treatment by occupational therapists. Occupational therapists are the caregivers in the rehabilitation team to whom the patient with apraxia will most likely be referred. Occupational therapists are concerned with the consequences of the disease, and not with the disease itself. The discipline focuses on people who are physically and/or mentally impaired, disabled or handicapped, either temporarily or permanently (Driessen, 1997). The principles of strategy training for patients with apraxia are, therefore, elaborated in a protocol for occupational therapists.

Since it is plausible that the impairment will remain present, the therapist will teach the patient strategies to carry out tasks. Careful selection of the tasks to be trained is required, as well as careful selection of the environment in which training takes place; active participation of the patient in the training of ADL-activities is wanted (De Poy and Burke, 1992; Trombly, 1995). Besides the careful selection of the tasks to be trained, the following variables have to be selected as well during training: the situation under which training takes place, the type of intervention and the level of independence to aim for.

The selection of the tasks to be trained is based on the choices, ordening and performance of persons in everyday occupation (Kielhofner, 1985). These choices and behaviours are influenced by individual characteristics and environmental factors. In relearning daily activities it is essential to train those activities which are important for the patients themselves. Integrating the patients habits, routines and interests into therapy will enhance the chance of success. Commitment is reached through active participation.

Habits and routines are also important for the situation under which training takes place: the automatic processes involved in dressing, for instance, cannot be addressed when dressing takes place in a limited area of space like a small tent. Most stroke patients experience problems when a known activity has to be performed in a new or unknown environment. The situation under which a task is trained will be varied by the therapist depending upon the capacities of the

individual patient. In our therapy program the situation can be chosen by the therapist, provided that the situation is natural for the patient and the task at hand (e.g. washing and bathing takes place in the bathroom).
In addition to the task and the situation during training, the therapist selects the appropriate type of interventions. The interventions correspond to the problems the patient is experiencing. This way, treatment is tuned to the results of the ADL-observations executed during the diagnostic phase (see figure 3.2).

Figure 3.2. Schematic presentation of the correspondence between diagnosis and treatment

diagnosis	**treatment**
initiation	instructions
execution	assistance
control	feedback

When a patient predominantly has problems during the initiation of an activity, the therapist adapts his or her instructions. If problems occur during the execution of activities, specific assistance is offered. If, eventually, a patient does not detect and/or correct performance errors, the therapist will give appropriate feedback.
The various ways to offer instruction, guidance and feedback we elaborated in the program are based on strategies for compensation. Compensation can be internal or external. An example of internal compensation is teaching patients to consciously verbalize the proper sequence of the distinct steps of which an activity consists, while performing the activity. Another possibility is to have the patient name the objects needed to perform the activity. External compensation is established by modifying the demands of the task or the environment. External aids can be used to overcome a disrupted activity, for instance by showing the patient pictures of the proper sequence of the activity. Modification of the task is applied when a patient cannot button a shirt; alternative ways of fastening can be chosen (e.g. a zipper). Similarly, a patient can be trained to use

instant coffee instead of going through the complete coffee making procedure.
In carrying out the therapy program, the occupational therapist follows three consecutive stages: the diagnostic procedure, the actual treatment period, and a repetition of the diagnostic measurements in order to evaluate the changes in functioning after treatment. The number of treatments per week is determined by the therapists. Frequency of treatment is not standardized but therapists are encouraged to practice with the patient as frequently as possible. Interviews in clinical practice revealed that occupational therapists in the Netherlands treat stroke patients 3 to 5 times per week, while each treatment session takes 30 minutes.
During a three months treatment period, ADL-activities are trained which are chosen every two weeks. Activities are trained that are relevant for the patients to (re)learn. The decision about the activity to be trained is made together with the patient. The occupational therapist is encouraged to use a decision tree to guide the choice of an activity or to use a checklist with activities carried out by the patient before the occurrence of the stroke and activities that are important for the patient to carry out in the near future. After this two-week period, a new treatment goal is considered, based upon the improvement in the patient's functioning.

Study design and research questions

The purpose of the study was twofold. The first part of the study concerned the development of a diagnostic procedure for apraxia and the investigation of the clinimetrical quality of the two diagnostic instruments: the apraxia test and the set of ADL-observations. As for the apraxia test the following questions will be answered:

- Do the subtests for ideational apraxia and ideomotor apraxia (of which the apraxia test consists) measure the same underlying concept or can the test be used to distinguish between different forms of apraxia? The homogeneity of the test will be assessed by computing Cronbach's alpha, and by performing Mokken scale analysis (chapter 4).
- Does the apraxia test have sufficient discriminative capacity to differentiate between patients with apraxia, patients without apraxia and healthy persons (diagnostic value)? The diagnostic value of the apraxia test will be determined by comparing the test scores of apractic patients with scores of stroke patients without apraxia and with scores of healthy

elderly persons (chapter 4).

As for the ADL-observations the following questions will be asswered:

- To what extent do two observers agree when they independently observe the same patient performing ADL-activities (inter-rater reliability)? The inter-rater reliability will be expressed by means of the degree of agreement between two observers (chapter 5).
- Do the items of the observational scales collectively measure the same underlying concept? The internal consistency of the ADL-observations will be presented by means of Cronbach's alpha and the results of Mokken scale analysis (chapter 5).
- Is the observational procedure valid in measuring apraxia and its consequences, in other words: what can be said concerning the clinical validity and the construct validity of the ADL-observations? The clinical validity will be investigated by comparing the scores of a group of stroke patients with apraxia with those of a group of stroke patients without apraxia. The construct validity will be examined by investigating the relations between the different measures of interest: the apraxia test, a motor functioning test, the ADL-observations and the Barthel index as a general measure of disability (chapter 6).

The second part of the study concerned the development of a treatment program and the evaluation of the effects of treatment. To this end a group of stroke patients with apraxia was treated according to the guidelines of the treatment program. The level of independent functioning was measured before and after treatment. The outcome of the program was evaluated in a pre-post test design; there was no control group of patients. The following research questions will be answered:

- Do changes occur in the functioning of patients who have been treated according to the guidelines of the program or more specifically: do patients function more independently after therapy than before? The changes in functioning will be considered for the total group (effect sizes) as well as for individual patients (reliable change index). In addition, subjective improvement is considered (chapter 7).
- What individual factors predict the outcome of the therapy program? To this end an exploratory study will be presented in which variables that influence the outcome of treatment are identified (chapter 8).

In the present study stroke patients treated at occupational therapy departments in general hospitals, rehabilitation centers or nursing homes were considered eligible for the study, on the basis of a set of inclusion and exclusion criteria. The sample of patients was confined to patients who had a stroke in the left hemisphere. Apraxia occurs more frequently following left than right brain damage. Right hemispheric patients were excluded from the study because a different pattern of deficits can unfold following right brain damage; many other cognitive disorders can be present which could interfere in diagnosing apraxia. Especially the agnosias were expected to be a source of influence. Left hemispheric patients diagnosed to have apraxia, either by the referring physician or the occupational therapist on the basis of clinical evaluation, were included. In addition, a set of exclusion criteria was applied to patients with apraxia who could be candidates for the study (see appendix chapter 5). Of all patients entering the study their informed consent was asked.
The design of the study was not an experimental one. A control group of patients not receiving strategy training was not included. Since there is no consensus in clinical practice concerning assessment and treatment of apraxia, which instruments to use, what principles of treatment to follow, it is not advisable to conduct a randomized controlled study. Instead, a study focussing on the evaluation of the diagnostic procedure and the treatment of apraxia is to be preferred. In the following chapters the study design and results will be presented in detail.

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Part II

RESEARCH STUDY

"A great many people think they are thinking when they are merely rearranging their prejudices"
[William James, 1842-1910, Attr.]

Chapter 4

A DIAGNOSTIC TEST FOR APRAXIA IN STROKE PATIENTS:

internal consistency and diagnostic value

C.M. van Heugten, J. Dekker, B.G. Deelman, J.C. Stehmann-Saris, A. Kinebanian. A diagnostic test for apraxia in stroke patients: internal consistency and diagnostic value (submitted).

Abstract

In this paper the internal consistency and the diagnostic value of a test for apraxia in stroke patients are presented. The results indicate that the items of the test form a strong and consistent scale: Cronbach's alpha as well as the results of a Mokken scale analysis present good reliability and good scalability. The diagnostic value of the test was determined by comparison of test results in three groups of subjects: a group of 44 stroke patients with apraxia (patients), a group of 35 stroke patients without apraxia (patient controls) and a group of 50 healthy nursing home residents with no history of stroke (normal controls). The diagnostic value is expressed by means of the sensitivity and specificity and the predictive value of the test. In addition, ROC-curves are presented. The sensitivity and specificity of the apraxia test appeared to be good: all values are higher than 80%. The test also has high predictive value. The ROC-curves illustrate that the test is sufficiently discriminative to allow a differentiation between persons with apraxia and persons without apraxia.

Introduction

Apraxia is one of the classic neuropsychological impairments which can be the consequence of left-hemisphere stroke. For a patient with apraxia, it is difficult or impossible to perform purposeful activities of daily living (ADL). These problems in ADL-functioning are the result of the absence or disturbance of a plan of action. These disturbances in the organisation of voluntary actions are not due to primary motor or sensory impairments; the patient has, for instance, sufficient muscle strength or motor coordination to perform the actions. Neither are these difficulties the result of lack of motivation, attention or comprehension. Other impairments, like aphasia or hemiplegia, may be present, but these deficits are not the cause of the inability to perform purposeful acts (Geschwind, 1975; Kolb & Whishaw, 1990; De Renzi, 1989).

In the literature many different classifications and forms of apraxia are described and discussed (Luria, 1966; Roy, 1978; Concha, 1987; De Renzi, 1989; Tate & McDonald, 1995). However, there is not one accepted taxonomy and the literature is often inconsistent and confusing. The first, now classic theory of apraxia was formulated by Liepmann (1920), in which he proposed three different types (ideational apraxia, motor apraxia, and limb-kinetic apraxia). Later, Luria (1966) discussed yet three other forms of apraxia (frontal, premotor, and kinesthetic apraxia). These forms are all associated with the limbs. Apraxia can also be classified in terms of the body-part affected; for instance oral apraxia (Heilman & Gonzalez-Rothi, 1985). In addition, many forms of apraxia are described in relation to the activity that is disturbed; for instance constructional apraxia (Kleist, 1934) or dressing apraxia (Brain, 1941). Many forms of apraxia have been the object of research studies, and some forms have been dismissed or at least disputed. The present study is restricted to ideational and ideomotor apraxia. These two forms have been the object of many studies in recent years and are sometimes labeled as the two classic forms of apraxia (Tate & McDonald, 1995). A patient with ideational apraxia does not know what to do: the very concept or idea of the motor act is lacking or not retrievable from memory (De Renzi & Lucchelli, 1988; De Renzi, 1989). A patient with ideational apraxia will have problems organizing performance; series of movements get disrupted (Arnadottir, 1990; De Renzi & Lucchelli, 1988). In ideomotor apraxia the idea or plan of action is not impaired (i.e the patient does know what to do), but the implementation of the movement

sequence into a proper mode of action is disrupted (i.e the patient does not know how to do it; De Renzi, 1989). Patients with ideomotor apraxia "have difficulty with the selection, sequencing and spatial orientation of movements involved in gestures including emblems and pantomime" (pg. 134, Heilman & Gonzalez-Rothi, 1985). In the literature the existence and autonomy of these two forms of apraxia have been brought under discussion. At some point in time the claim was made that ideational apraxia is only a severe form of ideomotor apraxia (e.g. Liepmann, 1920; Sittig, 1931; Zangwill, 1960). Others, however, claimed that ideational apraxia is a distinct form of apraxia (De Renzi & Lucchelli, 1988). Several authors claimed ideomotor apraxia to be merely an artefact of testing performance, since the patient may not be able to perform on request, whereas in a natural setting he or she is able to carry out the same activity perfectly well (De Renzi, Motti & Nichelli, 1980). This claim was challenged by other researchers demonstrating disturbances in everyday activities following ideomotor apraxia (Bjorneby & Reinvang, 1985; Sundet, Finset & Reinvang, 1988; De Renzi & Lucchelli, 1988). The two forms of apraxia frequently occur together, but since different mechanisms are disrupted and different structures are involved, the two forms should be kept separate, according to De Renzi, 1989. This statement can however be disputed.
Measuring or, more specifically, diagnosing apraxia is difficult and standardized tests are hardly available (Schellekens, 1989; Kolb & Whishaw, 1990; Wade, 1992). The majority of testing procedures for apraxia now available were developed to elaborate theoretical models and explanations, and were applied in empirical studies. Results of applied research concerning assessment of apraxia are not available. Until this moment no scoring system for apraxia has been generally accepted, because of uncertainty about what to score and how to score it (Lezak, 1995). Clinicians attempting to diagnose apraxia mainly rely on personal experience, clinical impression and intuition (Poeck, 1986).

To overcome some of these limitations, a diagnostic procedure for apraxia was developed, based on the ideas of De Renzi (De Renzi et al, 1980, 1982, 1988). The procedure involves a neuropsychological test for apraxia, including tasks for demonstration of object use and imitation of gestures. Typically, ideational apraxia is examined in tests requiring the use of objects, while ideomotor apraxia is most commonly tested by asking the patient to imitate gestures (De Renzi, Motti & Nichelli, 1980; De Renzi, Faglioni & Sorgato, 1982; De Renzi &

Luchelli, 1988). The goal of our test is to facilitate a differentiation between patients with apraxia and patients without apraxia, thereby offering a method to objectify the clinician's impression. First, the homogeneity of the apraxia test is assessed in order to determine whether the two subtests measure different forms of apraxia. This examination is conducted in order to form a judgement concerning the autonomy of the two forms of apraxia. Second, before actually using the apraxia test it is important to determine its discriminative capacity. In the present paper the diagnostic value of the test is described in terms of sensitivity, specificity, and predictive values.

Subjects and methods

Subjects

Three groups of subjects participated in the present study: 44 left brain damaged patients with apraxia (patients), 35 left brain damaged patients without apraxia (patient controls), and 50 elderly nursing home residents with no history of stroke or other central deficits (normal controls). Inclusion criteria for patients with apraxia were stroke in the left hemisphere in combination with apraxia, diagnosed on the basis of clinical evaluation. A left-hemisphere stroke is diagnosed when acute clinical symptoms of a focal dysfunction of the left hemisphere are present; these signs and symptoms last at least 24 hours, and there is most likely no other than a vascular origin (WHO, 1989; Van Crevel, 1991). Apraxia is diagnosed when the patient is fully or partly unable to carry out purposeful activities, this not being due to primary motor or sensory impairments, nor to deficits of comprehension, memory, or motivation. Other impairments may be present, but they are not the cause of the inability to perform purposeful acts (Kolb & Whishaw, 1990). Likewise, the patient controls had survived a left-hemispheric stroke, but had not been diagnosed to have apraxia. Normal controls were included when free from present or previous brain injury. Exclusion criteria for all groups were: age younger than 25 years or older than 95 years, no working knowledge of the Dutch language, and a selected set of premorbid or present pathologies: psychiatric or psychogeriatric history, addiction to alcohol, medical or other drugs, contusio cerebri, personality, intellectual or learning disorders, temporary loss of consciousness, or other injuries to the central nervous system.

Assessment

An apraxia test was used on the basis of tests described in the literature (De Renzi et al, 1980, 1982, 1988, 1989). The test consists of two subtests: demonstration of object use and imitation of gestures; these two tasks are the most widely accepted tasks to test for ideational apraxia and ideomotor apraxia respectively (De Renzi et al, 1980, 1982, 1988).

The use of objects, a method for the assessment of ideational apraxia, is tested in three different conditions (De Renzi et al, 1982). Sets of objects are presented to the patient with the same instruction: 'show me how you would use ... (this object)'. Each set contains three objects used in daily activities; first set: key, hammer and toothbrush; second set: spoon, hammer and scissors; and third set: eraser, comb, and screwdriver. The first set of objects is presented only by verbal request, without the object present. The second set of objects is presented visually; the subject may look at the objects, but not touch them. With the third set of objects actual use is tested: the objects are handed to the patient, who may see and feel them.

The subtest of imitation of gestures, aimed at ideomotor apraxia specifically, contains the following 6 gestures which have to be imitated by the patient immediately upon demonstration by the researcher: sticking out one's tongue, blowing out a candle, closing one's eyes, waving goodbye, saluting, and making a fist (De Renzi et al, 1980).

To avoid interference of motor or sensory impairments the patients (patients and patient controls) used the hand ipsilateral to the side of the brain lesion (i.e the 'healthy' hand, which is in our case the left hand) in both subtests. The normal controls were allowed to use the hand of preference, since De Renzi et al (1980) found no difference between the performance of normal control patients who used the right hand and those who used the left hand. The scoring procedure was based on De Renzi and Lucchelli (1988): the performance is correct and appropriate (3 points); the performance resembles the correct one, but is somewhat imprecise or the patient uses a body part as object (2 points); the performance only weakly resembles the correct one but is executed in the correct place, or it is correct but carried out in a wrong place (i.e. moving the toothbrush in front of the forehead; 1 point); and the performance is not correct or so incomplete that it is not recognizable (0 points). Each subject was asked to try carrying out the activity; if the performance was correct at first attempt, a score of 6 was given. If the execution was not quite correct or even totally

wrong, the subject was allowed to try again. The scores of both attempts were added up to arrive at a score per item (maximum score of 6). This way the maximum subscore for demonstration of object use was 54 and for imitation of gestures 36. The maximum total score was 90.

Testing Procedure

Once stroke patients - patients and patient controls - had consented to participate in the study, a diagnostic procedure including the apraxia test was started. The measurements were performed at occupational therapy (OT) departments in general hospitals, rehabilitation centers and nursing homes in the Netherlands. Each patient was tested by the experimenter in a one-hour testing session, during which the test of apraxia and tests for additional impairments were conducted. The patient sat facing the experimenter in a quiet room suitable for testing.

The elderly inhabitants (normal controls) were tested by the experimenter in a session which consisted solely of the test of apraxia. Participation took place on the basis of informed consent. Here too, the person sat facing the experimenter in a quiet room suitable for testing.

Statistical analyses

The internal consistency of the apraxia test was assessed by computing Cronbach's alpha, and by performing Mokken scale analysis. Alpha is an indicator of the internal consistency of a test, expressed by the average correlation of the items within the test. The homogeneity of the test is considered to be good if alpha is higher than 0.80 (De Haan, 1994). However, the use of alpha can be misleading, since alpha depends on the number of items in the test (Drenth & Sijtsma, 1990). Hence, a Mokken scale analysis was executed additionally. Mokken scale analysis is a scaling technique for determining the homogeneity of a scale. The degree to which one or more unidimensional scales are formed is indicated by the scalability coefficient Loevinger's H (a value of 0.50 or higher represents good scalability), by the reliability coefficient Rho, and by a hierarchical order for the level of difficulty of the items (Mokken, 1971; Mokken & Lewis, 1982).

The diagnostic value of a test can be expressed by means of its sensitivity and specificity. The sensitivity of a test is expressed by the percentage of patients with a certain disease being classified by the test as 'ill'; the specificity of a test is

shown by the percentage of a group of persons not having the disease for which the test was developed being classified by the test as not having the specific disease.
In clinical practice, an important property of a test is its predictive value: the chance that subjects with a certain testscore actually have the disease. A positive predictive value describes which part of the subjects under study with a positive testscore actually have the disease. A negative predictive value describes which part of the subjects under study with a negative testscore are healthy.
In computing these discriminative variables, a cut-off score is needed: a score below this value indicating the presence of the disease. Usually the clinical literature on apraxia gives cut-off points based on the poorest (but-one) score found in normal control patients (De Renzi et al, 1980, 1988). A person free from brain injury may yield low scores as a result of clumsiness, which should not be interpreted as an indicator of apraxia. The optimal cut-off score depends on the situation under which the test is administered. For this reason various possible cut-off scores have been examined in our study. In test research the mean score of normal controls minus one standard deviation and minus two standard deviations are often used as cut-off points. These two possibilities are both examined. Additionally, the poorest score of normal controls is considered.
The above mentioned quantities can be derived from a 2 X 2 table (table 1). The sensitivity is calculated by a/(a + c); the specificity is determined by d/(b + d). The positive predictive value equals a/(a + b) and the negative predictive value is calculated by d/(c + d).

The trade-off between the sensitivity and the specificity can be illustrated by a Receiver Operator Characteristics (ROC) curve. An ROC-curve is obtained by plotting the sensitivity against the complement of the specificity for each possible cut-off point. The area under the curve represents the overall accuracy: the best discrimination is obtained when a curve approaches the left upper corner. The discriminative capacity increases as the area increases. This area theoretically ranges from 0.5 (no accuracy, along the diagonal) to 1.0 (perfect accuracy). On the basis of the trade-off between true-positives and false-positives the decision can be taken concerning the optimal cut-off point to be chosen for a certain application of the test under study.

Table 1. Schematic presentation of the relationship between the results of a diagnostic test and the presence or absence of a disease

		disease		
		present	**absent**	
test	**positive**	true-positive (a)	false-positive (b)	a + b
	negative	false-negative (c)	true-negative (d)	c + d
		a + c	b + d	a + b + c + d

All statistical analyses were performed using SPSS/PC+, version 5.0, except for the Mokken scale analysis, which was performed using MSP, version 3.0 (Molenaar, 1994).

Results

Characteristics of the subjects

The characteristics of the three groups of subjects are presented in Table 2. In all groups more females than males entered the study. In the two patient groups the numbers of females are comparable (patients and patient controls; p=0.48). In the control group the number of females differs significantly from the patients (p=0.01) as well as from the patient controls (p=0.09). The ages of the subjects in the three groups are not comparable (all p-values are < 0.01); the normal controls are older. The two patient groups do not differ significantly as regards the type of stroke (p=0.11). Concerning the time since stroke there is a difference of 4.6 weeks between the two groups, but this difference is not significant (p=0.10).

Table 2. Characteristics of the subjects

Group	stroke patients with apraxia (patients)	stroke patients without apraxia (patient controls)	healthy elderly (normal controls)
Gender			
Male	20	14	11
Female	24	21	39
Age			
mean	69.9	61.2	83.6
sd	10.8	12.3	6.0
Institution			
Hospital	16	10	-
Rehab. center	15	20	-
Nursing home	13	5	50
CVA			
Cerebral haemorrhage	10	11	-
Cerebral infarction	30	22	-
Unknown	4	2	-
Time since stroke (in weeks)			
mean	8.4	13.2	
sd	5.0	16.0	
Hand of preference			
Right hand	38	32	46
Left hand	1	3	4
Unknown	5	-	-
N (total)	44	35	50

Internal consistency of the apraxia test

In table 3 the indices representing the homogeneity of the apraxia test are shown. This table is based on the scores of the group of stroke patients with

apraxia. The alpha values as well as the results of the Mokken scale analyses present good reliability and good scalability. The coefficients indicate that the subtests for demonstration and imitation together form one unidimensional scale; the H-coefficient of the total scale has a value of 0.72, which indicates a strong scale. The rho-value of the total scale is 0.97. The H-values of the subtests (0.76 for demonstration of object use, and 0.71 for imitation of gestures) differ only slightly from the H-value of the total scale. This result indicates that the test of apraxia does not consist of two subtests measuring different concepts, but should rather be considered to be a homogeneous test measuring the same underlying construct, most probably being apraxia.

Table 3. Homogeneity of the apraxia test

(Sub)test	Alpha	H	Rho
Demonstration	0.95	0.76	0.95
Imitation	0.92	0.71	0.93
Total	0.96	0.72	0.97

The items can be ordered hierarchically from less difficult to more difficult (table 4). For this group of apraxia patients, imitation of gestures is less difficult than demonstration of object use. Within the latter subtest it appears that actual object use is less difficult than demonstration with the object present; while demonstration with the object present is less difficult than demonstration of object use on verbal request only.

Table 4. Mokken scale analysis

Items	Mean	Scalability coefficient
hammer (1)	2.59	0.78
spoon (2)	2.68	0.77
key (1)	2.75	0.72
toothbrush (1)	2.80	0.73
scissors (2)	2.95	0.70
hammer (2)	3.05	0.75
eraser (3)	3.25	0.74
screwdriver (3)	3.55	0.63
saluting (4)	4.41	0.67
sticking out tongue (4)	4.43	0.71
blowing out a candle (4)	4.43	0.69
comb (3)	4.48	0.78
waving goodbye (4)	4.50	0.60
making a fist (4)	4.82	0.71
closing eyes (4)	4.98	0.81

Coefficient of Scalability H = 0.72
Coefficient of Reliability Rho = 0.97

1 = demonstration, verbal request
2 = demonstration, visual presentation
3 = demonstration, actual use
4 = imitation of gestures

Difference between groups

The results of the apraxia test are shown in Table 5. As can be seen in the table, the mean value on both subtests - demonstration of object use and imitation of gestures - as well as the total mean score is much lower for the group of stroke patients with apraxia than for the two other groups. A t-test shows that the total mean score of the group of patients with apraxia differs

significantly from the total mean score of the patient controls (t=7.34; p=0.000) and from the normal controls (t=7.56; p=0.000). The total mean score of patient controls and normal controls do not differ significantly (t=1.34; p=0.18). The standard deviation and the ranges of the apraxia patients show considerably more variation than those of the other two groups. On the total test the patient controls did not score below 75. Among the normal controls 78 was lowest score. The apraxia patients scored across the total range of possible scores (0-90). Sixtyfour per cent of the apraxia patients had scores below the lowest score of the patient controls; 70% of the apraxia patients had scores below the lowest score of the normal controls (Table 6).

Table 5. Results of the test of apraxia for the apraxia patients, the patient controls and the normal controls

Group	Stroke patients with apraxia (n=42) (patients)		Stroke patients without apraxia (n=35) (patient controls)		Healthy elderly (n=50) (normal controls)	
Subtest	Mean (sd)	Range	Mean (sd)	Range	Mean (sd)	Range
Demon-stration	28.1 (20.0)	0-54	52.3 (3.5)	43-54	53.6 (1.7)	48-54
Imitation	27.6 (11.3)	0-36	35.7 (1.0)	32-36	35.2 (1.5)	30-36
Total	55.7 (29.0)	0-90	88.0 (3.3)	75-90	88.8 (2.4)	78-90

Table 6. Score distribution for the three groups of subjects

	patients	patient controls	normal controls
< 75	27	-	-
75	1	1	-
76	1	-	-
77	-	-	-
78	2	-	1
79	1	-	-
80	-	-	1
81	1	1	-
82	-	-	-
83	3	2	-
84	1	1	1
85	1	1	-
86	2	1	2
87	-	1	-
88	2	3	10
89	-	9	4
90	2	15	31
Total	44	35	50

Broken lines indicate the three cut-off scores presented in the text

Sensitivity and specificity

The sensitivity and specificity can be derived from the score distribution as presented in Table 6. If the poorest score of normal controls (78) is considered as a cut-off point, the sensitivity of the test is 66%. The specificity of the test is 97% for the patient controls, and 100% for the normal controls.

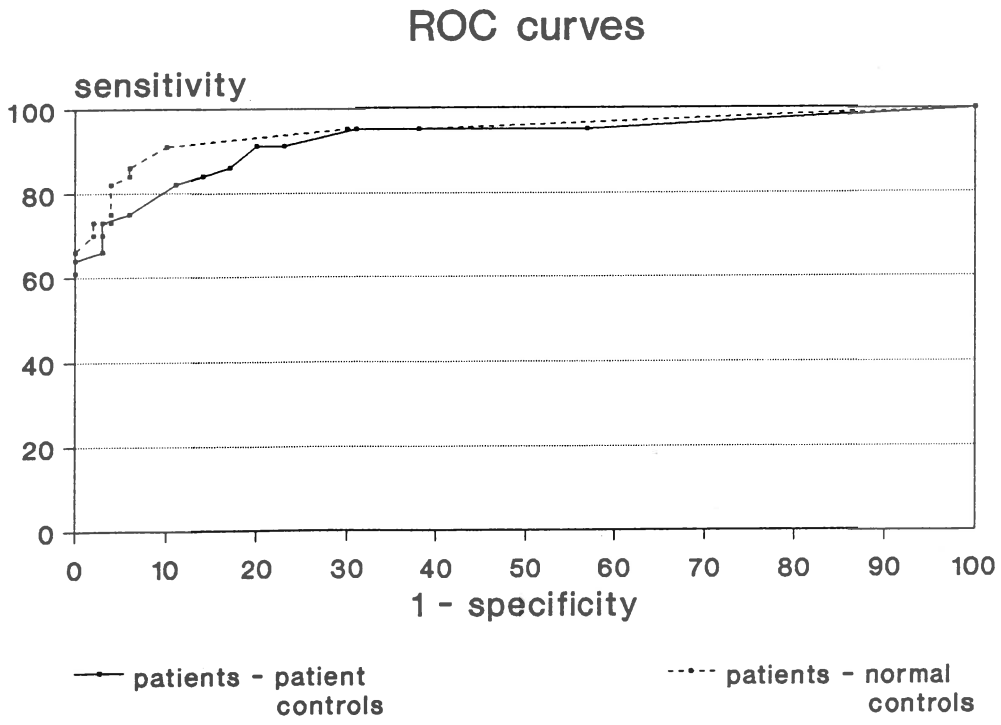
Based on a cut-off point of the mean score minus one standard deviation (86.4) the sensitivity of the test is 91%. The specificity is 80% when the patient controls are considered. For the normal controls the specificity is 90%.

If a cut-off point of the mean score minus two standard deviations (84) is chosen, the sensitivity is 82%. The specificity is 89% and 96% for the patient

controls and the normal controls respectively.
The optimal cut-off point can be defined as the point with the best combination of the sensitivity and the specificity. This optimum can be determined by averaging the sensitivity and the specificity for each cut-off point; the highest mean value can be considered optimal. For our data this optimum appears to be a cut-off point of 86, which is the mean score minus one standard deviation.

The trade-off between the sensitivity and the specificity is illustrated by presenting a ROC-curve. In Figure 1 two ROC-curves are shown: one for the scores of the apraxia patients and the patient controls, and one for the scores of the apraxia patients and the normal controls. Both curves approach the upper left corner, producing a large area under the curve.

Figure 1. *ROC-curves for stroke patients without apraxia (patient controls) and healthy elderly (normal controls)*



Predictive values

The positive and negative predictive values of the apraxia test are calculated on the basis of the score distribution in Table 6. If a cut-off point of the poorest score of normal controls (78) is considered, the positive predictive value is 97% for the patient controls and 100% for the normal controls. The negative predictive values are 69% and 77% for the patient controls and the normal controls respectively.

If a cut-off point of the mean score minus one standard deviation (86.4) is chosen, the positive predictive value is 87% for the patient controls and 89% for the normal controls. The negative predictive values are 88% and 92% for the patient controls and the normal controls respectively.

If a cut-off point of the mean score minus two standard deviations (84) is chosen, the positive predictive value is 90% for the patient controls and 95% for the normal controls; the negative predictive values are 79% for the patient controls and 86 % for the normal controls.

Discussion

This paper presented the results of a study of a test for apraxia in stroke patients. The assessment of the homogeneity of the test shows that the diagnosis of apraxia is possible on the basis of the total score: the two subtests together measure the same underlying construct. Nevertheless, the subtest imitation of gestures seems to cause less difficulty in performance than the subtest demonstration of object use.

The items of the two subtests for demonstration of object use and imitation of gestures can be combined into one strong and consistent scale. This implies that both subtests measure the same underlying concept. In other words, the test of apraxia can not be used for distinguishing between ideational and ideomotor apraxia. Or, to put it differently, the two forms of apraxia are not autonomous forms. This result does not confirm suggestions of some authors that both forms of apraxia can occur separately (e.g. Poeck, 1985; De Renzi & Lucchelli, 1988), although it is not impossible that in another group of apractic patients the dissociation between the two forms of apraxia would be apparent. Our data indicate that the example set by Dee, Benton and van Allen (1970),

Kimura and Archibald (1974) and later by Lezak (1995) should be followed: it is more apt to use descriptive terminology (e.g. observable problems in functioning) than distinguishing different forms of apraxia in theoretical terms.

The diagnostic value was expressed by means of the sensitivity and the specificity on the one hand, and the positive and negative diagnostic values on the other. The results indicate that the sensitivity and the specificity of the test are good. This conclusion is illustrated by the ROC-curves, which depict the interaction between the indices: the areas under the curves are close to 1.0, indicating that the test shows sufficient discriminative capacity. This implies that the apraxia test enables us to differentiate between persons with apraxia and persons without apraxia. The ROC-curve then supports a decision on where the best cut-off point would be for a certain application (Jelles and Bennekom, 1995). On the basis of the current data, a cut-off score of the mean score minus one standard deviation is recommended for the apraxia test. This score can be considered optimal in terms of the best combination of the sensitivity and specificity. However, in present daily practice the prevalence of apraxia is overestimated: stroke patients experiencing problems in the execution of daily activities are sometimes wrongly classified as apractic. In other words, the test must diminish false-positives and therefore be highly specific. This would argue in favour of the mean score minus two standard deviations. The situation for which the test is applied will have to guide the actual decision on the optimal cut-off point.
For the development of a diagnostic test, Feinstein (1985) recommends a procedure with several phases: in the first phase a maximal contrast is established by testing patients and healthy controls; in the second phase a patient-control design is used. In our study both possibilities are explored. Indeed, our conclusions are based on tests involving three groups of subjects: stroke patients with apraxia, stroke patients without apraxia, and healthy elderly persons. Comparison between the groups could be influenced by the age of the normal controls: the normal controls are considerably older than the subjects in the two patient groups. This difference however, reinforces our conclusions concerning the specificity of the test for apraxia: despite the high age of the normal controls, the discriminative capacity of the test is good.

In conclusion, the apraxia test presented in this paper offers a simple and

consistent instrument. This instrument makes it possible to distinguish between patients with apraxia and patients without apraxia, as indicated by its discriminative capacity. An important aspect which should be investigated next is the inter-rater reliability of the instrument: to what extent do two observers reach the same conclusions when observing the same performance.

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Chapter 5

ASSESSMENT OF DISABILITIES IN STROKE PATIENTS WITH APRAXIA:

internal consistency and inter-observer reliability

C.M. van Heugten, J. Dekker, B.G. Deelman, J.C. Stehmann-Saris, A. Kinebanian. Assessment of disabilities in stroke patients with apraxia: internal consistency and inter-observer reliability. Occupational Therapy Journal of Research 1998 (in press).

Abstract

In this paper the internal consistency and inter-observer reliability of the assessment of disabilities in stroke patients with apraxia is presented. Disabilities were assessed by means of observation of activities of daily living (ADL). The study was conducted at occupational therapy departments in general hospitals, rehabilitation centers and nursing homes in the Netherlands. Patients (n=42) diagnosed to have had a stroke in the left hemisphere and to have apraxia as well, participated in the study (48% male, aged 31 - 91). Guidelines were offered for the ADL-observation and the assessment of disabilities in these activities. The internal consistency of the scales is expressed by means of Cronbach's alpha and Mokken-scale analysis. The inter-observer reliability is expressed by means of percentage of agreement between two observers, Cohen's kappa and the intra-class correlation coefficient (ICC). The internal consistency of the observations is good: alpha is high (0.94). The Mokken-analysis confirms this finding: an H-coefficient of 0.58 and corresponding rho of 0.94 indicate a strong and reliable scale composed of the set of all ADL-observations.

Results indicate that the inter-observer reliability can be considered fair to good: all kappa values were higher than 0.44; the maximum kappa was 0.95. Percentages of agreement vary between 60% and 96%. The ICC range from 0.62 to 0.98. The results of this study imply that the ADL-observations can be considered an internally consistent and reliable instrument for the assessment of disabilities in stroke patients with apraxia.

Introduction

A considerable number of patients surviving a stroke in the left hemisphere have apraxia. It has been estimated that apraxia occurs in about 30% of left-hemispheric patients tested in the acute phase following a stroke (De Renzi, 1989). Apraxia has also been reported to follow right hemispheric lesions, albeit considerably less frequently (De Renzi, 1989; De Renzi, Motti & Nichelli, 1980). Apraxia refers to the inability to perform learned and purposeful activities which is not the result of primary motor or sensory impairments or of deficits in motivation or comprehension (Kolb & Whishaw, 1990). In some cases the patient will recover from apraxia in the acute phase following a stroke. In other cases, apraxia may cause chronic and severe disablement in the performance of activities of daily living (e.g dressing), and for that reason extensive rehabilitation is preferable.

Several tests have been developed to measure the presence and severity of apraxia (e.g., De Renzi, 1989; De Renzi et al, 1980; Kolb & Whishaw, 1990; Heilman & Gonzalez-Rothi, 1985; De Renzi, Faglioni & Sorgato, 1982; De Renzi & Lucchelli, 1988; Shelton & Knopman, 1991). However, generalizing the results of these tests to activities of daily living is extremely difficult. Neuropsychological tests measuring apraxia concern the performance of activities in a rather artificial environment. Poor performance in these tests does not necessarily indicate that the patient will also experience problems in daily life. In other words, incompetence in a laboratory setting does not necessarily imply incompetent behaviour in one's own environment (Smith & Clark, 1995; Roorda, Roebroeck, Lankhorst, van Tilburg & Bouter, 1996). Rehabilitation, however, is directed to the consequences of apraxia in daily functioning. Assessment of disabilities due to apraxia is therefore necessary to complement the (laboratory) apraxia tests. An essential part of a diagnostic procedure for the assessment of apraxia should therefore be the observation of ADL-activities focussed on the disabilities due to apraxia. Several instruments are available measuring disabilities as a consequence of stroke in general (Wade, 1992). The Barthel Index for instance is primarily intended to measure physical disability. Physical disability can however be the result of problems in motor functioning, which is not the case in apractic patients. This implies that an instrument specifically measuring disabilities following apraxia is necesssary. To our knowledge a standardized procedure for the observation of ADL-activities and the scoring of

disabilities regarding these activities due to apraxia, is not yet available. Arnadottir (1990) gave an impetus to this end, but her evaluation method aims at examining many different functions and does not focus on apraxia specifically.

In the present study we have developed a set of standardized ADL-observations for the assessment of disabilities due to apraxia. Four activities are scored on four different measures: an independence score and three scores for the nature of deficits in the performance. The independence score indicates to what extent the patient is able to perform the activity without assistance. In order to assess the nature of deficits in the performance in greater detail, three specific scores for quantitative aspects of the activity are given (see method section).

Before using this observational method it is important to investigate the (clinimetrical) quality of the instrument. The quality of an instrument is dependent upon its reliability and validity, but also the relevance and its practical use. The present paper reports on a study into the reliability of the observational method. To this end the internal consistency of the ADL-observations (i.e. do the ADL-observations measure the same underlying concept) and the inter-observer reliability (i.e. to what extent do two observers reach the same conclusions when observing the same performance) were investigated.

Method

Patients

The data were collected at occupational therapy departments (OT) of general hospitals, rehabilitation centers, and nursing homes in the Netherlands between September 1993 and February 1995. The patients were selected on the basis of a set of criteria for inclusion and exclusion (Appendix 1). Patients diagnosed to have had a stroke in the left hemisphere and to have apraxia, were included. Human research was approved by the local institutions.

The presence of apraxia was at first diagnosed on the basis of clinical reasoning. In addition, a test of apraxia was used, adapted from De Renzi and collegues (1980, 1982, 1988), consisting of two subtests: demonstration of object use and imitation of gestures. We investigated the internal consistency of this apraxia test which proved to be good as indicated by Cronbachs alpha and the results of a Mokken scale analysis. We also examined the diagnostic value

of the test; the test appears to have sufficient discriminative capacity to allow a differentiation with regard to persons with apraxia and persons without apraxia (van Heugten, Dekker, Deelman, Stehmann-Saris and Kinebanian, 1997).

Materials

The assessments are based on a method developed by Arnadottir (1990). Arnadottir uses a functional independence scale to evaluate to what extent the patient is able to perform activities without help or assistance. After consulting experts in the field of stroke patient rehabilitation, we adapted this scale, in order to generate more detailed information. The resulting independence score contained 4 levels ranging from 'the patient is totally independent and does not need any assistance' (0), to 'the patient is totally dependent upon full assistance from the therapist' (3). Additionally, we generated scales to evaluate the nature of deficits in the performance in ADL-activities. In other words, qualitative aspects of behaviour are observed. With regard to the framework of information processing, we have distinguished three aspects of an activity: initiation, execution and control. The ADL-activities can be conceptualized as being composed of these aspects, being successive events. The concept of stages of processing is quite old (Donders, 1868/1969), but the idea has been popularized by recent cognitive psychologists (e.g. Sanders, 1980; Schmidt, 1988). The more recent efforts have led to the idea that various stages can be defined, which can be either serial or parallel in nature. A patient with apraxia, who for example cannot use objects appropriately, may have a deficit at in one of the stages of an activity, following the information processing approach. By assessing the aspects of an activity, in which the stages are reflected, the nature of the deficit can be identified, and plans for treatment can be formulated accordingly (Grieve, 1993).

For initiation, the patient has to understand and interpret the instructions given, construct a plan for the action and activate a command for execution. Secondly, during execution, the activity has to be performed in the proper sequence and by using the appropriate objects. And finally, the activity has to be controlled and the performance corrected if necessary. To put it differently, the proper plan of action as well as the correct objects have to be selected (initiation), followed by adequate performance of the plan (execution), which has to be evaluated in terms of the outcome (control). For each aspect we developed a scale relevant for the kind of problems that can be expected. In this way three scales were

developed. The observation and scoring of activities is shown in Appendix 2.
Each scale is divided into different levels ranging from 'there are no observable problems, the patient performs well without help' to 'the therapist has to take over in order to get action or result'. The scales are developed using levels of functioning comparable to the scales of Arnadottir (1990). For the aspect of control, in the scale a difference is made between feedback concerning the results of the activity (knowledge of results) and feedback concerning the execution of the activity (knowledge of performance). Both forms are important categories of extrinsic post-response feedback in motor learning (Schmidt, 1988).
Four activities were observed: three activities were prescribed by our guidelines; the fourth activity could be chosen by the therapist (e.g., an activity adapted to the patients needs and capabilities or one of the institution's standard observation procedure). The three pre-determined ADL-activities were: personal hygiene (washing the face and upper body), dressing (putting on a shirt or blouse) and preparing food (preparing and eating a sandwich). The ADL-activities can be considered to be standard in occupational therapy departments in the Netherlands. With regard to the fourth activity, the one chosen by the therapist in almost 90% of the cases the OT selected making coffee or tea for observational purposes. In some cases the OT chose to observe shaving, preparing breakfast or doing the dishes.

Procedure

Training. Before the study started, the OTs attended one training session. During this session the use of the observational scales was explained. A videotape of a patient with disabilities as a result of apraxia was shown and the scoring was practised.
Data collection. For each patient two OTs observed the four ADL-activities simultaneously, scoring their findings independently. One of the observers was the OT treating the patient; the second observer was an OT working at the same department as the first observer. The OTs were not matched on the basis of certain characteristics (e.g. age, gender, years of experience). During the observations there was no communication between the therapists about the patient. The number of pairwise observations are not exactly the same for each activity. Due to organizational problems, such as absence of a therapist (illness, vacation, etc), and timing and scheduling problems, some patients could not be

observed by two therapists at the same time.

Statistical analyses

Aspects of the reliability of our diagnostic instrument are investigated by means of the internal consistency and the inter-observer reliability. Determining the internal consistency is important because the instrument is composed of several items, measuring different aspects of the same underlying concept. The inter-observer reliability is determined because it is important to know that when the instrument is used by different persons, reproducable scores are obtained.

In assessing the internal consistency we used two measures. First, Cronbach's alpha was computed (Cronbach, 1951), since this is one of the most commonly used homogeneity coefficients. Alpha is an indicator of the internal consistency of a test, expressed by the average correlation of items within the test. Alpha ranges from 0 to 1: a high alpha denotes good homogeneity. The homogeneity of a test is considered to be good if alpha is higher than 0.80; the homogeneity is excellent when alpha is 0.90 or higher (De Haan, 1994). However, the use of alpha can be misleading (Drenth & Sijtsma, 1990), since alpha depends on the number of items of the test: an alpha of 0.90 can be characteristic of a long test with low inter-item correlations or a short test with high inter-item correlations. In addition, a high value for alpha can be found while in fact the test is heterogeneous. This can be the case when a test is composed of subgroups of items. Concerning our observational instrument this is the case.

Because of these limitations, a Mokken scale analysis was executed additionally. A Mokken scale analysis is a scaling technique for determining the homogeneity of the scale which can be used when ordinal data are collected (Mokken, 1971; Molenaar, Debets, Sijtsma & Henker, 1994; Mokken & Lewis, 1982). The degree to which one or more latent unidimensional scales are formed (i.e. the quality of the Mokken-scale) is expressed by two indices. First, the H-coefficient of Loevinger for determining the cumulativity of the total scale and, secondly, the rho-coefficient as measure of the reliability of the scale. A scale is said to be strong if H-coefficient is higher than 0.50; an H-coefficient between 0.30 and 0.50 indicates a weak to moderate scale; and an H-coefficient of 0.30 or less refers to a test which is not unidimensional (Molenaar et al, 1994; Mokken & Lewis, 1982). A rho value higher than 0.80 can be seen as an indicator of high reliability; if rho is higher than 0.60 the instrument can be used. With a Mokken scale analysis it can be determined whether a hierarchy in the

scores exists: in a perfect hierarchy the items and subjects can be ordered hierarchically, with respect to the unidimensional scale, from less difficult (i.e. the patient is independent) to more difficult (i.e. the patient cannot cope without assistance).

The inter-observer reliability is expressed by three measures. Percentage of agreement between the two observers was computed. This equals the number of cases for which the two observers fully agree, proportional to the total number of cases. For this measure, inter-observer reliability is considered to be satisfactory if the percentage of agreement is 80% or higher. The fact that two observers can also agree by chance is not accounted for by this measure. To overcome this limitation, we used a second measure to determine the degree of agreement: Cohen's kappa (Cohen, 1960) which denotes the level of agreement with correction for agreement by chance. Kappa is computed by taking the percentage of actual agreement minus the percentage of agreement by chance and dividing by the percentage potential agreement minus the percentage agreement by chance. When Cohen's kappa equals zero there is no agreement, while a value of 1 means perfect agreement. A kappa value below 0.40 is considered to indicate little agreement, between 0.40 and 0.75 indicates fair to good agreement, and a kappa value higher than 0.75 indicates excellent agreement (Fleiss, 1981; Schouten, 1985; Driessen, Dekker, Lankorst & Van der Zee, 1995). For each activity, both percentage of agreement and kappa were computed separately. We also wanted to assess what the inter-observer reliability would be when the scores were averaged over the four activities. These average scores can be used to reduce the number of data. For this purpose, the intra-class correlation coefficient (ICC) is more appropriate than Cohen's kappa, since there are more categories in the average scores than there are in the separate scores. The ICC is defined as the ratio of the variance among subjects over the total variance; the advantage of the ICC is found in the correction for systematic variability (Shout & Fleiss, 1979; Roebroeck, 1994). A value of 0.60 or higher is said to be a satisfactory to good indication for the inter-observer reliability.

Mokken scale analysis was performed using the computer program MSP (Mokken scale analysis for polytomous items, version 3.0). The ICC's were calculated by using Genova, version 2.2. All other statistical analyses were carried out using SPSS/PC+, version 5.0.

Results

Patients

In total, 42 patients were included in the study: 20 males and 22 females. The mean age of the patients was 70.2 years (sd = 10.9; range 39 - 91 years). Characteristics of the patients and their diagnoses are given in Table 1. For some patients the dataset is not complete as a result of scheduling problems within the participating institutions that conducted the measurements. For this reason the number of patients is mentioned in every table.

Table 1. Characteristics of the patients (n = 42)

	N	%
Gender		
Male	20	47.6
Female	22	52.4
Setting		
Hospital	16	38.1
Rehabilitation center	15	35.7
Nursing home	11	26.2
Stroke		
Cerebral haemorrhage	10	23.8
Cerebral infarction	31	73.8
Unknown	1	2.4
Age		
mean (sd)		70.2 (10.9)
Time since stroke (in weeks)		
mean (sd)		8.3 (5.2)

Internal consistency

The analyses show that the observational methods are internally consistent. The internal consistency of the observations is assessed by computing Cronbach's

alpha for the four aspects, the four activities and the total scale (Table 2). Cronbach's alpha is high for this total scale: 0.94. The alphas for the separate scores are satisfactory to good.

Table 2. Internal consistency as indicated by Cronbach's alpha

Score	Number of items	alpha
Independence	4	0.79
Initiation	4	0.81
Execution	4	0.77
Control	4	0.81
Hygiene	4	0.86
Dressing	4	0.92
Preparing food	4	0.92
Choice	4	0.81
Total scale	16	0.94

N = 36

The results of the Mokken-scale analysis (Table 3) show a consistent scale as well. The H-coefficient has a value of 0.58, which indicates a strongly homogeneous scale. The rho-value is 0.94. There are no items removed from the 16-item scale, which indicates that all items together form a homogeneous scale. In table 3 the items are ordered hierarchically according to their means. The items are ordered from the highest score to lowest score. A high score on all scales indicates that the patient needs assistance of some kind, while a score close to

zero denotes independent functioning. The mean scores indicate that the choice activity requires the most assistance from the therapist, while the initiation of all activities requires the least assistance. This implies that when initiation of the activity raises difficulties, patients will also experience problems in executing and controlling an ADL-activity. Mokken-scaling could not be conducted for the separate scores because of the low number of levels (n=4) (Molenaar et al, 1994).

Table 3. Internal consistency as indicated by Mokken-scale analysis
The items are organised by rank order of the means

Items	Mean	Scalability coefficient
independence (choice)	1.56	0.42
execution (choice)	1.28	0.40
control (choice)	1.28	0.45
independence (dressing)	1.22	0.64
execution (dressing)	1.14	0.61
independence (hygiene)	1.11	0.54
control (hygiene)	1.11	0.67
control (dressing)	1.06	0.60
independence (prep. food)	1.00	0.64
execution (hygiene)	0.97	0.59
execution (prep. food)	0.97	0.68
control (prep. food)	0.94	0.63
initiation (choice)	0.83	0.36
initiation (dressing)	0.72	0.61
initiation (hygiene)	0.67	0.61
initiation (prep. food)	0.50	0.71

Coefficient of scalability H = 0.58
Coefficient of reliability Rho = 0.94

N = 36

Inter-observer reliability

In Table 4 the level of agreement as indicated by percentages of agreement, Cohen`s Kappa and the intra-class correlation coefficients is shown. These

measures are shown for the individual and total ADL scores. For every score the number of pairwise observations is reported.
The table shows that the percentages of agreement and kappas are highest for the independence scores. The lowest Kappa value on independence scores is 0.70 indicating fair agreement. Finally, the ICC are presented, again showing good reliability. For the aspects of initiation, execution and control the results indicate that the reliabilities of these assessments are fair, although the reliability of the total scale is by far the best.

The ICC for all scores are satisfactory to good, ranging from 0.62 to 0.98. These results suggest that the observations of both therapists do not differ systematically. This is confirmed by a Wilcoxon test: this test was executed to determine whether there are systematic differences between the two observing occupational therapists. No significant differences between the scores of the two kinds of observers were found ($p>0.05$).

Table 4. Inter-observer reliability of the observation of activities scored for independence, initiation, execution and control

Activity	N	% of agreement	Kappa-value	ICC
Independence score				
1. Hygiene	35	91	0.88	0.81
2. Dressing	36	81	0.70	0.86
3. Preparing food	28	96	0.95	0.98
4. Choice	30	97	0.95	0.97
Sumscore	26	-	-	0.64
A. Initiation				
Activity				
1. Hygiene	35	74	0.61	0.76
2. Dressing	36	83	0.73	0.82
3. Preparing food	28	86	0.75	0.90
4. Choice	30	77	0.63	0.81
Sumscore	26	-	-	0.69
B. Execution				
Activity				
1. Hygiene	35	60	0.44	0.62
2. Dressing	36	69	0.49	0.76
3. Preparing food	28	86	0.79	0.91
4. Choice	30	80	0.65	0.77
Sumscore	26	-	-	0.73
C. Control				
Activity				
1. Hygiene	35	77	0.68	0.88
2. Dressing	36	67	0.52	0.80
3. Preparing food	28	79	0.69	0.89
4. Choice	30	63	0.50	0.78
Sumscore	26	-	-	0.94
Sumscores activities				
Hygiene	35	-	-	0.90
Dressing	36	-	-	0.89
Preparing food	28	-	-	0.97
Choice	30	-	-	0.96
Total scale	30	-	-	0.98

Discussion

The aim of the present study was to investigate aspects of the quality of an observational method we developed. The quality of an instrument is - among other things - dependent upon the reliability of the instrument. Results were presented of a study into the internal consistency and inter-observer reliability of assessments of disabilities in stroke patients with apraxia. The value of Cronbach's alpha as well as the results of the Mokken-analysis show that the ADL-observations together measure the same construct: the indices (alpha, H and rho) raise excellent values, which means that a strong and consistent scale is obtained. No items were rejected in the analyses. These results imply that the ADL-observations form an instrument which can be used to measure the same underlying concept, being most likely disabilities due to apraxia.
Inter-observer reliability was determined by means of percentages of agreement, Cohen's kappa and intra-class correlation coefficients. The inter-observer reliability of the independence score is good to excellent. This result is found for the separate scores as well as for the sumscores for all measures. The scores representing the three different aspects of an activity show considerably more inter-observer variation. Nevertheless, the kappa indicates fair to good agreement. When the number of data is reduced by averaging the scores over the four activities, the inter-observer reliability is found to be satisfactory as well.

As mentioned, the inter-observer reliability of scores for the three aspects of which an activity consists are not really satisfactory. In this respect, it should be noted that inter-observer reliability can be affected by several factors: the observers, as well as the instrument itself, and the subjects can cause variability (Soeken & Prescott, 1986). Some of these factors are discussed hereafter.
Some researchers suggest that a rater who does not know the patient will overestimate the patient's ability (Chau, Daler, Andre & Patris, 1994). In our study only one of the two observers actually knew the patient (i.e. the therapist treating the patient). The results (i.e. the ICC and Wilcoxon test) indicate, however, that no systematic difference is found between the two groups of observers in our study.
Inter-observer variation may be reduced by standardisation of methods (Brennan & Silman, 1992). In our study, the activity as well as the situation in which the activity is observed, could be standardized further. For instance,

observing an activity like washing the face and upper body could be defined more strictly by defining the upper body as the chest, thereby excluding the arms and back. The situation in which the activity is observed could for example be supplemented by a more detailed description for the use of objects.
Next to the fact that the items themselves can be a cause of variation between observers, the extent of training received by the users of the instrument is also an important source of variability (Arnadottir, 1990; Berk, 1979). Training sessions during which several activities as well as several patients are observed, are highly recommended. A description of specific problems occurring during the performance of apractic patients should also be made.

In summary, the results of this study show that we have developed an internally consistent and reliable observational instrument for the assessment of disabilities in stroke patients with apraxia. Training sessions are recommended in order to improve the reliability of these scores. Future research will be aimed at other aspects of the quality of this observational method. The instrument should not only be a reliable instrument. Moreover, the validity is an important aspect as well.

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APPENDIX 1. Criteria for the selection of patients

Inclusion criteria

Patients are eligible for inclusion if they satisfy the criteria for left-hemisphere stroke and the criteria for apraxia.

A left-hemisphere stroke is diagnosed if the following criteria are met:

- acute clinical symptoms and signs of a focal dysfunction of the left hemisphere
- these signs and symptoms are transient or permanent, but last at least 24 hours
- there is no other than a vascular origin
- the stroke is one of the following types: cerebral infarction or haemorrhage

Apraxia is diagnosed if the following criteria are met:

- inability or restrictions in the ability to carry out purposeful activities
- these restrictions are not due to primary motor or sensory impairments, nor to deficits of comprehension, memory, or motivation
- other impairments may be present but they may not be the cause of the inability to perform purposeful acts
- the apraxia is one of the following types: ideational or ideomotor apraxia

Exclusion criteria

Patients are excluded if any of the following criteria are applicable:

- the patient is younger than 25 or over 95 years of age
- the patient does not have a working knowledge of the Dutch language
- the treating physician, the occupational therapist and/or the patient do not judge treatment of apraxia necessary
- the patient shows one or more of the following premorbid impairments:
  a. psychiatric or psychogeriatric history
  b. addiction to alcohol, medical or other drugs
  c. contusio cerebri in combination with a period of coma or post traumatic amnesia
  d. intellectual or learning disorders
  e. disturbances of consciousness
  f. personality disorders
  g. central neurological injuries
- the patient does not give informed consent.

APPENDIX 2. Observation and scoring of ADL-activities

Purpose:
- to assess the presence of disabilities resulting from apraxia
- to gain an insight in the style of action of the patient and the sort of errors made
- to prepare treatment goals for specific training

Method:
The therapist observes the following activities and scores the findings for each activity and each aspect.
1. personal hygiene: washing the face and upper body
2. dressing: putting on a shirt or blouse
3. feeding: preparing and eating a sandwich
4. an activitiy is chosen by the therapist which is relevant for the patient or standard at the department.

I. Score of independence
0 - the patient is totally independent, can function without any help in any situation
1 - the patient is able to perform the activitiy but needs some supervision
- the patient needs minimal verbal assistance to perform adequately
- the patient needs maximal verbal assistance to perform adequately
2 - the patient needs minimal physical assistance to perform adequately
- the patient needs maximal physical assistance to perform adequately
3 - the patient cannot perform the task despite full assistance

II. The course of an activitiy
In every aspect the patient can encounter problems, however for each aspect only one score can be entered.

A. Initiation
0 - there are no observable problems: the patient understands the instruction and initiates the activity
1 - the verbal instruction has to be adapted/extended
- the therapist has to demonstrate the activity
- it is necessary to show pictures or write down the instruction
- the objects needed to perform the task have to be given to the patient
2 - the therapist has to initiate the activitiy together with the patient
- the activity has to be modified in order to be performed adequately

3 - the therapist has to take over

B. Execution

0 - there are no observable problems: the activitiy is performed correctly
1 - the patient needs verbal guidance
- verbal guidance has to be combined with gestures, pantomime and intonation
- pictures of the proper sequence of action have to be shown
2 - the patient needs physical guidance
3 - the therapist has to take over

C. Control

0 - there are no observable problems: the patient does not need feedback
1 - the patient needs verbal feedback about the result of the performance
- the patient needs physical feedback about the result of the performance
2 - the patient needs verbal feedback about the execution
- the patient needs physical feedback about the execution
- it is necessary to use mirrors or video recordings
3 - the therapist has to take over.

Chapter 6

MEASURING DISABILITIES IN STROKE PATIENTS WITH APRAXIA:

a validation study of an observational method

C.M. van Heugten, J. Dekker, B.G. Deelman, A.J. van Dijk, J.C. Stehmann-Saris, A. Kinebanian. Measuring disabilities in stroke patients with apraxia: a validation study of an observational method (submitted).

Abstract

Objective: To determine the clinical and construct validity of the assessment of disabilities in stroke patients with apraxia. Disabilities were assessed by means of observation of activities of daily living (ADL), such as washing the face and upper body and putting on a blouse or shirt.

Setting: Occupational therapy departments in general hospitals, rehabilitation centers, and nursing homes.

Patients: Patients diagnosed to have had a stroke in the left hemisphere and to have apraxia

participated in the study (n=45, 21 males, age 39-91).

Methods: Guidelines were offered for the ADL-observations and the assessment of disabilities in these activities. Clinical validity was investigated by comparing the scores of the patients with those of a group of stroke patients without apraxia (n=36, 14 males, age 35-88). Construct validity was examined by investigating relationships between several measures of interest: an apraxia test, a motor functioning test, a set of ADL-observations and the Barthel index as a general measure of disability.

Results: Comparison of the results of the apractic patients with the control group of stroke patients without apraxia showed that the clinical validity of the ADL-observations is good: on the basis of the ADL-observations differences between patients with apraxia and patients without apraxia are measured. Correlational analyses showed that the ADL-observations were highly associated with apraxia, but only to a lesser degree with motor impairments; while motor impairments correlated strongly with the Barthel index (a general measure of physical disability), but only marginally with the ADL-observations. A LISREL analysis supported these findings.

Conclusions: The results indicate that the ADL-observations have clinical validity and that the construct validity of the observational method is good. The ADL-observations seem to measure disabilities caused by apraxia in stroke patients.

Introduction

A considerable number of stroke survivors suffers from persisting neurological impairments and lasting physical disabilities[1]. Particularly cognitive deficits following stroke result in severe disabling situations. When these cognitive impairments cause restrictions in the ability to carry out purposeful ADL-activities, the patient is considered apractic. Apraxia refers to a spectrum of deficits affecting the meaningful execution of activities, this not being the result of primary motor or sensory impairments, nor of deficits of comprehension, motivation or memory. Apractic problems in ADL-functioning are the result of the absence of or a disturbance in the plan of action. Other impairments may be present in the stroke patient, but these deficits are not the cause of the inability to perform purposeful acts[2,3,4].

Current testing procedures for apraxia that have been developed to measure the presence and severity of apraxia mainly involve neuropsychological tests[3,4,5]: The most widely accepted tasks in these tests are demonstration of object use and imitation of gestures. Poor test performance does however not necessarily indicate that the patient will also experience problems in daily life. In other words, generalizing the results of these tests to ADL performance is difficult. Neuropsychological tests measuring apraxia concern performance in a rather artificial setting. Since the absence of or a disturbance in a plan of action cannot be assessed directly, assessing apraxia by means of a neuropsychological apraxia test is the best approach to assess the disturbed function in the praxis. For the purpose of rehabilitation it is essential to gain an insight into the disabilities in daily life, caused by apraxia. Rehabilitation focusses on the consequences of the pathology, rather than on the disease itself. Assessment of the consequences of apraxia in daily functioning is therefore necessary to complement apraxia tests. Currently several instruments are available for measuring general disabilities as a consequence of stroke[6]. These more general disability measures - such as the Barthel index - are primarily intended for measuring physical disability[7]. Physical disability can be the result of primary motor impairments. The problems experienced by apractic patients in the execution of daily activities are - by definition - not the result of primary motor impairments. This implies that there is a need for instruments which specifically measure disabilities caused by apraxia. To our knowledge such instruments are currently not

available. Arnadottir[8] developed an observational instrument for assessing the consequences of cortical dysfunction, but this method is not aimed at apraxia specifically.

We have developed an assessment procedure through which the performance of standardized ADL-tasks (activities of daily living such as washing and dressing) is observed in stroke patients with apraxia[9]. Before using this observational method in clinical practice it is important to investigate the clinimetrical quality of the instrument. As always, the first step was to test the reliability of the instrument: the internal consistency and the inter-observer reliability of the observations were tested and proved to be good[9] (see method section). The next step now is a study concerning the validity of the instrument. The present paper reports on a study into the clinical validity and the construct validity of the assessment procedure: does the instrument discriminate between patients with apraxia and patients without apraxia (clinical validity) and to what extent does the assessment procedure measure consequences of stroke which are specific to apraxia (construct validity). The following expectations were tested. *First* (clinical validity), patients with apraxia were expected to function less independently than patients without apraxia when assessed with the ADL-observations. *Second* (construct validity), a relationship was expected to exist between the ADL-observations and a neuropsychological apraxia test; this would indicate that the ADL-observations are indeed measuring disabilities caused by apraxia. *Third* (construct validity), it was expected that the ADL-observations are not or only weakly associated with a motor functioning test. However, this motor functioning test was expected to be associated with a general measure of disability (the Barthel index). *Fourth* (construct validity), the ADL-observations and the general measure of disability (the Barthel index) were expected to correlate, since these instruments cover comparable domains.

Methods

Patients

Occupational therapists in general hospitals, rehabilitation centers and nursing homes in the Netherlands selected the patients on the basis of a set of inclusion

and exclusion criteria. Patients diagnosed to have had a stroke in the left hemisphere and to have apraxia were included. A left hemisphere stroke was diagnosed when acute clinical symptoms of a focal dysfunction of the left hemisphere are present; when these signs and symptoms last at least 24 hours, and when there is no other than a vascular origin[10,11]. Apraxia was diagnosed when the patient is fully or partly unable to carry out purposeful activities, this not being caused by primary motor or sensory impairments, nor to deficits of comprehension, memory or motivation[3,4]. Exclusion criteria were: age younger than 25 years or older than 95 years; no working knowledge of the Dutch language; and a set of premorbid or present pathologies: psychiatric or psychogeriatric history, addiction to alcohol, medical or other drugs, personality, intellectual or learning disorders, temporary loss of consciousness, or central neurological injuries.

A group of stroke patients without apraxia was also selected on the basis of the same inclusion- and exclusion criteria as the first group, but were not diagnosed to have apraxia.

All patients entering the study gave their informed consent. This research was approved by the local institutions.

Measurements

The measurements are divided into two groups. The first group contains measures aimed at (neuropsychological) functioning, as close to the impairment level as possible. These measures are not intended to measure performance in daily activities. The second group of measurements focusses on disabilities that appear in the execution of daily activities.

Apraxia. The apraxia test consists of two subtests: demonstration of object use and imitation of gestures[12]. The use of objects was tested in three different conditions. All subsets were presented with the same verbal instruction 'show me how you would use ... (this object)'. The objects were presented by verbal command only, without the object being present, visual presentation of the object, accompanied by verbal command, and the third condition based on actual use of the object. Each subset contained three objects used in daily activities. The imitation of gestures subtest contains 6 gestures which have to be imitated by the patient, directly upon demonstration by the researcher. A total score of 90 could be reached. The internal consistency of the apraxia test proved to be good[12]: the items of the test form a strong and consistent scale, as

indicated by Cronbach's alpha (0.96) and the results of a Mokken scale analysis (Loevingers H=0.72, rho=0.97). The diagnostic value of the test was also examined. The test appears to have sufficient discriminative capacity to allow a differentiation between stroke patients with apraxia, stroke patients without apraxia and healthy elderly persons. Based on a cut-off score of the mean score of normal controls (i.e. 50 healthy elderly persons) minus one standard deviation (86.4) the sensitivity is 91% and the specificity is 90%[12].

Motor functioning. An adaptation of the motricity index[6] was used to assess the level the patients' motor functioning. The test consists of 8 simple tasks concerning the bodyside, contralateral to that of the brain lesion. The patient could gain a maximum score of 16 in this test; each task was scored 0 if execution was not possible at all, 1 if execution of the movement was laborious but possible, and 2 if the patient was able to execute the task correctly. Cronbach's alpha for this test is 0.94.

The second group of measurements is aimed at ADL performance.

ADL-observations. The occupational therapist executed a set of standardized ADL-observations, aimed at assessment of the disabilities caused by apraxia[9]. Four ADL-activities were observed, of which three activities were prescribed (i.e washing the face and upper body, putting on a shirt or blouse and preparing food), and the fourth activity could be chosen by the occupational therapist. The activities are scored on four aspects: independence, initiation, execution, and control. Subsequently, the four measures can be added to a total score. Cronbach's alpha for the total scale is 0.94. The results of a Mokken scale analysis indicated that the ADL-observations form a strong homogeneous scale: Loevinger's H-coefficient is 0.58; the rho-value is 0.94. The inter-observer reliability is good, as indicated by an intra-class correlation coefficient of 0.98 for the total score[9].

Barthel index. The Barthel index offers a simple and quick, clinically relevant way of identifying the most important physical disabilities[7,13]. The Barthel index expresses disability on a scale ranging from 0 (totally dependent) to a maximum score of 20 (totally independent). The Barthel index is a reliable instrument[13]: in the current study we found Cronbach's alpha to be 0.92.

Testing Procedure

Once a stroke patient consented to participate in our study, an assessment

procedure was started. The measurements were performed at occupational therapy departments in three general hospitals, eight rehabilitation centers and five nursing homes in the Netherlands. Each patient was tested by the experimenter in a one-hour testing session, during which the apraxia test and the tests for additional impairments were conducted. The patient sat facing the experimenter in a quiet room suitable for testing. Occupational therapists carried out the ADL-observations and the additional measurements of disability, including the Barthel index. The observations were conducted in an appropriate environment for the task at hand, as well as at a relevant time of day for the specific task (e.g. washing in the bathroom, after getting out of bed).

Statistical analyses

The results of the assessment procedure are presented by means of descriptive statistics. For all measurements the number of patients is presented. Some patients had severe language comprehension problems which interfered with the instructions; other patients could not finish the complete set of tests because of their state of health. Thirty subjects did the full battery of tests.

The clinical validity of the observational method was investigated by comparing the scores of two groups of stroke patients, using the chi-square statistic and the t-test for independent samples.

The construct validity of the ADL-observations was investigated using the scores of the stroke patients with apraxia. Bivariate relationships are presented by means of Pearson's product moment correlation coefficients. Multivariate techniques were conducted to test the expected associations between variables using the LISREL-8 computer program (Linear Structural Relationships)[16]. In general LISREL combines the many possibilities of regression analyses, path analyses and factor analyses. In our study, the analyses using LISREL allow multivariate analyses in which both dependent variables can be taken into account jointly. The LISREL computer program permits a decision on whether the hypothesized model fits the data. The estimates for all hypothesized relationships are presented. Statistical significance of the estimates is based on t-tests. Evaluation of the fit of the model is based on the chi-square statistic, the goodness of fit index (GFI), and the root mean square error of approximation (RMSEA). A GFI of 0.90 or more indicates that the specified model represents the data well[17,18]. The value of RMSEA should be less than 0.05 for a model that fits well; values above 0.10 indicate poor fit[19,20].

The significance level was set at 0.05. The correlation analyses were performed using SPSS/PC+, version 5.0; the LISREL-analyses were performed using LISREL, version 8.03.

Results

Characteristics of the patients

Fourtyfive stroke patients with apraxia were included in the study: 21 males and 24 females. The mean age of the patients was 70.4 years. In table 1 the characteristics of the patients are presented.

Thirtysix stroke patients without apraxia were included in the control group (table 1). The groups did not differ significantly with respect to gender (chi-square=0.49, df=1, p=0.48). The age of the patients without apraxia was lower (mean=59.9; sd=12.8; range=35-88) than the age of the patients with apraxia (t=3.97, p=0.00). The group of stroke patients without apraxia did not differ significantly from the group of apractic patients in the type of stroke (chi-square=4.46, df=2, p=0.11) and in the interval post stroke (t=1.84, p=0.07).

Table 1. Characteristics of the stroke patients with apraxia

	Patients with apraxia	Patients without apraxia
Gender		
Male	21	14
Female	24	22
Age		
mean	70.4	59.9
sd	10.9	12.8
range	39-91	35-88
Institution		
Hospital	16	10
Rehabilitation center	16	20
Nursing home	13	6
CVA		
Cerebral haemorrhage	10	11
Cerebral infarction	31	23
Unknown	4	2
Time since stroke (in weeks)		
mean	8.6	13.5
sd	5.0	15.8
N (total)	45	36

Clinical validity

In Table 2 the results of the impairment tests are presented, that is to say the apraxia test and the motor functioning test. The motor functioning test showed no significant difference between the two groups of patients ($t=1.26$; $p=0.21$). The values suggest that patients in both groups suffer from primary motor impairments. However, no normscores are available.

As can be seen in the table, the total mean score of the apraxia test is much lower for the patients with apraxia than for the patients without apraxia. The difference between the two groups is significant (t=7.34; p=0.000). Using a cut-off point of the mean score of normal controls (i.e. 50 healthy elderly persons) minus one standard deviation (86.4)[12], 91% of the apraxia patients scores below this value. For the group of patients without apraxia only 20% of the subjects has a score below this cut-off.

Table 2. Scores of the apraxia test and the motor functioning test for both the stroke patients with apraxia and the stroke patients without apraxia

	Patients with apraxia			Patients without apraxia			p (diff.)
	N	Mean (sd)	Range	N	Mean (sd)	Range	
Instrument							
Motor functioning	45	8.1 (6.1)	2 - 16	35	9.8 (6.0)	2 - 16	0.21
Apraxia	44	55.7 (29.0)	0 - 90	35	88.0 (3.3)	75 - 90	0.00

In Table 3 the results of the disability measures are shown: ADL-observations, Barthel index, ADL-questionnaire (OT), and ADL-questionnaire (pt). On all measures the patients in the control group obtained higher scores than the apractic patients, indicating a higher level of ADL-functioning. Concerning the ADL-observations, the two groups differ significantly (t=6.73; p=0.000). The patients without apraxia score close to zero, which denotes full independence. The apractic patients obtained a mean score of 1, which indicates that they need some verbal assistance to perform each activity. Also on the Barthel index the patients with apraxia function less independently than the patients without apraxia (t=3.67; p=0.000).

Table 3. Assessments of the level of disabilities: scores on the ADL-observations and the Barthel index

	Patients with apraxia			Patients without apraxia			p (diff.)
	N	Mean (sd)	Range	N	Mean (sd)	Range	
Instrument							
ADL-observations	36	1.0 (0.7)	0.19-2.88	34	0.2 (0.3)	0.00-1.25	0.00
Barthel index	37	10.3 (5.6)	2-20	35	14.8 (4.9)	2-20	0.00

Correlational analyses

In table 4 bivariate correlations between the measures of interest are presented for the apractic patients. No significant relationship was found between the apraxia test and the Barthel index (r=0.07). The strongest significant relationships were found between the apraxia test and the ADL-observations (r=-0.43), between the motor functioning test and the Barthel index (r=0.57), and between the disability measures: the ADL-observations and the Barthel index (r=-0.60).

Table 4. Bivariate correlations

	ADL-obs.	Apraxia	Motor func.
ADL-observations			
Apraxia	-0.43**		
Motor func.	-0.37*	0.30*	
Barthel index	-0.60**	0.07	0.57**

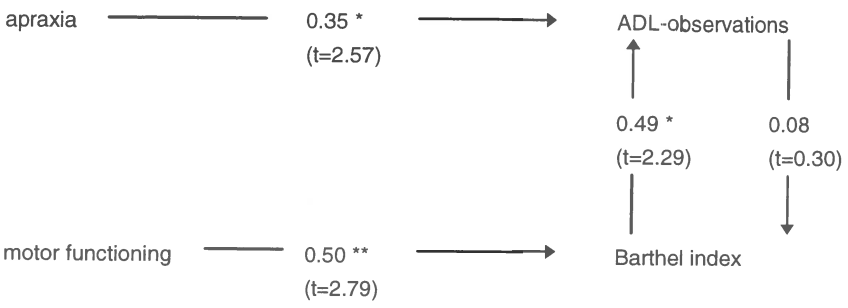
(* $p < 0.05$: ** $p < 0.01$).

Lisrel analyses

The results of the Lisrel analysis are shown in Figure 1. The relationships specified in the analysis are significant: the t-values are higher than 1.96 (p=0.05). The expected correlation between the apraxia test and the ADL-observations is strong (gamma=0.35). The expected relationship between the motor functioning test and the Barthel index is prominent as well (gamma=0.50). Finally, there appears to be an association between the disability measures as indicated by the ADL-observations and the Barthel index, which is only significant in one direction. These results imply that the score on the Barthel index does predict the score on the ADL-observations, but problems in ADL-functioning as measured with the ADL-observations do not indicate the presence of physical disabilities, as measured with Barthel index.

The hypothesized model meets the criteria of acceptable fit, as indicated by the chi-square (p=0.49), the GFI (0.99) and the RMSEA (0.00). This finding indicates that the relationships which were entered in the model specifically result in a better fit than an alternative model in which all possible relationships are tested. Put differently, the relationships between apraxia and the ADL-observations, and the relationship between motor functioning and the Barthel index, are stronger and significant as opposed to the relationship between apraxia and the Barthel index or the relationship between motor functioning and the ADL-observations.

Figure 1. Results of the LISREL analysis



Goodness-of-fit indices:	
chi-square (1)=0.49:	p=0.49
goodness-of-fit (GFI) index:	0.99
root mean square error of approximation (RMSEA):	0.0

(* $p < 0.05$; ** $p < 0.01$)
All hypothesized relationships are presented, accompanied by the estimates, based on t-tests.

Discussion

The aim of this study was to establish the validity of an observational method for the assessment of disabilities in ADL performance in stroke patients with apraxia. The internal consistency and the inter-observer reliability of the observational method had been investigated earlier and proved to be good. In the present study the clinical validity and three assumptions concerning the construct validity of the method were tested.

The clinical validity of the ADL-observations was examined by comparing two groups of stroke patients: a group with apraxia and a group without apraxia. The two groups are comparable in terms of patient characteristics, but some words of caution are in place here, since differences in age are displayed. The apractic patients are older than the patients without apraxia. Cognitive functioning can

decline with age, which could influence our data. However, no relationships were found between age on the one hand and the scores of the apraxia test or the ADL-observations on the other (r=0.16 and r=0.17 respectively) in the patient group, nor were there any significant relationships between age and the apraxia test (r=0.17) or the ADL-observations (r=0.06) in the group of patients without apraxia.

The first expectation concerned the level of independence as measured with the ADL-observations. The two groups differ significantly as regards the scores obtained with the ADL-observations: the patients with apraxia function less independently. Moreover, the level of motor functioning was not significantly different for the two groups: both the stroke patients with apraxia and the stroke patients without apraxia display motor problems to some degree. This finding justifies the conclusion that the problems in ADL-functioning, as measured with the ADL-observations, are not the result of primary motor deficits. By definition, apraxia causes restrictions in ADL-functioning that do not result from motor impairments. We therefore conclude that by using the ADL-observations differences between patients with apraxia and patients without apraxia are assessed.

Concerning the construct validity of the ADL-observations, three further expectations were examined by means of correlational and LISREL analyses. The results of these analyses corresponded to a large degree to the expectations. The second expectation concerned the relationship between the ADL-observations and the neuropsychological apraxia test. The results show that an association is present between the ADL-observations and the apraxia test. This suggests that the ADL-observations indeed measure disabilities which are related to apraxia.

The third assumption concerned the differentiation between disabilities caused by apraxia and physical disabilities caused by impaired motor functioning following stroke. The ADL-observations correlate with the motor functioning test, but this association is small in comparison to the other significant relationships. This finding is further supported by the results of the LISREL analysis. The hypothesized model did not address the relationships between apraxia and Barthel index on the one hand, and motor functioning and ADL-observations on the other hand. The fact that the hypothesized model meets the criteria for good fit implies that these latter relationships are not significant compared to the associations between apraxia and ADL-observations on the one hand, and

motor functioning and Barthel index on the other hand. The motor functioning test however, is closely related to the Barthel index, being a measure of physical disability. These results indicate that the ADL-observations do not address physical disabilities caused by motor impairment. Moreover, the ADL-observations are concerned with disabilities caused by apraxia.

Finally, the association of the ADL-observations with general disability measures was considered. Since all disability measures are intended to measure the consequences of stroke at the level of restrictions or lack of ability to perform activities, no great disparity between the ADL-observations and the general disability measures was expected. This expectation has been confirmed by our results: the ADL-observations and the Barthel index are closely related. Surprisingly, the relationship between the ADL-observations and the Barthel index is significant in only one direction. This finding could be the result of the fact that a general measure of disability (i.e. the Barthel index) can to a certain extent predict the degree to which specific disabilities (as a result of apraxia) occur, but specific disabilities (i.e. the ADL-observations) do not necessarily indicate general disabilities (as a result of stroke).

In summary, the ADL-observations indeed seem to measure disabilities in ADL performance in stroke patients which are most probably caused by apraxia. This result supports the validity of the observational method. As noted in the introduction, suitable instruments for measuring disabilities caused by apraxia were not available. This deficiency raises problems in clinical practice as well as in research. Since the goal of rehabilitation is to improve the functional status of the patient, it is essential for those who evaluate treatment to have relevant assessment methods at their disposal. The assessment procedure we presented offers a reliable and valid observational method for the assessment of disabilities caused by apraxia. An important aspect which will be investigated next is the responsiveness of the procedure: can the instrument be used for measuring clinically relevant changes over time (sensitivity to change).

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Chapter 7

OUTCOME OF STRATEGY TRAINING IN STROKE PATIENTS WITH APRAXIA:

a phase-II study

C.M. van Heugten, J. Dekker, B.G. Deelman, A.J. van Dijk, J.C. Stehmann-Saris, A. Kinebanian. Outcome of strategy training in stroke patients with apraxia: a phase-II study. Clinical Rehabilitation, volume 12, number 4, pg. 294-303, 1998.

Abstract

Objective: Evaluation of a therapy program for stroke patients with apraxia. The program is based on teaching patients strategies to compensate for the presence of apraxia. This program was designed for assessment and treatment by occupational therapists.

Design: The outcome was studied in a pre-post test design. Measurements were conducted at baseline and 12 weeks later.

Subjects: Thirtythree stroke patients with apraxia were treated at occupational therapy departments in general hospitals, rehabilitation centers and nursing homes.

Main outcome measures: The following measurements were conducted: an apraxia test, a motor functioning test, observation of ADL-activities, Barthel index, and an ADL-questionnaire for the therapist and the patient.

Results. The patients showed large improvements in ADL-functioning on all measures and small improvements on the apraxia test and the motor functioning test. The effect sizes for the disabilities, ranging from 0.92 to 1.06 were large compared to the effect sizes for apraxia (0.34) and motor functioning (0.19). The significant effect of treatment is also seen when individual improvement and subjective improvement are considered. Measured with the Barthel index for instance, 71% of the patients improved.

Conclusions: These results suggest that the program seems to be successful in teaching patients compensatory strategies, which enables them to function more independently, despite the lasting presence of apraxia.

Introduction

The term apraxia is widely used to describe one of the more disabling deficits following stroke. Apraxia is a disorder affecting the purposeful execution of learned and meaningful activities. The inability to perform activities is not the result of primary motor or sensory impairments, or of deficits of comprehension, memory or motivation[1,2]. The patient for instance has sufficient muscle strength and/or motor coordination to perform the task. Additionally, the patient does not experience problems because a command was given which was not understood or remembered. Other impairments, like hemiplegia or aphasia, may be present in the stroke patient, but these deficits are not the cause of the inability to perform purposeful acts. The problems in ADL-functioning are the result of the absence or disturbance in the plan of action. The action plan cannot be retrieved from memory or the patient is unable to properly implement the plan of action to result in a purposeful activity [1,3]. As De Renzi describes[1]: a patient with apraxia does not know what to do, because the concept or idea of the motor act is lacking, or the patient does know what to do, but not how to do it, because the implementation into a precise motor program is disrupted.
Despite the disabling effect of apraxia on daily functioning, no studies have been published that evaluate treatment of stroke patients with apraxia. In a meta-analysis of stroke rehabilitation such studies were absent[4]. A recent review of the empirical literature on apraxia includes definitions, taxonomies and examination procedures, but rehabilitation or therapeutic possibilities are not discussed[5]. Occasionally, the results of a single case of rehabilitation are found in the literature[6], but to our knowledge systematic research into the outcome of apraxia treatment has not been conducted.

In the present study a therapy program for patients with apraxia was developed. The program was designed for assessment and treatment of patients with apraxia by occupational therapists. Treatment is aimed at improving the performance of the apractic patients by teaching them strategies. The potential benefit of teaching patients strategies is that it enables them to function more independently, despite the persisting presence of apraxia following a stroke. Strategy training is not aimed at recovery of functions. Instead, this method aims to improve functioning in spite of the presence of impairments. Compensatory techniques can help the patient to effectively use residual skills and so to

minimize the extent to which the impairment influences the performance in daily life[7,8].

In apraxia, strategy training concentrates on teaching the patient ways to compensate for the impairment. The performance or the environment can be changed or restructured in order to minimize the influence of the distorted functions. Compensation is established by learning to carry out ADL-activities in a way different from the one the patient was used to prior to the stroke. Compensation can be external or internal. External compensation means that the ADL-activity is carried out with help from outside the individual. One speaks of external compensation when for instance (technical) aids are used to overcome a disrupted function. When a patient cannot structure the performance due to sequencing problems, the distinct steps in the activity can be presented to the patient by showing him or her pictures. Internal compensation involves cognitive functions other than the distorted ones, for instance visual or verbal functions. An example of internal compensation is teaching the patients consciously verbalizing the proper sequence of distinct steps of which an activity consists, while performing the activity[9,10,11].

In this paper the outcome of the therapy program is evaluated. A group of stroke patients with apraxia was treated according to the guidelines of the program. Changes were expected in the performance of ADL-activities of the patients after treatment. More specifically, we expected improvements in ADL-functioning but no or only small changes in the severity of apraxia. These expectations are based on the fact that the therapy program focusses on teaching patients strategies to compensate for a probably lasting apraxia. There is no specific literature citing that apraxia is irreversible, but by now it is widely acknowledged that it is not plausible to restore higher cognitive functions completely[10,11]. Recovery of apraxia is therefore not a realistic goal for therapy, neither by aiming for spontaneous recovery, nor by repeatedly stimulating brain structures through cognitive retraining.

The present study was exploratory, only one group of patients was tested. This noncontrolled phase-II study is essential however, since it is a necessary first step to be taken before a randomized controlled trial can be relevant. In a phase-II study one can investigate whether the intervention or therapy shows positive results. In addition, the assessment instruments and the criteria for selection can be optimized, while the next step should be to formally test these

interventions in a clinical trial (phase-III research).

Methods

Selection of patients

Occupational therapists (n=26) at 16 occupational therapy (OT) departments in general hospitals, rehabilitation centers, and nursing homes selected the patients. Patients were eligible if they met the following inclusion criteria: patients diagnosed to have had a stroke in the left hemisphere and to have apraxia, diagnosed by either the referring physician or by the OT on the basis of clinical evaluation. A left-hemisphere stroke is diagnosed when acute clinical symptoms of a focal dysfunction of the left hemisphere are present; these signs and symptoms last at least 24 hours, and there is most likely no other than a vascular origin[12,13]. Apraxia is diagnosed when the patient is fully or partly unable to carry out purposeful activities, this not being due to primary motor or sensory impairments, nor to deficits of comprehension, memory, or motivation. Other impairments may be present but they are not the cause of the inability to perform purposeful acts[2].

Exclusion criteria were: age younger than 25 years or older than 95 years; no working knowledge of the Dutch language; and a set of premorbid and present pathologies: psychiatric or psychogeriatric history, addiction to alcohol, medical or other drugs, contusio cerebri, personality, intellectual or learning disorders, temporary loss of consciousness, or other injuries of the central nervous system. All patients entering the study gave their informed consent and were subsequently treated according to the guidelines of the therapy program.

Treatment

The program for assessment and treatment of apraxia in stroke patients was developed on the basis of an extensive literature search and consultation of experts in the fields of occupational therapy, neurology, neuropsychology and rehabilitation medicine. The patients were treated for a period of 12 weeks. The number of treatments per week was determined by the therapists. In some of the participating institutions the frequency of treatment was determined by institutional policies. Therapists were encouraged to practice with the patients as frequently as possible. On the basis of interviews in clinical practice it appeared

that occupational therapists in the Netherlands treat stroke patients about 3 to 5 times per week, while each treatment session takes 30 minutes (interviews not published).

During the treatment period activities were trained, that were relevant for the patients to (re)learn. This means that the focus of the program is on disabilities resulting from apraxia, appearing in everyday life. The decision about the activity to be trained was made together with the patient. The occupational therapist was encouraged to use a decisiontree to guide the choice of an activity or to use a checklist with activities which were carried out by the patient before the occurrence of the stroke and activities which are important for the patient to carry out in the near future. Every two weeks an activity was chosen. After this two-week period a new treatment goal was considered, based upon the improvement in the patient's functioning.

The specific interventions administered during treatment corresponded with the specific problems that were assessed during standardized ADL-observations (see section below). ADL-activities are conceptualized as being composed of three aspects, being successive events, according to the framework of information processing: phases of initiation, execution, and control. The proper plan of action as well as the correct objects have to be selected (initiation of an activity), followed by adequate performance of the plan (executing the activity), which has to be evaluated in terms of the result (controlling and if necessary correcting the activity). A patient with apraxia, who for example cannot use objects appropriately, may have a deficit at any one of the stages of which an activity consists. By assessing the different aspects of the activity, the nature of the deficit can be identified and plans for treatment can be formulated accordingly. When a patient predominantly showed problems with initiating an activity, emphasis during treatment was placed upon instructions. The instructions were varied depending on the patients level of functioning. This means that verbal instructions were given when minimal problems occurred. If, however, the patient could not initiate the activity, the therapist could, for instance, hand the objects to the patient one at a time. Specific assistance was given when the execution of the activity causes problems. Assistance could be verbal or physical. Finally, the therapist offered feedback when the patient did not detect or correct performance errors. Feedback could, for instance, be verbal by telling the patient what went wrong, or the therapist could use a mirror to show to the patient the result. All forms of intervention (instructions, assistance and

feedback) could be varied depending on the patient's functioning[14].
The specific interventions in the form of instructions, assistance, and feedback, were presented to the occupational therapist in a protocol. In the protocol the interventions are ordered hierarchically in terms of the level of functioning of the patient. The interventions are presented in Appendix 1.

Study design and measurements

The outcome of the therapy program was studied using a pre-post test design. The measurements were performed at baseline (pretest) and 12 weeks later (posttest). At both occasions the researcher visited the patient to administer a set of neuropsychological tests. These tests were conducted in a one-hour session while the patient sat facing the experimenter in a quiet room suitable for testing. The set of tests contained measures intended to characterize the patient sample, and two outcome measures intended to assess the level of motor functioning and the degree of apraxia. A *test of motor functioning* was used, consisting of 8 tasks concerning the bodyside opposite to the brain lesion. The 8 tasks involve: trunk balance, shoulder movement, arm movement, grasp and release a cylinder, grasp and release a dice, and a test for the sensitivity of the back of the hand. For each task a score of 2 was given when the patient was able to execute it, 1 when the patient could carry it out with some effort, and 0 when the patient was not able to execute it. This way a maximum score of 16 could be reached. In addition, a *test of apraxia* was developed, consisting of two subtests, adapted from De Renzi[15]. The first subtest was designed to evaluate the use of objects. Three sets of three objects were presented in different conditions: presentation of the object only by verbal command, without the object present; visual presentation of the object, accompanied by verbal command; and the third condition based on actual object use. A total score of 54 could be reached. The second subtest involved the assessment of the ability to imitate gestures. Six gestures had to be imitated by the patient, immediately after demonstration by the researcher. For this part a score of 36 could be reached. The total score could add up to 90.
The occupational therapist assessed the level of disabilities in ADL-activities. Three outcome measures were selected. First, the occupational therapist executed standardized *ADL-observations.* A procedure was used to guide the OT through specific observations of performance in apractic patients. Before the study started the OTs attended training sessions, during which the use of the

observational scales was explained. A videotape of a patient with disabilities as a result of apraxia was shown and scoring was practised. Applying the ADL-observations, the OT observed the patient executing four ADL-activities, three of which were prescribed: personal hygiene (washing the face and upper body), dressing (putting on a shirt), and preparing food (preparing and eating a sandwich). The fourth activity could be chosen by the OT and depended on the capabilities and needs of the patient or depending on the department's standard observation procedures. In most cases (n=30; 90%) this fourth activity turned out to be preparing coffee or tea. These observations were scored on four aspects: independence, initiation, execution, and control. Subsequently, the four measures were added to arrive at a total score[16]. Next, *the Barthel index* was used, which offers a simple and quick, clinically relevant way of both identifying the most important physical disabilities and measuring their overall extent[17,18,19]. Finally, the OT was asked to give grades ranging from 1 to 10 for 16 different ADL activities, i.e. *the ADL-questionnaire (OT)*. A grade of 1 was given when the performance was very difficult or impossible for the patient; a grade of 10 was given when the performance was perceived as being normal and adequate. The score 'not applicable' was given when the patient had not performed the activity at all since the occurence of the stroke. The same questionnaire was also presented to the patient *(ADL-questionnaire (pt))*; after the treatment period the patient was asked to judge whether performing these 16 activities had improved. This judgement was represented on a six-point scale ranging from 'completely recovered' to 'much worsened'. The ADL-questionnaire is derived from the Rivermead ADL-index[20,21].

Statistical analyses

The differences between baseline and posttreatment scores were calculated to establish the effect of treatment. The t-test for paired samples was used for comparison of measures before and after treatment. Effect sizes were calculated by dividing the mean changes in scores by the standard deviation of the pretest score. An effect-size of 0.2 is regarded as small; an effect-size of 0.5 as medium; and an effect-size of 0.8 or higher indicates a large effect[22]. A multivariate analysis of variance (MANCOVA for repeated measures) was executed to test the change in ADL-functioning (i.e disabilities) while correcting for the change in apraxia and motor functioning. To correct for 'spontaneous recovery', the MANCOVA's also included time since stroke as covariate. This

way MANCOVA's were executed for the three disability measures separately (i.e ADL-observations, Barthel index and ADL-questionnaire OT), taking into account three covariates (i.e motor functioning, apraxia, and time since stroke). Thus, in the repeated measures analysis the disability measures were entered as several dependent variables representing measurements at different times on the same subject. Each of the variables is regarded as a different level of a within-subjects factor. The analyses were at two levels (pre and post treatment scores) with three covariates, while the full factorial model is specified and the user missing values are included.

For determining the number of patients who had improved after treatment, the reliable change index (RC) is used. The RC is calculated by $RC = (x_2-x_1)/S_{diff}$ in which x_1 is the score at baseline, x_2 is the posttreatment score, and S_{diff} is the standard error of the difference between the two scores. S_{diff} can also be calculated as $\sqrt{(2(Se)^2)}$, in which Se is the standard error of measurement[23,24,25]. All statistical analyses were carried out using SPSS/PC+, version 5.0. The level of significance was set at 0.01.

Results

Patients

Between December 1993 and February 1995 a total of 45 patients was included in the study. The patient flow is presented in table 1. For 33 patients pre- and posttreatment scores were available. Twelve patients were excluded from the measurements at 12 weeks for various reasons: comorbidity, right hemisphere stroke, refusal of treatment, death and early discharge. In some cases the set of outcome measures was not complete due to organisational problems within the participating institutions or the current health status of the patient. For this reason the number of patients for which a comparison between baseline and posttreatment could be made, is presented in each table. Characteristics of the patients are shown in Table 2. Concerning the size and site of the lesion, detailed information was not gathered systematically, but in most cases clinicians reported that the lesion was located in the parietal area.

Table 1. Patient flow

registered patients n=48	
patients included at baseline n=45	**patients excluded:** comorbidity n=1 right-hemisphere stroke n=2
patients receiving treatment n=43	**patients without treatment:** patient refused treatment n=2
posttreatment measures at 12 weeks n=33	**no posttreatment measures:** patient died n=2 early discharge n=8

Table 2. Characteristics of the patients (n=33)

	N
Gender	
Male	18
Female	15
Age	
mean	70.1
sd	11.0
range	39-91
Institution	
Hospital	11
Rehab center	14
Nursing home	8
CVA	
Cerebral haemorrhage	9
Cerebral infarction	23
Unknown	1
Time since CVA (in weeks)	
mean	8.9
sd	5.2
range	1.6-21.4

Outcome

Table 3 shows the baseline and 12-week results of the outcome measures. Improvement in functioning was seen in most outcome measures. The change in functioning after treatment was significant for the test of motor functioning ($t(33)=3.28$, $p<0.05$) and for the test of apraxia ($t(31)=3.28$, $p<0.01$).

The disability measures (i.e. ADL-observations, Barthel-index and ADL-questionnaire (OT)) showed strong and significant results. The ADL-observations showed a reduction of disabilities ($t(25)=6.84$; $p<0.01$). This result is also seen in the Barthel index ($t(28)=5.99$; $p<0.01$) and the ADL-questionnaire (OT) ($t(28)=6.47$; $p<0.01$).

Table 3. Treatment outcome

Instruments	N	Baseline mean (sd)	Posttreatment mean (sd)	p	Effect size
Motor functioning	33	7.64 (6.2)	8.80 (6.3)*	0.03	0.19
Apraxia	31	58.10 (28.0)	67.58 (26.9)**	0.00	0.34
ADL-observations	25	0.98 (0.65)	0.38 (0.47)**	0.00	0.92
Barthel index	28	10.14 (5.54)	14.89 (5.04)**	0.00	0.86
ADL-questionnaire (OT)	28	5.36 (1.57)	7.03(1.79)**	0.00	1.06

** $p < 0.01$, * $p < 0.05$

Effect size

As was expected, the effect sizes for the apraxia and motor functioning were small compared to the effect sizes for the disabilities (table 3). The effect size statistic of the ADL-questionnaire was highest (1.06) and the effect size of the test of motor functioning was lowest (0.19).

Multivariate analyses

MANCOVA's for repeated measures were executed to test whether the improvement in ADL-functioning was significant when corrected for changes in apraxia and motor functioning, and the time since stroke. These analyses were carried out separately for the ADL-observations, the Barthel index, and the ADL-questionnaire. The ADL-observations showed a significant improvement in functioning when the three covariates were taken into account ($F(1,20)=38.65$; $p<0.01$). Similar results were obtained for the Barthel index and the ADL-questionnaire; the analyses of variance showed a significant improvement after treatment ($F(1,22)=23.16$, $p<0.01$ and $F(1,22)=28.87$, $p<0.01$ respectively).

Individual changes

In clinical practice it is interesting to know whether a group of patients shows

significant improvement as a result of treatment but, perhaps more importantly, whether an individual patient responds positively to the treatment given.
For each patient the reliable change index (RC) was calculated. Based on the RC, significantly improved patients can be defined as patients showing an RC higher than 1.96, because in this case significant change ($p< 0.05$) occurs (see method section). Table 4 presents the percentage of patients showing significant improvement from baseline to 12 weeks follow up. As was hoped for, on an individual level most patients showed significant improvement in ADL-functioning (ADL-observations, Barthel index, and ADL-questionnaire). Improvement in motor functioning and apraxia occurred in a minority.

Table 4. Proportions and percentages of patients improving significantly

Outcome measures	proportion	%
Motor functioning	7/33	21
Apraxia	11/31	35
ADL-observations	20/25	80
Barthel index	20/28	71
ADL-questionnaire (OT)	21/28	75

Subjective improvement

In addition to objective measures of improvement, it is important to know how the patients themselves evaluate the effects of treatment. In our study the perceived treatment effect was determined by means of the ADL-questionnaire (pt). The results on this six-point scale are shown in table 5. As the table shows, 84% of the patients (n=22) judged the treatment to have resulted in complete recovery or much improvement. Comparison of this result with the ADL-questionnaire completed by the OT before and after treatment showed that in 87% of the cases the patient and the therapist agreed that improvement in functioning had taken place (not shown in a table).

Table 5. Subjective improvement

judgement	N	%
completely recovered	7	27
much improved	15	57
slightly improved	2	8
no change	1	4
slightly worsened	1	4
much worsened	0	0

Discussion

To our knowledge this is the first study on the outcome of treatment of stroke patients with apraxia. The treatment was offered by means of a therapy program aiming at teaching patients strategies to compensate for the apraxia. It was expected that improvement in ADL-functioning would be more evident than recovery of the apraxia and/or motor impairments.

The expectations were confirmed. The results of this study showed large and significant effects on all measures in ADL-functioning. The improvement in functioning was found in the ADL-observations, as well as the Barthel index and the ADL-questionnaire. There was significant, but small change on the test of apraxia and the test of motor functioning. The effect sizes of these measures were small. The results were further supported when changes in individual functioning and subjective improvement were considered.

Similar results were obtained in a study of memory rehabilitation[7,10]. Patients with memory problems were given strategy training, as opposed to drill and practice or no treatment. The group of patients receiving the strategy training showed significantly improved subjective as well as objective memory performance, but no significant improvement was found with respect to memory tasks for which the use of strategies was not possible. The more recent studies in cognitive rehabilitation thus suggest that strategy training can be applied when spontaneous recovery seems unlikely since the impairment is frequently

irreversible or the time since injury is prominent.
We should be somewhat modest concerning the successful treatment outcome. Since the design was a preexperimental one (i.e. no control group was present), the conclusions remain tentative. In the current design spontaneous recovery is not controlled for. However, the time post stroke was more than 2 months on average, which exceeds the acute phase for recovery. More importantly, the improvement in ADL-functioning was still significant when corrected for the improvement on the test of apraxia, the test of motor functioning, and the time since stroke. Thus, the multivariate analyses support the conclusion that strong improvement in ADL-functioning was found after treatment. Correction for confounding factors did not alter this robust outcome. And finally, if the improvements were the result of spontaneous recovery, one would expect a comparable effect on all measures. The differences between the magnitude of the effect sizes for the measurements allow the conclusion that improvement in ADL-functioning was considerable, while recovery of the underlying impairments (apraxia and motor functioning) was less marked. Testing of our conclusions in a controlled study remains however a logical and necessary next step.
The number of treatments per week varied between the patients. Categorising the patients according to the amount of treatment received is not possible on the basis of the data. Analyses determining whether degree of improvement was related to amount of training were thus not performed.
Because of the assumed effect of care and attention given, and because of general motivational aspects, it is not possible to attribute the positive effect of treatment solely to the strategy training. This issue cannot be resolved given the current researchdesign. However, one would expect care and attention to influence all measures equally, which is not the case.
It is therefore concluded that the therapy program succeeded in teaching patients compensatory strategies, which enabled them to function more independently. Recovery of the apraxia or motor impairments is a less likely explanation for the successful outcome.

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APPENDIX 1. Interventions

The specific interventions are built up in a hierarchical order, depending upon the level of functioning of the patient. The therapist can use instructions, assistance, and feedback:

Instructions

The occupational therapist can give the following instructions:

- start with a verbal instruction,
- shift to a relevant environment for the task at hand,
- alert the patient:
  - by touching
  - using the patients name
  - asking questions about the instruction,
- use gestures, point to the objects,
- demonstrate (part of) the task,
- show pictures of the activity,
- write down the instruction,
- place the objects near the patient, point to the objects, put the objects in the proper sequence,
- hand the objects one at a time to the patient,
- start the activity together with patient one or more times,
- adjust the task to make it easier for the patient,
- and finally take over the task because all efforts did not lead to the desired result.

Assistance

The following forms of assistance can be given by the therapist:

- there is no need to assist the patient during the execution of the activity,
  verbal assistance is needed:
  - by offering rythm and not interrupting performance
  - stimulate verbalization of the steps in the activity
  - name the steps in the activity or name the objects
  - direct the attention to the task at hand,
- use gestures, mimics, and vary intonation in your speech,
- show pictures of the proper sequence of steps in the activity,

- physical assistance is needed:
  - by guiding the limbs
  - positioning the limbs
  - use the neurodevelopmental treatment method (NDT)
  - use aids to support the activity
  - take over until the patient starts performing
  - provoke movements,
- and finally take over the task.

Feedback

Feedback can be offered the following way:

- no feedback is necessary because the result is adequate,
- verbal feedback is needed in terms of the result (knowledge of results),
- verbal feedback by telling the patient to consciously use the senses to evaluate the result (tel the patient see, hear, feel, smell or taste),
- physical feedback is needed in terms of the result (knowledge of results):
  - evaluate the posture of the patient
  - evaluate the position of the limbs
  - support the limbs,
- physical feedback is given by pointing or handing the objects to the patient,
- verbal feedback is needed in terms of performance (knowledge of perfor mance),
- physical feedback is needed in terms of the performance (knowledge of performance),
- place the patient in front of a mirror,
- make video recordings of performance the patient and show the recordings,
- take over the control over the task and correct possible errors.

Chapter 8

REHABILITATION OF STROKE PATIENTS WITH APRAXIA:

the role of additional cognitive and motor impairments

C.M. van Heugten, J. Dekker, B.G. Deelman, J.C. Stehmann-Saris, A. Kinebanian. Rehabilitation of stroke patients with apraxia: the role of additional cognitive and motor impairments (submitted).

Abstract

The present study investigated which additional cognitive and motor impairments are present in stroke patients with apraxia and which of these factors influence the effects of treatment. A group of 33 patients with apraxia were treated according to the guidelines of a therapy program based on teaching patients strategies to compensate for the presence of apraxia. Patients were treated at occupational therapy departments in general hospitals, rehabilitation centres and nursing homes. The outcome of the strategy training was studied in a pre-post test design; measurements were conducted at baseline and after 12 weeks of therapy. The following variables were analyzed: additional neuropsychological deficits (comprehension of language, dementia-like cognitive impairments, neglect, and short term memory), level of motor functioning, severity of apraxia and ADL-performance, and some relevant patient characteristics (gender, age, type of stroke, time since stroke, and location of treatment). The results show that the presence of apraxia is associated with additional cognitive and motor impairments. The successful outcome of strategy training is not negatively influenced by cognitive comorbidity. The outcome seems to be more prominent in patients who are more severely impaired at the start of rehabilitation in terms of the degree of motor impairments, the severity of apraxia and the initial ADL-dependence. The ADL-observations, however, display a ceiling effect. Demographic variables, especially age, did not predict the outcome of treatment. We suggest that the effect of this training is stronger in more severely disabled patients. However, neither the presence of additional cognitive impairments nor the severity of motor problems should be an indication for refraining from treating apraxia.

Introduction

Identification of patients who will benefit more than others from a specific treatment is important for a number of reasons. Prognosis of the outcome is essential to the caregivers: realistic rehabilitation goals can be formulated (Jongbloed, 1986) and health care services can be allocated in the most efficient way when factors affecting outcome are identified. The caregivers and, perhaps even more importantly, the patients themselves as well as their relatives should be informed adequately about the expected outcome. Finally, concerning research in rehabilitation, knowledge of prognosis facilitates stratification of stroke patients into different prognostic groups for clinical trials (Graham, Harwood & Barer, 1992). In designing randomised clinical trials, this makes it possible to create more homogeneous groups of patients.

Most prognostic studies do not differentiate between spontaneous recovery and the effects of treatment; instead, recovery after stroke in general is examined. In a recent review, many studies on prognosis of stroke patients were analyzed and variables capable of predicting functional outcome after stroke were identified on the basis of those studies that met sound methodological principles of prognostic research (Kwakkel, Wagenaar, Kollen & Lankhorst, 1996). Kwakkel et al identified the following negative predictors for functional recovery after stroke: old age, previous stroke, urinary incontinence, loss of consciousness at onset, disorientation in time and place, severity of paralysis, poor sitting balance, bad admission ADL score, low level of social support, and metabolic rate of glucose outside the infarct area in hypertensive patients.

Kwakkel et al studied stroke patients in general; the present study focuses on stroke patients with apraxia in particular. Basso, Capitani, Della Sala, Laiacona and Spinnler (1987) investigated the recovery from ideomotor apraxia (IMA) in acute stroke patients and assessed whether variables capable of predicting the evolution of IMA could be identified. They found that recovery is related to the site of the lesion: patients with anterior lesions appeared to have a better chance of recovery. Improvement was not related to age, education, sex, type of aphasia, and the initial severity or the size of the lesion. A study by Sundet, Finset and Reinvang (1988) was designed to investigate how apraxia (among other variables) present at the start of rehabilitation, may predict the level of ADL-dependency after discharge. These authors found that variables associated with apraxia at the start of rehabilitation correlated significantly with

the level of help needed for managing alone at home after discharge: apraxia on admission indicated a higher dependency on aids and other persons in order to manage alone. From these results, however, the effect of rehabilitation or spontaneous recovery cannot be differentiated.

In the present paper the influence of several variables on treatment is explored: baseline performance (baseline degree of apraxia and ADL-performance), and a number of relevant patient characteristics (age, gender, type of stroke, time since stroke, and location of treatment). Perhaps more importantly, in the present paper the role of additional cognitive and motor impairments is investigated. First, it will be examined whether the apractic patients in the study indeed suffer from other impairments besides apraxia. This is done by comparing the pretreatment scores of the patients with apraxia with normscores and with scores of a control group of stroke patients without apraxia. Next, an attempt is made to identify those variables that influence the outcome of treatment, as measured with standardized ADL-observations. We expect that the presence of additional neuropsychological and motor deficits will have a negative influence on functional outcome. Obviously, these deficits can have a negative influence on independent functioning; therefore it is important to determine whether the outcome of treatment specifically aimed at apraxia will be worse when patients suffer from comorbidity. Patients having apraxia without (or with less) cognitive and motor comorbidity are expected to benefit more from treatment.

Method

Selection of patients

Therapists at occupational therapy departments in three general hospitals, eight rehabilitation centres, and five nursing homes in the Netherlands selected the patients. Patients were eligible if they met the following inclusion criteria: patients diagnosed as having had a stroke in the left hemisphere, and having apraxia. A left hemisphere stroke is diagnosed when acute clinical symptoms of a focal dysfunction of the left hemisphere are present at least during 24 hours and probably have a vascular origin only (WHO, 1989; Van Crevel, 1991). Apraxia is diagnosed when the patient is fully or partly unable to carry out purposeful activities, this not being due to primary motor or sensory

impairments, nor to deficits of comprehension, memory, or motivation (Kolb & Whishaw, 1990). Exclusion criteria were: age younger than 25 years or older than 95 years; no working knowledge of the Dutch language; and a set of premorbid or present pathologies: psychiatric or psychogeriatric history, addiction to alcohol, medical or other drugs, personality, intellectual or learning disorders, temporary loss of consciousness, or other injuries of the central nervous system.
A group of stroke patients without apraxia was selected on the basis of the same inclusion- and exclusion criteria as the first group, but they were not diagnosed as having apraxia. All patients in both groups entering the study gave their informed consent.

Treatment

The patients eligible for the study took part in an assessment procedure and were subsequently treated according to the guidelines of a therapy program for a period of 12 weeks. Treatment was aimed at improving the performance of the apractic patients by teaching them strategies. The potential benefit of this is that it enables them to function more independently, despite the persisting presence of arpaxia. Strategy training concentrates on teaching the patient ways to compensate for the impairment. The number of treatments per week was determined by the therapists, and varied between three to five sessions per week. During treatment, activities were trained that were relevant for the patients to (re)learn. The focus of the program is on disabilities resulting from apraxia, and having an influence on the patient's functioning in daily life. Every two weeks an activity was chosen. The decision about the activity to be trained was made together with the patient. After this two-week period a new treatment goal was chosen, based upon the improvement in the patient's functioning.
The specific interventions administered during treatment corresponded with the specific problems that were assessed during ADL-observations (Stehmann-Saris, van Heugten, Kinebanian, Dekker, 1996). ADL-activities are conceptualized as being composed of three aspects: phases of initiation, execution, and control. The proper plan of action as well as the correct objects have to be selected (initiation of an activity), followed by adequate performance of the plan (executing the activity), which has to be evaluated in terms of the performance and the result (controlling and if necessary correcting the activity). By assessing these different aspects of the activity, the nature of the deficit can

be identified and plans for treatment can be formulated accordingly. When a patient predominantly showed problems with initiating an activity, emphasis during treatment was placed upon instructions. Specific assistance was given when the execution of an activity caused problems. Finally, the therapist offered feedback when the patient did not detect or correct performance errors. The specific interventions in the form of instructions, assistance, and feedback had been presented to the occupational therapist in a protocol.

Study design and outcome measures

The outcome of the therapy program was studied using a pre-post test design. The following measurements were performed at baseline (pre test) and 12 weeks later (post test):

Apraxia. A test of apraxia, consisting of two subtests (Van Heugten et al, 1997b), based on tests of De Renzi (1989) was used. The first subtest was designed to evaluate the use of objects. Three sets of three objects were presented in different conditions. A total score of 54 could be reached. The second subtest involved the assessment of the ability to imitate gestures. Six gestures had to be imitated by the patient, directly upon demonstration by the researcher. For this part a score of 36 could be reached. The total score could add up to 90. The internal consistency (alpha=0.96) and the validity of this test were investigated; both clinimetrical properties appeared to be good (Van Heugten et al, 1997b).

Motor functioning. A short and simple test of motor functioning was used, based on other motor functioning tests (e.g. the motricity index; Wade, 1992). The test consists of 8 tasks involving the body side opposite to the brain lesion. For each task a score of 2 was given when the patient was able to execute the task, 1 when the patient could carry it out with some effort, and 0 when the patient was not able to execute the task. This way a maximum score of 16 could be reached. The internal consistency of this test is good (alpha=0.94; not published).

ADL-observations. The occupational therapist executed a set of four standardized ADL-observations aiming at assessing abilities and disabilities following apraxia. The OT observed the patient executing four ADL-activities, three of which were prescribed (i.e. personal hygiene, dressing, and preparing food), while the fourth activity could be chosen by the OT. The findings of these observations were scored on four different scores: a score of independence,

initiation, execution and control. The four measures consisted of 4 levels ranging from 'there are no observable problems, the patient performs well without help' (0), to 'the therapist has to take over the activity' (3). Subsequently, the four measures were added to arrive at a total score. The internal consistency (alpha=0.94) and inter-observer reliability (ICC=0.98) of the ADL-observations are good (Van Heugten, et al, 1997c).

Additional measures

In order to assess whether the patients with apraxia suffered other neuropsychological deficits as well, the following measurements were conducted:

Comprehension of language. An aphasia test battery for auditive and verbal use of language has been developed and validated in the Netherlands (SAN-test; Deelman, Koning-Haanstra, Liebrand and Van den Burg, 1981, 1987; Visser, van Vliet, Mulder, Evers and Ter Laak, 1982). We used the subtest 'comprehension of sentences' designed to test the ability to comprehend simple sentences. A maximum score of 45 was given when all sentences were judged correctly by the patient.

Cognitive orientation. The Cognitive Screening Test (CST) is a short, reliable, and valid standardized instrument to measure cognitive impairments, specifically due to dementia, by asking the patient about simple facts, usually learned in the past. The test differentiates very well between healthy elderly and patients with the dementia syndrome (de Graaf and Deelman, 1991). When all items of the test are answered correctly, the patient gets a score of 20.

Unilateral visual neglect. The Star Cancellation test is a subtest of the Behavioural Inattention Test (Halligan, Cockburn & Wilson, 1991). It is a short test to measure unilateral visual neglect and is considered to probably be the most sensitive single test (Halligan, Marshall and Wade, 1989; Wade, 1992). The patient has to detect a specific stimulus in a visual array of many different stimuli. The number of target stimuli (i.e. small stars) that are omitted is scored; the maximum number of omissions is 56.

Short term memory (digit span). A series of digits was presented verbally to the patients. Patients were asked to recall each series immediately upon presentation (forward recall). The total score represents the number of series remembered correctly (Lezak, 1995).

Testing procedure

Patients with apraxia as well as the control patients without apraxia were tested by the experimenter in an one-hour testing session, during which the apraxia test, the motor functioning test and the tests for additional impairments were administered. The patients sat facing the experimenter in a quiet room suitable for testing. The occupational therapists carried out measurements assessing the level of disabilities in ADL-activities. The ADL-observations were conducted in an environment appropriate for the task at hand, as well as at a time of day relevant for the specific task (e.g washing in the bathroom, after getting out of bed).

Statistical analyses

The baseline scores of the apractic patients were compared to normscores to determine whether they suffer from additional impairments. Next, the scores in the present sample were compared to a control group of stroke patients without apraxia to determine whether the presence of additional impairments is related to the presence of apraxia. The scores of the two groups are compared using t-tests for independent samples.

Change scores, indicating improvement in functioning, were calculated for each patient by subtracting the results after twelve weeks follow-up from those at baseline. The t-test for paired samples was used for comparison of measures before and after treatment. Effect sizes were calculated by dividing the mean changes in scores by the standard deviation of the pre-test score. The analyses as regards treatment outcome are presented in more detail in Van Heugten et al (1997a).

Correlation coefficients between the pre-test scores (baseline performance, additional neuropsychological tests, and some patient characteristics) and the change score of the main outcome measure (i.e. the ADL-observations) were calculated. Bivariate relationships are expressed by means of Pearson's product moment correlation coefficients. In addition, for categorical variables Eta is presented. Eta is used for the relationships between the ADL-change score and gender (male, female), type of stroke (cerebral haemorrhage, cerebral infarction) and location of treatment (hospital, rehabilitation centre, nursing home). Eta varies between 0 and 1 and is used for associations between nominal and interval variables (Ferguson, 1966).

All statistical analyses were performed using SPSS/PC+, version 5.0. The

significance level was set at 0.05.

Results

Characteristics of the patients

Table 1. Characteristics of the stroke patients with apraxia and the control patients without apraxia

	patients with apraxia	patients without apraxia
Gender		
Male	18	14
Female	15	22
Age		
mean	70.1	59.9
sd	11.0	12.8
range	39-91	35-88
Location of treatment		
Hospital	11	10
Rehabilitation centre	14	20
Nursing home	8	6
Type of CVA		
Cerebral haemorrhage	9	11
Cerebral infarction	23	23
Unknown	1	2
Time since CVA (in weeks)		
mean	8.9	13.5
sd	5.2	15.8
N (total)	33	36

A total of 45 patients with apraxia was included in the study. For 33 stroke patients with apraxia pre- and posttreatment scores were available; twelve patients were excluded from the measurements at 12 weeks for various reasons (e.g. bad medical condition, refusal of treatment, death and early discharge).
Thirty-six patients without apraxia constituted the control group. This group of patients was only tested at baseline. The two groups did not differ significantly as regards gender, type of stroke and time since stroke; the apraxia patients, however, were significantly older than the stroke patients without apraxia ($p<0.01$). In table 1 the characteristics of the patients with and without apraxia are presented.

Baseline scores

The baseline scores of the patients with and without apraxia are shown in table 2. As expected, the baseline score on the apraxia test was much lower for the patients with apraxia than for the patients without apraxia ($t=6.16$; $p<0.01$). On the motor functioning test the mean score of the patients with apraxia was not significantly different from the reference group without apraxia. The scores suggest that both the patients with apraxia and the patients without apraxia suffer from primary motor impairments.

The poorest performance on the test for comprehension of language by healthy persons older than 65 years (normscore) is 40 items correct (Deelman et al, 1987). Seventy-three per cent of the apractic patients in our group scored below this normscore, and only one patient reached the maximum value of 45. In the group without apraxia 9% of the patients scored below the normvalue, while more than half of the subjects reached the maximum score. The mean scores of the two groups differ significantly ($t=6.83$; $p<0.01$). On the Cognitive Screening Test a maximum of 20 could be reached, while the patients with apraxia in our study obtained a mean score of 13.8. Normscores indicating the presence of dementia are based on a cut-off score of 12.1 (de Graaf & Deelman, 1991); 41% of the apractic patients obtained a score below this value. In the control group only 6% scored below the normscore. The two groups differ significantly ($t=4.26$; $p<0.01$). If more than 3 stimuli are omitted on the test of unilateral visual neglect the subject is considered to show some degree of neglect. This normscore is based on a study by de Kort (1996) in which the lowest score of subjects in a control group (i.e. elderly persons without central neurological

damage) was the omission of 2 stimuli. In the group of patients with apraxia 19% of the patients had omitted more than 3 stimuli, while in the group of patients without apraxia 6% of the patients had more than 3 omissions. The groups do not differ significantly. The last test was included to measure short term memory functioning. Apractic patients score significantly worse than non-apractic patients ($t=5.64$; $p<0.01$).
In summary, the presence of apraxia seems to be associated with impairments in motor functioning, comprehension of sentences, cognitive orientation and short term memory functioning.

Table 2. Baseline measurements for patients with apraxia and patients without apraxia

Instrument	patients with apraxia		patients without apraxia		
	N	mean (sd)	N	mean (sd)	t
Outcome measures					
Apraxia	32	57.8 (27.6)	35	88.0 (3.3)	6.16**
Motor functioning	33	7.6 (6.2)	35	9.8 (6.0)	1.47
ADL-observations	29	1.0 (0.6)	34	0.2 (0.3)	6.22**
Additional measures					
Comprehension of language	28	32.3 (8.5)	35	43.5 (2.5)	6.83**
Cognitive orientation	25	13.8 (4.8)	35	18.5 (2.9)	4.26**
Neglect	26	1.9 (2.6)	35	0.8 (1.8)	1.78
Short term memory	23	2.8 (2.1)	30	5.5 (1.4)	5.64**

** $p < 0.01$; * $p < 0.05$

Treatment outcome

Treatment outcome is presented in more detail in van Heugten et al (1997a). The results are summarized in table 3; the baseline scores, 12-week results and

effect sizes are presented. The ADL-observations show large improvement; apraxia and motor functioning show significant though less improvement. As was expected, the effect sizes for apraxia and motor functioning were small compared to the effect size for the ADL-observations.

Table 3. Treatment outcome

Instrument	N	Baseline	Post-treatment	Effect size
Apraxia	31	58.10 (28.0)	67.58 (26.9)**	0.34
Motor functioning	33	7.64 (6.2)	8.80 (6.3)*	0.19
ADL-observations	25	0.98 (0.65)	0.38 (0.47)**	0.92

** $p < 0.01$; * $p < 0.05$

Bivariate relationships

In table 4 the correlations between all baseline scores and improvement in independent functioning (i.e. the change scores of the ADL-observations) are presented. A significant correlation is found between the level of ADL-functioning at baseline and the improvement in ADL-functioning, as measured with the ADL-observations ($r=0.69$; $p<0.01$). This means that the more dependent the patient is before treatment, the more improvement is seen after treatment. The improvement in ADL-functioning is negatively associated with the level of apraxia and motor functioning at baseline ($r=-0.46$, $p=0.02$ and $r=-0.42$, $p=0.04$ respectively). For both tests, it applies that the lower the pre-test score (i.e. the more severely impaired the patient) the more improvement in ADL-functioning is seen. In other words, the most severely impaired patients showed the most marked improvement. The significant relationships (ADL-improvement and baseline ADL-functioning, motor functioning and apraxia) are graphically presented in figure 1.

Other neuropsychological impairments at baseline did not show significant

since stroke, gender, type of stroke and treatment setting no significant correlations were found with the change in ADL-functioning (all p-values exceeded 0.10).

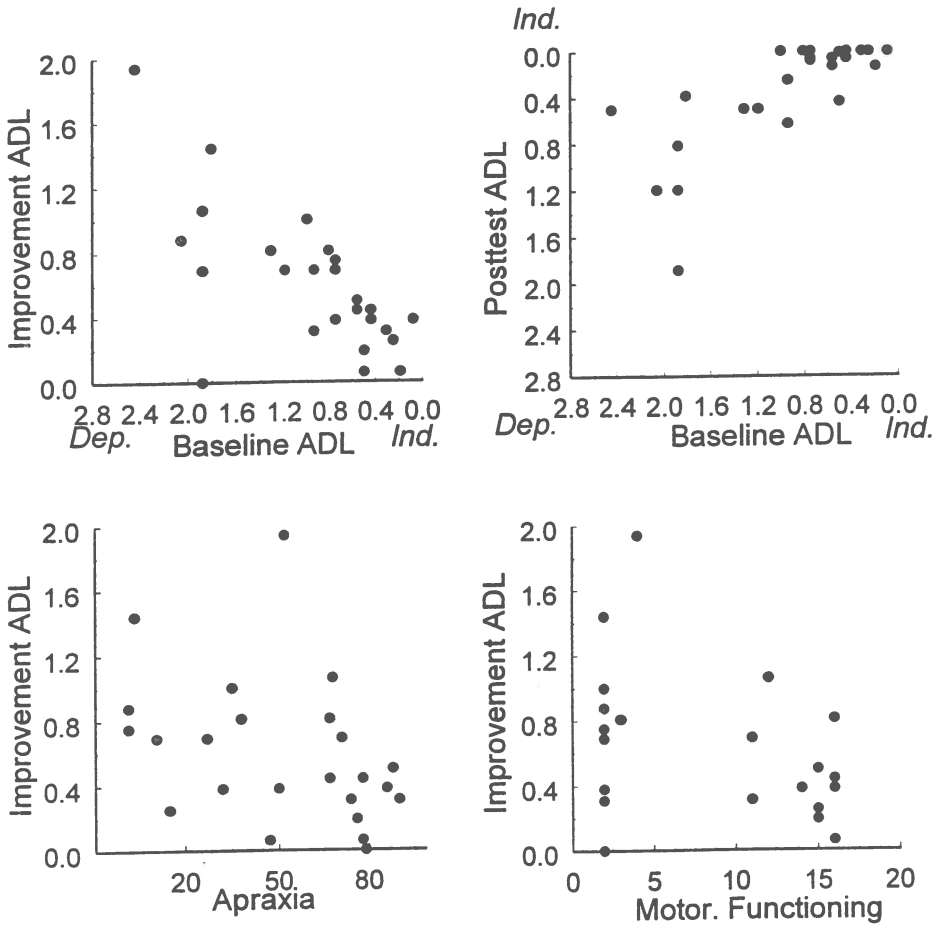
Table 4. Bivariate relationships between improvement on the ADL-observations and baseline scores, neuropsychological scores and patient characteristics

Change scores	ADL-observations
Baseline scores	
Apraxia	-0.46 *
Motor functioning	-0.42 *
ADL-observations	0.69 **
Neuropsychological functioning	
Comprehension of language	-0.12
Cognitive orientation	-0.09
Neglect	-0.02
Short term memory	-0.22
Patient characteristics	
age	-0.03
time since stroke	-0.01
gender^	0.05
type of stroke^	0.34
location of treatment^	0.28

^ Eta

** $p < 0.01$; * $p < 0.05$

Figure 1. *Relationships between the change score of the ADL-observations and the baseline score of the ADL-observations (1a), the baseline ADL versus posttest ADL scores (1b), the apraxia test (1c), and the motor functioning test (1d)*



Discussion

The aim of the present study was twofold. First, it was investigated which cognitive and motor impairments are associated with apraxia following stroke. And second, prognostic variables related to functional outcome, were examined.

The presence of additional impairments in stroke patients was found to be far more prominent in the group of patients with apraxia than in the group of patients without apraxia. In comparison with patients without apraxia, the apractic patients in our sample seem to have more problems in comprehending sentences, in cognitive dementia-like tasks, and in remembering series of digits correctly. Motor impairments were present in both groups.
Surprisingly, this cognitive comorbidity does not seem to cause a less favourable treatment outcome. Apparently, the presence of additional cognitive impairments is not an impediment for this kind of treatment. Likewise, bad motor functioning was expected to have a negative influence on functional improvement as well (Kwakkel et al, 1996). However, more improvement in ADL-functioning was found in those patients who initially had more problems in motor functioning.
Next we investigated the predictive value of baseline performance on the apraxia test and the ADL-observations. In our study it appears that for both instruments the initially more severely impaired patients show the most marked improvement in independent functioning.
This latter result is remarkable and not expected; further investigation of the measurements is therefore needed. Inspection of figure 1 provides insight. For the relationship between the ADL-baseline scores and the improvements in ADL-functioning (figure 1a) the regression to the mean phenomenon should be considered: patients starting with a positive score will tend to get a lower score, while patients with a negative score at the start will tend to get a better score. This statistical problem cannot be seen in the figure. It can, however, be seen, that part of the data is clustered in the upper corner. This indicates a ceiling effect: patients functioning independently before treatment cannot improve any more. This could indicate that the ADL-observations are not capable of detecting changes towards the positive end of the scale.
As regards the ADL-observations, the observed ceiling effect is an issue of discussion. In the present sample a considerable number of patients already

functioned rather independently before treatment and thus could not improve any more; this is a natural ceiling effect. However, on the basis of clinical decisionmaking the patients functioning good before treatment were admitted to the treatment program. If these patients could not improve any further this would not have been decided. Thus, it can also be argued that the ADL-observations were not capable of detecting clinically relevant improvements in independent functioning; this would suggest an instrumental ceiling effect. Not all activities which were observed might have been sufficiently difficult to raise problems in functioning. A more complex task could have shown a stronger differentiation in improvement towards the end of the scale.

As regards the prognostic value of patient characteristics the following conclusion can be drawn. We did not find age to be a significant predictor. The other demographic variables we examined did not yield significant results either. Unfortunately, in our study we could not examine the relationship between functional outcome and the site of the lesion, which appeared to be a relevant factor in the recovery of ideomotor apraxia (Basso et al, 1987).

In conclusion, the bivariate relationships were presented with some words of caution; more definite conclusions concerning the ceiling effect should be drawn on the basis of additional studies. There seems to be a need for an instrument differentiating more towards the positive end of the scale. We conclude that there is no indication that the effect of this training is weaker in more severely disabled patients. Neither the presence of additional cognitive impairments nor the severity of motor deficits nor old age seems to be an indication for refraining from treating apraxia.

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Part III

CONCLUSIONS AND IMPLICATIONS

"If a man will begin with certainties, he shall end in doubts; but if he will be content to begin with doubts, he shall end in certainties"
[Francis Bacon, 1561-1626; Advancement of Learning]

Chapter 9

GENERAL DISCUSSION AND CONCLUSIONS

In this final chapter methodological issues and problems will be considered and the main findings of the study reviewed. Finally, implications for clinical practice and for further research will be discussed.

Methodological issues

Patient sample

An important point is the relatively small number of patients studied (45 patients included at baseline). We had initially planned to include more stroke patients with apraxia. As in most studies involving patients, we encountered problems with finding them. This phenomenon has been denoted as Lasagna's law: when you start recruiting patients for research, eligible patients seem to disappear (Spilker, 1996). The availability of suitable patients for research is overestimated in many instances (Beurskens, 1996). In order to enlarge the number of patients, more occupational therapists were asked to participate in the study, the recruitment period was lengthened, and extra training and feedback sessions were organized for the therapists. Between December 1993 and February 1995, 45 patients were included. A considerable drop-out of patients occurred: for 33 patients pre- and post-treatment scores were available, which means that 27% was lost at follow-up for various reasons (i.e. refusal of treatment (n=2), death (n=2) and early discharge or transfer to another institution (n=8)). Given the disease under study it is not uncommon that a drop-out of patients occurs due to death, poor medical condition, cognitive problems and problems due to the organisation of care. The pretest scores and characteristics of the patients for whom no posttest scores are available were not significantly different from the patients who were studied before and after treatment; slightly more women were lost at follow up (data not published). The drop-out of patients appears not to be selective.

The results in this relatively small group of stroke patients with apraxia were compared to those of two other groups of patients: 36 stroke patients without apraxia and 50 healthy elderly persons. Reliability and validity of the instruments were examined, of which in the literature data are rarely found. Only in one of the many studies on apraxia (Goodglass and Kaplan, 1963) the inter-judge agreement of measurements was determined and found to be acceptable. Very recently, an ADL-test for apraxia was developed and the reliability of the

assessment was found to be good (Goldenberg & Hagman, 1998).
The present study is one of the first studies investigating the outcome of treatment in a group of stroke patients with apraxia. So, our results await cross-validation. The few reports found in the literature are concerned with the treatment of a single patient with apraxia; for instance, the study of patient G.F. by Pilgrim and Humphreys (1994) and the treatment of C.R. (Maher, Rothi and Greenwald, 1991). Very recently, a study was published in which 15 patients with apraxia were admitted to therapy involving the training of ADL activities (Goldenberg & Hagman, 1998).
Thus, despite the small number of patients, the studies investigating the diagnostic procedure as well as the evaluation of treatment of apraxia are both still the largest studies.

Age of the control group

Another problem concerns the control group of patients without apraxia. This sample was used in the examination of the diagnostic value of the apraxia test and of the clinical validity of the ADL-observations. These stroke patients without apraxia appeared to be younger than the stroke patients with apraxia. As cognitive functioning and ADL-performance can decline with age, this could have had consequences for our results.
However, the relationships between age on the one hand and the results on the apraxia test and the ADL-observations on the other hand showed that no significant correlations existed. The absence of a relationship between age and testscores was found in both groups of stroke patients. This implies that, at least in this sample, age did not influence the testscores of the apraxiatest and the ADL-observations of either patientgroup. Age is therefore not likely to be a factor resulting in bias.

Study design

An important restriction concerning our conclusions on outcome is brought forward by the design of the effectstudy. In the present study one group of patients was treated: there was no control group of patients receiving no treatment. Although this study design obviously has its limitations, it is a valuable step to be taken before a randomized controlled trial (RCT) is relevant or will be financed. An RCT is the most powerful research design to study the effects of treatment. However, some fields of rehabilitation, including occupational

therapy, are not yet sufficiently professionalised to conduct an RCT properly and thoroughly. Complaints of patients and the treatments given are highly heterogeneous (Dekker, 1997). Before an RCT can be executed, information concerning the consequences of the diseases and the indication for treatment, as well as the most beneficial interventions should be made explicit. In a pre-experimental study the criteria for the selection of patients are formulated (i.e. explicitation of the indication for treatment), the content of treatment is described and standardised, and the instruments for measuring outcome are developed and examined in terms of clinimetrical quality. On the basis of these results, an RCT can be structured and conducted with more efficiency and chance of success.

In this study the next best alternative to an RCT was used by comparing pre- and post-test measurements on both target and control tasks: improvements were expected in ADL-functioning (i.e. target task), but no or only small changes were expected in the severity of apraxia and motor impairment (i.e. control tasks). A possible effect of care, attention and general motivational aspects as well as spontaneous recovery would have influenced all measures to the same extent; the difference in effect sizes suggest that these aspects did not interfere with the outcome of treatment. The differences in effect sizes between the target and control tasks allow the conclusion that recovery due to spontaneous processes or due to the underlying impairments was less marked. Multivariate analyses for repeated measures including these covariates further supported this conclusion.

Revisiting the main findings of the study

Assessment of apraxia

In this study an attempt was made to solve part of the problems clinicians face in the assessment of apraxia. In the literature numerous testing procedures and scoring methods can be found, but results are often inconsistent and confusing. Many existing examinations are not specifically aimed at apraxia, and clinicians rely on personal experience and clinical reasoning. In this study a diagnostic procedure for apraxia and its consequences for daily life was developed. In this procedure a distinction is made between behavioral performance on a neuropsychological apraxia test in a standardized context and behavioral

performance on ADL-activities which were observed in a more ecologically valid context.
Very recently, a study on assessment and treatment of apraxia was published by Goldenberg and Hagman (1998). It is interesting that these researchers also used a diagnostic procedure consisting of two tests, largely resembling the present procedure: first, clinical assessment of apraxia, including imitation of meaningless gestures, pantomime and use of objects; and second an ADL-test, in which three activities from the domains eating, dressing and grooming were observed. However, in the study of Goldenberg and Hagman the apraxia test was included to find out whether apraxia influences ADL functioning; this test was therefore strictly used for research purposes. The authors found that problems in ADL performance were primarily related to the severity of apraxia.

The development of the diagnostic procedure was followed by a thorough investigation of the quality of the instruments. Little is known about the reliability and validity of assessment instruments for apraxia. Goodglas and Kaplan (1963), in the only study addressing clinimetrics, reported the inter-judge agreement to be acceptable. The recent study of Goldenberg and Hagman (1998) examined the inter-rater reliability of their ADL-test; on the basis of correlations between two raters the reliability was found to be reasonably good. The present study addressed further aspects of reliability and validity, resulting in two satisfying instruments for assessing apraxia and its consequences.

Apraxia test
The apraxia test differentiates well between stroke patients with apraxia and stroke patients without apraxia as well as healthy elderly persons. The discriminative capacity of the test is good. This simple and consistent test can be used as a diagnostic instrument to detect the presence and severity apraxia in a group of stroke patients.
The apraxia test addresses two forms of apraxia: ideational apraxia and ideomotor apraxia. In the literature these forms of apraxia are sometimes labeled as the two classic forms, but there is much debate about the autonomy of each form. In the apraxia test the two forms were operationalized by means of tasks involving the demonstration of object use - typically used in testing ideational apraxia - and the imitation of gestures - to test for ideomotor apraxia. If these tasks were to reveal separate deficits, one would expect the test not to

be internally consistent. Moreover, when performing scale analyses two scales should be the result. However, the two subtests could be combined into one strong, reliable and consistent scale. This implies that both subtests measure the same underlying concept. Apparently, it is just not possible, nor clinically relevant to distinguish between those forms of apraxia in theoretical terms. Instead, one should focus on the observable problems in ADL-functioning caused by ideational apraxia and ideomotor apraxia. This line of reasoning was already proposed by Dee, Benton and Van Allen (1970) and Kimura and Archibald (1974). Lezak (1995) later followed by stating that the idea of distinguishing different forms of apraxia in theoretical terms should be abandoned, and instead one should use terminology describing what is wrong in the performance of apractic patients. Recent studies in which the quality of performance was characterized in terms of the type of errors made by apractic patients, also show that this approach is clinically more useful (Tate & McDonald, 1995). Moreover, even the results of error analyses have not led to a clear differentiation between ideational and ideomotor apraxia. This further supports our claim that it seems very dubious that the two forms of apraxia exist. This claim is based on the results of the present study investigating a group of patients. Obviously, it is conceivable that in case studies investigating single patients the two forms of apraxia are found independently, but then it would probably be an exceptional case.

A final finding concerning the apraxia test of clinical relevance is the degree of difficulty of the separate tasks found by using scale analysis. The items of the apraxia test were ordered hierarchically, from less difficult to more difficult. For this group of patients, imitation of gestures appeared to be less difficult than demonstration of object use. This implies that patients having problems performing imitation tasks will also have difficulties demonstrating the use of objects.Concerning object use, it appeared that actual object use is less difficult than demonstration of object use with the object being present, which in its turn is less difficult than demonstration of object use on verbal request only, without the object being present.

ADL-observations

The consequences of apraxia for everyday life were assessed observing ADL-activities. The observable problems in ADL-functioning due to apraxia were conceptualized in three scales measuring qualitative aspects in patient

performance. In line of the information processing approach, an activity was considered to consist of the aspects initiation, execution and control. For assessing each aspect a separate scale was used by which problems in functioning could be scored. This observational method appeared to be a reliable instrument. When two observers independently observed the same patient the same conclusions concerning the apractic performance were reached. The ADL-observations form an instrument which can be used to measure one and the same underlying concept, most probably being disabilities following apraxia.

The observational instrument did not distinguish between problems in each stage of processing, which, in scale analyses, would have resulted in three separate scales instead of one strong scale. Instead, all items together formed a homogeneous scale. This was an unexpected finding, which indicates that the aspects of these activities could not be disentangled.

Again, the scale analysis produced a clinically important result. The items of the ADL-observations were ordered hierarchically, from the highest score indicating dependent functioning, to the lowest score indicating independent functioning. The hierarchy showed that the initiation of all four activities required the least assistance from the therapist: this implies that when the initiation of an activity poses difficulties, patients will also experience problems in executing and controlling the activity.

Finally, the validation study of the ADL-observations showed that a clear differentiation was made between stroke patients with apraxia and stroke patients without apraxia. While both groups were comparable in terms of patient characteristics and degree of motor impairments, the stroke patients with apraxia functioned far less independently than the stroke patients without apraxia. This is of importance because many believe that apraxia has little negative impact on patients' lives. Some state that apraxia shows only during tests and that it does not interfere with spontaneous object use (Poeck, 1985; Faglioni & Basso, 1985). However, other studies have also demonstrated the negative effects of the deficit in everyday life (for instance Sundet, Finset & Reinvang, 1988). The results of the present study support the ecological significance of apraxia. The strong significant correlation we found between the apraxia test and the ADL-observations further emphasizes apraxia has an influence on independent functioning. Two very recent publications on apraxia (Rothi & Heilman, 1997; Goldenberg & Hagman, 1998) also supported the

finding that apraxia exists outside the artificial context of testing.

Using the ICIDH for studying apraxia

In the assessment procedure for apraxia, the consequences of stroke are captured at two conceptual levels, according to the framework of the ICIDH. Despite the discussion concerning the application of the ICIDH model to the area of psychology, in the present study the distinction between impairments and disabilities appears to be useful for clinical practice when it comes to assessing patients with apraxia. The apraxia test differentiates between patients with apraxia and patients without apraxia, but the scores on this test do not give information on the performance on daily life activities. Incompetence in a test situation does not necessarily indicate incompetence in a more ecologically valid context. Rehabilitation is concerned with the consequences of the disease and its implication for the patient's daily life. Assessment of the consequences of apraxia for daily functioning is, therefore, a necessary complement to the apraxia test. Empirically, the apraxia test and the ADL-observations correlate significantly, which indicates that both measurements are associated. However, with a view to rehabilitation, and supported by the results of the present study, the distinction between the impairment apraxia and the disabilities resulting from the deficit is relevant and essential in studying outcome of treatment. Rehabilitation focuses on the consequences of the disease and therefore diagnostic information on daily life performance is essential.

Treatment of apraxia

The results of the study suggest that the therapy program is successful in teaching patients compensatory strategies which enable them to function more independently despite the lasting presence of apraxia. Despite the heterogeneous composition of the patient sample (i.e. cognitive comorbidity) the effects of treatment were strong. This was one of the first studies to evaluate outcome of apraxia treatment in a group of patients. Sofar, the effects of treatment had mostly been investigated in single case studies. Recently, a book was published containing a collection of papers by various authors working in the area of apraxia (Rothi & Heilman, 1997). The chapter on management and treatment of limb apraxia, by Maher and Ochipa, presents several reasons why treatment of apraxia has received so little attention. First, patients with apraxia rarely complain and often do not seem to be aware of their deficit. Second,

many clinicians and researchers believed that apraxia would recover spontaneously; recent studies, however, suggest that apraxia can be persistent. Third, many believe that apraxia is only apparent in test situations and does not influence everyday life; again, recent studies have shown the negative impact apraxia has on daily functioning. Maher and Ochipa conclude that the influence of apraxia on independent functioning should be an important reason for clinicians to address treatment of apraxia as part of the overall treatment plan. Consequently, more studies should be designed to evaluate the efficacy of apraxia treatment. Furthermore, Maher and Ochipa state that 'future attempts at intervention might be directed toward a more applied, functional and pragmatic treatment approach in the natural environment' (pg. 88).

The present study clearly is an example of this approach. Very recently a similar study was published (Goldenberg & Hagman, 1998). Fifteen patients were admitted to their therapy study. The aim of the therapy was to restore ADL-independence. As in the present study, the therapy of Goldenberg and Hagman involved training of ADL-activities, one at a time. Therapy sessions were given by an occupational therapist five times a week, and the mean duration of therapy was about 4 weeks. Two treatment approaches were combined: assistance during the execution of an activity in order to reduce the amount of errors made, and training of details. The therapy led to a significant improvement of trained ADL-capabilities, while virtually no recovery was found when the same capabilities were not trained. The authors conclude that the patients would never have acquired ADL independence without therapy. Some patients were examined at follow-up while living at home with their families. It appeared that the rehabilitation success was stable if the patient had continued performing the ADL-activities in the home situation. In our study the positive effects of training ADL-functioning were established as well; the stability of the effects was not investigated.

Maher and Ochipa (1997) state that, depending on one's philosophy of rehabilitation, treatment approaches can be either restitutive or substitutive. Restitutive treatments are what in the present study have been denoted as drill and practice or cognitive retraining: training is aimed at restoration of the impaired function. Substitutive treatment aims to achieve the behavioural goal in a new way; e.g. by compensatory techniques. In our study, strategy training is applied, based on the use of compensatory techniques. These are designed to help the patient effectively use residual skills by finding ways to minimize the

extent to which apraxia causes problems in daily life. In strategy-training the patient is helped to master a method instead of a specific task. This should lead to generalization to other tasks besides the training task. The idea of learning a method instead of mastering a task suggests that the positive results will generalize to activities that have not been trained specifically during treatment. However, the present study was not designed to measure this effect of generalization. In our research design we did not include the observation of ADL-activities that were not trained. Nevertheless, the improvements on other measures of disabilities (i.e. Barthel index and ADL-questionnaire) were marked as well. Since in these measures other activities are incorporated, these can be considered as tasks measuring generalization and some degree of generalization seems to be present. Obviously this claim would have been stronger if specific control activities had been included in the design. Goldenberg and Hagman (1998) did design their study in order to determine the effect of generalization: activities that had not been trained during a certain week were also submitted to an ADL-test. The results showed that the effect of training remained limited to the activity trained: the success of training did not generalize to non-trained activities. The issue of generalization should, therefore, be addressed in further research.

Implications for clinical practice

Evaluation of the program by the occupational therapists

The therapy program presented in this dissertation offers the clinician guidelines for assessment and treatment. The occupational therapists who assessed and treated apractic patients according to the guidelines were interviewed at the end of the period of testing (Van Heugten, Dekker, Stehmann-Saris & Kinebanian, 1995). In total 26 therapists had used the program. In general, they were enthusiastic about the leads and instructions for diagnosis and therapy it contains. In their opinion, the program offers a clear structure for the therapeutic process.

As regards the assessment of apraxia, the therapists reported that the ADL-observations are a useful instrument: observing the four activities on the basis of a clear description of steps to follow offers the therapist relevant diagnostic information in a short period of time. They reported that at an early stage of

rehabilitation the consequences of apraxia for daily functioning became more clear. This in turn led to better communication with other disciplines, such as physical therapists. The distinction of the three aspects of an activity (i.e. initiation, execution and control) were considered theoretically logical and clear, but in the actual performance the three aspects can overlap and interpretation of performance can become difficult. Nevertheless, the therapists reported that the aspects are of practical use in that they support and structure their clinical impression, identify the nature and the consequences of the deficit and plans for treatment can be formed accordingly.
During the treatment period ADL-activities were trained that were relevant for the patient to (re)learn. This focus on disabilities resulting from apraxia was found to be very useful by the therapists. Determining treatment goals in terms of the activity to be trained in a two-week period gave the therapists a clear direction. Therapists reported that they became more aware of their own therapeutic activities; the program offers possibilities to act precisely and thoroughly.
An important observation in clinical practice is that the guidelines did not lead to routine work following strict rules. The therapy program provides opportunities to focus on each stroke patient individually. This was said to be of vital importance because each stroke patient has a unique profile of impairments and disabilities following brain damage.

Application of the therapy program

The present study has focused on apraxia in left-hemispheric stroke patients. In this sample of patients strategy-training seemed to be successful, even in aphasic patients. Apractic problems in daily functioning can, however, also occur in right-hemispheric patients. Moreover, apraxia can occur as a result of other diseases such as Alzheimer's disease (Ochipa, Gonzalez-Rothi & Heilman, 1992; Taylor, 1994) and Huntington's disease (Shelton & Knopman, 1991). The occupational therapists participating in our study reported that they also use the therapy program for patients with apraxia other than the left-hemispheric stroke patients. In clinical practice therapists can consider using this method of rehabilitation, but strategy-training for patients with apraxia due to right-hemisphere damage or diseases other than stroke should first be evaluated.

Guidelines, standards and protocols

Development of guidelines, standards and protocols for assessment and treat-

ment is important for rehabilitation and health care in general. Standardization provides tools for the professionalization of the health care disciplines. In the Netherlands the number of employed occupational therapists is growing rapidly, but the profession is still in an early stage of professionalization. The functional consequences of disease are usually assessed by occupational therapists in a non-standardized way. Almost no assessment methods to objectify and quantify the functional consequences of disease are available for the profession (Driessen, 1997). In recent years reliable and valid assessment methods have been developed in other countries (for instance, the A-one, Arnadottir, 1990; Assessment of Motor and Process Skills, Fisher, 1996) and the development of treatment protocols has gained more attention as well. The development of standardized interventions for which the efficacy and effectiveness have been determined is an important issue in the current debate concerning evidence based medicine (Dekker, 1997). This program for assessment and treatment of apraxia in stroke patients hopes to contribute to the quality of OT practice.

Implications for further research

Responsiveness of the ADL-observations

As regards the instruments for the assessment of apraxia which were used in the present study, one issue is still to be addressed in further detail. This concerns the responsiveness of the outcome measures: can the instruments be used to measure clinically relevant changes over time? The ADL-observations are considered as a primary outcome measure. For this instrument it is important to assess whether a discrimination between clinically important and clinically unimportant changes can be made. The study of prognostic factors displayed a ceiling effect: towards the positive end of the scale a number of patients did not improve much after treatment, mainly because they already functioned well before treatment. The capability of the ADL-observations to detect small improvements on an individual level should be improved further. One of the possibilities to examine responsiveness is by comparing testscores to those of an instrument for which responsiveness has already been established. In the present study this was difficult because the Barthel index was used, which is a general measure of disability and therefore not specifically suitable for patients with apraxia. Moreover, the Barthel index is known also to

display a ceiling effect which is indicative of a poor responsiveness. An alternative method would be to compare the results to an intervention which has already been found effective. Since research ontreatment outcome has only recently been started, the issue of responsiveness will be difficult to solve. Nevertheless, strong significant improvements after treatment became apparent with the ADL-observations on a group level. The effect sizes are considerable. This striking effect was found despite the number of patients in the study being small. This implies that in the present sample the instrument was at least able to detect changes over time.

Randomized controlled trial

As noted earlier, this study was a pre-experimental study and replication in an RCT is necessary: in a controlled study the efficacy of strategy-training in stroke patients with apraxia should be cross-validated. In rehabilitation research it is a common method to vary the kind of treatment. Currently an RCT is being conducted in which a comparison is made between the outcome in (I) a group of apractic patients receiving strategy-training, which is incorporated into the usual treatment by occupational therapists, and (II) a group of apractic patients receiving the usual treatment by occupational therapists (which is not strategy training)*.

Research in cognitive rehabilitation

The present study was directed towards stroke patients with damage to the left-hemisphere, leading to apraxia. Strategy-training aimed at reduction of disabilities seemed to be effective in this sample of patients. This approach has been successful in other areas of cognitive rehabilitation as well. For instance, strategy training has succesfully been applied to patients with memory impairments (e.g. Berg, Deelman & Koning-Haanstra, 1991) and slow information processing (Fasotti & Kovacs, 1995). Future research in cognitive rehabilitation could be aimed at investigating the efficacy of strategy-training in other areas (e.g. right-hemispheric damage, agnosia). Rehabilitation of patients with severe neglect, for instance, has been successful in some studies (De Kort, 1996). Robertson, Halligan and Marshall (1993) reviewed some promising ideas

*) This RCT is being conducted at the Netherlands Institute of Primary Health Care, which is supported by a grant from the Netherlands Heart Foundation and the Health Insurance Council.

for interventions which are based on the use of external aids to change the spatial representation. The present study set an example for further research. Rehabilitation of patients with apraxia by means of strategy training was shown to be successful.

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Summary

APRAXIA IN STROKE PATIENTS:

assessment and treatment

Apraxia is a disorder affecting the purposeful execution of learned and meaningful skills. Apraxia is one of the classic neuropsychological syndromes, along with aphasia, agnosia and amnesia. A patient with apraxia has difficulty with, or is not able to perform learned and purposeful activities. By definition, these disturbances in the organisation of voluntary actions are not due to primary motor or sensory impairments. Neither are these difficulties the result of lack of motivation, attention, memory or comprehension. Other impairments may be present in the stroke patient, but these deficits are not the main cause of the inability to perform purposeful acts. Diagnosis and treatment of apraxia have as yet not been structured systematically nor investigated properly. Elaboration on, and further research in this field of rehabilitation is necessary. In the present study a program for assessment and treatment of apraxia in stroke patients was developed and evaluated.

In *chapter 1* a brief introduction of the study is given. The purpose of the study was twofold. First, development of a diagnostic procedure and examination of the quality of the diagnostic instruments; and second, development of a treatment program and evaluation of the effects of treatment.

A review on apraxia is presented in *chapter 2*. Apraxia is frequently found in stroke patients, and occurs mostly following left-hemispheric lesions. Apraxia is sometimes associated with aphasia, because of involvement of contiguous structures. Many different classifications, taxonomies, and forms of apraxia are described in the literature; however, a generally accepted taxonomy for the apraxias is not available. Two forms of apraxia that have been the object of many studies were described in more detail: ideational and ideomotor apraxia. For the assessment of apraxia numerous testing procedures and scoring methods are found in the literature, but results are often inconsistent and confusing. Clinicians trying to diagnose apraxia are confronted with many other problems as well: clinical testing batteries for apraxia are hardly available, and clinicians mainly rely on personal experience and clinical reasoning; in addition, apraxia is frequently accompanied by several other cognitive deficits; and finally, patients with apraxia can fail when performance is requested, but may act correctly when behaviour is spontaneous. Treatment of apraxia has not been the subject of many research studies, and neither has much attention been paid to the identification of prognostic factors. So, at present few data are available

on methods and efficacy of rehabilitation of apraxia. Occasionally, the results of the rehabilitation of a single case are reported.

In *chapter 3* the ICIDH is presented as a framework for studying apraxia. Apraxia can be studied at two conceptual levels: at the level of the impairment, apraxia can be defined as the breakdown of the concept or plan of action, or implementation of the concept into a motor program, while at the level of disabilities the patient with apraxia experiences restrictions in the ability to carry out purposeful ADL-activities (Activities of Daily Life). Next, an overview of different treatment methods in cognitive rehabilitation is given, of which in the present study strategy-training is chosen for the rehabilitation of apractic patients.
The assessment procedure which was developed is described. Two instruments are used to assess (1) the presence and severity of apraxia (i.e. a neuropsychological apraxia test at the level of the impairment) and (2) consequences of apraxia for daily life (i.e. ADL-observations at the level of disabilities). The apraxia test consists of two subtests: demonstration of object use (i.e. to test for ideational apraxia) and imitation of gestures (i.e. to test for ideomotor apraxia). The goal of this test is to differentiate between patients with apraxia and patients without apraxia, thereby offering a method to objectify the clinician's impressions. Disabilities following apraxia were assessed by means of a set of standardized ADL-observations. Guidelines were offered for the observation and assessment of four ADL-activities. Each activity is conceptualized as being composed of three aspects: initiation, execution and control. By assessing the aspects of which an activity consists and by giving an overall judgement of the level of independence, the nature of the disabilities should be identified and plans for treatment can be formulated accordingly. The principles of strategy training are incorporated into a program, designed for assessment and treatment by occupational therapists. Treatment is aimed at improving the performance of apractic patients by teaching them strategies, which enable them to function more independently, despite the probably lasting presence of apraxia. At the end of this chapter the study research questions and the research design are presented. The following research questions are answered:

- do the subtests for ideational apraxia and ideomotor apraxia measure the same underlying concept (chapter 4)?
- does the apraxiatest have sufficient discriminative capacity to differentiate

between persons with and persons without apraxia (chpater 4)?
- to what extent do two observers agree when they independently observe the same patient performing ADL-activities (chapter 5)?
- do the items of the observational scales collectively measure the same underlying concept (chapter 5)?
- is the observational procedure valid in measuring apraxia and its consequences (chapter 6)?
- do changes occur in the functioning of patients who have been treated according to the guidelines of the therapyprogram (chapter 7)?
- what individual factors predict the outcome of the therapy program (chapter 8)?

In *chapter 4* the internal consistency and the diagnostic value of the apraxia test are presented. The internal consistency was determined by computing Cronbach's alpha, and by performing Mokken scale analysis; the testscores of a group of 44 stroke patients with apraxia were used. On the basis of Cronbach's alpha (0.96) as well as the results of the Mokken scale analysis (Loevinger's H=0.72; rho=0.97) it appears that the two subtests for ideational apraxia and for ideomotor apraxia together form a strong and consistent scale. This finding indicates that the two subtests measure the same underlying concept and that it is not possible to distinguish between the two forms of apraxia on the basis of this test.

The diagnostic value of the test is expressed by means of the sensitivity, specificity and the predictive value. The diagnostic value was determined by comparison of testresults in three groups of subjects: 44 stroke patients with a clinical diagnosis of apraxia, 35 stroke patients without a clinical diagnosis of apraxia and 50 healthy nursing home residents with no prior history of stroke. The results indicate that the sensitivity and specificity of the test are good. This conclusion is illustrated by a Receiver Operator Characteristics (ROC) curve, depicting the interaction between the indices: the area under the curve represents the overall accuracy, indicating sufficient discriminative capacity. It was concluded that the test enables a differentiation between persons with and persons without apraxia. Various possible cut-off points for the apraxia test were considered; the optimal cut-off point depends on the specific aims of assessment.

Summary

Chapter 5 describes the investigation of the internal consistency and the inter-rater reliability of the observational method for the assessment of the disabilities resulting from apraxia. The internal consistency of the ADL-observations was expressed by means of Cronbach's alpha and a Mokken scale analysis; the scores of 42 stroke patients with apraxia were used. The indices alpha (0.94), Loevinger's H (0.58) and rho (0.94) raise excellent values, which indicates that the scales of the observations together form a strong and consistent scale.
The inter-observer reliability was determined by means of percentages of agreement, Cohen's kappa, and intra-class correlation coefficients. The results showed that when two observers observe the same patient performing ADL-activities, fair to good agreement is obtained: the lowest Kappa value was 0.70, indicating fair agreement, while the reliability of the total scale was by far the best (ICC=0.98). The inter-observer reliability of the three aspects of an activity (initiation, execution and control) were not completely satisfactory. Several factors affecting the reliability were discussed: the observers, the instrument, and the subjects being observed. Training sessions are recommended in order to improve the reliability of these scores. Overall the instrument is internally consistent and a reliable method for the assessment of disabilities in stroke patients with apraxia.

In *chapter 6* the validity of the ADL-observations was investigated: does the instrument display differences in scores between patients with apraxia and patients without apraxia (clinical validity or diagnostic value) and to what extent does the assessment method measure consequences of stroke which are specific to apraxia (construct validity). Comparison of the results of a group of patients with apraxia (n=45) and a group of patients without apraxia (n=36) showed that the clinical validity of the ADL-observations is good. Highly significant differences between the groups were found for the ADL-observations. The construct validity was examined by means of correlational analyses and a LISREL analysis. The ADL-observations were significantly associated with apraxia (r=0.43; gamma=0.35), but to a lesser, but significant degree with motor impairments (r=0.37); while motor impairments correlated significantly and strongly with the Barthel index (a general measure of physical disability; r=0.57; gamma=0.50), but marginally with the ADL-observations (r=0.37). The findings indicate that the ADL-observations indeed seem to measure disabilities which are caused by the presence of apraxia.

In *chapter 7* an evaluation of the therapy program for stroke patients with apraxia is presented. To determine whether the program was successful in this respect, a group of apractic patients (n=33) was treated according to the guidelines of the treatmentprogram for a period of 12 weeks. The outcome was studied in a pre-post test design. Large improvements were found on all target measures of disability (i.e. ADL-observations, Barthel index, and ADL-questionnaire), while the improvements seen on the apraxia test and motor functioning test (i.e. the control tasks) were significant but small. The effect sizes for the disabilities were large (ranging from 0.92 to 1.06) compared to the effect sizes for apraxia (0.34) and motor functioning (0.19). These results were supported when changes in individual functioning and subjective improvement were considered. A MANCOVA for repeated measures was executed to test the change in ADL-functioning while correcting for the change in apraxia and in motor functioning, and while correcting for the time since stroke. The improvements in ADL-functioning are significant when these three covariates are taken into account. The results suggest that the therapy program is successful in teaching patients compensatory strategies, which enables them to function more independently, despite the lasting presence of apraxia.

In *chapter 8* it was investigated which additional cognitive and motor impairments are present in stroke patients with apraxia and which of these factors influence the effects of treatment. The following variables were analyzed as prognostic factors: additional neuropsychological deficits (comprehension of language, dementia-like cognitive impairments, neglect, and short term memory), initial level of motor functioning, baseline severity of apraxia and ADL-performance, and some relevant patient characteristics (gender, age, type of stroke, time since stroke, and location of treatment). The results show that the presence of apraxia is associated with the presence of additional cognitive and motor impairments. However, the outcome of treatment is not negatively influenced by this cognitive comorbidity nor by motor impairments. The outcome seems to be more prominent in patients who are more severely impaired at the start of rehabilitation in terms of the degree of motor impairments, the severity of the apraxia and the initial ADL-dependence. The ADL-observations, however, display a ceiling effect, which is taken into account in discussing these results. Demographic variables, especially age, did not predict the outcome of treatment. We conclude that there is no indication that the effect of strategy-training

is weaker in more severely disabled patients. Neither the presence of additional cognitive impairments nor the severity of motor problems nor old age should be an indication for refraining from treating patients with apraxia.

In *chapter 9* some methodological issues are considered: the size of the study sample, the age of the control group, the design of the outcome study and of the prognostic study. Next, the main findings of the study are reviewed. As regards the assessment of apraxia it is concluded that two useful, reliable and valid instruments were developed, measuring apraxia as close to the impairment level as possible by means of a neuropsychological apraxia test; and the consequences of apraxia for daily life by means of standardized ADL-observations in a more ecologically valid context. This seems to be one of the first studies offering diagnostic instruments of which the quality in terms of the reliability and validity were determined. As regards treatment it is concluded that this kind of strategytraining had a strong positive effect on the level of independent functioning in patients with apraxia; this study was one of the first to show this outcome. Effects of generalization could not be established due to the research design; this remains an important issue to address in further studies. Finally, implications for clinical practice and implications for further research are discussed.

Samenvatting

APRAXIE NA EEN BEROERTE:

diagnostiek en behandeling

Apraxie is een stoornis waarbij de doelgerichte uitvoering van aangeleerde en betekenisvolle handelingen is aangedaan. Apraxie is een van de klassieke neuropsychologische syndromen, zoals afasie, agnosie en amnesie. Een patiënt met apraxie heeft problemen met, of is niet in staat om aangeleerde en doelgerichte handelingen correct uit te voeren. Volgens de definitie van apraxie kan dit onvermogen niet worden verklaard door primaire motorische of sensorische stoornissen, noch zijn deze moeilijkheden het gevolg van een tekort aan motivatie, aandachts-, geheugen- of (taal) begripsproblemen. Andere stoornissen kunnen aanwezig zijn bij de CVA (Cerebro Vasculair Accident; beroerte) patiënt, maar deze stoornissen mogen niet de belangrijkste oorzaak zijn van de beperkingen in het dagelijks handelen. Diagnostiek en behandeling van apraxie zijn tot op heden nog weinig systematisch vorm gegeven, noch is er veel gedegen onderzoek naar diagnostiek en behandeling van apraxie verricht. Nadere uitwerking en verder onderzoek van dit onderwerp op het gebied van de revalidatie is dan ook noodzakelijk. In het huidige onderzoek is een programma (protocol) voor diagnostiek en behandeling van apraxie bij CVA patiënten ontwikkeld en geëvalueerd.

In *hoofdstuk 1* wordt een korte introductie op het onderzoek gegeven. Het doel van het onderzoek was tweeledig. Ten eerste, ontwikkeling van een diagnostische procedure en onderzoek naar de kwaliteit van de diagnostische instrumenten; en ten tweede, ontwikkeling van een behandelprotocol en evaluatie van het resultaat van behandeling.

Een literatuuroverzicht met betrekking tot apraxie wordt gepresenteerd in *hoofdstuk 2*. Apraxie treedt vaak op na een beroerte en komt vooral voor na letsel in de linker hemisfeer. Apraxie is soms geassocieerd met afasie, als gevolg van de betrokkenheid van aangrenzende hersenstructuren. Veel verschillende classificaties, taxonomieën en soorten apraxie zijn beschreven in de literatuur; echter, een algemeen geaccepteerde taxonomie voor de apraxieen is niet aanwezig. Twee soorten apraxie zijn onderwerp van veel studies en zijn in dit hoofdstuk uitgebreider beschreven: ideatoire en ideomotorische apraxie.
Voor de diagnostiek van apraxie worden talrijke testprocedures en scoringsmethoden gepresenteerd in de literatuur, maar de resultaten zijn vaak inconsistent en verwarrend. Zorgverleners die de diagnose apraxie proberen te stellen worden bovendien geconfronteerd met vele andere problemen: klinische

testbatterijen voor apraxie zijn nauwelijks verkrijgbaar en zorgverleners vertrouwen voornamelijk op persoonlijke ervaring en klinische indruk; tevens gaat apraxie nogal eens gepaard met andere cognitieve stoornissen; en tenslotte kunnen apraxie patiënten problemen vertonen bij gedrag op verzoek, terwijl spontaan gedrag correct wordt uitgevoerd.
Behandeling van apraxie is nog nauwelijks onderwerp geweest van onderzoeksprojecten; bovendien is er tot op heden ook weinig aandacht besteed aan de identificatie van prognostische factoren. Incidenteel worden de resultaten van de behandeling van een enkele patiënt gerapporteerd.

In *hoofdstuk 3* wordt de ICIDH gepresenteerd als referentiekader voor het bestuderen van apraxie. Apraxie kan worden bestudeerd op twee conceptuele niveaus: op het niveau van de stoornis kan apraxie worden gedefinieerd als een defect in het concept of actieplan, of implementatie van het actieplan in een motor- programma; terwijl op het niveau van de beperkingen de patiënt met apraxie problemen ondervindt in de mogelijkheid om doelgericht ADL-activiteiten (Activiteiten van het Dagelijks Leven) uit te voeren.
Aansluitend wordt een overzicht gegeven van verschillende behandelmethoden in de cognitieve revalidatie. In het huidige onderzoek is strategietraining gekozen voor de revalidatie van apractische patiënten.
Vervolgens wordt de ontwikkelde diagnostische procedure besproken. Twee instrumenten zijn ontwikkeld om (1) de aanwezigheid en ernst van de apraxie vast te stellen (een neuropsychologische apraxietest op het niveau van de stoornis) en (2) de gevolgen van apraxie voor het dagelijks leven vast te stellen (ADL-observaties op het niveau van de beperkingen). De apraxietest bestaat uit twee onderdelen: demonstratie van voorwerpgebruik (een test voor ideatoire apraxie) en imitatie van gebaren (een test voor ideomotorische apraxie). Deze test is bedoeld om te kunnen differentiëren tussen patiënten met en patiënten zonder apraxie, waarmee een methode wordt aangereikt om de klinische indruk te objectiveren. Beperkingen ten gevolge van apraxie worden gediagnostiseerd aan de hand van een set gestandaardiseerde ADL-observaties. Aan de hand van richtlijnen worden vier ADL-activiteiten geobserveerd en beoordeeld. Aan elke activiteit kunnen drie aspecten worden onderscheiden: initiatie, uitvoer en controle. Aan de hand van de beoordeling van deze aspecten van een handeling en een algeheel oordeel over het niveau van onafhankelijkheid, wordt de aard van de beperkingen geïdentificeerd en kunnen aansluitend plannen voor

behandeling worden geformuleerd.
De principes van strategietraining zijn verwerkt in een protocol voor behandeling door ergotherapeuten. De behandeling is gericht op verbetering van het functioneren van apractische patiënten door middel van het aanleren van strategieën, waardoor de patiënten onafhankelijker kunnen functioneren, ondanks de blijvende aanwezigheid van de apraxie. Het hoofdstuk wordt afgesloten met een beschrijving van de onderzoeksvragen en de onderzoeksopzet. De onderzoeksvragen luiden als volgt:

- meten de subtests voor ideationele apraxie en ideomotorische apraxie hetzelfde onderliggend concept of kan de test gebruikt worden om onderscheid te maken tussen verschillende vormen van apraxie (hoofdstuk 4)?
- kan de apraxietest gebruikt worden om te differentiëren tussen personen met apraxie en personen zonder apraxie (hoofdstuk 4)?
- in welke mate wordt overeenstemming bereikt als twee beoordelaars dezelfde patiënt observeren bij de uitvoer van dagelijkse handelingen (hoofdstuk 5)?
- meten de verschillende schalen waaruit de ADL-observaties zijn samengesteld gezamenlijk één onderliggend concept (hoofdstuk 5)?
- laten de ADL-observaties verschillen zien tussen patiënten met en zonder apraxie en in welke mate kan de observatiemethode gebruikt worden om de gevolgen van apraxie te meten (hoofdstuk 6)?
- treden er veranderingen op in het functioneren van apraxie patiënten die zijn behandeld volgens de richtlijnen van behandeling (hoofdstuk 7)?
- welke factoren zijn van invloed op het resultaat van de behandeling (hoofdstuk 8)?

In *hoofdstuk 4* worden de interne consistentie en de diagnostische waarde van de apraxietest gepresenteerd. De interne consistentie is bepaald aan de hand van Cronbach's alpha en Mokken schaalanalyse; de testscores van een groep van 44 CVA patiënten met apraxie werden gebruikt. Op basis van Cronbach's alpha (0.96) en de resultaten van de Mokken analyse (Loevinger's H=0.72; rho=0.97) blijkt dat de twee subtests voor ideatoire en ideomotorische apraxie samen één sterke en consistente schaal vormen. Dit resultaat betekent dat de twee subtests hetzelfde onderliggend concept meten en dat het met deze methode niet mogelijk is de twee soorten apraxie te onderscheiden.
De diagnostische waarde van de test is uitgedrukt aan de hand van de

sensitiviteit, specificiteit en de voorspellende waarde. De diagnostische waarde werd bepaald aan de hand van een vergelijking van testscores van drie groepen proefpersonen: 44 CVA patiënten met de klinische diagnose apraxie, 35 CVA patiënten zonder de klinische diagnose apraxie en 50 gezonde bewoners van een verpleeghuis die niet eerder een CVA hadden gehad. De resultaten laten zien dat de sensitiviteit en de specificiteit van de test goed zijn. Deze conclusie wordt geïllustreerd aan de hand van een Receiver Operator Characteristics (ROC) curve, waarin de interactie tussen de indices wordt uitgebeeld: het oppervlak onder de curve representeert de nauwkeurigheid van de testscores en geeft aan dat de test voldoende onderscheidend vermogen heeft. De conclusie luidt dat de apraxietest kan worden gebruikt om te differentiëren tussen personen met en personen zonder apraxie. Verschillende afkappunten voor de test zijn in overweging genomen; het optimale afkappunt hangt echter af van de specifieke toepassing van de test.

Hoofdstuk 5 beschrijft een onderzoek naar de interne consistentie en de interbeoordelaarsbetrouwbaarheid van de observatiemethode voor de diagnostiek van beperkingen ten gevolge van apraxie. De interne consistentie van de ADL-observaties is bepaald aan de hand van Cronbach's alpha en Mokken schaalanalyse; de scores van 42 CVA patiënten met apraxie werden gebruikt. De indices alpha (0.94), Loevinger's H (0.58) en rho (0.94) laten hoge waarden zien, hetgeen betekent dat de schalen van de observaties gezamenlijk één sterke en consistente schaal vormen.
De interbeoordelaarsbetrouwbaarheid werd bepaald aan de hand van percentages overeenstemming, Cohen's kappa en de intra-class correlatiecoëfficiënt (ICC). De resultaten laten zien dat als twee beoordelaars dezelfde patiënt observeren bij de uitvoering van een ADL-handeling, redelijk tot goede overeenstemming wordt bereikt: de laagste kappa is 0.70, terwijl de betrouwbaarheid van de totale schaal goed bleek te zijn (ICC=0.98). De interbeoordelaarsbetrouwbaarheid van de drie aspecten waaruit een activiteit bestaat (initiatie, uitvoer en controle) was niet geheel naar tevredenheid. Verschillende factoren die van invloed kunnen zijn op de betrouwbaarheid worden besproken: de observatoren, het instrument en de personen die geobserveerd worden. Training-sessies worden aangeraden om de betrouwbaarheid van deze scores te verbeteren. In zijn geheel is het instrument intern consistent en een betrouwbare methode voor de diagnostiek van

beperkingen ten gevolge van apraxie bij CVA patiënten.

In *hoofdstuk 6* is de validiteit van de ADL-observaties onderzocht: laten de ADL-observaties verschillen zien tussen patiënten met en patiënten zonder apraxie (klinische validiteit) en in welke mate kan de observatiemethode gebruikt worden om gevolgen van een beroerte te meten die specifiek zijn voor apraxie (construct-validiteit)? Vergelijking van een groep CVA patiënten met apraxie (n=45) en een groep CVA patiënten zonder apraxie (n=36) laat zien dat de klinische validiteit van de ADL-observaties goed is. Sterk significante verschillen werden gevonden tussen de groepen op de ADL-observaties. De construct-validiteit is bepaald aan de hand van correlatieanalyses en een LISREL analyse. De ADL-observaties zijn significant geassocieerd met apraxie (r=0.43; gamma=0.35), maar in mindere mate met motorische stoornissen (r=0.37). Motorische stoornissen zijn sterk significant gecorreleerd met de Barthel index (een algemene maat voor fysieke beperkingen; r=0.57; gamma=0.50), maar slechts in geringe mate met de ADL-observaties (r=0.37). De resultaten geven aan dat de ADL-observaties inderdaad gebruikt kunnen worden om beperkingen te meten die veroorzaakt worden door apraxie.

In *hoofdstuk 7* wordt de evaluatie van het behandelprotocol voor CVA patiënten met apraxie gepresenteerd. Om te kunnen bepalen of de behandeling succesvol is, is een groep CVA patiënten met apraxie (n=33) behandeld volgens de richtlijnen van het behandelprotocol voor een periode van12 weken. Het resultaat van de behandeling is bestudeerd aan de hand van een pre-post testdesign. Grote verbeteringen in functioneren werden gevonden op alle targetmetingen van beperkingen (de ADL-observaties, de Barthel index en een ADL-vragenlijst), terwijl de verbeteringen op de apraxietest en de test voor motorisch functioneren (de controle metingen) significant, maar klein waren. De effectgroottes voor de beperkingen waren groot (variërend van 0.92 tot 1.06) in vergelijking met de effectgroottes voor apraxie (0.34) en motorisch functioneren (0.19). Deze resultaten werden ondersteund door verbeteringen op individueel niveau en subjectief ervaren verbeteringen in functioneren. Een MANCOVA voor herhaalde metingen werd uitgevoerd om te bepalen of de veranderingen in ADL-functioneren kunnen worden aangetoond na correctie voor de verandering in apraxie en motorisch functioneren en na correctie voor de tijd die sinds het CVA verstreken is. De verbeteringen in ADL-functioneren bleken significant te zijn

wanneer deze drie covariaten worden meegenomen in de analyses. De resultaten suggereren dat het behandelprotocol succesvol is in het aanleren van compensatoire strategieën, waardoor de patiënten zelfstandiger functioneren ondanks de aanwezigheid van apraxie.

In *hoofdstuk 8* is onderzocht welke bijkomende cognitieve en motorische stoornissen aanwezig zijn bij de CVA patiënt met apraxie en welke van deze factoren van invloed zijn op het resultaat van de behandeling. De volgende variabelen zijn geanalyseerd als mogelijke prognostische factoren: bijkomende neuropsychologische functiestoornissen (problemen met taalbegrip, dementie-achtige cognitieve stoornissen, neglect en problemen met het korte termijn geheugen), het niveau van motorisch functioneren, de aanvankelijke ernst van de apraxie en ADL-functioneren en enkele relevante patiëntenkenmerken (geslacht, leeftijd, soort CVA, tijd sinds het CVA en plaats van behandeling). De resultaten laten zien dat de aanwezigheid van apraxie is geassocieerd met de aanwezigheid van andere neuropsychologische en motorische stoornissen. Het resultaat van de behandeling wordt echter niet negatief beïnvloed door deze cognitieve co-morbiditeit, noch door motorische stoornissen. Het behandelresultaat lijkt beter te zijn bij patiënten die aan het begin van de behandelperiode slechter functioneren in termen van de ernst van de motorische stoornissen, de ernst van de apraxie en de ADL-afhankelijkheid. De ADL-observaties laten echter een plafondeffect zien, hetgeen is meegenomen in de discussie van de resultaten. Demografische variabelen, met name leeftijd, bleken geen voorspellers te zijn van het resultaat van de behandeling. Er is geconcludeerd dat er geen indicatie is om aan te nemen dat het effect van strategietraining zwakker zou zijn bij slechter functionerende patiënten. Ook de aanwezigheid van bijkomende cognitieve stoornissen, noch de ernst van motorische problemen of een hoge leeftijd zouden een reden kunnen zijn om af te zien van behandeling van patiënten met apraxie.

In *hoofdstuk 9* tenslotte worden enkele methodologische zaken besproken: de grootte van de onderzoeksgroep, de leeftijd van de controlegroep en de opzet van de effectstudie en de prognostische studie. Vervolgens zijn de belangrijkste resultaten van het onderzoek onder de loep genomen. Met betrekking tot de diagnostiek van apraxie is geconcludeerd dat twee bruikbare, betrouwbare en valide instrumenten zijn ontwikkeld, waarmee (1) apraxie zo dicht mogelijk bij

het niveau van de stoornis wordt gemeten aan de hand van een neuropsychologische apraxietest; en waarmee (2) de gevolgen van apraxie voor het dagelijks leven worden gemeten aan de hand van gestandaardizeerde ADL-observaties in een meer ecologisch-valide context. Dit is een van de eerste studies die diagnostische instrumenten oplevert, waarvan de kwaliteit in termen van betrouwbaarheid en validiteit is bepaald. Wat betreft de behandeling van apraxie is geconcludeerd dat strategie training een sterk positief effect heeft op het niveau van onafhankelijk functioneren van patiënten met apraxie; dit onderzoek was een van de eerste studies waarin dit resultaat is aangetoond. Generalisatie-effecten konden niet worden onderzocht op basis van de huidige onderzoeksopzet. Generalisatie blijft echter een belangrijk onderwerp voor verder onderzoek. Tenslotte worden implicaties voor de klinische praktijk en implicaties voor toekomstig onderzoek besproken.

MET DANK AAN ....

Het doek valt. Het was een mooi toneelstuk. De spelers komen nog even terug op het podium om hun welverdiende applaus in ontvangst te nemen. Er verschijnen nu veel meer mensen op het toneel dan tijdens de voorstelling te zien waren. De produktie kwam tot stand door een bundeling van vele krachten, op het podium maar vooral ook erachter.

Dit is ook het geval bij de totstandkoming van een proefschrift. Zonder de steun en hulp van velen, zowel voor de schermen als erachter, was deze dissertatie nooit geworden wat het nu is: een prestatie om trots op te zijn. Het schrijven van mijn dissertatie zal mij dan ook altijd doen herinneren aan een belangrijke periode in mijn leven, maar vooral ook aan alle mensen die in die periode op welke manier dan ook voor mij een rol hebben gespeeld. Hen wil ik graag vanaf deze plek bedanken.

Op de eerste plaats gaat mijn dank uit naar mijn beide promotoren, prof.dr. B.G. Deelman en prof.dr. J. Dekker. Betto, mijn tochtjes naar Groningen hebben mij altijd veel inspiratie opgeleverd; bijzondere waardering heb ik voor de wijze waarop je mijn werk altijd zeer nauwkeurig en uitgebreid hebt beoordeeld, terwijl je ook de grote lijnen van het onderzoek niet uit het oog verloor. Joost, je was mijn projectleider, co-promotor en uiteindelijk ook mijn promotor, maar je was bovenal een zeer waardevolle coach. Ik dank je voor de vele leermomenten en het vertrouwen tijdens het gehele traject.

Veel dank ben ik verschuldigd aan Fieneke Stehmann-Saris en Astrid Kinebanian. Fieneke en Astrid, het hele voortraject van dit promotieonderzoek kwam uit jullie koker. Jullie hebben mij enorm veel geleerd over de ergotherapie en mij waardering voor het vak gebracht. Onze samenwerking in de projectgroep heb ik als bijzonder prettig ervaren.
Ook Esther Steultjens heeft haar deskundigheid en enthousiasme op het gebied van de ergotherapie en neuropsychologie met mij gedeeld. Esther, hopelijk kan ik jou in toekomstig onderzoek nog eens van dienst zijn.

De Hogeschool van Amsterdam, de Nationale Commissie Chronisch Zieken en het NIVEL hebben dit promotieonderzoek in praktische en financiële zin mogelijk gemaakt.

Met dank aan ....

Een drietal personen wil ik met name noemen voor hun inspanningen rond de presentatie van het boekje. Lieneke Noteboom, zeer consciëntieus heb je de Engelse teksten van correcties voorzien; onze besprekingen hadden bovendien een prettig karakter. Mieke Cornelius, na een voorzet van mijn ouders heb je - ondanks mijn wat afwijkende wensen - voor een mooie omslag gezorgd. Josien Houben, met veel geduld en doorzettingsvermogen heb je de binnenkant verzorgd; het is fijn dat niet alleen ik het er perfect wilde laten uitzien.

Mijn collegae op het NIVEL en de vele gezichten van 'paramed' in het bijzonder, hebben altijd gezorgd voor een fijne en vruchtbare werkomgeving: naast serieuze momenten was er gelukkig ook genoeg tijd voor een vrolijke noot. Mijn paranimfen, Margriet en Suzanne, hebben vooral een belangrijke rol gespeeld. Margriet, je bent mijn collega, kamergenoot en promotiemaatje, maar bovenal ook een vriendin.
Deze dissertatie is voltooid tijdens mijn aanstelling bij het iRv. Mijn iRv en Synchron collegae hebben het laatste jaar intensief meegeleefd en een prima omgeving gecreëerd om de klus te klaren.

Dank gaat ook uit naar alle ergotherapeuten die hebben meegewerkt aan het onderzoek. De fase waarin het protocol voor diagnostiek en behandeling werd uitgetest op de afdelingen ergotherapie was van essentieel belang voor het slagen van het project. Daarbij hebben de patiënten uiteraard een belangrijke rol gespeeld: zonder hun was dit proefschrift nooit geschreven. Vanaf deze plaats wil ik graag de patiënten - en hun familie - bedanken voor hun medewerking aan het onderzoek.

Uiteraard vergeet ik mijn naaste familie en goede vrienden niet. Ik kan helaas niet iedereen persoonlijk bedanken, maar de interesse in mijn werk en vooral ook de afleiding die velen mij bezorgd hebben door leuke dingen te doen is van grote waarde geweest.

Peter, ik weet dat je op deze plek liever niet genoemd wilt worden. Maar de moeizame eindsprint was zonder jou toch een stuk minder aangenaam geweest en wat er ook gebeurt, dat verandert niet meer. Mijn oprechte dank voor de liefde, warmte en goede zorgen waarmee je mij het laatste jaar hebt omringd.

Tenslotte richt ik het woord tot mijn ouders. Pappa en Mady, het boekje is eindelijk klaar. Ik wil jullie bedanken voor de onvoorwaardelijke steun en het vertrouwen in alles wat ik wil doen. Er is altijd belangstelling voor mijn volgende onderneming; mijn verhalen zijn altijd welkom. De voedingsbodem voor het schrijven van deze dissertatie was zeer vruchtbaar en werd gekoesterd tot het einde toe. De dissertatie is ook van jullie, simply for being there.

CURRICULUM VITAE

Caroline van Heugten werd geboren op 31 juli 1965 te Leiden. Zij volgde het VWO aan de Christelijke Scholengemeenschap "de Vlietschans" te Leiden en behaalde in 1984 haar diploma. In 1987 begon zij, na enkele startproblemen, aan haar studie Psychologie aan de Rijksuniversiteit te Leiden. Haar doctoraalexamen behaalde Caroline - overigens zonder finishproblemen - met lof in 1992. Tijdens haar studie heeft zij een jaar doorgebracht aan de University of Massachusetts (Amherst, USA), alwaar zij haar scriptie-onderzoek verrichtte. Het onderwerp betrof bewegingscoördinatie, een specialisatie binnen haar afstudeerrichting Functieleer.

Vanaf 1 januari 1993 was Caroline als onderzoeker werkzaam bij het Nederlands Instituut voor Onderzoek van de Gezondheidszorg (NIVEL) te Utrecht. Bij het NIVEL is het promotie-onderzoek uitgevoerd, naast een aantal andere onderzoeksprojecten met name op het gebied van de paramedische zorg. Naast haar werk als onderzoeker, volgde zij enkele cursussen op het gebied van de epidemiologie en (project)management.

Medio 1997 is Caroline aangesteld bij het Kenniscentrum voor Revalidatie en Handicap (iRv) te Hoensbroek. Als senior staflid is zij tevens primair verantwoordelijk voor Synchron, het coördinatiecentrum chronisch zieken te Limburg. Het proefschrift is in Hoensbroek voltooid.

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