THE RELATIVE DISCRIMINATORY POWER OF A SELECTION OF NEUROPSYCHOLOGICAL TESTS IN ALZHEIMER'S DISEASE

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DECLARATION

I declare that this thesis is my own work and that all the sources I have used or quoted have been indicated and acknowledge by means of complete references.

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CHAPTER 1: INTRODUCTION AND LITERATURE REVIEW

1. Course, Etiology and General Clinical Features of Alzheimer's Dementia

The course, etiology and general clinical features of Alzheimer's Dementia have been extensively described in the literature (for example, Diagnostic and Statistical Manual of Mental Disorders-III-Revised, DSM-III-R, 1987; Lezak, 1983; Lishman, 1978; Walsh, 1985; Walsh, 1987; White, 1992). This section contains a synthesis of the information on Alzheimer's Dementia contianed in these general psychiatric and neuropsychological texts.

A Dementia is defined by the DSM-III-R (1987) as an organic syndrome involving the "...impairment in short and long term memory, associated with impairment in abstract thinking, impaired judgement, other disturbances of higher cortical function, or personality change." (p.103). Dementia of the Alzheimer's Type is a disease with an insidious onset involving a generally progressive and deteriorating course. It accounts for approximately fifty percent of patients with dementia. It is estimated that it occurs in one out of every 20 people over the age of 65 . The prevalence of Alzheimer's disease increases dramatically with age. Therefore, because of the trend toward extended life span in the modern day

population, the number of individuals with the disease will rise significantly in the foreseeable future.

The etiology of this disease is still largely a mystery, although it has been discovered that there is a strong genetic component. There is a two to six times greater risk of contracting Alzheimer's Disease in first degree relatives of people with the disease than first degree relatives of healthy people. Environmental factors and/or non-genetic factors may contribute to the manifestation of Alzheimer's disease as suggested by studies of monozygotic identical twins which found that the time of the onset may differ markedly for each sibling.

Alzheimer's Disease is further described as the progressive degeneration of nerve cells within the cerebral hemispheres accompanied by a progressive global deterioration of intellect and personality. Neurologically, Alzheimer's Disease is associated with the presence of neurofibrillary tangles (tangled bunches of fine fibres within the nerve cell bodies) and senile plaques (products and by-products of neuronal degeneration), both of which occur throughout the brain but especially in the hippocampal and amygdaloid areas. Senile plaques are also frequently found in the parietal lobe. Computerized Tomography (CT) scans often reveal evidence of cerebral atrophy in the form of thinning of the cortical mantle, enlargement of the lateral ventricals and a flattening of the surface ventricles. Biochemical abnormalities of

certain neurotransmitters have been reported in post-mortem examinations . Although CT scans can be useful in the diagnosis of Alzheimer's disease, a definitive diagnosis on a physiological basis can only be made on post-mortem as ante-mortem examinations have proved to be unreliable and inaccurate.

The earliest signs of Alzheimer's disease are not physiological but usually occur on a cognitive and behavioral level and consist of failing memory, depression and irritability. The onset is insidious and family members are often unaware that there is anything wrong until the patient becomes confused and disorientated when forced to deal with unfamiliar situations. The onset is so gradual that most simple functions remain intact and therefore undetected by informal testing of language, sensory and motor functions. Early symptoms of inattentiveness, mild cognitive dulling, social withdrawal and emotional blunting or agitation are often confused with depression. At this point orientation usually remains intact even though there are subtle signs of cognitive impairment. A neurological disorder is usually only suspected when the deterioration has developed to the point of behavioural changes such as severe amotivation, continuous and inappropriate repetition of old habit patterns, aggressive demands and irritability, poor judgement and inability to care for oneself.In the final stages of the disease, the patient experiences apraxias, impaired speech production, disturbances of posture and gait as well as incontinence which leaves him/her totally debilitated. The disease eventually results in the death of the patient.

The initial signs of subtle cognitive dysfunction occur before neurological or physiological change, thus neuropsychological assessment is a very important tool in the detection of Alzheimer's Disease. This has led clinicians including Lezak (1983), Walsh (1985) and more recently White (1992) to recognise that there is a great need for neuropsychological tests that are sensitive to Alzheimer's disease and that will aid in the diagnosis thereof.

2. A Unitary versus a Multidimensional Approach to Neuropsychological Assessment

Authors such as Lezak (1983) and Walsh (1985 and 1987) provide an outline of the early history of clinical neuropsychology which initially resulted in the formation of a unitary approach to neuropsychological assessment. Later developments, which led to the rejection of the unitary approach in favour of a multidimensional approach, are also delineated by the above authors. The following paragraphs contain a synthesis of their discussions of these developments.

Neuropsychological Assessment as an applied science began to develop on a large scale in the 1930's when there was a dramatic increase in brain damage incurred by soldiers as a result of war-related injuries. In the short-term this created a specific need for the screening and diagnosis of brain-injury in soldiers. This also had a more long term effect on the field of neuropsychology in

that there was an increase in cooperation between the members of the medical profession and psychologists, who began to show interest in other areas of neuropsychology such as brain related illnesses, mental retardation and gerontology. At this time an approach to neuropsychological assessment known as the "Unitary Approach" began to emerge.

2.1 Unitary Approach: Many clinicians such as Goldstein (1939) treated brain-damage as if it were a unitary phenomenon known as "organicity". It was assumed that brain-damage was characterised by a single, universal behavioural defect. It was believed that a solitary test such as the Visual Motor Gestalt Test (Bender, 1938) or the Memory-for-Designs (Kendall, 1966), would be useful in diagnosing brain-damage. Neuropsychological assessment consisted of the administration of only one test, such as one of those mentioned above, which, on its own, would supposedly indicate if a person was brain-damaged or not. This procedure proved to be invalid in that no matter what test was used a large percentage of patients who were organically impaired remained undetected by the test. Furthermore, it was discovered that functional illnesses could not be distinguished from organic illnesses on the basis of any single test used in isolation.

2.2 Multidimensional Approach: The realisation that there is no single phenomenon that is unique and common to all people with brain-damage, along with an improved understanding of the

functioning of the brain, resulted in a new approach to neuropsychological assessment. Brain damage was now seen as a multidimensional phenomenon. Researchers such as Luria (1970) and Wepman (1968) recognised that the results of brain damage vary from person to person according to factors such as the nature, severity, location and duration of the damage.

This recognition resulted from conclusions drawn from a large body of research which showed that various regions of the brain govern different behavioural, cognitive, and emotional functions. Various aspects of the neuropathology involved, as well as different types of pathology, will therefore result in different effects on the functioning of the brain-damaged patient. For example, a space-occupying lesion (tumour) will effect the functioning of a person depending on its location, size and type. Furthermore, a tumour which causes localised and generalised diffuse damage owing to the pressure it exerts, will have different effects on a person's functioning than a dementia such as Alzheimer's disease which results in generalised diffuse damage owing to cerebral atrophy.

This information has led to a change of approach in neuropsychological assessment. The emphasis in assessment is now on the measurement of different functions to determine if there has been a deterioration or loss of a specific function which can be linked to a particular neuropathological process. A deterioration or loss of a function is known as a deficit and the process is

therefore known as deficit measurement. However, in order for the neuropsychologist to reach any useful conclusions in the diagnosis of pathology, it is important to have a working knowledge of the patterns of deficits that occur with various types of pathology. Therefore, studies of deficits occurring in specific illnesses has been an important focus of recent research.

3. Cognitive Deficits in Alzheimer's Disease

As far as can be ascertained, prior to 1985 there are very few research papers which examined the types of cognitive deficits occurring in Alzheimer's Disease. However, since then, this body of research has grown considerably. The following deficits have been found to occur commonly in people with Alzheimer's Disease:

Visuo-Spatial Perception: This refers to the processing of visual information such as drawings, with regard to factors such as their dimension, shape and orientation in space. Numerous studies have compared copies of simple drawings made by Alzheimer's patients to copies of drawings made by normal elderly subjects who were matched for age and education. These studies all found marked visuo-spatial impairment in the subjects with Alzheimer's Disease (Cronin-Golomb, Corkin, Rizzo, and Cohen, 1991; Freedman and Oscar-Berman, 1989; Grossi, Orsini, and Ridente, 1977; Grossi and Orsini, 1978; Henderson, Mack, and Williams, 1989; Huber, Shuttleworth, and Friedenberg, 1989; Kirk and Kertesz, 1991; Nissen et al., 1985;

Ska, Poissant, and Joanette, 1990; Sulkova and Amberla, 1982; Teng, Chui, Schneider, Metzger, 1987).

In a comparative study of patients with Alzheimer's Dementia and patients with Multi-Infarct Dementia, Gainotti, Parlato, Monteleone, and Carlomagno (1992) used copies of drawings and the Ravens Progressive Matrices respectively in order to ascertain whether there was visuo-spatial impairment in the samples. They discovered that both samples showed signs of visuo-spatial impairment when compared to a normal control group. On a quantitative level the severity of impairment was the same for Alzheimer's patients and Multi-Infarct patients. However, qualitatively the Alzheimer's patients were more severely impaired. They tended to produce "odd" responses that were markedly different from the correct responses, whereas the responses of the Multi-Infarct patients approximated the correct response.

Delis et al. (1992) looked at visuo-spatial deficits in different sub-groups of people with Alzheimer's Disease. They claimed that clinicians in the past have divided Alzheimer's patients into two groups: those who performed better in visuo-spatial tasks than verbal tasks and vice-versa. Clinicians then tended to class them as verbally impaired or visuo-spatially impaired respectively. However, Delis et al. claim that the above distinction is misleading. They discovered that both groups had visuo-spatial deficits but that they differed qualitatively in their impairment.

The group who had visuo-spatial strengths could correctly perceive the stimulus as a whole, but displayed visuo- spatial impairment when analysing the local features, or details of complex visual stimuli. The group with verbal strengths were able to analyze local features but displayed deficits mainly in analysing the global features of complex stimuli - they were unable to perceive accurately the stimulus as a whole.

Verbal Memory. Verbal memory refers to memory tasks which involve a language component such as memory of words and sentences. Research has shown that Alzheimer's patients have deficits in several areas of verbal memory functioning including

a) verbal immediate free recall. Immediate free recall refers to the ability to remember information a few seconds after having encountered this information for the first time. Verbal immediate free recall is often tested by reading a list of words or a paragraph to the subject and then asking him/her to repeat it soon after the examiner has read the list or paragraph. Research using tests such as Paired Associates and Logical Memory of the Wechsler Memory Scale have found that people with Alzheimer's disease are impaired in this function (Baddeley, Della Sala, and Spinnler, 1991; Bayles, Boone, Tomoeda, and Slauson, 1989; El Awar, Becker, Hammond, Nebes, and Boller, 1987; Grafman et al., 1990; Helkala, Laulumaa, Soininen, and Riekinen, 1989; Herlitz and Backman, 1990; Kopelmen, 1986; Lines et al., 1991; Mitchell, Hunt, and Schmit,

1986; Moss, Albert, Butters, and Payne, 1986; Parlato, Carlomagna, Merla, and Bonavita, 1988; Strauss, Weingartner, and Thompson, 1985; Tienney, Snow, Reid, Zorzitto, and Fisher, 1987; Troster et al., 1993).

b) verbal delayed recall. Delayed recall refers to the ability to remember information ranging from approximately an hour to a few days after having being presented with the information. The same or similar tests to the ones mentioned in the paragraph on immediate recall were used by various researchers. Alzheimer's patients were found to perform worse than normal subjects on tasks involving delayed recall (Bayles et al., 1989; El Awar et al., 1987; Hart, Kwentus, Taylor, and Harkins, 1987; Hartman, 1991; Helkala et al., 1989; Knopman and Ryberg, 1989; Kopelman, 1986; Lines et al., 1991, Moss et al., 1986; Troster et al., 1993).

c) verbal recognition. This refers to the ability to remember that one has recently encountered a stimulus after being presented with the same stimulus for a second time. Verbal recognition is often tested by presenting a list of words to a subject and then presenting a list of words consisting of new words as well as words form the first list. The subject is required to indicate the words that are common to both lists. Patients with Alzheimer's disease have been found to be impaired on tasks involving verbal recognition (Abenhuis, Raaijmakers, and van Woerlan, 1990; El Awar et al., 1987; Hartman, 1991; Lines et al., 1991)

d) new learning ability. This refers to the ability to further increase the amount of information remembered after an initial memory task. This is usually tested by using the same test as for immediate recall but repeating the test for several trials in order to see if the subject continues to learn the new information. Research has shown that People with Alzheimer's Disease have impaired new learning ability (El Awar et al., 1987; Lines et al., 1991; Parlato et al., 1988; Strauss et al., 1985)

e) verbal incidental recall. This refers to the ability to remember information without the involvement of conscious effort to store the information. Subjects are presented with verbal information in a task not directly related to memory, without being told that they will have to recall this information at a later stage. The subjects are then asked to recall the information after the subject matter has been withdrawn by the researcher. Alzheimer's patients have been shown to be deficient in this function (Grafman et al., 1990; Strauss et al., 1985).

f) verbal working memory. This involves the ability to perform the dual task of holding information in short-term memory and manipulating that information in some way in order to provide the correct solution. Baddeley, Logie, Bressi, and Della Sala, (1986) found Alzheimer's patients to have deficits in verbal working memory.

g) retrieval from verbal long term memory - deficits in verbal fluency and/or the presence of anomia. Long term memory retrieval involves the ability to retrieve information that was well known and learned in the past. Two examples of deficits in this memory function are impaired verbal fluency and anomia. The former refers to the inability to spontaneously generate words. The latter refers to the inability to recall the correct words for objects, actions etc. Verbal fluency is often tested using the Controlled Word Association Test in which the subject is allowed one minute to recall as many words beginning with the letter "F", as s/he can. The process is repeated using the letters "A" and "S". Research using this test or similar variations has shown that patients with Alzheimer's Disease have deficits in long term memory retrieval in that they display poor verbal fluency and/or anomia (Bayles et al. 1989; Emmery and Breslau, 1989; Hart, Smith, and Swash, 1988; Huber et al.; 1989; Kirshner, Well, and Kelly, 1984; Lines et al., 1991; Nicholas, Ober, Albert, and Helm-Estabrooks, 1985; Ober, Donkers, Koss, Delis, and Friedland, 1986; Powell, Cummings, Hill, and Benson, 1988; Tienney et al., 1987).

Non-verbal memory: Non-verbal memory refers to memory tasks which do not involve a verbal component including memory of shapes, drawings and spatial relationships. Research has shown that patient's with Alzheimer's disease have deficits in several non-

verbal memory functions. These functions are similar to those of verbal memory, except that they involve the memory of non-verbal material. Researchers used non-verbal memory tests such as the Visual Reproduction sub-test of the Wechsler Memory Scale. It has been found that patients with Alzheimer's disease have deficits in the following non-verbal memory functions:

a) **non-verbal free recall** (Baddeley et al., 1991; Hartman, 1991; Herlitz and Backman, 1990; Moss et al., 1986; Troster et al., 1993).

b) **non-verbal delayed recall** (Moss et al., 1986; Troster et al., 1993)

c) **non-verbal new learning ability** (Freedman and Oscar-Berman, 1989)

d) **non-verbal incidental learning** (Hart, Kwentus, Wade, and Hamer, 1987; Knopman and Nissen, 1987). The latter researchers found that only some patients with Alzheimer's disease had deficits in this area. This research did not divide patients according to the severity of their dementia. This could be a possible explanation for the inconsistent findings of this research.

e) **non-verbal working memory** (Filoteo et al., 1992). These researchers examined the difference in performance of Alzheimer's

patients in directed and divided attention tasks in comparison to a normal sample matched for age and education. Directed attention involves a task where the subject's attention is directed to one unitary stimulus. Divided attention refers to a task where the subject has to work simultaneously with two different stimuli. This is called double tracking by Lezak (1982) and is also known as working memory (Baddeley, 1986). In order to test directed attention, their subjects were asked to copy global stimuli (large shapes) made up of local stimuli (smaller shapes) of the same type, for example a large figure of the number 1 made up by smaller figures of the number 1. In order to test divided attention, their subjects were asked to copy global stimuli made up of local stimuli that were different to the global stimuli for example a large 1 made up of small 2's. The research found that the Alzheimer's patients showed cognitive slowing in the directed attention task when their scores were compared to a normal age related control group. The scores of the Alzheimer's patients in the divided attention task were disproportionately slower than the controls, indicating that Alzheimer's patients were impaired with regard to directed attention. Although the researchers have neglected to state explicitly the specific modality that they were looking at, it is clear that they were dealing with the visuo-spatial modality. It can, therefore, be concluded that the above research found that people with Alzheimer's disease have impairment in the area of visuo- spatial working memory.

Cognitive slowing: It has been found that people with Alzheimer's disease take longer to perform cognitive tasks (regardless of the nature of the task), than normal controls of similar age and education (Friedman, Hamberger, Stern, and Marder, 1992; Filoteo et al., 1992; Ker et al.,1992; Nebes and Brady,1992).

4. Factors concerning the Patient that influence Neuropsychological Assessment

Apart from the nature of brain damage, a further group of factors that have influenced the modern multidimensional approach involves the recognition that the demographic details of a patient have an effect on cognitive, behavioural and emotional functioning.

4.1 Aging: One important factor is that of age. Part of the normal ageing process involves structural changes in the brain which are similar (but less extreme) to the atrophy that occurs in some of the dementing illnesses (Jernigan, Zatz, Feinberg and Fein, 1980). It is, therefore, not surprising that many researchers have found that elderly people perform more poorly then younger people on certain tasks involving the following functions: new learning ability especially in tasks such as the supraspan which involves learning one item beyond the person's normal storing capacity (Craik, 1977); verbal recall (Botwinick and Strorandt, 1980);

nonverbal memory (Joy, Fein and Kaplan, 1992; Riege and Williams, 1980; Bode and Shuttleworth-Jordan, 1993); abstract conceptualisation (Botwinick, 1977); adaptation to new situations and solving of problems not previously encountered (Botwinick, 1977); cognitive slowing (Botwinick,1977; Kramer and Jarvik,1979); motor slowing (Benton,1977).

4.2 Education:

The extent of education is also a factor that effects a person's level of performance on neuropsychological tests (Lezak, 1983; Walsh, 1987). Researchers such as Finlayson, Johnson, and Reitan (1977) and Stanton, Jenkins, Savageau, and Zyzanski (1984) reported that in clinically normal people, higher education was associated with better performance. The same conclusion was also reached, regarding people with neuropathology (Finlayson, 1977). A danger lies in comparing the scores of a person with higher education with those of a person of lower education. A person with higher education may have a superior premorbid functioning. However, even though neuropathology could result in a loss of functioning, s/he may still be able to perform at the same level as a person with lower education who is neurologically intact. It is, therefore, necessary when doing a neuropsychological assessment to compare a person's scores with normative data obtained from populations of equivalent education.

Furthermore, Lezak (1983) and Naugle, Cullum, and Bigler (1990) suggest that higher education may allow for a degree of compensation, so that relatively elementary tasks and/or tasks emphasised by educatory systems may not reflect deficits in neurologically impaired individuals even when their scores are compared to normal people of equivalent education. Therefore certain tests that are sensitive to neuropathology in people with a relatively low education may not be as sensitive in people with a relatively high education. For example it is feasible that the Supraspan Test- which involves a relatively elementary level of verbal new learning (a cognitive function emphasised by Western education) may be less sensitive to neuropathology such as Alzheimer's Disease, in people with a relatively high level of education.

5. Three studies which collected normative data concerning elderly subjects with more than ten years of education

During the last two years, three papers were made available which provide normative data for elderly people on a South African population, who had more than 10 years of education. Bode and Shuttleworth-Jordan (1993) collected normative data on the Finger Tapping, Digit Symbol and Digit Symbol Incidental Recall tests. Shuttleworth-Jordan (1992) provided normative data on the Digits

Forward, Digits Backward, Digits Difference and Supraspan Tests. Finally Cornfield and Shuttleworth-Jordan (1994) obtained normative data on the Trail Making Test parts A and B. These three research projects used the same basic sample for their research although in each study certain subjects were excluded or added to the original sample for various reasons. For example, Cornfield and Shuttleworth-Jordan (1994) had access to an additional number of subjects and decided to take advantage of this in order to increase their sample size. Bode and Shuttleworth-Jordan (1993) had to exclude certain subjects, who had participated in the study of Shuttleworth-Jordan (1992), which only involved verbal functions, because of physical ailments such as arthritis which resulted in an impairment of manual dexterity.

6. Previous research concerning the neuropsychological tests that were used in the above studies

Finger Tapping Test

Numerous forms of the Finger Tapping Test have been used as a measure of manual dexterity. One frequently employed form of this test requires the subject to tap repeatedly a target within a specified length of time. For the sake of simplicity this section will refer to any study that uses a timed test where the subject is required to perform simple repetitive movements of the fingers

without the simultaneous involvement of any other cognitive tasks. Lezak (1983) claims that motor slowing occurs with age, particularly over the age of 60. Several research papers (Nagasaki, Itoh, Maruyama, and Hashizume, 1988; Shimoyama, Ninchoji, and Uemura, 1990; York and Biederman, 1990) have found that aging has a significant effect on the Finger Tapping Test. Studies have also shown that subjects with various neurological disorders are slower in the Finger Tapping Test than normal subjects. These disorders include Parkinson's Disease (Nagasaki et al., 1988; Shimoyama et al., 1990), Cerebrovascular accidents (Najenson, Ron, and Behroozi, 1989; Shimoyama et al., 1990) and Cerebellar disease (Shimoyama et al., 1990). Muller, Weisbrod, and Klingberg (1991) found that subjects in the early stages of Alzheimer's Disease also performed significantly slower than normal subjects in the Finger Tapping Test. However, as far as it can be ascertained, there are no studies of the Finger Tapping Test on people with Alzheimer's Disease who have been stratified for a relatively high level of education.

Digits Forward and Digits Backward

Lezak (1983) states that Digits Forward is a test related to attention span rather than memory per se. The Digits Backward test involves working memory i.e. the person has to perform the dual task of storing information and manipulating the data in order to produce the correct response (Lezak;1983). Numerous studies (Black

and Strub, 1979; Costa, 1975; Mcfie, 1969; Richardson, 1977; Weinberg, Diller, Gerstman, and Shulman, 1972) support the hypothesis that a lowering of scores in the Digits Forward test is related to left hemisphere brain-damage whereas the lowering of scores in the Digits Backwards test is related to right hemisphere and/or diffuse brain-damage. This body of research supports Lezak's claim (1983) that the performance in the Digits Forwards Test is not affected by right hemisphere damage or the diffuse damage that occurs in Alzheimer's Disease. Black (1983) found that there was a strong correlation between low scores obtained by subjects with right hemisphere damage in the Digits Backward Test and scores that they obtained in the Bender-Gestalt Test. This supports the hypothesis that the Digits Backwards Test is affected by visuo-spatial impairment caused by right hemisphere damage. However, in the same study Black (1983) found that there was a weak correlation between low scores obtained by subjects in the Digits Forward and the number of errors in the Bender-Gestalt Test. This suggests that visuo-spatial impairment may influence the performance of the Digits Forwards Test although to a lesser extent than it influences the performance of the Digits Backwards Test. Another explanation not mentioned by Black (1983) is that the Bender-Gestalt may have a verbal component which may be the common factor between the Bender-Gestalt and the Digits Forward Test. This would explain why previous research has found that right hemisphere damage does not affect the performance of the Digits Forwards Test. Nevertheless Black's study (1983) does cast doubt on previous findings and therefore further research is needed.

As far as can be ascertained there are no studies which examine the Digit's Forwards and Digits Backwards Tests as separate entities with regard to the performance of patients with Dementia of the Alzheimer's Type.

Digits Difference

Digits Difference refers to the relative difference between the raw scores of the Digits Forward and the Digit Backwards tests. A three point difference between the Digits Forwards and the Digits Backwards tests occurs more frequently in brain-damaged children than in non-brain-damaged children (Black, 1983). As far as can be ascertained, there are no studies that demonstrate conclusive results regarding adults, however Black (1986) found that there is some indication that adults with visuo-spatial deficits display a larger than normal discrepancy between the two tests. There is clearly a paucity of research regarding Digits Difference in adults and the researcher was unable to find any studies involving Digits Difference in people with Dementia of the Alzheimer's Type.

Digit Supraspan

This test as described by Zangwill (1943) and McFie (1975) is a useful measure of verbal new learning ability. Deficits in new learning ability often occur in many kinds of neuropathology involving localised and/or diffuse brain-damage (Lezak;1983). As far as can be ascertained there are no studies on the Supraspan

test involving patients with brain-damage, or more specifically on the performance of patients with Alzheimer's Dementia in the Digit Supraspan Test.

Digit Symbol

This is a test involving numerous functions including motor persistence, sustained attention, response speed, and visuo-spatial perception and coordination (Lezak;1983). A number of studies show that there is a marked deterioration in the performance of people over the age of 60 in this test (Ivnik et al., 1992; Salthouse, 1978; Bode and Shuttleworth-Jordan, 1993). Storandt (1976) attempted to discover which functions that are tested by the Digit Symbol Test are responsible for the decline in the performance of healthy subjects above the age of sixty. In order to do this, some of the functions that this test is reported to measure were examined individually. It was found that both the copying task, which is a measure of psychomotor speed, and the coding task which is a measure of perceptual-cognitive ability, contribute towards the substantial age decline in the total Digit Symbol performance. Russell (1986) reports that in an earlier study of his in 1979, that involved looking at the subtest patterns of the Wechsler Adult Intelligence Scale (WAIS), it was found that patients with diffuse brain-damage, right hemisphere damage and left hemisphere damage, all scored worst on the Digit Symbol subtest. Hart, Kwentus, Wade, and Hamer (1987) compared the WAIS Digit Symbol performance of normal subjects, patients with early Dementia of the Alzheimer's

Type and depressed patients who were matched for age and education. The performance of the patients with early Alzheimer's Disease and those with depression were equally poorer than the normal subjects. It is fairly well-established, therefore, that this test is a good indicator of Alzheimer's Disease. However, as far as it can be ascertained, there are no studies of the Digit Symbol Test on people with Alzheimer's Disease who have been stratified for a relatively high level of education.

Digit Symbol Incidental Recall

This test is useful in detecting non-verbal short term memory impairment (Lezak;1983). Short term memory impairment is very sensitive to the effects of diffuse brain-damage and any pathology involving the build-up of intracranial pressure, for example closed head injuries, haematomas, space occupying lesions. It is also often the first reported presenting problem of patients with degenerative disease (Lezak;1983, Lishman;1978, Walsh,1985). Hart, Kwentus, Wade, and Hamer (1987) compared the performance in the Digit Symbol Incidental Recall Test of normal subjects, patients with early Dementia of the Alzheimer's type, and patients with depression. It was found that the patients with early Alzheimer's Dementia performed significantly worse than both the normal and the depressed subjects. These findings suggest that this test is sensitive to Alzheimer's Disease and, furthermore, is useful in differentiating between this disease and depression. However, as far as it can be ascertained, there are no studies of the Digit

Symbol Incidental Recall Test on people with Alzheimer's Disease who have been stratified for a relatively high level of education.

Trail Making Part A and Part B

Trail Making Parts A and B both involve a number of mental functions including: number fluency, mental flexibility, (Armitage, 1946; Corrigan and Hinkeldey, 1987; Golden, Osman, Moses, and Berg, 1981); visuo-spatial scanning, motor skills and speed (Corrigan and Hinkeldy, 1987; Golden et al., 1981); planning abilities (Armitage, 1946); and attentional functions (Lezak, 1983). Trail Making B involves the additional function of having to hold one set of information in short term memory while working with another set of information (Armitage, 1946; Golden et al.,1981). This is also known as working memory (Baddeley, 1986).

Although the Trail Making Test has been found to be a useful indicator of brain-damage (Armitage, 1946; Reitan, 1955), there is considerable controversy over the claim by Reitan and Tarshes (1959) that patients with right hemisphere damage perform more poorly on Part A, while those with left hemisphere damage perform more poorly on Part B. This claim is supported by Lewinson (1973, cited in Lezak, 1983) and disputed by Lezak (unpublished paper cited in Lezak, 1983) and Wedding (1979 cited in Lezak, 1983). Lezak (1983) therefore concludes that attempts at predicting the side of a lesion on the basis of the Trail Making Test are not

advisable. However, the Trail Making Test has been found to be useful in differentiating between depressed patients and patients with brain injuries (Alvarez, 1962). Storandt and Hill (1989) found that a test battery of four tests including Part A of the Trail Making Test was successful with a 98% accuracy in differentiating between subjects with mild Alzheimer's Dementia and normal healthy controls who were matched for age. Barr, Benedict, Tune, and Brandt (1992) found that there was a significant difference in the performance of the Trail Making Test between subjects with Alzheimer's Dementia and subjects with Vascular Dementia, with the Alzheimer's subjects performing more poorly. However, as far as it can be ascertained, there are no studies of the Digit Trail Making Test on people with Alzheimer's Disease who have been stratified for a relatively high level of education.

7. Aims of this study

The above-mentioned normative studies provide an important opportunity to compare the normative data of elderly subjects with more than ten years education with the results of Alzheimer's patients of equivalent age and education. Furthermore it has been shown that the tests (except for Digits Forward) used in the normative studies measure deficits similar to those that have been found to occur in Alzheimer's Disease. Some of the tests, namely, Finger Tapping, Digit Symbol and Trail Making part A and B have been specifically shown to be diagnostic of Alzheimer's Disease.

However, there is a paucity of research regarding the specific sensitivity of some of these tests to Alzheimer's Disease, namely Digits Backwards, Digits Difference, and Digit Supraspan. Moreover, in the researcher's knowledge there is no research that has specifically investigated the diagnostic utility of these tests on a sample restricted to a relatively high level of education. Therefore, the main aim of this research was to determine whether the following frequently employed neuropsychological tests are in fact sensitive to Dementia of the Alzheimer's Type, in people with a relatively high level of education: Finger Tapping Test; Digits Backwards; Digits Difference; Supraspan; Digit Symbol; Digit Symbol Incidental Recall; Trail Making parts A and B.

CHAPTER 2: METHODOLOGY

1. Subjects

The clinical sample in this research consisted of Alzheimer's patients who were residents in a geriatric frail care unit, which is the only private clinic in Port Elizabeth that admits patients with Alzheimer's Disease for long term care. They were diagnosed as having Alzheimer's Disease by a medical team, including general practitioners and a district surgeon, social workers and nursing staff. The diagnostic criteria stipulated in the DSM-III-R (1987) were adhered to. During the period 1/9/93 - 31/10/93, the team was asked to refer all patients to the researcher who, on the basis of the clinical history, medical tests and examinations, did not have any other physical or neurological conditions, which might account for their illness. In addition all patients with alcohol or drug abuse, psychiatric illness, serious physical illnesses such as cardio-vascular conditions, cerebral vascular disease, head trauma or any neurological condition other than Alzheimer's Disease, impaired vision not corrected by visual aids such as glasses, impaired hearing, arthritis or impaired manual dexterity due to non neurological causes, were not referred to the researcher.

Permission to take part in the research was obtained by the medical practitioners and nearest relatives of the patients. The patients themselves were also given the choice of participating in the study and were further given the option of withdrawing at any stage.

Three patients did not wish to participate in the research. No subject chose to withdraw from the research once they had agreed to participate.

The Alzheimer's patients that were referred to the researcher, were further categorised on the basis of the severity of the disease. This assessment was conducted by the medical team who found the subjects to have either mild or moderate dementia according to the criteria in the DSM-III-R. The Alzheimer's subjects were divided into two groups as follows:

(i) three subjects between the age of 70 and 79 who were assessed as having mild dementia.

(ii) nine subjects who were between the age of 80 and 89 who were assessed as having moderate dementia.

The subjects were primarily assigned to the two groups on the basis of age so that their scores could be compared to normative data obtained from subjects in the same age group. The fact that all the subjects in the first group had mild dementia whereas the subjects in the second group all had moderate dementia, occurred as a result of situational factors rather than by the design of the researcher. However this was judged to be a favourable circumstance because it nullifies the influence of an extraneous variable, namely the severity of the dementia. It also allows the researcher to make the distinction between mild and moderate dementia.

As a final means of assuring that the subjects in the two groups of Alzheimer's patients were in fact suffering from a dementia, the Mini Mental State Examination (MMSE) was administered. The means, standard deviations and ranges obtained from the MMSE scores of the two groups of Alzheimer's patients are reported in Table 1. These scores were markedly lower than the age specific cutoff scores, established on a non-clinical elderly population, provided by Bleecker, Bolla-Wilson, Kawas, and Agnew (1988), of 28 and 26 for the 70-79 and 80-89 age groups respectively. This provides further evidence that the subjects in the two clinical groups were suffering from a dementia. Furthermore the MMSE scores lent support fort the division of Alzheimer's subjects with respect to severity that was made on the basis of clinical history. The moderate dementia group scored much lower (mean = 19.11) than the mild dementia group (mean = 25.33).

As a means of controlling for the effect of education all subjects in the present study had a minimum of 10 years education, which was the minimum level of education in the three normative studies of Shuttleworth-Jordan (1992), Bode and Shuttleworth-Jordan (1993), and Cornfield and Shuttleworth-Jordan (1994). The mean level of education of the Alzheimer's patients was 14.67 and 14.44 for the 70-79 and 80-89 age groups respectively. This is highly comparable to the mean scores for the equivalent age groups in the Bode and Shuttleworth-Jordan (1993) Shuttleworth-Jordan (1992) and the Cornfield and Shuttleworth-Jordan (1994) studies, which were 14.97

and 14.82 (Bode and Shuttleworth-Jordan, 1993; Shuttleworth-Jordan, 1992), and 15.3 and 15 (Cornfield and Shuttleworth-Jordan, 1994).

A breakdown of the demographic characteristics of the two groups of Alzheimer's patient's is presented in Table I.

Table 1 Breakdown of Age Groups by Gender, Age, Years of Education and MMSE

Age Groups	n	Gender		Age			Years of Education			MMSE		
		M	F	*M*	*SD*	Range	*M*	*SD*	Range	*M*	*SD*	Range
70 - 79	3	1	2	74.33	3.79	71-78	14.67	2.31	12-16	25.33	0.58	25-26
80 - 89	9	3	6	85.22	3.27	81-89	14.44	3.05	11-20	19.11	3.14	15-23

2. Procedure

2.1 Test Conditions

Numerous authors including Lezak (1983) , Walsh (1985) and White (1985) warn researchers that the performance of elderly people during testing tends to be very sensitive to environmental factors such as room temperature, adequate lighting, noise etcetera. Therefore special care has to be taken in order to eliminate any adverse environmental conditions. The current research was conducted in accordance with the recommendations made by these authors as well as steps taken by the researchers in the normative studies of Shuttleworth-Jordan(1992), Bode and Shuttleworth-Jordan

(1993) and Cornfield and Shuttleworth-Jordan (1994). Testing was administered in a room with no distractions such as noise and glaring light. The temperature of the room was controlled according to the preferences of the subject. Adequate lighting was provided.

Time was spent with each subject before the tests in order to allay any anticipatory anxieties. Encouragement and a supportive environment was provided throughout the testing process thereby allowing the researcher to develop an alliance and a trusting relationship with the subject.

Elderly people are easily fatigued and therefore testing of each subject was carried out over two days. The testing on the second day took place at the same time slot as the previous day. On the first day the following tests were administered: MMSE; Finger Tapping; Digits forward; Digits Backward; Digit Supraspan. The following tests were administered on the second day: Digit Symbol; Digit Symbol Incidental Recall; Trail Making A; Trail Making B.

2.2 Procedure and scoring for each test

The following is a summary of the procedure used to administer each test in the order that the tests were carried out.

Finger Tapping Test (Denckla,1973)

Subjects were requested to tap each finger against the thumb, beginning with the index finger. When they reached the last finger on the hand they were told to return to the index finger so that the procedure was repeated continuously, however the subjects were not told how many taps were required. After a brief practice attempt, the subjects were asked to begin. The score was the time it took to complete 20 taps. The test was administered on preferred and non-preferred hands separately.

Digits Forwards (South African Adult Itelligence Scale - SAWAIS Manual, 1969)

The format described in the SAWAIS Manual was used. The researcher read out loud a sequence of numbers. The subjects were asked to repeat them in the correct order as soon as the researcher had finished reading them. Each trial had a pair of number sequences of the same length. If the subject correctly repeated at least one of the pairs of the sequence, the researcher continued with the next trial which had one more number added on to the sequence. If the

subject incorrectly repeated both sequences of the same length, the test was discontinued and the number of the digits in the last correctly recalled sequence was recorded.

Supraspan (Shuttleworth-Jordan, 1992)

After the subject had failed both sequences of equal length in the SAWAIS Digits Forward Test, the researcher repeated the last incorrectly recalled sequence until the subject recalled it correctly. The score was the number of attempts (trials) the subject took to get the sequence correct was recorded (see appendix 3). Note: the first repetition of the sequence by the researcher after the discontinuance of the Digits Forward Test was recorded as trial 1.

Digits Backward (SAWAIS Manual, 1969)

The format described in the SAWAIS Manual was used. The researcher read out loud a sequence of numbers and the subjects were instructed to repeat the numbers in the reverse order.

Digits Difference (Shuttleworth-Jordan, 1992)

A score was obtained by subtracting the score of the Digits Backwards Test from the score of the Digits Forward Test.

Digit Symbol (SAWAIS Manual, 1969)

The SAWAIS version of this test was used. This format is different from that of the Wechsler Adult Intelligence Scale -Revised (WAIS-R) in that the SAWAIS only has three rows of digits consisting of 67 symbols whereas the WAIS-R has four rows consisting of 90 symbols. The subjects were told to draw symbols under a series of numbers according to a key at the top of the page. They first completed a sample section consisting of eight blocks. Any errors made by the subjects during the practise trial were pointed out so that they had the correct version in the examples. Subjects were told to fill in the symbols associated with the digit, as in the key, as quickly as possible. Subjects were stopped after 90 seconds and the number of symbols filled in correctly during that time was recorded.

Digit Symbol Incidental Recall (Bode and Shuttleworth-Jordan, 1993)

The literature regarding the administration of this test, which was developed by Kaplan (cited in Lezak, 1983) is confused. This is due to the fact that various researchers use different formats of the Digit Symbol Test for example WAIS, WAIS-R and SAWAIS. Furthermore the number of symbols that the subject has to complete before actually commencing the test differs from study to study. Often researchers just mention the number of lines they require their subjects to complete without specifying the exact number of

symbols. This creates difficulty in countries where these test formats are not used and/or are unavailable. An example of this is the study of Hart, Kwentus, Wade, and Hamer (1987), who used the WAIS format of the Digit Symbol Test. They require their subjects to complete the digit symbol substitutions until the end of the last line. However they do not report the actual number of symbols that were completed. The most commonly used method is that of Kaplan as described by Lezak (1983). This method requires subjects to complete the digit symbol substitutions until the end of the *second to last row* of the WAIS-R (68 pairs). This is roughly the equivalent of the *last row* of the SAWAIS format (67 pairs). This method was adopted by Joy et al. (1992), who obtained normative data from a sample aged 50-90 years with a mean education of 13.58 years. Shuttleworth and Bode (1993) required their subjects to complete the digit symbol substitutions until the end of the second to last row of the SAWAIS, which is only 42 pairs. However the normative scores obtained by Joy et al. (1992) on the 68 pair version, and those obtained by Bode and Shuttleworth-Jordan (1993) on the 42 pair version, were very similar. Statistically there was no significant difference between the scores of the two studies, on the 60-69 and 80-89 year old age groups; the difference on the 70-79 year old groups just reached significance with the Joy et el. (11992) group slightly higher than the Bode and Shuttleworth-Jordan (1993) Group.

For the purposes of this research it was decided to adhere as closely as possible to the original 68 pair method of Kaplan as described in Lezak (1983). Subjects were therefore required to complete the symbols until the last row of the SAWAIS Digit Symbol Test (67 symbols) immediately after completing the Digit Symbol Test. This researcher used a form where the last row of the Digit Symbol test had been printed again, lower down on the page, so that the page could be folded in half in order to conceal the completed Digits Symbol Test. Subjects were required to fill in as many of the nine symbols as they could recall. The number of correctly matched symbols were recorded. Each symbol was only counted once so that there was a maximum score of 9.

Trail Making A (Reitan, 1956)

Subjects were instructed to join numbers in the correct sequence without lifting their pencils from the page. The numbers were distributed around an A4 size page. The subjects first completed a mini trial before proceeding to the actual test. If the subjects made a mistake then it was pointed out to them and they were required to correct it immediately. They were not penalised for lifting their pens off the page. The score was the time taken to complete this task was recorded.

Trail Making B (Reitan, 1956)

This test is similar to Trail Making A excepting that this time subjects were requested to alternate numbers and letters so that they proceeded from 1 to A, from A to 2, from 2 to B etcetera. The rest of the administration and scoring was the same as in Trail Making A.

3. Statistical Procedure

The scores of the two groups of Alzheimer's patients were compared with the normative data provided by Shuttleworth-Jordan (1992), Bode and Shuttleworth-Jordan (1993) and Cornfield and Shuttleworth-Jordan (1994). t-tests were carried out on all the tests in the test battery in order to ascertain whether there was a significant difference between each Alzheimer's group and the normal group.

CHAPTER 3. RESULTS

The individual scores of the group of Alzheimer's patients between the ages of 70 and 79 and the group of Alzheimer's patients between the ages of 80 and 89 can be found in tables 2. and 3. respectively.

The mean scores, standard deviations, ranges and p values of the subjects between the ages of 70 and 79 are reported in table 4. In this age group there was a highly significant difference at the one percent level - $p < 0.01$, between the scores of the Alzheimer's and the control group in the following tests: Finger Tapping Test - non preferred hand; Trail Making A; Trail Making B. There was a significant difference at the five percent level - $p < 0.05$ in the following tests: Finger Tapping Test - preferred hand; Digits Difference; Digit Symbol. There was no significant difference in the Digits Forward, Digits Backwards, Supraspan and Digit Symbol Incidental Recall tests.

The mean scores, standard deviations, ranges and p values of the subjects between the ages of 80 and 89 are reported in table 5. In this group there was a highly significant difference at the one percent level on the following tests: Finger Tapping Test - preferred and non-preferred hand; Digits backward; Digits Difference; Digit Symbol; Digit Symbol Incidental Recall; Trail Making A and Trail Making B. There was no significant difference onthe Digits Forward and Supraspan tests.

RAW SCORE DATA ON ALZHEIMER'S PATIENTS

Table 2. Raw Scores of Mild Alzheimer's Dementia Subjects, Age Range 70-79 years

Subjects	F. Tapping Preferred Hand	F. Tapping Non Pref. Hand	Digit Span Forwards	Digit Span Backwards	Digits Difference	Supraspan	Digit Symbol	Digit Symbol Incidental Learning	Trail Making A	Trail Making B
1.	10	12	7	4	3	2	23	0	65	150
2.	9	10	8	4	4	6	21	4	72	194
3.	7	8	8	5	3	7	22	3	67	203

Table 3. Raw Scores of Moderate Alzheimer's Dementia Subject, Age Range 80-90 years

Subject	F. Tapping Preferred Hand	F. Tapping Non Pref. Hand	Digit Span Forwards	Digit Span Backwards	Digits Difference	Supraspan	Digit Symbol	Digit Symbol Incidental Learning	Trail Making A	Trail Making B
1.	7	8	7	3	4	4	8	0	180	530
2.	10	12	7	3	4	9	9	0	195	630
3.	7	7	6	3	3	3	16	3	180	603
4.	10	12	7	4	3	3	8	0	150	640
5.	15	17	5	3	2	9	9	0	260	660
6.	7	8	5	2	3	5	6	0	187	640
7.	7	8	7	4	3	6	8	0	137	516
8.	16	12	6	3	3	6	12	0	210	635
9.	12	14	8	4	4	4	11	1	154	520

STATISTICAL DATA ON NORMAL AND ALZHEIMER'S SUBJECTS

Table 4. Statistical Data of Subjects, age range 70 - 79 years

	F. Tapping Preferred Hand	F. Tapping Non Pref. Hand	Digit Span Forwards	Digit Span Backwards	Digits Difference	Supraspan	Digit Symbol	Digit Symbol Incidental Learning	Trail Making A	Trail Making B
Normal Subj.										
number	31	31	33	33	33	33	31	31	38	38
mean	6.49	6.62	7.18	5.52	1.67	4.36	35.92	3.50	35.64	85.00
SD	1.40	1.35	1.10	1.00	1.13	2.82	9.80	1.48	7.63	38.71
Range	3.18 - 8.33	3.10 - 8.89	5 - 9	4 - 7	1 - 3	1 - 9	20 - 58	1 - 6	23 - 56	45 - 179
Alzheimer Subj. (mild)										
number	3	3	3	3	3	3	3	3	3	3
mean	8.67	10	7.67	4.33	3.33	5.00	22.00	2.33	68	182.33
SD	1.53	2.00	0.58	0.58	0.58	2.65	1.00	2.08	3.61	28.36
range	7 - 10	8 - 12	7 - 8	4 - 5	3 - 4	2 - 7	21 - 23	0 - 4	65 - 72	150 - 203
p - value	0.0175 *	0.0005 **	0.4584	0.0524	0.0174 *	0.7063	0.0209 *	0.2132	< 0.0001 **	< 0.0001 **

Table 5. Satistical Data on Subjects, age range 80 - 89

	F. Tapping Preferred Hand	F. Tapping Non Pref. Hand	Digit Span Forwards	Digit Span Backwards	Digits Difference	Supraspan	Digit Symbol	Digit Symbol Incidental Learning	Trail Making A	Trail Making B
Normal Subj.										
number	28	28	25	25	25	25	28	28	34	34
mean	6.71	6.88	6.92	5.09	1.84	3.88	31.38	3.11	47.85	131.03
SD	1.32	1.46	0.86	0.94	0.94	3.00	5.98	2.14	13.15	43.73
Range	3.65 - 8.86	4.02 - 9.93	5 - 8	3 - 8	0 - 3	1 - 9	20 - 46	0 - 8	29 - 80	81 - 270
Alzheimer Subj. (mod.)										
number	9	9	9	9	9	9	9	9	9	9
mean	10.11	10.89	6.44	3.22	3.22	5.44	9.67	0.44	183.67	586
SD	3.55	3.37	1.01	1.07	0.67	2.30	5.98	1.01	36.87	66.07
Range	7 - 16	7 - 17	5 - 8	2 - 4	2 - 4	3 - 9	8 - 16	0 - 3	137 - 260	503 - 660
p - value	0.0002 **	< 0.0001 **	0.1833	< 0.0001 **	0.0003 **	0.1653	< 0.0001 **	0.0010 **	< 0.0001 **	< 0.0001 **

* = $p < 0.05$

** = $p < 0.01$

CHAPTER 4: DISCUSSION, EVALUATION OF THIS RESEARCH, AND RECOMMENDATIONS FOR FUTURE RESEARCH

1. Discussion

Generally the results of this research indicate that in people within the age range 70-79 years, who have a relatively high level of education (>10 years education; mean = 14.67), the following tests are sensitive to mild Alzheimer's Disease: Finger Tapping - preferred and non-preferred hand; Digits Difference; Digit Symbol; and Trail Making parts A and B. The most sensitive tests are: Finger Tapping non-preferred hand; and Trail Making parts A and B. The following tests were not found to be sensitive to Alzheimer's Disease in this group: Digit Backwards; Supraspan; and Digit Symbol Incidental Recall. The results of this research also indicate that in people within the age range 80-89 years who have a relatively high level of education (>10 years education; mean = 14.44), the following tests are all highly sensitive to moderate Alzheimer's Disease: Finger Tapping preferred and non-preferred hand; Digits Backward; Digits Difference; Digits Symbol; Digit Symbol Incidental Recall; and Trail Making parts A and B. Supraspan is not sensitive to Alzheimer's Disease in these people. Digits Forward was not sensitive to Alzheimer's Disease in either of the above mentioned groups.

The above tests' degree of sensitivity to mild Alzheimer's Dementia, when compared with their degree of sensitivity to moderate Alzheimer's Dementia, reveals an increase in sensitivity with regard to moderate Alzheimer's Dementia in the following tests: Finger Tapping Test - preferred hand; Digits Backward; Digits Difference; Digit Symbol; and Digit Symbol Incidental Recall. This increase is consistent with the process of deterioration that occurs in Alzheimer's Disease.

Specific indications with respect to each test are as follows:

1.1 Finger Tapping - preferred and non-preferred hand

The findings of this research support and extend the conclusions of Muller et al. (1991), who found that people in the early stages of Alzheimer's Disease are slower than normal subjects in the Finger Tapping Test. The current research has found that this conclusion is also true of a group which has been stratified for a relatively high level of education. The Finger Tapping Test was found to be significantly slow, relative to normals, in both mild and moderate Alzheimer's Dementia in the age groups 70-79 and 80-89, respectively.

The current research also found that in subjects with mild dementia, although the Finger Tapping Test with both the preferred hand and non-preferred hand were sensitive to Alzheimer's Disease,

the Finger Tapping Test - non-preferred hand was more sensitive than the Finger Tapping Test - preferred hand. People are less familiar with having to do tasks with their non-preferred hands. Therefore it can be concluded that in people with mild dementia, there is still the ability to compensate for deteriorating function in the more familiar modality, and there is a greater deterioration in functioning with regard to hand motor-speed and/or manual dexterity when there is a decrease in familiarity with a task. However, in patients with moderate dementia the test was equally highly sensitive in the preferred and non-preferred hands. This suggests that as the disease progresses, and the ability to compensate breaks down, familiarity ceases to play a significant role.

1.2 Digits Backwards and Digits Difference

The current research found that Digits Backwards when used on its own was not sensitive to mild Alzheimer's Dementia in a group that has been stratified for a relatively high level of education. It was found that the p value of the t-test missed the 0.05 level of significance by a very narrow margin. However the Digits Difference, which used the Digits Backwards in relation to the Digits Forwards score by subtracting the former from the latter, *was* sensitive to mild Alzheimer's Disease. This finding is consistent with Lezak (1983) who claims that the Digits Difference is a more sensitive measure than when the Digits Forwards and

Backwards are added together or used on their own in isolation of each other. It is also consistent with Baddeley et al. (1986) who reported verbal working memory deficits in people with Alzheimer's Disease.

The findings of the current research have important implications for the clinical applications of these tests when testing for mild Alzheimer's Disease. The findings imply that mild Alzheimer's Disease in some people who have more than 10 years education may go undetected if Digits Backwards is used on its own. However if it is used as part of the Digits Difference score, the verbal working memory deficit will be adequately reflected by their score.

Finally it was found that both Digits Backwards and Digits Difference were highly sensitive to moderate Alzheimer's Dementia in a group that has been stratified for a relatively high level of education.

1.3 Supraspan

This test is reported to be a test of verbal new learning ability (Zangwill, 1943; Mcfie, 1975). Despite the fact that previous research has shown that people with Alzheimer's Disease have impaired verbal new learning ability (El Awar et al., 1987; Lines et al., 1991; Parlato et al., 1988; Strauss et al., 1985), the current researcher found that the Supraspan was not sensitive to

mild or moderate Alzheimer's Dementia in people with more than 10 years education. Therefore it is suggested that the Supraspan involves a level of verbal new learning ability that is too rudimentary to detect deficits in the subjects of this research. The researcher was not able to find any other research using the Supraspan on subjects with Alzheimer's Disease. It is therefore not possible to ascertain whether the level of education of the subjects in this research had an effect on the sensitivity of this test. However, it is possible that on this population with a relatively high level of education, more difficult versions of the Supraspan Test might be able to differentiate between normal people and those with Alzheimer's Disease. For example, teaching two digits (instead of one) above the actual span of the subject would increase the stringency of this test.

1.4 Digit Symbol

It was found that this test is sensitive to mild Alzheimer's Dementia and highly sensitive to moderate Alzheimer's Dementia, in people with a relatively high level of education. Generally, these results provide support for research findings such as those of Russell (1986), who found that this test was sensitive to diffuse brain damage, which as is universally accepted, occurs in patients with Alzheimer's Disease. Furthermore, it is in accordance with Hart, Kwentus, Wade, and Hamer (1987), who found that this test is

a good indicator of mild Alzheimer's Dementia. Their conclusion, however, can now be extended to include people with more than 10 years education.

1.5 Digit Symbol Incidental Recall

This test was not sensitive to mild Alzheimer's Dementia in people with more than 10 years education. This is not consistent with Hart, Kwentus, Wade, and Hamer (1987), who found that this test is sensitive to mild Alzheimer's Dementia. It is possible that this discrepancy may be owing to differences in administration between the two studies. Hart, Kwentus, Wade, and Hamer (1987) required their subjects to complete the WAIS version of this test until the last line before the patients were required to remember the pairs of numbers and symbols. In this research, similarly, the subjects were required to complete the SAWAIS version until the end of the last line, but Hart, Kwentus, Wade, and Hamer (1987) do not report the number of pairs used in their test administration. The current researcher was not able to locate a copy of the WAIS version of this test, which is not generally used in South Africa and is now replaced by the WAIS- R in America and Great Britain. Therefore, the current researcher is unable to evaluate the extent to which the two forms are identical, since forms do vary and thus could have resulted in the discrepancy. However, since the SAWAIS was based on the original WAIS it is highly probable that the number of

pairs completed in the two studies, were the same. Thus it seams probable that the subjects' level of education may explain this discrepancy. It appears that this test may *not* be sensitive to mild Alzheimer's Disease in people who have more than 10 years education but *is* sensitive to people who have a lower level of education. It seems that people with higher education, who are in the early stages of this disease are able to retain the same level of non-verbal incidental memory functioning as normal people with an equivalent level of education. However, it is possible that a more stringent version of this test recommended by Bode and Shuttleworth-Jordan (1993) would be sensitive to deficits in this relatively high functioning group. These researchers used a method where only the second line of the SAWAIS was completed before the memory task in which there are less pairs to practice prior to the recall task, and thus constitutes a more stringent form of the test.

Digit Symbol Incidental Recall was highly sensitive to moderate Alzheimer's Dementia in people with more than 10 years education. It can be concluded that as the disease progresses there is a deterioration in non-verbal incidental memory functioning. This occurs to such an extent that these people's education no longer plays a role in sustaining a level functioning, necessary for a degree of performance in this test, that is equivalent to that of a normal population.

1.6 Trail Making parts A and B

The present research indicates that both parts of this test are highly sensitive to mild and moderate Alzheimer's Dementia in people with a relatively high level of education. This test (both parts A and B), with the exception of Finger Tapping non-preferred hand, was in this study, found to be the most sensitive test to mild Alzheimer's Disease. Although the current researcher could not find other studies which restricted their samples to people with more than 10 years education, this conclusion is consistent with Storandt and Hill (1989) who found that part A of this test was highly sensitive to mild Alzheimer's Dementia and could differentiate Alzheimer's patients from normal controls with an accuracy of 98 percent. The findings of this research are also consistent with the fact that this test involves functions such as visuo-spatial scanning, motor skills and speed (Corrigan and Hinkeldy, 1987; and Golden et al., 1981) that have been found to be impaired in people with Alzheimer's Disease by a large body of researchers including Cronin-Golomb et al. (1991), Muller et al. (1991) and Friedman et al. (1992), respectively.

1.7 Digits Forward

As was expected this test was not sensitive to mild or moderate Alzheimer's Disease in people with a relatively high level of

education. This conclusion is consistent with Lezak (1983), who claims that people with Alzheimer's Disease perform relatively well on this task even when the disease has progressed to such an extent that the patient is no longer able to care for him/herself.

2. Evaluation of this Research and Recommendations for Future Research

The researcher decided to select subjects using stringent criteria. Firstly it was decided only to include patients who had been firmly diagnosed by a psychiatric team as having Alzheimer's Disease. This team had gone to great lengths such as administering medical examinations, careful analysis of clinical histories etcetera, before reaching a diagnosis. If the team had doubts as to the diagnosis, the patient concerned was not referred to the researcher for participation in the research. This meant that the researcher could be fairly certain that the sample was a true representation of people with Alzheimer's Disease. Secondly, patients were not referred for participation in the research if there were any elements that would serve as confounding variables such as physical or psychiatric complaints unrelated to Alzheimer's Disease.

This stringency resulted in a limited number of subjects who were able to participate in the research. As has been explained Alzheimer's Disease is extremely difficult to detect in its early stages especially with the scarcity of medical resources in South

Africa. Alzheimer's Disease is difficult to differentiate from other diseases in its early stages. There were therefore only a few patients, especially those with mild Dementia, where there was a reasonable certainty as to their diagnosis. Furthermore physical ailments such as coronary disease, and psychiatric ailments such as depression, are extremely prevalent amongst elderly people. This resulted in an even greater reduction of the number of patients able to be referred by the psychiatric team for participation in this research. Nevertheless it was decided that the benefit of having a truly representative sample of patients with Alzheimer's Disease as well as the elimination of extraneous variables was more desirable than increasing the numbers of the sample.

In spite of the small numbers, the present research has clearly indicated the relative utility of the tests used in this study, in discriminating clinically normal people from those with mild and moderate Alzheimer's Dementia, when there is a high level of education. In particular, the research has succeeded in highlighting the relative ineffectiveness of the Supraspan and Digit Symbol Incidental Recall tasks, in their *present* forms, as diagnostic indicators of dementia on highly educated individuals. Thus further research should focus on investigating the discriminatory capacity of the more stringent forms of these two test as described above (cf. pp 5 and 7). A further recommendation for future research would be to examine the relative discriminatory power of tests on subjects with more than 10 years education, which

measure functions that have been found to be impaired in people with Alzheimer's Disease, which have not been covered by the tests used in this research. These include verbal memory functions such as delayed recall, recognition, incidental recall, and retrieval from long term memory, as well as non-verbal memory functions such as delayed recall and new learning ability.

In sum this research has highlighted the diagnostic utility of the Finger Tapping - preferred and non-preferred hand, Digits Difference, Digit Symbol and Trail Making parts A and B tests in mild and moderate Alzheimer's patients, with a relatively high level of education. The diagnostic utility of Digits Backwards and Digit Symbol Incidental Recall in moderate Alzheimer's patients, with a relatively high level of education, was also highlighted. The Supraspan with regard to mild and moderate Alzheimer's patients and the Digit Symbol Incidental Recall with regard to mild Alzheimer's patients, were found to be less discriminating. Therefore, new stringent versions of these tests are advocated to enhance their diagnostic efficiency for the assessment of Alzheimer's patients with more than 10 years education.

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