CHAPTER 17

VISUAL AGNOSIA

17.1. INTRODUCTION

The V-P-M Test Battery could be used to diagnose the visual-perceptual-motor syndrome of visual agnosia which is described in this chapter.

17.2. DEFINITION OF VISUAL AGNOSIA

Many writers have attempted to define visual agnosia (Goodglass and Kaplan 1972, Rubens 1979, Kolb and Whishaw 1985 and 1990) but the definition given by Frederiks (1969b) is the simplest and most encompassing. Frederiks defined agnosia as

> *"the impaired recognition of an object which is sensorily presented while at the same time the impairment cannot be reduced to sensory defects, mental deterioration, disorders of consciousness and attention, or non-familiarity with the object"* (page 13).

To this is often added the stipulation that the same object must be recognised via other sensory modalities. This definition encompassed agnosias in general but it might also be applied to the visual system. Humphreys and Riddock (1987) stated that somebody who had this disorder was able to "*see objects ... that is, they may be able to describe the parts of an object or they may be able to copy a picture of it, but they have no idea what the object is or how it might be used*" (pg. 7).

Visual agnosia should be distinguished from a word naming defect. When a patient failed to name but could indicate visual recognition by other means e.g. gesture, the failure could be considered to be anomic in nature and part of a more general aphasic disturbance (Rubens 1979).

However, Geschwind (1965) argued that agnosia was not a defect of an unitary process of recognition, but was a special form of modality-specific naming deficit. He viewed this as a disconnection syndrome i.e. the intact speech area was disconnected from an intact sensory area, hence he viewed the mis-identification as "confabulated responses". Rubens (1979) said that the visual-verbal discrimination hypothesis was supported by the fact that visual agnosia was commonly associated with a right homonymous hemianopia, alexia and colour agnosia, a triad of symptoms known to occur with damage to the left emesial occipital lobe and nearby collossal fibres.

Critchley (1953) stated that visual object agnosia was a rarity in clinical practice. "*The cases are not only uncommon, but they are difficult and tantalising problems for study...*" (pg. 279).

17.3. Types Of Visual Agnosia

Lissauer who was the first to describe visual agnosia in 1890, suggested that the disorder could be classified into two types i.e. apperceptive and associative (Le Doux 1979).

17.3.1. Apperceptive Agnosia

According to Lissauer apperception was the art of conscious perception of sensory information and disorders of apperception led to defective perceptual processing (Le Doux 1979). A patient with apperceptive visual agnosia apparently could not draw mis-identified items or match them to a sample. They were also unable to point to objects named by the examiner (Rubens 1979). The disorder involved all the elements of the visual environment that require shape and pattern perception (faces, objects and letters) this meant that even the simplest line drawings might be impossible to recognise.

According to Rubens (1979) many patients with an apperceptive agnosia behaved as though they were unaware or were unconcerned about their visual defect. When they were confronted with visual recognition tasks they then acknowledged that they could not see clearly. "*They may complain that the visual environment appears to change as they try to scrutinise it and that objects disappear or are not visible until they are moved*" (Rubens 1979:237).

Luria (1980) has suggested that simultanagnosia might be the basic underlying disturbance of apperceptive visual agnosia. Simultanagnosia referred to the inability to recognise or abstract the meaning of whole pictures or series of pictures i.e. the patient only perceived one thing or one part at a time.

In the cases of apperceptive agnosia reported in the literature (Tyler 1968, Benson and Greenberg 1969) a syndrome described by Balint in 1909 was also identified. It appeared that agnostic symptoms were part of this syndrome. Balint's syndrome involved an inability to voluntarily look into the peripheral field, the patient directed his gaze thirty to forty degrees to the right and only perceived what was lying in that direction. (This was contrary to the right homonymous hemianopic described by Rubens (1979)). The patient also experienced a severe deficit in manual reaching under visual guidance, termed optic ataxia by Balint. Lastly, there was a disturbance of visual attention affecting mainly the periphery i.e. once the patient's attention was directed towards an object, he noticed no other stimulus (Rubens 1979, Kolb and Whishaw 1985). This latter symptom was similar to Luria's description of simultanagnosia
Lezak (1995) used the term Balint's syndrome synonymously with simultanagnosia. Luria et al (1963) concluded that apperceptive visual agnosia represented a complex perceptual motor breakdown of the active, feature by feature analysis necessary for the visual processing of a visual scene. Thus simultanagnosia might result from the increase in time needed to perceive all parts of the visual field (Williams 1979). Bender and Feldman (1972) reiterated the role played by inattention but added that they felt that this type of agnosia also represented a complex interaction of primary visual sensory stimuli.

Aperceptive agnosia is, therefore, a complicated phenomenon which could mean virtual blindness in the patient if Lissauer's description is accepted. Critchley (1959:278), however, stated that Lissauer meant by apperceptive agnosia "*...a distortion of the appearance of objects viewed.*"

Rubens (1979) stated that cases of apperceptive agnosia were disorders of primary sensory function due to lesions of the primary sensory fields and their connections, the lesion being bilateral in area seventeen of the occipital lobe (Rubens 1979, Luria 1980). Le Doux (1979) on the other hand stated that apperceptive agnosia appeared to result from right hemisphere lesions. Thus it seems that the exact nature and cerebral location of problems in apperceptive agnosia have not yet been comprehensively defined.

Lezak (1995) summarised apperceptive agnosia as the patient's inability to:

> *"Synthesise what they see. They may indicate an awareness of discrete parts of a word or phrase, or recognise elements of an object without organising the discrete percepts into a whole. Drawings by such patients are fragmented ..." (page 72).*

17.3.2. Associative Visual Agnosia

According to Rubens (1979:245) the clinical picture of associative visual agnosia "*...is one of a patient who fails to name or to describe verbally or by gesture the nature of visually presented material...*", but who was able to draw or to match the mis-identified material with identical samples. Pointing to objects named by the examiner was typically better than identifying objects verbally or by gesture (Kertesz 1979, Lezak 1983). Objects appeared to lose their meaning as there was a disruption of the processes whereby visual perceptions were linked with memory processes stored in other modalities.

Although there were many aspects of this type of agnosia which would suggest a deficit in the visual verbal link i.e. anomia, impairment of short term verbal memory and a right homonymous hemianopia, this type of inability to recognise objects or the pictures of objects was apparently not seen in the naming performance of aphasics (Corlew and Nation 1975). However, there was also a failure to sort objects and pictures into categories or to match non morphologically identical representations of the same object which suggested verbal links (Rubens 1979).

Lezak (1995) summarised associative agnosia as a breakdown in aspects of the patients store of knowledge, thus confirming the memory impairment described by Corlew and Nation (1975).

17.3.3. Other Types of Visual Agnosia

Other types of Visual Agnosia have been named. These types would appear to belong to the category of apperceptive agnosia.

- Visual Objective Agnosia. A person with visual object agnosia was, when shown an object, able to see it but unable to name it, to demonstrate its use or to remember having seen it before (Kolb and Whishaw 1985). This included identifying shapes. Visual object agnosia is rare and there seems to be a general consensus that it is due to a lesion of the left occipital lobe, although the damage may be bilateral.

- Agnosia for Pictures and Drawings. Patients with this type of agnosia were not able to recognise complex pictures of geometrical figures, pictures of letters and numbers or relatively simple pictures when part of the pictures were masked (figure-ground tests). They were also not able to recognise incomplete figures (part-whole perception) and abstract drawings (Frederiks 1969b, Kolb and Whishaw 1985). The lesion causing this type of problem is most likely to be located in the secondary, and tertiary visual areas i.e. areas eighteen to twenty-one on either side although the right hemisphere is implicated more frequently (Kolb and Whishaw 1985).

- Colour Agnosia. This is the impairment of colour recognition and is discussed in Chapter Eighteen.

- Agnosia for Faces - Prosopagnosia. It appeared that patients with this disorder were unable to recognise faces although they could recognise objects, forms and colours. According to Hecaen and Albert (1978) patients were able to differentiate one face from another but could not differentiate previously known faces by relying only on visual input. It seemed that memory might play a role.

Kolb and Whishaw (1985) quoted Leuber and Yin who hypothesised that facial recognition was brought about by a special processing mechanism in the right hemisphere which was analogous to that of verbal recognition carried out in the left hemisphere. As quoted in chapter three of this thesis, Critchley (1953) and Walsh (1987) queried the presence of this defect as a separate syndrome. Bruce (1988) pointed out that face perception was as much the domain of social perception as it was of a cognitive skill and therefore involved much more than a plain visual perception task.

Kertesz (1979), stated that failure to recognise common objects in the visual modality without blindness or aphasia was a rare clinical entity.

In the light of this Humphreys and Riddoch (1987) have abandoned the term visual agnosia and instead use the term object recognition deficits.

17.4. TESTS OF VISUAL AGNOSIA

There are very few standardised tests available for evaluating the presence of a visual object agnosia and agnosia for pictures but the tests that do exist fall into the following categories:

17.4.1. Recognition And Matching Of Real Objects

These tests are described in chapter five.

17.4.2. Recognition And Matching Of Drawn Designs

This type of test is described in chapter six.

17.4.3. The V-P-M Battery

The Form Matching test of the V-P-M battery was specifically constructed to evaluate the aspect of visual agnosia related to form recognition. In testing a variety of patients it became evident that Part A of the Perceptual Constancy test could also be of value in diagnosing agnosia for pictures. It was also apparent that the Figure-Ground test and the Part-Whole test of the V-P-M battery could help in the diagnosis of agnosia for pictures (see paragraph 17.3.6.) If visual agnosia were suspected as a result of these tests patients should be given objects, colours, words, geometric forms, faces, emblems and signs for recognition and matching purposes as well as for the production of drawings of objects not identified, as specified by Rubens (1979).

17.5. DETERMINING VISUAL AGNOSIA FROM RESULTS ON THE V-P-M BATTERY

Visual agnosia was said to be rare (Critchley 1953). A true case of visual agnosia was not diagnosed in the patient group evaluated in this study. Only one patient performed poorly on the form recognition test, but this failure was due to a severe visual neglect of the left half of space. Another patient, not included in the sample due to the fact that she had a left sided injury, showed agnosia for pictures as demonstrated by her difficulty in completing section A of the Perceptual Constancy test. To determine a visual object agnosia versus a part-whole or figure-ground problem more attention should be paid to the manner in which the patient executes the tests.

17.6. CONCLUSIONS

It was difficult to confirm that visual object or picture agnosia either in the form of an associative or apperceptive agnosia existed as a clinical entity from the results of the patients evaluated for this thesis. It was also apparent that visual agnosia, far from being the "simple recognition of an object", was an extremely complicated syndrome. The apparent lack of consensus on the anatomical location of the lesion producing the syndrome made it difficult to separate the verbal from the visual components of the problem and many more patients with both right and left sided lesions would have to be tested to establish the relevance of the V-P-M Battery for evaluating this problem. In addition, the Form Matching and the Perceptual Constancy tests of the V-P-M battery were not definitive tests for this problem, but might indicate the need for more in depth evaluation of the patient.

CHAPTER 18

COLOUR AGNOSIA

18.1. INTRODUCTION

In the previous chapter visual agnosias were discussed and agnosia for colours was named as a type of visual agnosia. The Colour Matching test of the V-P-M Battery was designed as a test of colour perception with the aim of diagnosing the presence of a colour agnosia from performance on the test.

18.2. DEFINITION OF COLOUR AGNOSIA

Colour agnosia is a defect in the ability to recognise colour. According to Brown (1972) there is no uniform picture of defective colour recognition. Patients might complain that they could not see colours or that colours had lost their brightness and that everything looked grey (Meadows 1974). Rubens (1979) defined colour agnosia as the inability to name a colour or to point to a colour named by the examiner, in the presence of the ability to perform *"normally on tests of colour perception"* (page 249). He said that the patient was able to read the Isihara plates' and to sort colours according to hue but was unable to *"...operate in the visual-verbal mode"* (page 252).

18.3. TYPES OF COLOUR AGNOSIA

Benton (1979) stated that there were a variety of performance defects sub-served under the title of impairment of colour recognition, these included colour imperception, colour agnosia, colour anomia, and amnesia for colours. Thus it could be seen that there was a lack of clarity as to what constituted a true colour agnosia.

However, It is clear from the two definitions above that there are two types of defects in the ability to recognise colour i.e. those associated with colour naming (called colour anomia) where the actual perception of colour is normal (Rubens 1979), and those defects associated with colour vision or perception of colour (achromatopsia) (Meadows 1974).

18.3.1. Impairment Of The Verbal Identification Of Colours

Frederiks (1969b) stated that it was difficult to differentiate the ability to recognise colours from that of naming colours and he found an apparent association of failure to recognise colour with pure alexia in a number of cases. These defects were associated with indications for lesions in the retrolandic area of the cerebral hemisphere. When colour agnosia was associated with alexia without agraphia and a right hemianopia, it constituted a classic syndrome which resulted from occipital lesions of the dominant hemisphere. The defects apparently resulted from the disconnection of the right visual from the left language centres (Geschwind and Fusillo 1966, Meadows 1974, Benton 1979).

According to Oxbury et al (1969) and De Renzi et al (1972), there was another type of disturbed verbal identification of colour which was part of a primary dysphasic disorder and which was termed colour anomia.

18.3.2. Impairment Of Colour Recognition

A defect in colour recognition, termed achromotopsia (Humphreys and Riddoch 1987), seemed to focus on the loss of the ability to distinguish hues, and the loss of the perception of the brightness of colours, rather than the actual miss-identification of the primary colours.

Critchley (1953) stated that other agnostic, apraxic, or aphasic symptoms quite often accompanied defects of colour perception, spatial disorientation being especially frequent as well as the symptoms of Gerstmann's Syndrome i.e. acalculia, agraphia, left-right spatial disorientation and finger agnosia. Critchley contended that it was doubtful that colour sense could be altered in cerebral lesions without some corresponding disturbance in the appreciation of form. He also stated that the colour defect might be restricted to one homonymous half field in non dominant hemisphere lesions. If the loss was unevenly distributed it was more likely to be due to a lesion of the dominant hemisphere.

Meadows (1974) analysed the literature dealing with disturbed perception of colour and found that other conditions were found in association with impaired colour perception i.e. prosopagnosia (twelve out of fourteen cases), impaired topographical memory (nine out of fourteen cases), and bilateral field deficits affecting the upper quadrants (seven out of fourteen cases) while none had bilateral defects of the lower quadrants. This pattern of loss pointed to the lower part of the optic radiation or striate cortex being affected i.e. area seventeen.

Luria (1966) described experiments in which area seventeen was stimulated. This resulted in visual sensations such as coloured rings, fog and tongues of flame. However, Luria has failed to describe disturbances of colour recognition with lesions of this area.

According to Benton (1979), there could be a loss of the ability to indicate the characteristic colours of familiar objects within the context of intact colour perception. This could also be related to aphasia and occurred particularly when the patient was asked to name the characteristic colour of familiar objects.

Brown (1972) hypothesised that there was a continuous process from colour reception (perception) to naming colours which might be interrupted at various points according to the *"locus of interruption with either the visual or the verbal segment of the process being the predominant clinical element"* (Brown 1972:244). It seemed, however, that only *"a small proportion of patients with lesions on the right and of the non-aphasic patients with left-sided lesions also have colour recognition problems"* (Lezak 1995 : 398). However, should these defects occur they would lead to problems in activities of daily living. Humphreys and Riddoch (1987) quoted two patients with achromotopsia who said *"Everything I see appears grey and the sky always appears cloudy and the sun appears dirty to me .... My shirts* *all look dirty and I cannot tell one of them from the other, I have no idea which tie to wear .... I cannot tell whether the light in a room is on or off. I have difficulty recognising certain foods..."*(Pg. 84).

18.4. TESTS OF COLOUR AGNOSIA

These were described in Chapter Fifteen. Tests are available to evaluate the loss of colour perception and include tasks of sorting, matching or arranging shades of one colour according to hue. There are also tests that evaluate colour naming through tasks of matching colours by means of written and spoken names and tests of colour association.

The Colour Matching test constructed for the V-P-M Battery was designed to test defective colour perception only, although a naming task could be incorporated if patients with left sided lesions were also to be tested.

18.5. DETERMINING COLOUR AGNOSIA FROM THE RESULTS OF THE V-P-M BATTERY

Patient number seven was the only patient who, it was felt demonstrated achromatopsia. When she was evaluated four months after having suffered a stroke, she was found to have a dense left hemiplegia and a left homonymous hemianopia. Her performance on the Colour Matching test was extremely poor. 100% of the items located on the left side of the multiple choice sheet were wrongly matched, all answers were selected from the items placed on the right side of the visual field. 37,5% (i.e. three out of eight) of the items on the right side were also incorrect. Thus the patient selected answers only from the right side of the multiple choice plate in spite of being reminded to scan the entire plate and giving the impression of doing so. She also checked and rechecked her answers making her extremely slow in the selection of the chosen colour. Her poor performance warranted further investigation of the colour problem and it was found that the patient:-

a) was able to state the correct colour of things in the environment such as sky and grass, etc.;

b) was unable to name colours in either the left or right visual fields although she was neither expressively or receptively aphasic and could read;

c) could not accurately describe the colour of the furniture in her lounge, it appeared that all was seen in hues of brown (the furniture was upholstered in pink);

d) was not consistent in the type of colour that was wrongly named and matched;

e) did not complain of colour disturbance although she described her environment as lacking in brightness when asked;

f) had a severe disturbance of spatial perception when tested using both motor and motor reduced tests as well as difficulty with complex visual recognition tasks e.g. Perceptual Constancy and Figure-Ground tests. However, many mistakes made were with the items situated in the left visual field;

g) tired very easily, her concentration was poor and perseveration occurred at this time;

h) showed attention defects and was untestable on the test of Figure-Ground perception for this reason.

Although the patient had difficulty naming colours, it was felt that this was not due to a language problem, but rather to the difficulty in distinguishing the correct colour hue. In addition there was no prosopagnosia, no disturbance of language, nor was there alexia. It would seem therefore that patient number seven could be diagnosed as having achromatopsia.

18.6. CONCLUSIONS

It was apparent that there were two types of defects i.e. defects related to a language disorder which were labelled colour agnosias and those related to the perception of colour or achromatopsia. Both types of conditions could be evaluated through the V-P-M battery. However, more detailed investigations would need to be carried out with any patient failing the Colour Matching test to determine the exact nature of the disturbance. The Colour Matching test would have to be supplemented by other tasks in this instance.

CHAPTER 19

SPATIAL DISORIENTATION

19.1. INTRODUCTION

Spatial disorientation as a syndrome is difficult to describe. Critchley (1953:326) stated "*the literature which treats this aspect of neurology is far from easy to follow not the least for want of clear thinking and clear writing upon the part of some authors.*" In order to describe space problems more clearly for this thesis, space concepts were "classified" into three groups i.e. the Practical Group or Body Space, the Subjective Group or Grasping Space and the Objective Group or Action Space (see chapter three). This chapter examines the different problems discussed in the literature in relation to these three groups and in relation to test findings based on the V-P-M Battery.

19.2. DEFINITION OF SPATIAL DISORIENTATION

To develop a definition it was necessary to examine briefly some of the concepts regarding the nature of space perception.

It was Hughling Jackson who, in 1876 first advanced the idea of "imperceptions" occurring as a result of brain injury (Benton 1979). This concept of "imperceptions" included visuo-spatial disability. Gordon Holmes in 1919 was the first to divide visuo-spatial disabilities into two major types i.e. disturbances in orientation, size and distance estimates; and disturbances in ocular fixation with consequent inability to find objects visually (Benton 1979). However, by 1950 a number of problems attributed to spatial deficits had been described e.g. impaired eye movements, poor visual localisation of stimuli in space, neglect of hemispace, right/left confusion, constructional apraxia, amnesia for routes and locations, poor drawing, impaired performance on tests of mental spatial transformation to name but a few (Critchley 1953, Kolb and Whishaw 1985).

Benton (1979) added defective localisation of points in space, defective judgement of direction and distance, defective typographical orientation and unilateral visual neglect. Luria (1980) referred to spatial disorientation and constructive apractagnosia which encompasses the above. He also named constructional apraxia as a spatial problem.

Spatial disorientation would, therefore, appear to be a deficit that interfered with the ability to relate to the position, direction or movement of objects or points in space (Lezak 1985) and involved the awareness of self in relation to one's surroundings. Lezak (1995 : 344) referred to the literature in pointing out that different types of spatial disorientation *"do not arise from a single defect but are associated with damage to different parts of the brain and involve different functions"*

Spatial disorientation, as in other kinds of defective performance, required careful analysis of its components to determine the extent to which the problem was one of verbal labelling, specific amnesia, visual scanning, visual agnosia, or a true spatial disorientation (Lezak 1983 and 1995).

19.3. TYPES OF SPATIAL DISORIENTATION

As can be seen from the above, numerous types of spatial disorientation have been described by Critchley (1953), Benton (1969 and 1979), Siev and Freishtat (1976), Luria (1980), Siev et al (1986), Kolb and Whishaw (1985 and 1990). Table 19.1 summarises the terms for space used by the above authors. As can be seen from the table several types of spatial problems have been named, but many of the terms have the same meaning and refer to similar skills or problems. For example, Lezak (1983), described problems with distance estimates as a spatial problem, this corresponded to the deficits Benton (1979) described as defective localisation of points in space. In discussing defective localisation of points in space, Benton referred to defects in absolute localisation (i.e. the localisation of a single entity) versus defects in relative localisation (i.e. spatial relationships between two stimuli as seen by the observer). Absolute and relative localisation were the same as egocentric and allocentric space described by Kolb and Whishaw (1985 and 1990) and corresponded to position in space and spatial relations defined by Luria (1983) and the candidate.

TABLE 19.1 SUMMARY OF TYPES OF SPATIAL DISORIENTATION ENUMERATED BY VARIOUS AUTHORS

AUTHOR	SPATIAL PROBLEM
Critchley (1953)	<u>Spatial Perception</u> - loss of stereoscopic vision - inability to detect alternatives in visual rivalry tests - inability to discern units of super-imposed figures - deceived by visual illusions - problems of visual orientation:- * inability to count objects in front of the patient * inability to locate the nearest object in space * inability to distinguish size * inability to point to objects in space <u>Conception of Space</u> Body Space - autopagnosia - alloeasthesia Touch Space - right/left confusion - tactile agnosia - apraxia Visual Space - visual discrimination <u>Interdimensional Spatial Manipulations</u> - Visual imagery - Typographical sense - Spatial aptitude - Sense of orientation - Drawing from memory - Map reading - Self extrication from a maze - Kohs' blocks - Construction of machinery from a blue-print
Lezak (1983 and 1995)	<u>Distance Estimations</u> - Same as Benton's distance estimation - Defective localisation of points in space <u>Mental Transformations</u> - Defective ability to conceptualise spatial transfer motions - Spatial relations, inversion, 3D forms from 2D stimuli - Mental rotations <u>Space Orientation Memory</u> which includes visual discrimination and spatial orientation <u>Spatial Dyscalculia</u> - Relative position of numbers <u>Route Finding</u> - Inability to find way around familiar places <u>Topographical Orientation</u> - Defective memory for routes - Impaired re-visualisation - Impaired retrieval or visuospatial knowledge

AUTHOR	SPATIAL PROBLEM
Benton (1969 and 1979)	<u>Defective Localisation of Points in Space</u> - Deficits within <u>grasping space</u> - pointing response - Deficits within <u>action space</u> - verbal judgement - <u>Absolute</u> localisation - a single response in relation to the observer - <u>Relative</u> localisation - spatial relationships between two stimuli as seen by the observer <u>Defective Perception and Distance Judgement</u> <u>Depth Perception</u> - Real and apparent which is produced through stereoscopic presentation <u>Defective Topographical Disorientation</u> - Failure to describe spatial characteristics of environment at the level of Representation or Revisualisation. <u>Unilateral Visual Neglect</u>
Siev and Freishtat (1976) Siev et al (1986)	<u>Spatial Relations Syndrome</u> - Figure-ground perception - Form constancy - Position in space - Spatial relations - Constructional apraxia - Dressing apraxia - Topographical disorientation - Depth and distance deficits
Luria (1980)	<u>Spatial Disorientation</u> - Spatial relationships - Position in space <u>Spatial Apractagnosia</u> - Topographical disorientation - Motor disturbances such as dressing and copying figures as a result of spatial disorientation
Kolb and Whishaw (1985 and 1990)	<u>Body Space</u> - Agnosia for body parts <u>Grasping Space</u> - Displaced visual attention - Inability to perceive more than one stimulus - Inability to follow a moving object and to fixate <u>Action Space</u> - Right/left confusion - Problems in Egocentric and Allocentric space - Topographical disorientation - Disturbance of spatial thought - Disturbance of spatial memory

Kolb and Whishaw (1990) suggested that there was a way of classifying spatial activities according to the sensory motor responses that people made when they moved around their environment. These reponses are:

- Positive responses: These responses are movements made with the body used as a reference. They require no external cues. These responses are also referred to as egocentric responses.

- Cue responses: These are movements directed by a particular cue.

- Place responses: These are movements that take the person to a particular location or object which is hidden from view.

The response to cue and place fall into the category of allocentric space. All three categories are encompassed in the classification of space used by Kolb and Whishaw (1990) and used in this thesis i.e. Body, Grasping and Action Space.

19.3.1. Body space

As already mentioned, disturbances of body space will not be discussed in this thesis as they do not involve visual perception.

19.3.2. Grasping Space

Grasping space (Kolb and Whishaw 1985 and 1990), touch space (Critchley 1953) or the subjective spatial group (Flavell 1963) are synonymous and refer to the space around the body in which objects can be seen, touched and manipulated. Cue responses are part of grasping space. The visual system is important in the exploration of space within the sphere of grasping space. *"Disorders of visual-spatial exploration could thus result from deficits in attending to visual stimuli or in making the necessary eye and body movement towards them"* (Kolb and Whishaw 1985: 578). The following deficits were therefore included as deficits of grasping space.

- Defective eye movements - such as the inability to follow a moving object or to maintain fixation. as well as abnormal search (Kolb and Whishaw 1985 and 1990). As these defects concern eye movements and not perception, they have not been included in this thesis as they are best evaluated by optometrists through specialised equipment.

- Directional Concepts. This has been defined by the candidate as the ability to perceive the directional location of an object in relation to the line of gravity and to transpose this concept into one dimensional form on paper (see chapter four). It would appear that defective judgement of direction (Benton 1979) and the inability to point to an object in space (Critchley 1953) fall within the ambit of directional problems.

- Spatial Relations. Spatial relations have been defined in this thesis as the ability to perceive two or more objects in relation to oneself and in relation to each other (see chapter four). The problems of relative localisation of objects in space (Benton 1979, Kolb and Whishaw 1985 and 1990); the inability to count objects (Critchley 1953); problems of spatial relationships named by Luria (1980) and Siev and Freishtat (1976) Siev et al (1986) would appear to correspond to problems of spatial relations as defined above.

Critchley's (1953) definition of relative localisation also corresponded to the concept of spatial relations as described in this thesis.

19.3.3. Action Space

Action Space (Kolb and Whishaw 1985 and 1990) is the objective group of spatial concepts. There was general agreement that a category of space perception existed in which problems may be seen in the ability to "visualise" space. The aspects of action space were therefore as follows:-

- Topographical Orientation. Topographical Orientation has been defined as the ability to perceive and remember the location of objects and places in space (see chapter four). This skill has been described by Siev and Freishtat (1976), Luria (1980), Siev et al (1986), and Kolb and Whishaw (1985 and 1990). Critchley (1953) also named map reading, self extrication from a maize and a sense of orientation all of which appeared to belong in this category. Benton (1979) described defective topographical orientation as the failure to describe the spatial characteristics of the environment which could occur at either the level of representation or re-visualisation. As has already been explained in chapter four the evaluation of representative topographical orientation is not covered in the V-P-M battery due to the subjective nature of the concepts. However, a subjective evaluatior could be used in patient assessment as it is an important part of space perception and can give additional insight to the problems experienced by the patient.

- Spatial Thought. This is the ability to manipulate spatial concepts in the mind withc'it concomitant physical manipulation of objects (see chapter four). According to Lezak (1983) it included the ability to conceptualise spatial rotations and inversions and construct three dimensional forms from two dimensional stimuli. This skill has been allocated to the category of position in space by the candidate, Siev and Freishtat (1976) and Luria (1980). One way of testing spatial thought processes is to require the patient to transfer two dimensional forms into three dimensional constructions and vice versa but these need to be relatively complex tests.

Depth and distance estimates (Benton 1979 and Lezak 1983) could be categorised as aspects of spatial thought, Benton (1979) defined these estimates as "real" perception.

19.3.4. Features of Spatial Problems

Critchely (1953), Benton (1979) and Luria (1983) enumerated the features of spatial problems that might be revealed through testing as follows:-

- Grasping Space

  a) The constructions or drawings might be crowded into a corner.

  b) There might be "closing in" of the design copied.

  c) Horizontal lines might be drawn or constructed in an oblique direction.

  d) The lines drawn might be tremulous.

  e) There might be inaccurate intersection of co-ordinates in drawing and construction tasks.

  f) The patient might tackle the task in a piece meal way, being unable to visualise the task as a whole.

  g) Form board patterns and puzzles might be difficult to put together. It appeared to be particularly difficult to arrange two right angled triangles to form an isosceles triangle (see Design Construction test of the V-P-M Battery).

  h) There might be the inability to hold a rod or a stick in a vertical or horizontal direction on command or to be able to position it as it lies on the table. (See Stick Construction Test of the V-P-M Battery).

- Action Space

  a) There might be a tendency to confuse three dimensional space. i.e. confusion of planes. For example a patient who is asked to draw a plan of his home might draw in flat chimneys or the roof onto the floor plan (Critchley 1953). This might also be associated with the inability to read the two dimensional blue-print of a building by a patient who had been able to do this previously. The use of perspective to represent space is a learnt skill (Concha 1983).

b) There could be abnormal representation of perspective and depth.

c) There might be abnormalities of relative size and articulation.

d) There might be muddled and incorrect orientation of verbal and written symbols.

e) Difficulty could be experienced in determining the meaning of adverbs such as up, down, in, out, back, front and difficulty in interpreting below and behind when looking at a two dimensional picture.

f) There might be a reversal of designs and letters in drawing and writing.

Critchely (1953) also stated that the patient often made excuses saying that *"he could never draw"* or there might even be a catastrophic reaction when confronted with spatial tasks with the patient showing annoyance, embarrassment or distress.

Functional activities might also be disturbed in that the patient is unable to correctly orientate his clothes for dressing, he may not be able to play board games such as draughts, fold a letter to put in an envelope or to interpret the position of the hands on a clock.

19.3.5. Summary

The literature review has dealt with only those references in which a classification of spatial constructs was given. Many studies have been published dealing with hemispheric localisation of space perception (Patterson and Zangwill 1944, Warrington et al 1966, Newcombe and Russel 1969, Benton and Hecaen 1970, Hannay et al 1976, Ratcliff 1979, Springer and Deutsch 1989) but a satisfactory explanation and description of the different categories of spatial skills discussed have not been provided in the literature. This thesis has made a clear differentiation between the different space constructs

19.4. Tests Of Spatial Discrientation

19.4.1. Grasping Space

19.4.1.1. Directional Concepts

The task described by Benton et al (1975) in which single and double line stimuli were presented followed by the presentation of a response card on which the patient was required to identify the line or lines that he had just seen, is an excellent task for the evaluation of directional concepts. Unfortunately, there are no normative data for this task and memory is a component of the test. The task has been further refined by Benton et al (1978 and 1983) and in the 1983 version the memory component was removed. In addition the scores of this more recent version were adjusted for individuals over fifty years of age.

The Standardised Road Map test of Directional Sense (Money 1976) evaluates a patient's ability to tell the direction that the examiner took at each turn while drawing a dotted pathway. Norms are available up to the age of eighteen years. Although it did not require motor ability from the patient it required the patient to accurately name right and left directions and therefore needed verbal output.

Directional sense might also be evaluated through having the patient draw a series of arrows in a specific direction (Goody and Reinhold 1963).

Stick Construction tasks as described by Butters and Barton (1970) and Goodglass and Kaplan (1972) might be used to diagnose directional problems although they are also used to evaluate spatial relations.

Dot to dot tests compiled by MacQuarrie (1953), Frostig (1966), Dennis and Dennis (1969), Grant (1969) and Ayres (1980a), are all suitable for the evaluation of directionality.

Of the above tests only the MacQuarrie Test (1953) has normative data against which adult performance can be judged.

19.4.1.2. Spatial Relations

Frostig (1966) named her dot to dot test a spatial relations test. Ayres (1980a) named her dot to dot test a design copying test and stated that it evaluated visual-motor behaviour. The Frostig test was the only test labelled as a spatial relations test that could be found by the candidate. However, tests such as the Token Pattern Test (Benson and Barton 1970) and the Block and Stick Construction tests described in this thesis can all be used for the evaluation of spatial relationships.

19.4.2. Action Space

19.4.2.1. Topographical Orientation

As previously mentioned, this aspect was not covered in the V-P-M battery and therefore suitable testing material will not be discussed here. Suffice it to say that there are no standardised tests as topographical orientation is a subjective experience.

19.4.2.2. Spatial Thought

Tests such as Luria's Parallelograms (Christensen 1975 and Golden 1985), the Location sub-test of the MacQuarrie test for Mechanical Ability (MacQuarrie 1953) and the Spatial Relations sub-test of the Primary Mental Abilities Test (Thurstone 1963) provided a means of evaluating space visualisation or spatial thought. The Position in Space test of the V-P-M Battery has proved to be a good test of this function. The test should play a useful part in evaluation as non of the more recent test batteries evaluate space visualisation.

19.4.3. The V-P-M Battery

An attempt was made to distinguish between the different types of spatial problems in drawing up the V-P-M battery. In each instance a test requiring motor output was constructed as well as one which was either motor reduced or motor free. This was done in order to distinguish between problems associated with apraxia and those not associated with it. Thus the following tests were designed for spatial function:-

- <u>Grasping Space</u> - Directional Concepts - The Arrow test and the Dot-Line test.

  - Spatial Relationships - The Spatial Relations test, Block and Stick Construction I tests and the Design Construction test .

- <u>Action Space</u> - Position in Space - The Position in Space test, the Block and Stick Construction II tests.

19.5. DETERMINING SPATIAL DISORIENTATION FROM RESULTS ON THE V-P-M BATTERY

As only those patients with lesions of the right hemisphere were selected for this study, it was not possible in this thesis to compare the type of problems that are experienced by right hemisphere patients with those of left hemisphere patients. Once it had been determined through low test scores, that a problem existed, the typical features of spatial problems were used to assist in making a diagnosis.

19.5.1. Problems of Grasping Space

19.5.1.1. Directional Concepts

The directional confusions of patient ten and twenty-two were clearly seen when they rotated the stimulus cards of the Arrow Matching test in an attempt to orientate the arrows in the same direction as those seen in various designs on the response sheet. Problems of directionality were seen in the drawing tests i.e. VMI figure 6.13 and 6.14, (see chapter six) and the Dot-Line test (chapter ten). Although the Dot-Line test was specifically constructed to evaluate directionality it seemed that directional problems were more evident in the VMI test. This was probably due to the fact that guidelines were present in the form of dots in the Dot-Line test. Directional problems might also be diagnosed from performance on the Stick Construction tests (Chapter Thirteen).

19.5.1.2. Spatial Relations

It has already been shown in chapter sixteen in which apraxia was described that the greater number of patients performed poorly on both constructional and motor free tests, of these several might be said to have a constructional apraxia. Only three patients had obvious spatial problems without an apraxia. As most of our daily activities involving space takes place in the sphere of grasping space, motor activity as the end point of space perception is extremely important. Critchely (1953) found that spatial problems were more evident in free-hand drawings for which greater spatial judgement is needed. It was however possible to separate spatial problems from apraxia and a patient might have spatial problems without a concomitant motor planning problem. The reverse, however, might not be so.

The following features of spatial problems were demonstrated in the execution of the tests of the V-P-M battery.

a) Horizontal or vertical lines drawn in an oblique direction (see Chapter Six).

b) Lines drawn were tremulous (Chapter Ten).

c) Inaccurate intersection of co-ordinates of drawing and construction (Stick Construction test) see Chapter Thirteen.

d) Reversal of designs (Figure 10.7 - Chapter Seven).

e) Incorrect orientation of parts of construction (see Figures 6.15, 6.16, 13.8, 13.9 and 14.7 in Chapters Six, Thirteen and Fourteen).

19.5.2. Problems Of Action Space - Spatial Thought

Poor space visualisation was seen in the performance of patient number twenty in the Position in Space test. Problems of positioning a block correctly in space was seen in figure 12.9, Chapter Twelve.

19.5.3. Patients With Specific Spatial Problems

The pattern of patient responses on tests involving space concepts can be found in table 19.2.

19.5.3.1. Directional Problems

Patient number twenty-two demonstrated directional problems. She was a woman aged fifty years who was tested four months after having the right middle cerebral artery clipped when an aneurysm was discovered. She achieved scores below the normal for her age in the Dot-Line test and Arrows test. Directional problems were also observed in the failed figures of the VMI test, although the overall score of the VMI was within normal range.

19.5.3.2. Space Relations and Position in Space

Most of the patients who performed poorly on the tests related to spatial relations i.e. the Spatial Relations test, Block Construction I, Stick Construction I and Design

Construction test, also performed poorly on the Position in Space test. There was no pattern in the performance on the Block and Stick Construction II tests in relation to the motor reduced Position in Space test. Four patients passed the Spatial Relations test but failed on the Position in Space test (see Table 19.2).

It seemed that determining different spatial constructs was possible through the V-P-M battery.

The question that needs answering, however, is - are the spatial skills of grasping space and action space hierarchical in nature i.e. does skill in grasping space form the basis upon which skills in action space are built? Will problems in grasping space automatically create problems in action space? According to De Ajuriaguerra and Tissot (1969), grasping space or subjective space develops in the child before that of action of objective space. The fact that all the patients who failed or were untestable on the Space Relations test also failed the Position in Space test seemed to indicate that the hierarchical nature of the skills was in operation in these motor reduced space tasks. This was not obviously apparent in the Block Construction tests as 52% of the patients who completed these tests passed both block tests, 22% failed both and equal number failed one or the other.

TABLE 19.2 PATTERN OF PATIENT RESPONSES ON TESTS INVOLVING SPACE CONCEPTS

(shaded box) = Problem. D = Discharged (empty box) = No Problem

PT NO	VMI	D-L	AR	PIS	SR	BC I	BC II	SC I	SC II	DC
1										
2		Untest-able								
3										
4										
5						Discharged				
6										
7										
8										
9	Untestable									
10										
11										
12										
13										
14										
15										
16										D
17										
18										
19										
20										
21	Untest-able									
22										
23										
24										
25	Untestable									
26	Untestable									
27	Untestable									
28	Untestable									
29					Discharged					
30						Discharged				
31			Discharged							
32			Discharged							
33			Discharged							

It seemed therefore that the Block Construction II test needs to be totally revised if it is to be an effective measure of a motor test in the area of action space.

These results could indicate that it is difficult to separate motor from motor free behaviour in the diagnoses of spatial problems in the adult C.V.A. patient. This may be due to the fact that adults have extensive experience in both types of tasks unlike the educationally disadvantaged child who may lack experience in the motor based spatial activity including drawing and construction (Concha 1985).

19.6. CONCLUSIONS

Determining different spatial constructs is possible through the V-P-M battery. It still remains unclear whether the different spatial constructs such directionality can appear as isolated problems. It is, however, apparent that problems in the sphere of action space i.e. poor visualisation can occur without concomitant problems in the sphere of grasping space but not vice versa thus confirming the developmental and hierarchical nature of spatial ability.

The necessity of having motor free and motor reduced tasks in a perceptual assessment test battery is for the purpose of being able to diagnose a constructional apraxia as distinct from a purely spatial problem.

It seems necessary to test many more patients on the V-P-M battery before a clear distinction can be made regarding its effectiveness in obtaining differences in the functional ability of the adult to perform motor based space tests as distinct from other spatial tests. The major advantage of the V-P-M battery over others is it's ability to separate and test different components of spatial function, and it will make research in this area much easier in the future.

Aspects of this chapter have been published in the South African Journal of Occupational Therapy, Volume 25:2, 1995.

CHAPTER 20

HEMIANOPIA, VISUAL INATTENTION AND UNILATERAL VISUAL NEGLECT

20.1. INTRODUCTION

The differences in the clinical manifestation of hemianopia, visual inattention and unilateral visual neglect are difficult to determine. The terms are often used interchangeably to add to the confusion. Heilman (1979) for example defined both hemi-inattention, and hemi-neglect as *"... the failure to respond to unilateral stimuli ..."* (page 268). He further stated that hemi-neglect was also termed visuo-spatial agnosia, hemi-spatial agnosia, visuo-spatial neglect and unilateral spatial neglect. Kolb and Whishaw (1990) used the term "contralateral neglect" i.e. neglect of stimuli on the side opposite to the lesion which might be accompanied by denial of the deficit. Kolb and Whishaw (1990) believed that recovery passed through two stages. *"The first, allesthesia, is characterised by the person beginning to respond to stimuli on the neglected side but doing so as if the stimuli were on the good side"* (page 425). The second stage is called simultaneous extinction i.e. the person *"... responds to stimuli on the hitherto neglected side unless both sides are stimulated simultaneously, in which case he or she notices only the stimulation on the side ipsilateral to the lesion"* (page 425-426). This phenomenon was labelled visual inattention by Critchley (1953) who said that the patient was unable to detect a visual stimulus on one side if a visual stimulus was simultaneously presented on the opposite side. Inattention was present on the side opposite to the lesion. Lezak (1983) stated that visual inattention was sometimes called visual neglect or visual extinction. She defined all three as *"... absence of awareness of visual stimuli in the left field of vision, reflecting its common association with right hemisphere lesions "* (page 342). In 1995, Lezak defined inattention as *"the tendency for decreased or absent awareness of events presented to the half of the body contralateral to the hemisphere side of the lesion"* (Lezak 1995 : 79). She went on to say that *"Left visual inattention is frequently, but not necessarily accompanied by left visual field defects, more usually left homonymous hemianopia."* (page 80). Heilman (1979) found lesions causing neglect to be located in the inferior parietal lobe. There seems, therefore, to be four categories of neglect of visual space as described in section 20.2.

20.2. Definitions

20.2.1. Hemianopia

Lesions of the visual tract causing characteristic field defects or hemianopia are well documented, (Gilroy and Meyer 1975). There is a quantitative loss in the opposite homonymous field in heminaopia constituting blindness for a part of the visual field. This defect is fairly common and is *"... associated with a neglect, disregard or forgetfulness of that half of space which subtends the heminaopia field i.e. the patient has an imperception for the objects contained within the extra-personal space on one or the other side of a vertical midline"* (Critchley 1953 : 271). Some patients adjust to this condition by turning their heads so that the visual stimulus falls within the intact field, other patients do not and treat the space as though it did not exist.

20.2.2. Unilateral Visual Neglect

Schenkenberg et al (1980) defined unilateral visual neglect as the *"... tendency of patients with cerebral damage or disease restricted to one hemisphere, to neglect or ignore visual stimuli that appear contralateral to the affected hemisphere"* (page 509). It seemed that recovery from neglect passed through the phases as enumerated by Kolb and Whishaw (1990). It also appeared that a unilateral visual neglect might not occur without a homonymous hemianopia and therefore it was difficult to separate hemi-neglect (unilateral neglect) from hemianopia. Unilateral neglect might be manifested by the patient drawing only half of a picture, quartering a line instead of bisecting it and failing to eat from one side of his plate etc.

20.2.3. Visual Extinction

Visual extinction or simultaneous extinction is the inability to detect a visual stimulus on one side if a visual stimulus is simultaneously presented on the opposite side. Patients tended to notice only the stimuli on the side ipsilateral to the lesion (Kolb and Whishaw 1990). According to Critchley (1953) this phenomenon was not usually discovered until specifically looked for *".. most patients being unaware of any defect which may arouse suspicions on the part of the examiner"* (page 317).

20.2.4. Visual Inattention

Visual inattention refers to a defective and therefore a reduced ability to attend to one or more components of the visual world. Although Albert (1973) used this description to refer to visual neglect, it was thought that his definition was a more apt description of visual inattention. Siev et al (1986) used the term to describe visual fixation. It was also possible that simultanagnosia described by Frederiks (1969b) was the same as visual inattention (see Chapter Seventeen).

It seems that visual inattention may occur without a visual field defect. The opposite is also true i.e. a visual field defect may occur without visual inattention and both may occur simultaneously. According to Albert (1973), the two occurred together more often when the lesion was in the right hemisphere. Visual inattention occurred in the centre of the field or on both sides more often than on the side contralateral to the lesion.

Albert (1973) also found that this type of visual defect occurred in almost as high a percentage of subjects with damage to the left side of the brain (30%) as those with right sided damage (37%). He, however, found that the neglect that occurred in the case of right damage was more severe than that of the left brain damaged cases.

Albert (1973) also proposed a model to account for this type of visual problem. This was verified by Heilman (1979) and Kolb and Whishaw (1990). According to the model, when stimuli are received by the normal individual, an initial process of perceptual integration takes place in each hemisphere with input from the contralateral visual field. Full visual perception then requires a process of bilateral integration in which cross transfer of function between hemispheres takes place although the right hemisphere is dominant for the final process of visuo-spatial organisation.

When there is brain damage the information transmitted to the opposite hemisphere is incomplete and inaccurate and arrives either too early or too late. Thus the normal bilateral integration of stimuli from the visual world is disturbed in both its temporal and its spatial aspects. This accounts for some defects within the so called normal field. Heilman (1979) said that this quantitatively asymmetrical sensory aspect to the two hemispheres might also account for the "extinction" phenomenon.

However, disturbances in general overall attention might account for at least some of the deficient performance observed. Heilman and Valenstein (1979) and Heilman and Van Den Abell (1980) proposed that neglect was manifested by an attention-arousal (alerting) disruption of the orientating response involving the cortico-limbic-reticular loop.

20.2.5. Qualitative Defects In The Visual Field

Field defects may improve but leave what Critchley (1953) termed qualitative field defects. He enumerated these as follows:-

- Visual disorientation (disordered spatial relationship of objects).
- Metamorphopsia (this is distortion of size, colour, orientation etc.).
- Altered visual adaptation rate.
- Loss of appreciation of small stationery objects.
- Altered rate in flicker fusion.
- Delayed recognition time.
- Loss of optokinetic nystagmus.

20.3. TESTS FOR VISUAL FIELD DEFECTS

20.3.1. Hemianopia

This is evaluated through confrontation testing (Siev et al 1986) perimetry and target testing (Heilman 1979).

20.3.2. Unilateral Visual Neglect

Unilateral neglect could be tested through the use of alternating simultaneous stimuli (Siev et al 1986) using finger movements (Heilman 1979).

Other tests such as the Line Bi-section Test (Schenkenberg et al 1980), and the Crossing Out Letter test of the Rivermead Perceptual Assessment Battery which was specifically constructed to evaluate visual neglect might also be used. The Right/Left Copy Shapes test and Right/Left Copy Words test of the RPAB (see Figure 6.7) were also designed to evaluate neglect. Oxbury et al (1974) used drawings of a daisy, block, and clock face for this purpose. Albert (1973) specifically constructed his Crossing Out Line Test to evaluate this function. The test consisted of a sheet of paper on which 40 lines were drawn at various angles and widely dispersed on either side of the midline. The patient was asked to cross out the lines. There were other tests that required the patient to cross out or cancel items such as lines, bells, stars, letters and symbols (Lesak 1995).

20.3.3. Visual Extinction

Visual extinction may be evaluated through the presentation of the patterns ascribed to Vernea and described by Lezak (1983 and 1995).

20.3.4. Visual Inattention

The patterns ascribed to Vernea were designed to test visual inattention i.e. in a 9x9 grid of squares, the patient was asked to put an x in any three spaces; on two rows of nine dots presented in parallel, the patient was asked to draw a vertical line between any three spaces (Lezak 1995). Bisiach and Luzzatti (1978) asked patients to describe a familiar location from two different viewing points. A diagram of the Piazza del Duomo in Milan was presented for this purpose and was therefore only suitable for patients familiar with Milan.

Lezak (1995) also described picture description tasks, reading tasks and drawing and copying tasks for visual inattention. The picture scanning component of the Behavioural Inattention Test compiled by Wilson, Cockburn and Halligan and the Indented Paragraph Test of Caplan as described by Lezak (1995) also appeared to be useful for this category of visual defect.

20.4. DETERMINING VISUAL FIELD DEFECTS FROM THE RESULTS OF THE V-P-M BATTERY

No specific tests were constructed to evaluate visual field deficits in the V-P-M battery. Unilateral field neglect may be ascertained on all tests when the subject neglects to complete the left side of the test. The Colour Matching, Form Matching, VMI, Arrows, Position in Space and Spatial Relations tests were particularly useful in this regard.

In patients eight, nine, fifteen and twenty-seven, clear neglect of the left visual field was demonstrated. Patient eight worked from right to left and neglected to complete tasks on the left side e.g. all the left VMI figures were not completed until the patient was reminded to complete all figures on the page.

Visual inattention was seen in patients one, two, seven, sixteen and eighteen. The Figure-Ground test proved to be a useful test for this diagnosis. Patient sixteen was interesting in that he stated that he could not see parts of the tests. This problem was not restricted to the left field. This problem could also be ascribed to one of simultanagnosia. Some of these patients also manifested poor concentration and general attention deficits thus confirming the findings of Heilman and Valenstein (1979).

20.5. CONCLUSIONS

It seems possible to be able to distinguish between a left field neglect and visual inattention affecting different parts of the visual field, through the V-P-M battery.

As hemianopias are clinically manifested in field neglect these two problems should be grouped together. Visual extinction, as Critchley (1953) has stated, must be specifically looked for. This was not done with the patients tested for this thesis, neither were the "qualitative defects" enumerated by Critchley (1953).

As line bi-section and line cancellation tasks have been found to be effective means of evaluating field defects, the line cancellation test described by Schenkenberg (1980) which has a standardised format for administration, could be included in any future version of the V-P-M test to make the diagnosis more specific. In addition should neglect of the visual field be noted, qualitative defects should be evaluated.

CHAPTER TWENTY-ONE

SUMMARY OF RESULTS AND THE CONCLUSIONS

21.1. INTRODUCTION

The purpose of this thesis was to construct a comprehensive battery of tests that was robust in terms of its psychometric characteristics to evaluate visual-perceptual-motor (V-P-M) function in the adult stroke patient. This was to meet the need for the occupational therapist to target specific deficits and thereby to provide an effective treatment to patients. The review of the literature demonstrated the need for such a test battery as no available tests met all the requirements for reliable and valid assessment tools. This demanded that each test be based on a sound theoretical model, supplied information on age related changes in V-P-M function and that the battery had undergone rigorous testing of the psychometric characteristics and consequent test adjustment before the collection of normative data.

To determine effectively whether patients suffered from perceptual problems as the result of a stroke, the tests were required to provide data that differentiated between the normal decline in function with age and the further decline that might result from brain dysfunction and damage from a stroke. Accordingly normative data for a range of ages needed to be provided.

For a test to provide norms against which a patient's function may be evaluated, a number of steps had to be taken to ensure that the test was appropriate, valid and reliable. These steps included constructing the items, testing a normal population, analysing the psychometric characteristics of the tests and reconstructing the tests after having dealt with the problems identified in the afore - mentioned analysis. Only then could the final testing take place to establish the norms for use in the evaluation process. This thesis concerned itself with the eleven steps leading to the formation of the final format of the tests in the battery. The final step (step twelve) i.e. the administration of the battery to a random sample of the population to obtain the normative data on test performance was not carried out in this study. This research has resulted in the development of a battery of tests for which normative data may now be collected.

In this chapter the candidate has summarised the results of each step of the standardisation process undertaken and the conclusions reached regarding the adequacy of the various tests for measuring the function for which they were constructed.

21.2. STEP 1 : DEFINITION OF THE TEST DOMAIN

For a standardised test to be acceptable it must be based on a guiding theory which provides definitions of the theoretical concepts and their relationships to one another. The theory is then tested through research aimed at operationalising the theory. The Visual-Perceptual-Motor Test Battery described in this thesis was constructed on the basis of a theoretical model, the individual components of which have been described in Chapter Four. As the battery of tests was constructed to measure V-P-M function, it was necessary to define this term. V-P-M function for the purposes of this thesis was defined as *"the processing and interpretation of visual stimuli as well as the selection and use of the correct motor pattern in response to that visual stimulus when appropriate."* The model concentrated on the components of visual perceptual function , although the need for different types of motor output were described. The model included the following skills:

<u>Form Perception</u> is the ability to recognise a form or shape as a whole, a skill that is needed for one to be able to use everyday objects appropriately. A motor free Form Matching (Form) test was constructed to measure this function.

<u>Overall Contour</u> is the skill that enables the individual to analyse the elements that make up a form and to reproduce these elements to form an outline. The Developmental Test of Visual Motor Integration (VMI) (Beery and Buktenica 1967,1982), was selected as an appropriate test for this purpose. It is the only published test in the V-P-M battery and consists of a sequence of twenty-four geometric forms to be copied on to paper with a pencil. The later versions of this test were not available at the time this study was begun. Although the normative data have changed with each new edition of the test, the twenty-four

geometric forms have not. The latest edition of the VMI provides normative data to the age of seventeen years.

Motor output patterns generated by sensory patterns are an inherent part of the visual perceptual process and although these patterns can be reduced to a bare minimum, they must be present in some form for the input to be verified. Copying forms in a paper and pencil test is an effective way of evaluating an individual's ability to analyse components of a perceptual structure. In addition the individual must be able to synthesise the sub-units to make a whole and the Part-Whole (P-W) test, a motor reduced test, requires the subject to combine different elements to make a complete figure. The term motor reduced is used to differentiate between those tests requiring the subject to point out the correct answers (motor free) and those that require the subject to place a cross on the correct alternative (motor reduced). A motor enhanced test requires the subject to exercise skilled motor activity in the performance of tasks such as in drawing and construction activities. To help in the diagnostic process, it is important to make the distinction between motor free, motor reduced and motor enhanced activities during testing.

Perceptual Constancy is the ability to perceive and to maintain in one's mind the invariant properties of a structure in spite of a variety of means of presentation. This skill is important as it enables the individual to keep his world stable and is evaluated in the motor reduced Perceptual Constancy (PC) test.

Figure-Ground ability is essential to help the individual focus on the task at hand and to place irrelevant stimuli into the background. Therefore, the Figure-Ground (F-G) test, was constructed to measure this aspect of the visual perceptual process.

Space Perception is an important and fairly complex component of V-P-M function described by various authors in different ways (see Chapter Nineteen). It was, therefore, necessary for the candidate to draw up a scheme of spatial perception as part of the V-P-M model on which to base the various space perception tests. The components of the scheme are as follows:

Directionality is a basic skill enabling the directional location of an object to be determined in relation to the line of gravity. This skill is included in two tests i.e. the Arrows (AR) test (a motor free test) and the Dot-Line (D-L) test which is a paper and pencil motor enhanced test requiring spatial concepts that emphasise the accurate analysis of line directions. It has become apparent from the process of determining the construct validity of this test that it also evaluates spatial relationships.

Space is further evaluated through a series of motor enhanced and motor reduced tests which analyse the ability to perceive:

<u>Spatial relations</u> is the ability to determine the relationships amongst objects (three dimensional form) letters and numbers (two dimensional form used in writing and arithmetic). Four tests were constructed for the purpose of evaluating this skill: the Spatial Relations (SR), the Block Construction I (BCI), the Stick Construction (SC I) and the Design Construction (DC) tests. The construction tests were compiled to evaluate spatial relationships in the three dimensional form (block construction) and in the two dimensional form (stick construction). The Design Construction test was formulated to evaluate relationships of objects that overlap in order to make use of the learned concept of perspective, a concept which is required for the interpretation of the spatial world. The motor reduced test i.e. the Spatial Relations test was designed to enable a distinction to be made between spatial problems associated with motor planning and those unassociated with this process.

<u>Position in space</u> is the ability to distinguish the specific position that an object, letter or number holds in space and requires space visualisation. Position in space was the term used in this thesis to label space visualisation tasks which required the spatial manipulation of objects in the mind. The term position in space has not been used by other authors for this purpose. There is no other existing test for space visualisation, although the term is referred to in the literature and is a skill upon which we depend for moving about in our environment. Three tests were constructed to measure this skill (the Position in Space (PIS) test, the Block Construction II (BC II) test and the Stick Construction II (SC II) test). These tests require the subject to manipulate spatial concepts in the mind and in the case of the Block II and Stick Construction II tests, to demonstrate this skill by completing a construction task. The construction of motor free, motor reduced and motor enhanced tests enabled the candidate to make the distinction between visual

perception and motor planning problems in the C.V.A. patient when these occurred.

Colour perception was the last visual perceptual skill evaluated and this was done through the Colour Matching (COL) test which requires the subject to match colours of different hues. Colour perception is necessary for the interpretation of objects as well as assisting in the visualisation of the spatial world.

Thus a unique battery of fifteen tests was created, based on a well defined model of V-P-M function.

21.3. STEP 2 : USES PLANNED FOR THE BATTERY OF V-P-M TESTS

The battery was designed to determine whether there were changes in V-P-M function in individuals who had suffered a stroke, particularly a stroke located in the right side of the brain as the right cerebral hemisphere is known to be dominant for the function of perception in the non-verbal sphere. Furthermore it is also claimed that V-P-M function decreases with age without necessarily interfering with the individuals' ability to effectively carry out their activities of daily living (see Chapter Two). However, tests available to date have not proved to be sensitive enough to changes occurring with age. Therefore, in the candidate's opinion, the relationship of V-P-M function to activities of daily living has not been satisfactorily determined. The V-P-M Battery was planned to evaluate the perceptual ability of stroke clients across a variety of ages with the ultimate aim of establishing relationships in the different functional categories of activities of daily living, perceptual function and motor ability. In this way the treatment of the cause of the dysfunction could be specifically directed.

The various items constructed for each of the V-P-M tests were carefully chosen to evaluate the different components of V-P-M function, and to offer interest and challenge at the correct level of difficulty for adults. Batteries of tests currently used by occupational therapists (e.g. RPAB by Whiting et al 1985 and the LOTCA by Itzkovich et al 1990) offer uncomplicated tests and many adults find them rather simple and become very demoralised when failing to complete items on the tests. Furthermore they do not demonstrate age related changes.

21.4. STEP 3 : TEST CONSTRAINTS AND VARIABLES

This step describes the variables that may influence the administration and performance on the tests mentioned in the previous step and the way in which these may be controlled. One important way of controlling variables in the execution of tests is to provide detailed information on the manner in which the tests should be administered and scored. Instructions for administering the tests are included in Appendix 1. A description of the variables and the way in which they may be controlled are to be found in Chapter Three.

21.5. STEP 4 : TEST BLUE-PRINT

Once steps 1-3 have been completed, the test blue-print must be finalised. This step consists of providing a detailed description of each skill to be measured by the test. This blue-print is found in Chapter Four in which is described the model of V-P-M function used in this thesis. However, the model has been reformulated as a result of the factor analysis. The adjusted model is described together with the overall results of the factor analysis in section 21.11.3.2. of this chapter.

21.6. STEP 5 : THE BATTERY OF V-P-M TESTS

As a result of the previous four steps, a battery of fifteen tests was conceptualised and fourteen unique tests were constructed by the candidate. Details of the fifteen tests are to be found in Chapters Five to Fifteen and Appendix 1.

21.7. STEP 6 : EVALUATION OF THE CONTENT BY EXPERTS IN THE FIELD TO ESTABLISH CONTENT VALIDITY

The contents of the V-P-M battery were evaluated by fifteen occupational therapists (Group One, see Chapter Three), for the purpose of providing content validity. The ratings provided by the occupational therapists helped to determine whether the tests measured what they were purported to measure. If a test were found to measure functions different from those proposed by the person constructing the test, changes would have to be made before its final standardisation. No modifications were made to the items in the tests as all but two of the tests in the V-P-M battery were found to be at least better than average in assessing the perceptual skill for which they were devised. The two exceptions were the Block Construction II and Stick Construction II tests. It was decided to leave these two tests unchanged to determine whether the factor analysis would confirm the constructs named by the candidate. This was done as it was felt that the therapists had evaluated the tests of the V-P-M Battery against the model of perceptual function proposed by Frostig in her test (Frostig 1966), rather than against the model proposed by the candidate. In Frostig's model space perception is divided into position in space, and spatial relations. Position in space in the Frostig's Model is evaluated in the two dimensional form and no visualisation is required. Smit (1996) confirmed the fact that various raters may differ on what constitutes the content of a test as one of the disadvantages of this method of evaluating content validity.

The ratings on individual tests were obtained by asking the therapists to evaluate each test on a scale of 0-5 according to how well they felt the test measured a perceptual skill and in this way a mean score for each perceptual skill on each test was obtained. A score of 3,75 or above indicated that the test was a very much better than average assessment of the particular skill. A score above 2,5 but below 3,75 indicated that the test was a better than average measure of the skill.

Table 21.1 summarises the skills that the therapists indicated were measured by each test and Table 21.2 shows the mean ratings awarded. Table 21.3 compares the skill for which each test was constructed with that ascertained through the therapists' rating.

It can be seen in tables 21.1 and 21.2 that the therapists felt that eight of the tests were only "better than average" measures of a particular perceptual skill, although five of these scored only 0,05 points below the cut off score for a "very much better than average" rating (i.e. Dot-Line, Position in Space, Block Construction I, Block Construction II and Design Construction tests) and were therefore placed in the upper bracket. The content validity will be discussed in relation to the factor analysis in section 21.11.3.2. of this chapter.

21.8. STEP 7 : ADMINISTERING THE BATTERY OF TESTS TO A SMALL GROUP OF SUBJECTS FOR WHOM THE TESTS ARE INTENDED (C.V.A. PATIENTS)

This step was intended to solve problems that might be encountered later when using the V-P-M tests with patients. Nine C.V.A. patients (Group Two) were used for this step (see Chapter Three for their selection). As a result of testing this group, some further changes were made to the instructions and administration of the tests. These changes concerned mainly the wording of the administration instructions. However, the method of administering the Perceptual Constancy test was changed so that the stimulus card for each item was left in front of the patient while the item was completed, thus eliminating memory from the test. The results of the tests of these nine patients were not included in the patient group (see section 21.10.2.) used for analysis in the thesis.

TABLE 21.1 SUMMARY OF SKILLS MEASURED BY EACH TEST AS EVALUATED BY THE OCCUPATIONAL THERAPISTS

TEST	VERY MUCH BETTER THAN AVERAGE ($\geq$3,75)	BETTER THAN AVERAGE ($\geq$2,5)
Form	Form as Mass	-
VMI	Overall Contour	Directional Sense Spatial Problems
P-W	Sub-Units of Form	-
PC	Perceptual Constancy	Figure-Ground
F-G	Figure-Ground	-
AR	Directional Sense	-
D-L	-	Spatial Relations Directional Space
SR	-	Spatial Relations Position in Space
PIS	-	Position in Space Perceptual Constancy
BC I	-	Spatial Relations
BC II	-	Spatial Relations
SC I	-	Spatial Relations
SC II	-	Directional Sense Spatial Relations
DC	-	Space Relations Colour
COL	Colour	-

- Did not fall into this category

TABLE 21.2 MEAN RATINGS OF FIFTEEN OCCUPATIONAL THERAPISTS (CONTENT VALIDITY)

Perceptual Skill	Form	VMI	P-W	PC	F-G	AR	D-L	SR	PIS	BCI	BCII	SCI	SCII	DC	COL
Form as Mass	4,2**	1,7	1,5	2,2	1,3	0,8	2,7*	1,4	2,0	0,7	0,8	0,7	0,7	1,4	0.2
Overall Contour	0,9	3,9**	1,7	1,6	0,6	0,7	2,1	1,5	1,3	2,0	2,0	2,0	2,0	1,3	0,0
Sub-Units(P-W)	0,3	2,4	4,0**	1,1	0,4	0,5	1,9	1,6	1,3	1,9	1,9	1,6	1,7	1,5	o,0
Perceptual Constancy	1,6	0,9	1,8	3,9**	1,3	1,0	0,7	2,3	3,4	0,8	1,1	0,9	1,0	1,3	0,4
Figure - Ground	1,4	1,3	1,0	2,5*	4,0**	1,7	2,3	2,1	1,4	0,7	0,8	0,6	0,7	0,7	0,7
Directional Sense	0,4	2,9*	0,7	0,6	0,5	3,8**	2,4	2,1	2,5	1,9	1,9	3,0	2,8	1,9	0,0
Space Relations	0,4	2,7*	1,6	0,4	1,1	2,0	3,7**	3,3*	1,6	3,7**	3,7**	3,3*	3,5	3,7**	0,0
Position in Space	0,2	2,0	1,4	0,7	0,7	1,7	0,8	2,9*	3,7**	1,1	1,1	1,3	1,4	1,9	0,2
Colour	0,0	0,0	0,2	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0	2,5*	4,7**

*≥2,5 = a better than average assessment of the skill

**≥3,75 = a very much better than average assessment of the skill

TABLE 21.3 COMPARISONS BETWEEN SKILL PLANNED FOR EACH TEST AND THERAPISTS RATING

TEST	SKILL FOR WHICH TEST WAS PLANNED	SKILL AS RATED BY OCCUPATIONAL THERAPISTS
Form	Form as Mass	Form as Mass
VMI	Overall Contour	Overall Contour
P-W	Sub-Units	Sub- Units
PC	Perceptual Constancy	Perceptual Constancy Figure-Ground
F-G	Figure-Ground Ability	Figure-Ground Ability
AR	Directional Sense	Directional Sense
D-L	Directional Sense	Directional Sense Spatial Relations
SR	Spatial Relations	Spatial Relations Position in Space
PIS	Position in Space (Space Visualisation)	Position in space Perceptual Constancy
BC I	Spatial Relations	Spatial Relations
BC II	Position in Space (Space Visualisation)	Spatial Relations
SC I	Spatial Relations	Spatial Relations
SC II	Position in Space (Space Visualisation)	Spatial Relations
DC	Spatial Relations	Spatial Relations Colour
COL	Colour Perception	Colour Perception

21.9. STEP 8 : PRELIMINARY TEST FORMAT

As a result of the work completed in Steps 1-7 the "preliminary" test battery was finalised and can be found in Appendix 2. "Preliminary" in this context means that changes may still need to be made to each test after the analysis of the psychometric characteristics and before the final standardisation is carried out.

21.10. STEP 9 : TESTING A GROUP FROM THE POPULATION FOR WHICH THE TESTS ARE INTENDED AND TESTING HYPOTHESES I AND II

Two populations were used for the testing carried out at this stage i.e. a group of normal men and women (n = 118) between the ages of twenty and seventy-nine years (Section 21.10.1). The results of the tests of this group provided the data for the analysis of the psychometric characteristics of the tests.

A group of patients (n = 33) was also tested (see Section 21.10.2). The patients' data were used only to evaluate the validity of the test for delimiting V-P-M problems in C.V.A. patients. Some patients' performance characteristics have been provided in this thesis to indicate the value of the tests in the diagnostic process (Chapters Seventeen to Twenty).

21.10.1. The Normal Group

21.10.1.1. Differences Between Men And Women

The numbers of men and women in each age category may be seen in Table 21.4. The scores of the tests for men and women were compared to determine whether their performance on the V-P-M battery was different. Fisher's Exact test was used to compare the accuracy scores and the U Test of Mann-Whitney to compare the time scores. The results can be seen in Table 21.5 and Table 21.6. The accuracy scores for the Form Matching test were not compared as there were no visible differences between the scores attained by both groups (range of scores 11-12 with a maximum score of 12).

Differences between men and women were found as follows:-

<u>accuracy scores</u> : the Colour Matching test in the age category fifty to fifty nine years only ($P < 0,05$) (see table 21.5).

<u>time scores</u> : the VMI test in the age groups twenty to twenty-nine and seventy to seventy-nine years (P<0,01);

the Stick Construction II test in the age category fifty to fifty-nine years (P<0,05) (see table 21.6).

The statistician felt that these results did not warrant separate analysis for men and women and both time and accuracy scores for men and women were combined for all other analyses.

There is no unanimity regarding gender differences in perceptual function. According to Lezak (1995) there were some gender differences in the structure of the brain, with the female brain being smaller. There was a tendency for the corpus callosum to get smaller with age in men,..."*but no such change occurs in women, suggesting that brain ageing may take place earlier in men than in women*" (pg. 297).

<u>TABLE 21.4 NUMBERS OF MEN AND WOMEN</u>

AGE	MEN	WOMEN	TOTAL
20-29	11	9	20
30-39	9	12	21
40-49	5	14	19
50-59	6	16	19
60-69	3	13	19
70-79	5	15	20
	39	79	118

Although the only difference in accuracy scores between men and women on the V-P-M battery was found in the Colour Matching test (age group fifty to fifty-nine years), Kolb and Whishaw (1990) found that *"males excel in visual* *spatial ability on tests of recall and detection of shapes, mental rotation of two or three dimensional figures, geometry, maize learning, map reading ... This difference is only about 0,4 of a standard deviation"* (pg. 391). However, in a test such as the Ray Figure which is a test of spatial ability, no gender differences were found between men and women by these authors.

TABLE 21.5 TESTING FOR DIFFERENCES BETWEEN ACCURACY SCORES FOR MEN AND WOMEN - P VALUES

AGE	20-29	30-39	40-49	50-59	60-69	70-79
Form	-	-	-	-	-	-
VMI	0,1698	0,6699	0,3378	1,0	0,5232	1,0
P-W	0,3359	1,0	1,0	1,0	1,0	0,3473
PC	0,3742	0,6731	1,0	0,3331	1,0	0,1313
F-G	0,6169	1,0	0,5696	0,3498	0,5820	0,6126
Ar	0,3189	0,3694	0,3378	1,0	0,2632	0,6126
D-L	1,0	0,6424	0,3034	1,0	0,5459	1,0
SR	0,3698	0,3964	1,0	0,6169	1,0	0,3473
PIS	0,3359	0,6108	1,0	0,3213	1,0	0,4474
BC I	1,0	0,6594	1,0	1,0	0,5304	1,0
BC II	1,0	0,3870	0,1409	1,0	0,5820	0,5598
SCI	0,4059	0,6108	0,1060	1,0	0,5232	0,3189
SC II	0,6699	1,0	1,0	0,1770	1,0	1,0
DC	1,0	0,5534	1,0	1,0	0,5304	0,6027
COL	0,1968	0,3972	0,6285	0,0173*	0,2105	1,0

* P < 0,05 - Not Calculated

Harshman et al (1983) found that females excelled at perceptual speed and males at perceptual closure and disembedding of visual patterns (figure-ground). This ability of men in figure-ground tasks is contradicted by Taylor (1968) who found women to be better than men at tasks requiring figure - ground perception. She also found that men tendeded to score better on visual spatial tasks than women. However, women have been found to be better than men in language skills. Feingold (1988) found that the differences between the genders on cognitive and perceptual tasks have declined over the years to be of no consequence today.

It was interesting to note that Beery (Beery and Buktenica 1967) in the first version of the VMI provided separate normative data for boys and girls, but further testing on larger samples indicated that there were no differences between the two groups (Beery 1989). Of the tests reviewed for this thesis, none provided information on any differences between men and women.

TABLE 21.6 TESTING FOR DIFFERENCES BETWEEN - TIME SCORES FOR MEN AND WOMEN - P VALUES

AGE	20-29	30-39	40-49	50-59	60-69	79-79
Form	0,7740	0,5669	0,3074	0,2706	0,5530	0,2493
VMI	0,0127*	0,6698	0,5786	0,4829	0,9056	0,0093**
P-W	0,3272	0,4769	0,5786	0,7256	0,9528	0,4237
PC	0,0864	0,9151	0,5786	0,2033	0,6784	0,3173
F-G	0,3691	0,9716	0,5784	0,7924	0,2604	0,7641
AR	0,1912	0,2265	0,1793	0,7253	0,3740	0,9601
D-L	0,8703	0,8035	0,4045	0,3338	0,2135	0,4839
SR	0,3070	0,5223	0,3306	0,9301	0,1549	0,6526
BC I	0,9348	0,5454	0,0640	0,0791	0,2861	0,5482
BC II	0,8058	0,1177	0,0956	0,0653	0,1386	0,6171
SC I	0,3909	0,8033	0,1636	0,8951	0,6782	0,3169
SC II	0,0660	0,6955	0,3074	0,0225*	0,8588	0,4835
DC	0,7132	0,6187	0,2286	0,3347	0,6784	0,9601
COL	0,3057	0,9433	0,5463	0,3794	0,9527	0,1205

* P < 0,05 ** P < 0,01

TABLE 21.7 NUMBERS OF YEARS AT SCHOOL - NORMAL GROUP

	MEN	WOMEN
$\bar{x}$	11,2	11,3
SD	1,4	1,2
Range	8-12	8-12

21.10.1.2. Number of Years at School

The number of years at school for the "normal" group was also recorded and is summarised in Table 21.7.

According to Parks et al (1993), age effects were most obvious on the performance sub-tests of the Wechsler Intelligence Scale (WAIS-R) and relatively minimal on the verbal sub-tests (see Chapter Two for a review of the literature on age effects). Moreover, the opposite was true for education. *"Education contributes to performance on many of the verbal sub-tests but only minimally to performance measures"* (Parks et al : 93). Similar findings were made by Albert and Heaton (1988) and Reynolds et al (1987). Although the educational variable was defined in the selection of normal subjects for this thesis it seemed that education had a minimal effect on performance on the type of tests used in the V-P-M Battery. The tests of the V-P-M battery are comparable to the performance measures of the WAIS-R. No difference was found between the educational levels of the normal group and the patient group used for this thesis.

21.10.1.3. Accuracy Scores

All the tests yielded an accuracy score. In each instance the results for each age band between twenty years and seventy-nine years were compared to determine if there were significant differences in the performance of the different ages (Table 21.8). In Table 21.8, the unbroken line indicates the ages for which no statistical difference existed in the accuracy scores obtained by the different age groups.

TABLE 21.8 SUMMARY OF THE DIFFERENCES FOUND IN ACCURACY SCORES FOR EACH OF THE V-P-M TESTS

AGE	20-29	30-39	40-49	50-59	60-69	70-79
Form	←	—	—	—	—	→
VMI	←	—	—	→	←	→
PW	←	—	—	→	←	→
PC	←	—	→	←	—	→
F-G	←	—	→	←	→	↔
AR	←	—	—	—	—	→
D-L	←	—	—	→	←	→
SR	←	—	—	—	→	↔
PIS	←	—	—	→	←	→
BC I	←	—	—	—	→	↔
BC II	←	—	—	—	—	→
SC I	←	—	—	—	—	→
SC II	←	—	—	—	—	→
DC	←	—	—	→	←	→
COL	←	—	—	—	—	→

Table 21.8 illustrates that six of the tests showed no age related changes when the accuracy scores of each group were compared. Three of these tests contained tasks which were fairly simple matching type tasks and three were construction tasks. Four of the tests in which age differentials were demonstrated showed decreased scores from the age of sixty years upwards. A further three tests

showed a decrease in test scores only at the age of seventy years and two tests demonstrated decreased function from the age of fifty years and one of these again at the age of seventy years. It has, therefore, been demonstrated to be essential that data on the performance of normal individuals be provided prior to testing adult patients for visual-perceptual-motor function, otherwise mistaken diagnoses could be made. Some authors of recent tests have recognised this by providing normative scores for different age groups although little evidence has been given regarding the change of scores with advancing age on these tests e.g. the VOSP (Warrington and James 1991).

Although changes in visual-perceptual function with age have been described (Horn and Cattell 1966, Gaylord and Marsh 1975, Birren and Schaie 1977, Cristarella 1977, Hayslip and Sterns 1979 and Botwinick 1981), tests for use by occupational therapists that took these changes into account only started appearing from 1982 (Concha 1982, Tyerman et al 1986, Warrington and James 1991). The tests of Tyerman et al and Warrington and James are suitable for evaluating V-P-M function in the adult but neither cover all the components of function described in this thesis. The COTNAB (Tyerman et al 1986) included tests for part-whole perception (Hidden Figures test), figure-ground perception (Overlapping Figures test), constructional ability and spatial relations (Block Printing test), whereas the VOSP (Warrington and James 1991) incorporated tests which covered part - whole ability, figure - ground, space relations and space visualisation (as evaluated by the candidate). There were no construction tests in the VOSP. It is, therefore, a motor free test.

Tyerman et al divided their data into ages sixteen to thirty-years, thirty-one to forty-nine years, fifty to sixty-five years and sixty-five years plus, and Warrington and James their scores between the twenty to fifty and the fifty to sixty-nine year old age groups, neither provided information on the reasons for these divisions or the statistical differences in the age groups.

Lezak (1995) stated that although it appeared that object and shape recognition remain intact in individuals older than fifty, there was a marked decrease in visuo-spatial judgement and visual closure, particularly from eighty years. This has been confirmed in this thesis a decrease in function being demonstrated in some tests from the age of fifty years.

It seemed that there were no age changes for gestural acts involving pointing. This may have contributed to the lack of age related changes seen in the Form Matching, Colour Matching and Arrows tests. The tests of Spatial Relations, Position in Space and Figure-Ground were motor reduced in nature, as pencil crosses were needed to indicate the subject's choice. The more complicated motor response could have contributed to the age related changes found in these tests. This did not, however, account for the lack of age related changes seen in the motor enhanced construction tasks. Lezak (1995) found tha,t on block design tests and object assembly tests, increased time was more closely associated with age than were the other factors. Benton et al (1983) found that even in their quite difficult three dimensional block construction tests, differences between younger (below fifty years) and older persons (fifty years and above) appeared to be very small, barely constituting even a trend. These findings were confirmed by the V-P-M battery in that three of the five construction tests showed no age differentials but differences in the time taken to complete the tests were demonstrated in all but one instance (i.e. the Stick Construction II test).

Drawing tasks seemed to be much more prone to the influence of age than construction tasks. Botwinick (1981), and Swilhart and Pirozzolo (1988) pointed out (see chapter two), that elderly subjects were less accurate than younger subjects in copying designs. The results of the VMI and the Dot-Line tests confirmed these findings.

As has already been mentioned in Chapters Six and Ten, many of the drawings of normal elderly persons resemble those of brain damaged individuals. Subjects older than sixty years tended to simplify drawings and these were also less well articulated than those of younger subjects. Poor co-ordination and tremor often compounded the problem, although out of the normal subjects tested for this thesis, only two in the seventy year old group demonstrated a co-ordination problem. This, however, did not seem to influence the results in terms of accuracy of articulation but might have affected the time taken to complete the test.

These facts led one to conclude that activities of daily living carried out in the concrete three dimensional world such as dressing, eating etc. might not be affected by age but that two dimensional tasks could be e.g. writing.

It would seem, therefore, that the tests constructed for the V-P-M battery provided an inclusive means of evaluating V-P-M function as well as providing comprehensive information on the changes that occurr with ageing within different visual perceptual spheres, changes that should be determined before perceptual problems in the adult C.V.A. patient can be diagnosed.

In order to evaluate the V-P-M function of each patient, percentile ranks were compiled based on the data from the normal subjects. These were compiled for the age bands twenty to thirty-nine, forty to fifty-nine, sixty to sixty-nine and seventy to seventy-nine years. This did not take into account the drop off in scores at the fifty year old level on two of the tests i.e. the Perceptual Constancy and the Figure-Ground tests. As the percentiles were provided only to give an indication regarding the relevance of the test scores for individual patients tested for this thesis and not for general practice purposes, the percentiles met the needs of this thesis. The percentiles in these two tests should NOT be used for diagnostic purposes in clinical practice until the final version of the test battery is available.

In six tests of the V-P-M Battery (i.e. the Form Matching, Arrows, Block Construction II, Stick Construction I and II and the Colour Matching tests) the null hypothesis that there will be no decreased ability in the accuracy of completing the tasks with advancing age can be rejected.

21.10.1.4. Time Scores

The time taken to complete the test was recorded in fourteen instances (Table 21.9). The Position in Space test did not have a time score as it was a timed test with a limit of five minutes per page. The picture of decreasing function with age with respect to the time scores was different to that of the accuracy scores. An increase in the time taken to complete the tests was seen in all but one instance (i.e. in the Stick Construction II test) and was seen at a variety of different ages. This confirmed the literature (Birren and Schaie 1977, Botwinick 1981, Lezak 1983 and 1995).

Percentiles for time scores were compiled using the same age groupings as were used for the accuracy scores. However, in reading these percentiles it must be remembered that the high scores demonstrated an increase in the time taken to complete the test. Therefore, to determine "normal" speed of performance

TABLE 21.9 SUMMARY OF SOME OF THE DIFFERENCES FOUND IN TIME SCORES FOR EACH OF THE V-P-M- TESTS

AGE	20-29	30-39	40-49	50-59	60-69	70-79
Form						
VMI						
P-W						
PC						
AR						
D-L						
F-G						
SR						
PIS						
BC I						
BC II						
SC I						
SC II						
DC						
COL						

the percentiles must be read in the opposite direction to those of the accuracy scores and any score above the eighty fifth percentile could be considered to be dysfunctional.

It will be unnecessary to record the time for all tests in any future version of the V-P-M battery as timing one motor free, one motor reduced (matching type task) and one motor enhanced test would give sufficient information on patient speed of performance. It is, therefore, proposed that the Colour matching test, Part-Whole test and the VMI or the Dot-Line test as well one construction test should be timed to provide this information.

The null hypothesis that there will be no increase in the time taken to complete the tasks can be rejected in all but the one instance i.e. in the case of the Stick Construction II test.

21.10.1.5. Effect of Health on Test Results

In testing the normal clients, no cognisance was taken of any systemic disease such as hypertension, diabetes, cardio-vascular and cerebro-vascular pathology, all of which commonly occur with ageing.

Dywan et al (1992) found that cardio-vascular disease accounted for twenty-eight percent of the variance in performance on a test of conceptual abstraction as did under-nutrition for the cognitively important vitamins B6 and B12 (Rosenberg and Miller 1992). However Parks et al (1993) stated that their *"analyses have failed to confirm a statistically reliable relationship between health status and intellectual or memory abilities"* (pg. 82).

Testing to obtain the normative data for the final version of the V-P-M Battery should record the health status of the normal person to clarify the role of systemic disease on intellectual function.

21.10.1.6. Place of Residence

Several of the normal elderly subjects lived in residential facilities for the elderly. This could also have contributed to the decline found with advancing age where the "*lack of stimulation and personalised care contribute to the severity...*"(Lezak1995:297) of any intellectual problems. This factor will also need to be taken into account in the future collection of data.

21.10.2. Results Of Testing Patients

21.10.2.1. Number of Patients

In order to determine whether the V-P-M battery was sensitive to perceptual function in patients who had suffered a C.V.A., a group of thirty-three left hemiplegic (right hemisphere C.V.A. patients) was evaluated on the V-P-M battery. However, not all of these patients completed all tests.

TABLE 21.10 NUMBER OF C.V.A. PATIENTS

AGE	MALE	FEMALE	TOTAL
20-29	-	2	2
30-39	3	2	5
40-49	3	1	4
59-59	4	2	6
60-69	5	5	10
70-79	2	4	6
TOTAL	**17**	**16**	**33**

21.10.2.2. Number of Years at School

The number of years spent at school by the patient group is to be found in Table 21.11.

TABLE 21.11 NUMBER OF YEARS AT SCHOOL - PATIENT GROUP

	MEN	WOMEN
$\bar{x}$	10,0	10,88
SD	1,6	1,15
Range	6-12	9-12

When comparing the level of education of the patient group to that of the normal group, it can be seen that the patient group spent a smaller number of years at school. There was, however, no statistical difference between the two groups in terms of schooling received.

21.10.2.3. Testing for Significant Differences in the Performance Between the Patient Group and the Normal Group

The results of the comparison between the accuracy scores obtained by the normal group of individuals and those obtained by the patients are to be found in Table 21.12.

These comparisons were made within the age groups between which no statistical difference was found in the scores obtained by the normal group. The unbroken line indicates these age clusters. The P value indicating the difference between the performance of the normal group and that of the patients is given above each line. In the following tests no difference was found between the patient group and the normal group:-

the Form Matching test	age 20-79 years
the Part-Whole test	age 60-79 years
the Space Relations test	age 70-79 years
the Position in Space test	age 60-79 years
the Colour Matching test	age 20-79 years

In the following instances the numbers of patients were too small to carry out a statistical analysis:

the Figure-Ground test	age 70-79 years,
the Space Relations test	age 70-79 years
the Block Construction I test	age 70-79 years.

Table 21.13 provides the corresponding percentile rank (see Appendix 2) for each accuracy score obtained by each patient. The shaded blocks indicate the scores that fell below the fifteenth percentile which was used as the cut off score for normal function. A score below this indicated a problem in this area of V-P-M function. The 15,9 percentile is equivalent to a z score of approximately -1.0. In diagnosing a perceptual problem it is common to use the z scores as a guide to determining dysfunction as eighty-four percent of a normally distributed population will receive a score equivalent to this or higher. The percentiles expressed in table 21.3 are in some instances estimations. For example, where a raw score fell blow the lowest score allocated a percentile in the tables (i.e. the patient obtained a score below the lowest score obtained by the normal group), the lowest percentile was recorded for the patient. If a score obtained by a patient was not allocated a percentile equivalent in the tables an estimate was made based on the existing scores. If there were doubts about whether the score would fall below the fifteenth percentile, the score was converted to a z score through the formula:

$$\frac{\text{Raw Score minus the Mean of the Raw Scores}}{\text{Standard Deviation}}$$

Any raw score obtaining a z score equivalent of less than -1.0 standard deviations below the mean was accepted as a failing score. For example, patient number twenty received a PIS score of eight. A score of fifteen for the Position in Space test was equal to a percentile of 16,7 and one of six was equal to 11,1. The z score equivelent for a score of eight was -1,3, thus confirming that a raw score of eight fell below the cut off point for intact function. As it is common to use raw scores that are normally distributed to provide a standard z score, the z score conversion should not be used for general practice purposes in this instance. It was used only as a guide to determining the correct percentile score.

The percentile equivalent for the patients' raw scores were used to help to decide on the appropriate tests for the battery. A definitive diagnosis could not be made at this stage as adequate normative data have not yet been collected.

On the basis of the above analysis it appeared that neither the Form Matching test nor the Colour Matching test distinguished statistically between the normal group and that of patients who had suffered a right-sided C.V.A. Only four patients failed the Form Matching test. In three out of the four cases, the patient failed all other tests in the V-P-M battery. It seemed, therefore that the Form Matching test could be used as a screening tool to determine when a patient was ready for more comprehensive assessment. On the other hand, the Colour Matching test did pick up problems with colour perception when these occurred (15 cases) and should not be dropped from the battery.

It can be seen from table 21.13 that six patients were discharged before all the tests in the battery could be administered. This is a problem in an acute care setting where patients are discharged as soon as they are medically stable and before rehabilitation can take place. The final test must, therefore, be short enough to be useful as an evaluation tool in any setting.

TABLE 21.12 TESTING THE DIFFERENCES BETWEEN NORMAL INDIVIDUALS AND PATIENTS - Accuracy Scores

	20-29	30-39	40-49	50-59	60-69	70-79	n
Form	n=2	n=5	No Diff. n=4	n=6	n=10	n=4	31
VMI	n=2	P<0,001 n=5	n=4	n=6	P<0,001 n=10	n=4	31
P-W	n=2	P<0,001 n=5	n=4	n=6	No Diff n=9	n=4	
PC		P<0,01 n=5	n=4	n=5	P<0,001 n=10	n=1	27
F-G	n=2	P<0,01 n=5	n=4	P<0,5 n=6	n=8	NotCalcula -tedn=1	26
AR	n=2	n=4	P<0,001 n=4	n=5	n=8	n=1	24
D-L	n=2	n=4	P<0,001 n=4	n=5	P<0,005 n=10	n=2	28
SR	n=2	n=4	P<0,001 n=4	n=6	n=8	No Diff n=3	27
PIS	n=2	n=4	P<0,01 n=4	n=4	No Diff n=6	n=1	21
BC I	n=2	n=3	P<0,01 n=4	n=5	n=8	Not Cal n=2	24
BC II	n=2	n=3	P<0,05 n=4	n=5	n=8	n=2	24
SC I	n=2	n=3	P<0,001 n=4	n=5	n=8	n=2	24
SC II	n=2	n=3	P<0,001 n=4	n=5	n=8	n=2	24
DC	n=1	n=3	P<0,001 n=4	n=5	P<0,01 n=8	n=0	21
COL	n=2	n=5	No Diff n=4	n=6	n=10	n=5	32
Total no. of patients in each age group	2	5	4	6	10	6	33

TABLE 21.13 ACCURACY PERCENTILES FOR EACH PATIENT(brought to the nearest whole number)

Pt No	FM	VMI	P-W	PC	F-G	AR	D-L	SR	PIS	BCI	BCII	SCI	SCII	DC	COL	AGE
1	100	10	17	6	2	28	4	0	12	5	5	37	5	7	5	68-6
2	3	2	5	2	2	2	2	0	U	2	3	3	2	2	8	53-5
3	98	23	34	68	10	100	7	27	49	100	12	34	63	22	17	21-11
4	97	24	37	47	15	50	100	42	30	100	100	100	21	11	2	48-11
5	98	10	73	12	6	100	5	27	90	dis	dis	dis	dis	dis	7	35-11
6	98	3	2	24	59	12	2	5	1	0	17	2	5	dis	7	23-5
7	84	5	56	7	U	31	8	5	8	21	10	10	16	47	5	65-2
8	97	2	16	37	12	21	7	10	8	5	24	2	45	29	24	49-5
9	0	2	U	2	U	U	1	0	U	0	0	0	0	0	5	64-11
10	98	1	1	2	4	1	1	1	10	20	7	1	2	7	5	36-0
11	97	21	11	2	8	2	21	11	11	100	55	3	14	29	3	58-0
12	84	21	78	15	53	20	16	5	6	100	100	100	11	47	7	60-8
13	3	2	5	11	16	21	7	42	16	5	100	36	13	5	2	43-11
14	97	2	66	47	18	100	21	11	16	5	42	36	45	3	24	55-0
15	3	2	11	5	2	1	7	11	2	5	2	11	2	2	2	55-2
16	100	5	20	7	5	7	5	30	32	20	50	10	0	dis	10	75-9
17	84	16	78	21	100	100	58	100	96	100	80	10	5	26	100	64-6
18	98	13	49	27	6	100	15	100	20	100	42	100	39	22	61	30-6
19	84	53	17	46	21	100	16	53	57	100	100	100	80	47	100	67-10
20	84	37	72	53	53	32	13	100	12	100	70	37	26	12	100	69-0
21	16	5	14	5	5	0	5	0	U	5	11	10	5	5	16	68-0
22	97	2	11	2	7	2	7	10	2	5	3	11	2	2	100	50-3
23	97	10	49	24	6	44	15	100	18	100	17	100	63	53	7	33-0
24	97	21	66	84	37	100	100	100	9	100	55	13	45	100	58	43-8
25	100	5	50	U	U	U	U	U	U	U	U	U	U	U	4	72-6
26	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	70-6
27	0	5	10	0	0	U	U	0	U	0	5	5	0	U	10	75-10
28	0	U	U	U	U	U	U	U	U	U	U	U	U	U	1	75-0
29	84	100	100	17	100	63	84	dis	86	dis	dis	dis	dis	dis	90	61-9
30	97	24	66	dis	8	dis	8	dis	dis	dis	dis	dis	dis	dis	24	58-6
31	100	21	20	dis	dis	dis	25	70	dis	dis	dis	dis	dis	dis	100	72-0
32	16	19	33	42	16	dis	14	53	dis	dis	dis	dis	dis	dis	100	61-8
33	98	10	20	2	4	dis	4	dis	dis	dis	dis	dis	dis	dis	100	34-2

U= Untestable Dis= Disharged prior to completing the test ☐= Below the 15%

21.11. STEP 10 : ANALYSIS OF THE PSYCHOMETRIC CHARACTERISTICS OF THE TESTS

21.11.1. Item Analysis

This section discusses the results of the analysis of the individual items of each test.

21.11.1.1. Item Efficiency

To evaluate the item efficiency of a test, the test should be administered to a *"sample of interest"* which *"should include a minimum ratio of two to three times as many subjects as test items"* (Bellack and Hersen 1984 : 240). The number of items in the tests of the V-P-M battery range from six to forty therefore the number of subjects to be evaluated to provide this information should be between eighty and 120. One hundred and eighteen normal subjects were evaluated on the tests.

Two ways of analysing the item efficiency were used i.e. through establishing the item difficulty index and the item discrimination index.

i) Item Difficulty Index

The value of this index (i.e. the difficulty p) varies between 0 (when no subject has answered the item correctly) and 1,0 (when everybody has answered it correctly) (Huysamen 1980). To obtain a satisfactory distribution, a mean value of at least 0,50 for the test items is required in the patient group. However, the normal group should have a mean of 0,70 or greater (Huysamen 1980).

Table 21.14 reflects the means of the item difficulty index for the normal group and for the patient group for each test. For calculating the mean difficulty (p) levels, all age groups were added together. Difficulty values were not calculated for the Form Matching test as the majority of individuals scored all items correctly. In addition, no difficulty indices were calculated for the Figure-Ground, Space Relations and Block Construction II tests for the patients in the age category seventy to seventy-nine years as too few of these patients were tested to make this possible. It was not possible to calculate the efficiency of items in the Position in Space test as it was a timed test.

TABLE 21.14 MEAN ITEM DIFFICULTY FOR EACH TEST

TEST	MEAN DIFFICULTY p FOR NORMAL GROUP	MEAN DIFFICULTY p FOR PATIENT GROUP
Form	-	-
VMI	0,80	0,58
P-W	0,70	0,64
PC	0,65	0,53
F-G	0,84	0,67*
AR	0,96	0,85
D-L	0,85	0,62
SR	0,96	0,90*
BC I	0,95	0,73*
BC II	0,76	0,56
SC I	0,89	0,64
SC II	0,75	0,34
DC	0,85	0,44
COL	0,92	0,78

* Patients aged 70-79 yrs are not included - Not Calculated

It can be see that, in all but one instance the mean item difficulty was at 0,70 or above and ranged from 0,65 to 0,96 for the normal group. The mean difficulty levels for the patient group showed a greater variation with eleven of the tests showing difficulty levels above the p = 0,50 level. Only the Stick Construction II and the Design Construction tests had a mean difficulty p with values below 0,50.

In each test, items that have a difficulty index below 0,20 and above 0,80 should be closely scrutinised before inclusion in the final test form and probably should be excluded (Huysamen 1980). According to Anastasi (1968), items should have a wide dispersion and any items between 0,15 and 0,90 should be considered for a test. Published tests nevertheless contain items with difficulty p values above the 0,90 level (Colarusso and Hammill 1972).

Anastasi's (1968) criteria for inclusion of items were considered to be appropriate to assist in the selection of test items for the tests of the V-P-M battery. The scores from the normal group of subjects were used for this purpose. As can be seen from table 21.15, no tests contained items with a difficulty index below 0,15. However, all but one of the tests contained items with a difficulty index of 0,90 or more. Of particular note were the Space Relations and Block Construction I tests, which consisted almost entirely of items with a difficulty p of 0,90 or above. Retention of these tests should be carefully considered as eliminating the items with a difficulty p above 0,90 would considerably shorten the tests. With respect to the other tests in the battery, withdrawing items with a difficulty score above 0,90 will make the tests more robust.

ii) Discrimination Index

"*The discrimination index refers to the items ability to* distinguish among subjects who possess the attribute being measured in differing degrees" (Huysamen 1980:221). Two approaches to determine the discrimination index were used i.e. one in which the upper 27% of responses was tested against the lower 27% of responses. If the difference between the two percentages was significant, the item was accepted as one which discriminated between those persons who could do the test and those who could not. Secondly, Flanagan's method (Downie and Heath (1974) of estimating *the value of the correlation co-efficient r* by plotting the upper and lower percentage figures on the graph and reading off the estimated r, was used (see Chapter Three). Table 21.16 lists the number of items for each test that showed the ability to discriminate among subjects. As can be seen from Table 21.16, six tests did not have the discrimination index calculated due to the high value of the difficulty p on each item. It was thus difficult to divide the items into the upper and lower 27% of scores for the calculation of the discrimination index in these instances.

TABLE 21.15 PERCENTAGE OF ITEMS WITH A DIFFICULTY p BELOW 0,20 AND ABOVE 0,90 FOR EACH TEST

Test	No. of Items	<0,20	>0,80	<0,15	>0,90
Form	12	-	-	-	-
VMI	24	0%	58%	0%	48%
P-W	12	0%	42%	0%	29%
PC	20	2%	50%	0%	35%
F-G	16	0%	78%	0%	50%
AR	24	0%	71%	0%	67%
D-L	16	0%	63%	o%	56%
SR	20	0%	98%	0%	95%
BC I	6	0%	0%	0%	92%
BC II	6	0%	0%	0%	33%
SC I	6	0%	83%	0%	66%
SC II	6	0%	33%	0%	0%
DC	6	0%	67%	0%	58%
COL	16	0%	88%	0%	69%

TABLE 21. 16 NUMBER OF ITEMS THAT SHOW A SIGNIFICANT DIFFERENCE BETWEEN UPPER 27% AND LOWER 27% (P<0,05)

TEST	NO. OF ITEMS	DISCRIMINATION INDEX	FLANAGAN'S METHOD
Form	12	-	-
VMI	24	9= 38%	14= 58%
P-W	12	9= 75%	0= 0%
FC	20	9= 45%	19= 95%
F-G	16	8= 50%	8= 50%
AR	16	3= 19%	-
D-L	16	8= 50%	8= 50%
SR	40	-	-
BC I	6	-	-
BC II	6	-	-
SC I	6	-	-
SC II	6	-	-
DC	6	6=100%	6=100%
COL	16	8= 50%	12= 75%

The Form Matching, Space Relations, Block Construction I and II, Stick Construction I and II tests, therefore, do not discriminate between those subjects who do and those who do not posses the attribute being tested. An analysis of the results of both types of discrimination indices indicated that more than 50% of the items discriminated between those persons who could do the test and those who could not in only seven of the tests. One test (Position in Space) did not have this index calculated as not all items were completed in the test.

When the discrimination indices for the normal group and the patient group were compared, only two tests had 50% of the items failing to discriminate between the normal group and the patient group i.e. the Part-Whole test and the Spatial Relations test. This comparison was not done for the Form Matching test as there was little variation in the scores obtained by the groups. The comparison was also not carried out for the Position in Space test as the time limitations prevented some participants from completing all items.

It has been suggested that various items in all of the tests be dropped from the final test form. The details were given in the chapters dealing with the individual tests (Chapters Five to Fifteen). Items that did not discriminate between those subjects who could do the test and those who could not, should be eliminated from the final test format.

TABLE 21.17 NUMBER OF ITEMS IN EACH TEST THAT DISCRIMINATE BETWEEN THE NORMAL AND THE PATIENT GROUPS

TESTS	NO. OF ITEMS IN TEST	NO. AND % THAT DISCRIMINATE
VMI	24	18 (75%)
P-W	12	5 (42%)
PC	20	13 (65%)
F-G	16	14 (88%)
AR	16	8 (50%)
D-L	16	13 (81%)
SR	40	17 (43%)
BC I	6	4 (67%)
BC II	6	4 (67%)
SC I	6	6 (100%)
SC II	6	6 (100%)
DC	6	6 (100%)
COL	16	8 (50%)

21.11.2. Test Reliability

Reliability refers to the *"stability, consistency, predictability and dependability of a test measure"* (Bellack and Hersen 1984). The Split-half reliability and the Kuder-Richardson formula 20 reliability calculations were carried out. The Pearson correlation coefficiencies for these reliability studies are to be found in Table 21.18. "*The Kuder Richardson method is better than the Split-half method insofar as it provides an estimate of the mean coefficient that can be obtained*" (Smit 1996:40).

"*Reliability coefficients, like all correlation coefficients, are influenced by... the variance within the groups. As variability within the group decreases, so the size of the correlation coefficient decreases*" (Smit 1996:41). If one compared the mean item difficulty levels for each test (table 21.14) with the reliability coefficients given in table 21.18, it is clear that those tests that had a high mean difficulty p have lower correlation coefficients than those with a lower mean difficulty p. Although, according to Smit (1996) there was no relationship between reliability and the difficulty value of a test, the test should aim at obtaining the widest distribution of scores possible and the probability of getting a correct response should be 0,50, thus decreasing the reliabilty coefficient. The level of significance if the realiabilty coefficient then becomes important.

Although some of the correlation coefficients were low, four of the tests showed Split-half correlation coefficients of r = 0,80 and above and seven showed Kuder-Richardson correlation coefficients of r = 0,80 and above in at least one age category. However, the reliability coefficients were generally significant at the P<0,001 level of significance. Usually there is a need to compromise between a desire to make the test as internally consistent as possible and the demands that the test be useful in the *"real world"* (Bellack and Hersen 1984). As reliability is also influenced by the length of the test, it is possible that the reliability figures for the Part-Whole test as well as the construction tests were influenced by their brevity. Taking all this into account, the reliability level of each test in the V-P-M Battery was satisfactory.

TABLE 21.18 RELIABILITY STUDIES

TEST	SPIT-HALF RELIABILITY	KUDER-RICHARDSON FORMULA 20
Form	-	-
VMI	0,72*** - 0.81***	0,53*** - 0,69***
P-W	0,54*** - 0,68***	0,57*** - 0,81
PC	0,56*** - 0,72***	0,86***- 0,95***
F-G	0,44** - 0,92***	0,61*** - 0,96***
AR	0,51***	0,40***
D-L	0,37** - 0,83***	0,48***- 0.80***
SR	0,43*** - 0,73***	0,87***- 0,94***
BCI	0.32 - 0,47***	0,73***
BCII	0,73	0,86***
SCI	0,56	0,56
SCII	0,48	0,80*
DC	o,43** - 0,89***	0,79***- 1,00***
COL	0,44	0,38

*P<0,05 **P<0,01 ***P<0,001

In comparison, the reliability coefficients of other published tests do not always reach the desired level of r = 0,80. For example, the Test of Visual Perceptual Skills (non-motor) Upper Level (Gardner 1992) showed reliability coefficients of r = 0,25 to 0,83 and five of the eight sub-tests had coefficients below r = 0,50. The VMI (Beery 1989) demonstrated Split - half correlation coefficients which ranged from r = 0,76 - 0,91. The manual of the Rivermead Perceptual Assessment Battery (Whiting et al 1985) provided only the test-retest coefficients (r = 0,27 to r = 1,0) and inter-rater reliability figures (r = 0,72 to r = 1,0). The VOSP (Warrington and James 1991) did not appear to have undergone reliability testing, nor did the COTNAB (Tyerman et al 1986) as there was no information provided in the manuals.

TABLE 21.19 INTER-RATER RELIABILITY

TEST	P VALUE ACCURACY	P VALUE TIME
Form	-	0,0421*
VMI	0,7470	0,3114
P-W	0,8825	0,8465
PC	0,8825	0,3114
F-G	0,4169	0,5134
AR	0,8825	0,8465
D-L	0,7470	0,1146
SR	0,8825	0,8465
PIC	0,3529	-
BC I	0,1353	0,0695
BC II	0,3114	0,1298
SC I	0,8825	0,1298
SC II	0,3114	0,4169
DC	0,6065	0,6065
COL	0,8465	0,9592

* P< 0,05

\- Not Calculated

Test-retest reliability was not performed for the V-P-M battery. Inter-rater reliability was assessed by using Friedman's two way analysis of variance as this is a more reliable statistic than the Pearson r. In using this statistical tool no differences were found among the three testers on each of the fifteen tests except in the recording of the time for the Form Matching test (Table 21.19).

As the scoring of the VMI test required some interpretation of the scores, inter-scorer reliability was sought. The relationship between the scores given by the candidate and those of an independent therapist was compared using the t test. No significant difference was found between the two sets of scores (P = 0,3082).

As the tests of the V-P-M battery were found to have inter-rater reliability, it appeared that the test instructions for administering and scoring made it possible for consistent results from different examiners on the same group of people. In comparison to published tests, the reliability coefficients of the tests of the V-P-M Battery were within acceptable limits.

21.11.3. Test Validity

"*Validity research tells us empirically what a test can and cannot do, its limitations as well as its advantages. Test validation is a long and tedious process ... ranging far beyond the work done for the initial establishment of a test*" (Bellack and Hersen 1984:253).

"*It is only possible to determine the premise of validity in a test by an overall weighing of the evidence, as the test does not exist in which all research comes up with the same answers and conclusions*" (Bellack and Hersen 1984:254). According to Smit (1996:50) " *it is erroneous to talk of test validity as if it were a specific property which a test possesses. A psychological test is valid for a specific purpose and validity is related to the purpose for which the test is used".*

The results of the studies on content and construct validity follow.

21.11.3.1. Content Validity

Content validation starts as the items are selected for a test and it is easiest to demonstrate when the test has been built from a defined theoretical orientation. Clearly, content validity is fairly subjective and depends on the theory used to generate the test items (Bellack and Hersen 1984). For this reason a model of V-P-M function was constructed and used as the basis for the V-P-M battery (see Chapter Four and section 21.2).

To establish content validity, fifteen occupational therapists were tested on the V-P-M Battery. They subsequently evaluated the content of each test according to the model of V-P-M function described in Chapter Four and summarised in section 21.2. The overall results have already been provided in Section 21.7, Table 21.1. According to this validity study, only two tests i.e. the Block Construction II and the Stick Construction II tests were not valid measures of the skill for which they were constructed. The content of each test and what it is purported to measure will therefore be re-examined together with the factor analysis. However, it was felt that a lack of clarity around the term position in space could have led to the fact that these two tests did not meet the criteria specified. As previously mentioned, Smit (1996) identified this problem as one of the disadvantages of this method of obtaining content validity.

21.11.3.2. Construct Validity

i) Ability to Differentiate Age Related Changes

The validity of a test is determined by a correlation between performance on the test and an independent objective measure of that behavioural aspect being measured (criterion). An example of a criterion measurement is age differentiation (Smit 1996). The ability of the tests to differentiate age related changes in V-P-M function was determined thus contributing to the construct validity of the test. Table 21.8 gives a summary of the tests and whether differences in performance were found among the age categories of the normal group. As can be seen from Table 21.8 tests such as the: the Form Matching, the Arrows , the Block Construction II, the Stick Construction I, the Stick Construction II and the Colour Matching did not prove to be determinants of age related changes. On the other hand these tests could be said to measure basic functions which did not deteriorate with age.

As one of the purposes of the V-P-M battery of tests was to determine age related changes in V-P-M function, tests other than those mentioned in the previous paragraph could be considered valid for this purpose.

ii) Ability To Differentiate Visual-Perceptual-Motor Problems

The sensitivity of the tests to visual-perceptual-motor problems in adult stroke patients with right hemispheric lesion was also evaluated as part of the construct validity studies. Table 21.12 summarised the level of sensitivity to these changes. Two of the tests i.e. the Form Matching test and the Colour Matching test did not show differences between the performance of the normal and the patient groups. However, the Colour Matching test in spite of the lack of statistical evidence to support differences between the two groups, did demonstrate instances when colour perception was disturbed. Other tests i.e. the Part-Whole test, the Space Relations test, the Position in Space test and the Block Construction I test did not appear to be sensitive to perceptual problems in patients older than seventy. Unfortunately, several of the older patients were found to be unable to complete the tests and a zero score should have been included in the analysis to obtain the full picture of patient ability. The following visual-perceptual-motor syndromes can be diagnosed from performance on the V-P-M battery:

SYNDROME	COMPONENTS OF THE SYNDROME
Constructional Apraxia	Drawing Construction
Apperceptive Agnosia	Agnosia for: Pictures Shapes Drawings
Visual Discrimination	-

Spatial Dysfunction	-	Grasping Space
		Directionality
		Spatial Relations
		Action Space
		Position in Space
		Space Visualisation
Left Neglect	-	
Visual Inattention	-	

The tests therefore could be considered valid for the purposes of providing information on V-P-M dysfunction and the syndromes related thereto. For a summary of the syndromes that may be diagnosed with each test see Table 21.20.

TABLE 21.20 SUMMARY OF PERCEPTUAL PROBLEMS EVALUATED BY THE V-P-M BATTERY

	Form	VMI	P-W	PC	F-G	AR	D-L	SR	PIS	BCI	BCII	SCI	SCII	DC	COL
Apraxia															
Ideational	-	-	-	-	-		-	-	-	-	-	-	-	-	-
Ideomotor	O	-	-	-	O	O	-	-	-	-	-	-	-	-	O
Constructional Construction	-	-	-	-	-	-	-	-	-	√	√	√	√	-	-
Drawing	-	√	X	X	-	-	√	-	-	-	-	-	-	-	-
Hemianopia	O	√	X	X	O	O	√	X	X	√	√	√	√	-	O
Unilateral Neglect	O	√	X	X	O	O	√	X	X	√	√	√	√	-	O
Visual Inattention	O	√	X	X	O	O	√	X	X	√	√	√	√	-	O
Visual Discrimination	O	-	-	-	O	O	√	X	X	-	-	-	-	√	O
Agnosia															
Apperceptive	O	√	-	-	O	O	-	X	X	-	-	-	-	-	O
Associative	-	-	-	-	-	-	-		-	-	-	-	-	-	-
Visual object	-	-	-	X	O	-	-	-	-	-	-	-	-	-	-
Simultanagnosia	O	-	X	X	O	O	-	-	-	-	-	-	-	-	O
Grasping space															
Direction	-	√	-	-	-	O	√	-	-	-	-	√	√	-	-
Spatial Relations	-	√	-	-	-	-	√	X	-	√	-	√	√	√	-
Action space															
Topographical	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spatial thought	-		X	X	-	-	-	-	X	-	√	-	√	-	-

√ = Motor Enhanced Test, X = Motor Reduced Test, O = Motor Free Test, - Skill not primarily evaluated with this test.

iii) Test Communality and Specificity

Both the communality and the specificity of tests can be evaluated. This helped in deciding which tests should be retained within the battery. "*The proportion of the total variance that is due to factors that the test has in common with other tests is the test's communality, and the portion due to factors specific to the test itself is the tests specificity....The communality of a (sub)test (*in a battery*) is computed as the sum of squares of the factor loadings on that (sub)test...(Aiken 1996:49).* The communalties are then subtracted from their mean reliability's to give the specificity. The specificity is the percentage of the tests total variance that can be accounted for by factors specific to that test. Table 21.21 gives the communality, $\bar{x}$ reliability and the specificity of the tests in the V-P-M battery.

There is a high degree of communality among the tests of the V-P-M battery. The tests with the highest communality values are the Arrows test and the Design Construction test at 0,74, the values ranging from 0,48 to 0,74. The specificity value of the Arrows test was also the highest at 0,29. The communality and the specificity could be compared to the Wechsler (WISC III) which has communality figures ranging from 0,34 - 0,79, with five of the tests having communality values of 0,70 and above (Aiken 1996). The V-P-M battery, therefore, seemed to have an acceptable range of values which could indicate the individual contribution that each test makes to the evaluation of V-P-M function.

TABLE 21.21 TEST COMMUNALITY AND SPECIFICITY

Test	COMMUNALITY	RELIABILITY($\bar{X}$)	SPECIFICITY
Form	-	-	-
VMI	0,59	0,69	0.10
P-W	0,64	0,65	0.01
PC	0,52	0,77	0,25
F-G	0,62	0,73	0,11
AR	0,74	0,45	0,29
D-L	0,67	0,62	0,05
SR	0,63	0,74	0,11
PIS	0,67	-	-
BC I	0,48	0,51	0,03
BC II	0,57	0,80	0,23
SC I	0,52	0,56	0,04
SC II	0,61	0,64	0,03
DC	0,74	0,78	0,04
COL	0,66	0,41	0,25

- Not Calculated

iv) Correlation Among The Different Tests In The Battery

The structural relationship of the tests to one another was also evaluated by carrying out multiple correlations among the tests (Table 21.22).

It can be seen from Table 21.22 that there are no correlations above r = 0,80. However, moderate correlations (i.e. r= 0,50 to r = 0,71) are to be found between the following tests:-

Part-Whole test and the
-VMI
-Dot-Line test
-Position in Space test
-Design Construction test

Perceptual Constancy test and the	-Figure-Ground test
	- Design Construction test
Figure-Ground test and the	-VMI
	-Dot-Line test
	-Design Construction test
Space Relations test and the	-Design Construction test
Position in Space test and the	-VMI
	-Design Construction test
Stick Construction I test and the	-Dot-Line test
Stick Construction II and the	-Dot-Line test
	-Design Construction test
Design Construction test and the	-VMI
	-Position in Space test

TABLE 21.22 CORRELATION MATRIX

	VMI	P-W	PC	F-G	AR	D-L	SR	PIS	BCI	BCII	SCI	SCII	DC	COL
vmi	1,0				0,27									
p-w	0,51	1,0	0,45	0,50	0,25	0,53	0,27	0,60	0,40	0,42			0,56	0,16
pc	0,46		1,0	0,53	0,31	0,48			0,44	0,32			0,56	0,21
f-g	0,51			1,0	33	0,62			0,42	0,44			0,59	0,03
ar					1,0									
d-l	0,71				0,35	1,0			0,46	0,38			0,63	0,07
sr	0,43	0,27	0,43	0,48	0,48	0,44	1,0	0,27	0,31	0,24	0,21	0,39	0,56	0,12
pis	0,56		0,37	0,42	0,25	0,49		1,0	0,2,	0,48			0,52	0,21
bc i	0,39				0,23				1,0					
bc ii	0,35				0,16				0,22	1,0				
sc i	0,36	0,47	0,37	0,36	0,14	0,51		0,36	0,37	0,30	1,0		0,47	0,21
sc ii	0,42	0,36	0,46	0,40	0,37	0,53		0,23	0,46	0,27	0,48	1,0	0,57	0,21
dc	0,61				0,32				0,64	0,39			1,0	0,23
col	0,14				0,01				0,13	0,00				1,0

v) Factor Analysis

The correlations of the tests should be viewed together with the factor analysis. The aim of a factor analysis is to determine the factor composition of the test battery i.e. how many psychological dimensions or factors the test is measuring and what weight or loading each test has on each factor (Aiken 1996). Every factor analysis has two stages: factoring and rotation. The factoring stage determines the number of factors needed to account for the relationships between each test on each factor. The rotation makes the factors more interpretable by providing "*a configuration in which only a few tests have high loadings and the majority have low loadings on any given factor*" (Aiken 1996:47).

TABLE 21.23 FACTOR ANALYSIS (Sorted Rotated Factor Loadings)

TEST	FACTOR I	FACTOR II	FACTOR III
PIS	0,80	0,00	0,00
BC II	0,74	0,00	0,00
P-W	0,73	0,00	0,00
VMI	0,63	0,41	0,00
D-L	0,61	0,52	0,00
F-G	0,58	0,54	0,00
SR	0,00	0,78	0,00
AR	0,00	0,75	0,00
SC II	0,00	0,60	0,46
DC	0,51	0,57	0,40
PC	0,37	0,52	0,33
SC I	0,46	0,00	0,53
BC I	0,27	0,48	0,42
COL	0,00	0,00	0,81

The correlation between each test and each factor is to be found in Table 21.23. If we group all tests that have a factor loading greater than 0,50 three factors are constituted and can be labelled by the candidate. The interpretation or labelling of a factor was essentially a subjective matter especially as no marker variables were included. The objective was to determine which factors underlaid this particular set of variables. Loadings less than 0,28 were replaced by zero, as loadings with less than this value should not be considered. The formula $3/\sqrt{\bar{N}}$ (where N equals the sample size) was the formula used to establish the lower cut off value (Huysamen 1980:65). Loadings above r = 0,50 were read as the relevant component of the factor.

The following criteria were used in the computer search for the best factor matrix (Huysamen 1980:72):

- *"each factor should have a number of zero loadings equal at least to the number of factors extracted in the analysis;*

- *for every pair of factors there should be several variables with zero loadings on the one factor but substantial loadings on the other;*

- *for every pair of factors there should be only a small number of variables with substantial loadings on both of them;"*

The V-P-M battery meets all these requirements.

The three factors within the V-P-M battery should be viewed in relation to the V-P-M model. The model (see Chapter Four), was developed on the basis of the developmental sequence of visual - perceptual - motor skills as Smythies (1956) found that recovery from brain damage in the adult took place in a sequence markedly similar to that occurring during development of V-P-M skills in the child. Therefore distinct aspects of form perception were described (see Figure 21.1). Space perception was also described as a distinct entity with the various components delimited i.e. directionality, spatial relations, position in space (space visualisation). Perceptual constancy with regard to colours, objects and size of objects as well as figure-ground perception were also separately delimited (Figures 21.1 and 4.3 in Chapter 4). Although motor free, motor reduced and motor enhanced tests were constructed so that praxis could be delimited, this aspect of function was not clearly defined in the V-P-M model in spite of the fact that the name of the model included the term "motor" and that the definition of perception included the motor output component. It was also interesting to note that the factor analysis did not separate the motor free, motor reduced and motor enhanced tests into separate factors but included tests with different motor components in the same factor.

On the basis of both the factor analysis and the correlation matrix it appeared that instead of the four separate perceptual components delimited in the model there were only three factors that subserve the V-P-M functions described in this thesis.

- **Factor I**

The following tests load for Factor I:
Position in Space

Block Construction I

Part-Whole

Test of Visual Motor Integration

Dot-Line

Figure-Ground

Design Construction

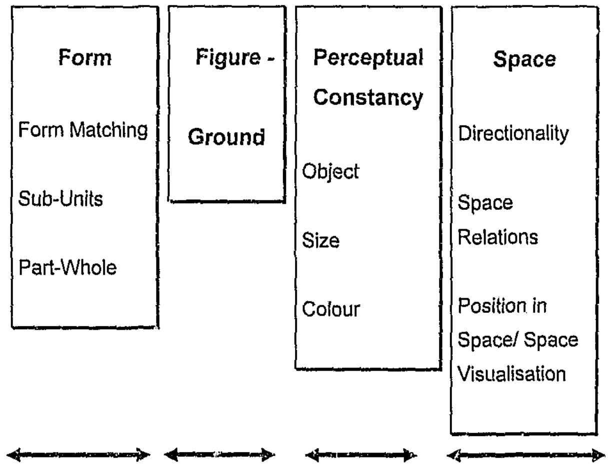


FIGURE 21.1 THE V-P-M FUNCTIONAL COMPONENTS

On analysing these tests in the light of the factor analysis, it seemed that all the tests loading for this factor measured components of space.

The low correlations among most of the tests loading for Factor I indicated that they measured different components of the space structure.

The VMI and the Part-Whole tests were constructed to measure different components of form perception and according to the content validation continue to do so. However, the factor analysis indicated that some type of space perception was needed in the execution of the tests.

It seemed that the space visualisation component in the Part - Whole test arose out of the method of administration and the words in the instructions ("*if you envisage a line completing the shape...*"). In addition some of the shapes were rotated and needed to be turned in one's mind before the correct choice could be made. If one analysed the patients' performance it could be seen that no patient failed the Part-Whole test and then passed the Position in Space test. It was, therefore, possible to use the Part-Whole test in its current form as a screening tool for the Position in Space test.

The VMI and the Dot-Line tests correlated with each other ($r = 0{,}71$) the only tests to correlate above the $r = 0.50$ level in this factor. This was probably due to the fact that both tests were drawing tests. The results indicated that one of the tests was not essential to the battery as directional concepts could be observed in the VMI test.

It was apparent that the spatial tasks could be sub-divided into concrete spatial manipulations utilising motor enhanced tasks and space visualisation using motor free tasks. These constructs are confirmed by the literature on space perception. Factor I, therefore, consists of the following space constructs which can be measured by tests in the V-P-M battery:

Grasping Space:

- Directional Concepts (evaluated in designs twelve, sixteen, nineteen, twenty and twenty four of the VMI).

- Space Relationships (evaluated by the BC II and the DC test as well as by components of the VMI e.g. designs ten, fourteen, fifteen and eighteen).

- Action Space:

Space Visualisation (evaluated by the Position in Space test).

There are aspects of action space that were not included in the V-P-M battery such as topographical memory which could be included in future versions of the test through the means ofunstandardised evaluations.

It can be observed that all those tests measuring grasping space are motor enhanced tests and it is, therefore, clear that this type of space behaviour results in complex motor function. In contrast, spatial functions within the sphere of action space, do not require motor planning and motor output although some motor activities such as moving around in the environment require action space function.

- **Factor II**

The following tests load for Factor II:
Space Relations
Arrows
Stick Construction II
Design Construction
Figure-Ground
Perceptual Constancy
Dot-Line

In analysing the factor loadings, the correlations and the content validation of the tests in Factor II, it was apparent that this factor could be labelled one of visual discrimination and figure-ground perception. Visual discrimination was defined as the ability to discriminate among complex visual stimuli, whereas figure-ground ability was defined as the ability to focus attention on important stimuli and to place irrelevant stimuli into the background. These are two related but different skills.

The correlations among the tests in this factor were all below r = 0,50, except for the correlation between the Space Relations test and the Design Construction test (r = 0,56). This seemed to indicate that, as in Factor I, Factor II had different components as follows:

- Visual discrimination (evaluated through the Space Relations test which should be renamed the Test of Visual Discrimination).
- Figure-ground perception (evaluated through the Figure-Ground test).
- Perceptual constancy (the different components evaluated through the Form Matching, a changed Part-Whole and the Perceptual Constancy tests).

The review of the literature indicated that perceptual constancy appeared as part of a developmental continuum i.e. form perception, then visual closure, and lastly perceptual constancy. The Part-Whole test should be changed by altering the instructions and the orientation of the components of each item in order to be a better evaluation of visual closure.

- **Factor III.**

Only one test had a high loading for this factor i.e. the Colour Matching test, It seemed, therefore, that Factor III was a colour factor and that colour discrimination was not part of perceptual constancy as previously thought.

vi) The New Model of Visual-Perceptual-Motor Function

The model of perceptual function should be modified in the light of these findings. Figure 21.2 depicts the visual perceptual components of the model, however, it should be remembered that this is only part of a complex process which consists of three distinct entities i.e. the sensory input through the visual, tactile, auditory and olfactory channels; the perceptual process (described for the visual pathway only in Fig. 21.3) and the motor or output process. The motor output reflects the perceptual components in co-ordinated and well planned movements. In the case of the V-P-M battery, these movements were chiefly of the hand and arm. Speech and general behaviour could also be observed. As mentioned in Chapter Four all of these form an integrated process which could be influenced by memory, learning, concentration, thinking and inherent intellectual ability as well as the individuals' emotional state. This thesis has demonstrated that a distinction can be made between "where" a shape or object is located (space) and "what" (visual discrimination) an object is. Hence the two major factors. According to Millar (1994) these two functions are subserved by different parts of the brain.

This thesis has dealt with an analysis of the visual-perceptual-motor process only and has attempted to find a systematic way of assessing this process using motor free, motor reduced and motor enhanced tests. The model failed to provide detail on the different types of output processes and therefore the revised model must take these into account including motor co-ordination. Co-ordination can be observed in the VMI, Dot-Line and the construction tests. The final version of the V-P-M battery should include a test specifically designed to measure fine motor co-ordination.

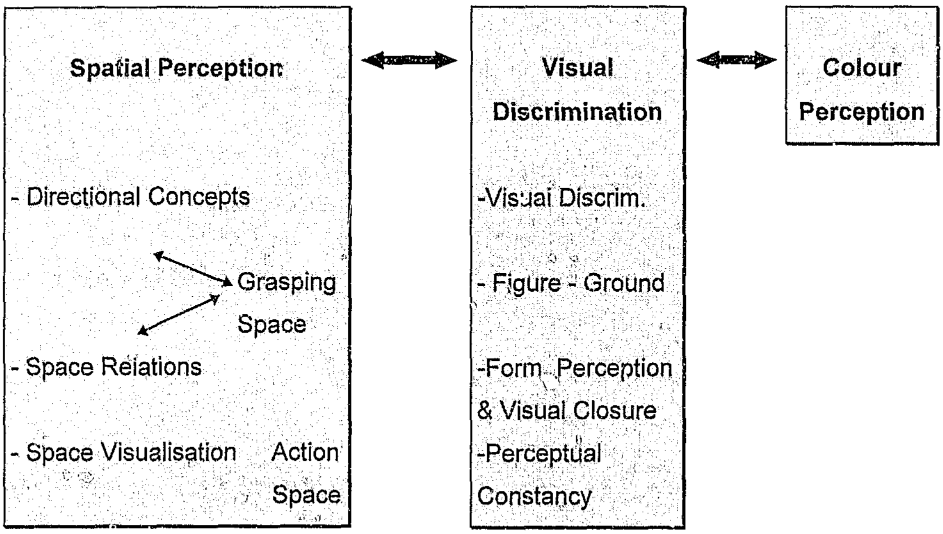


FIGURE 21.2 THE REVISED V-P-M- MODEL

The work for this thesis also sought to eliminate the effects of memory, learning, intellectual and emotional functions and to compensate for poor concentration. Thinking is, however, part of all cognitive tasks. The effects of the afore - mentioned on V-P-M functions should be investigated once a battery of standardised tests has been produced. In the comprehensive model (see Fig. 21.3) all components of V-P-M function have been included. It should be noted that spatial and discriminative functions can be applied to the auditory, olfactory and tactile senses as well as the visual.

Testing visual perception should, also take into account the integrity of the eye and its ability to absorb the stimuli forming the basis of the visual-perceptual process. This aspect has not been evaluated in the Battery.

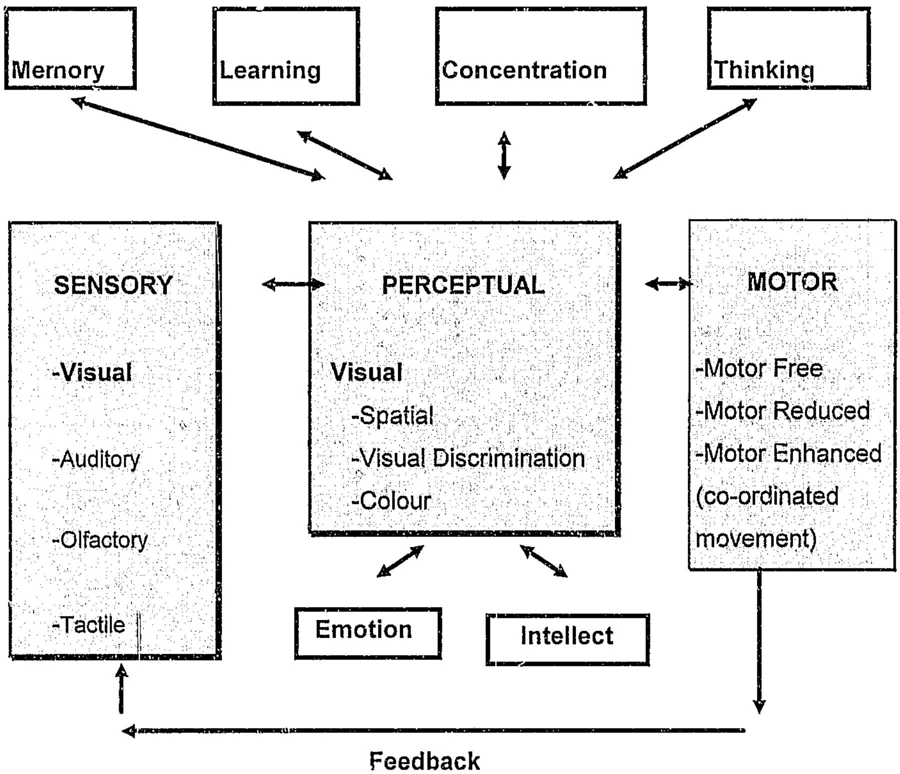


FIGURE 21.3. THE MODEL OF THE PERCEPTUAL PROCESS

21.12. STEP 11. - THE FORMATION OF A NEW TEST BATTERY

The penultimate step consisted of weighing up all the advantages and disadvantages of each of the fifteen tests, assessing the ability of each to evaluate a distinct component of visual-perceptual-motor function within the new model; assessing the strength of its psychometric characteristics and the unique contribution that it made to the field of visual perceptual testing for the stroke patient and then selecting the most appropriate tests for the battery.

Accordingly tests were selected for the V-P-M battery on the basis of a number of criteria (see table 21.24) i.e.

- The Construct Validity - in this case the ability to measure age related changes and to distinguish between normal performance and performance changed through brain injury caused by a C.V.A.
- Item difficulty and discrimination levels i.e. the spread of easy to difficult items with satisfactory average difficulty values for the items.
- Reliability of the test in terms of internal consistency, as well as, inter-rater reliability.
- Test specificity i.e. the ability of the test to make a unique contribution to the battery as a whole. The relevance of specificity was difficult to judge and could only be used as a guide (Aiken 1996).
- The factor analysis which identified the common dimensions underlying the scores of a sample of people on the collection of measurements and helped to formulate a functional model against which a diagnosis of dysfunction could be made.

- The unique contribution that each test made to the field of visual perceptual testing in the stroke patient. Thus the ability of the tests in the battery to help diagnose specific V-P-M problems such as hemianopia, object agnosia, apraxia etc.

TABLE 21.24 SUMMARY OF FINDINGS ON TESTS

	Age Related Changes	Diff Between Normal/ Patients	Item Difficulty x >70	Item Range 0,15- 0.90	Item Discrim. Normal/ Patients	Item Discrim.	Reliability x>r=.60	Construct Validity	Correlate with > r=.50	Factor	Speci- ficity
Form	-	-	-	-	-	-	-	-	-	-	-
VMI	√	√	√	√	√	√	√	√	P,W, F-G D-L, PIS	Factor I	1%
PW	√	Young Group Only	√	√	-	√	√	√	VMI, F-G, D-L, PIS, DC	Factor I	1%
PC	√	√	_	√	√	√	√	√	F-G, D-L	Factor II	25%
F-G.	√	√	√	√	√	√	√	√	VMI, D-L DC	Factor I(II)	11%
AR	-	√	√	-	√	-	-	√	Nil	Factor II	29%
D-L	√	√	√	√	√	√	√	√	VMI, DC SCII	Factor I(II)	5%
SR	√	√	√	-	-	-	√	√	DC	Factor II	11%
PIS		√	-	-	-	-	-	-	VMI, C P-W	Factor I	Not Cal
BC I	-	√	√	-	√	-	√	√	DC	-	3%
BC II	-	√	√	√	√	-		-	Nil	Factor I	23%
SC I	-	√	√	-	√	-	-	√	D-L, DC	Factor III	4%
SC II	-	-						-		Factor II	3%
DC	√	√	√	√	√	√	√	-	VMI PW, BCI, PC, D-L, SR	Factor I(II)	4%
COL	-	-	√	-	√	√	-	√	-	Factor III	25%

- = Research not conducted √= Category present

On the basis of all the results, V-P-M skills should be measured as follows:-

21.12.1. Spatial Perception

i) *Grasping Space*

Directional Concepts: Although referred to by both Critchley (1953) and Benton (1979), did not appear to be isolated in a specific test. Directional concepts could be diagnosed from performance on the VMI, particularly in designs twelve, sixteen and nineteen. The VMI test should, therefore, be retained. The Dot-Line test could be used as an alternate to the VMI should re-testing be required. Clinical observations of test taking behaviour during the execution of the Arrows test, (should this be used to evaluate visual discrimination), as well as the Dot-Line test could lead to the diagnosis of directional confusions.

Spatial Relations: As this is a concrete manipulative skill it should be measured through motor enhanced tasks such as the VMI and the Block Construction II tests. Although Lezak (1983), as well as, the candidate thought that compiling three dimensional constructions from a two dimensional model was a visualisation task, it appeared that the Block Construction II test tapped more concrete spatial manipulations than was originally thought. This met the criterion for construct validity as assessed by the fifteen occupational therapists. The Block Construction II test, therefore, should be retained but should include additional more complicated items.

ii) Action Space

Space Visualisation requires space concepts to be manipulated in the mind rather than through the use of the hands. Two tests were suitable for evaluating this skill. Firstly, the Position in Space test has proved to be a good measure of this skill and should be included in the final battery of tests. Secondly the Part-Whole test, although also measuring components of form closure (see construct validity), seemed to measure space visualisation. This test in its current form can also be used as a screening tool for the more complicated Position in Space test. However, it would be more advantageous to change this test so that it could be used to evaluate part-whole ability.

21.12.2. Visual Discrimination

Can be broken down into:

i) Figure-Ground perception which could be measured through the Figure- Ground test.

ii) Visual Discrimination - the Space Relations test, although constructed to measure space relations, appeared to be a more effective test for the evaluation of visual discrimination and its name should be changed to reflect this i.e. it should be called the test of Visual Discrimination. The Arrows test could be used in addition to the "Visual Discrimination Test" or as an alternate to it. In addition motor reduced testing can be compared with that of motor enhanced testing if the Stick Construction II and Design Construction tests are included.

iii) Perceptual Constancy: develops in a sequence and can be evaluated as follows:

- Form perception for which the Form Matching test could be used. This test should be used to determine whether the patient was mentally able to undergo further testing.

- Visual Closure which would be measured through a changed Part-Whole test.

- Perceptual constancy to be measured through the Perceptual Constancy test.

TABLE 21.25 PERCEPTUAL SKILLS IN THE NEW V-P-M BATTERY AND CORRESPONDING TESTS

SKILL	TEST
Spatial Perception	
-Directional Concepts	VMI (alt. Dot-Line test) Arrows test
-Spatial Relations	VMI Block Construction II test
-Space Visualisation	Position in Space test
Visual Discrimination	
-Figure-Ground	Figure-Ground test
-Visual Discrimination	Space Relations test/ Visual Discrimination Design Construction test Stick Construction II test Arrows test
Perceptual Constancy	
-Form	Form matching test
-Visual Closure	Part-Whole test (changed)
-Perceptual constancy	Perceptual Constancy test
Colour	Colour Matching Test

21.12.3. Colour Perception

Although the Colour Matching test was not robust in terms of its psychometric characteristics, it should be retained as a test for the evaluation of the ability to determine colour hue in appropriate cases.

21.12.4. The New V-P-M Battery

The V-P-M Battery should contain the eleven tests mentioned above (see table 21.25), thus reducing the number from fifteen. They should be redesigned taking into account the recommendations made in each chapter for the elimination and re-ordering of items.

The following procedure should be followed in the administration of the battery.

Step 1- The Form Matching test should be administered to cases where it is suspected that the patient might not be ready to undergo rigorous testing. A full score is required on this test before further assessment can take place.

Step 2- Administer a changed Part-Whole test and the Perceptual Constancy test.

Step 3 - Administer the VMI test (the Dot-Line test could be used as an alternate for repeat testing).

Step 4 - Visual discrimination should be assessed, starting with the Arrows test and then the Spatial Relations/Visual Discrimination test should be administered. Should the patient fail the Arrows test, the Space Relations/Visual Discrimination test should not be administered as eleven patients failed or were untestable on both tests. Only two patients passed the Space Relations test while at the same time failing the Arrows test, whereas five patients passed the Arrows test but failed the Space Relations test.

Step 5 - Administer the Figure-Ground test.

Step 6 - Administer the Position in Space test.

Step 7 -Administer the Block Construction II test, Design Construction and Stick Construction II tests.

Step 8 - Evaluate changes in colour perception through the Colour Matching test.

The above order was proposed so that patients will be subjected to a mix of motor free, motor reduced and motor enhanced tests providing needed breaks in the type of concentration required.

TABLE 21. 26 SUMMARY OF RESEARCH ON THE V-P-M BATTERY

STUDY	PURPOSE	RESEARCH QUESTION	DESIGN	SUBJECTS	RESULTS	CONTRIBUTION TO INSTRUMENT DEVELOPMENT
Content Validity Model of visual-perceptual-motor function	To use as a basis for constructing the test	Does the V-P-M Battery show content validity	V-P-M Model Constructed	No subjects - model constructed by the candidate	The model forms the basis of the test and was changed in light of research findings	Establishes content validity
Content Validity Expert Opinion	Provide content validity	Does the V-P-M battery posses content validity according to the experts	Occupational Therapists rated the tests on scale of 0-5	15 Occupational Therapists	All the tests possess content validity $\bar{x}$ >2.5	Content validity established
Construct Validity Factor Analysis	Determine the factors present	Are the factors named in the model distinct	Factor analysis with verimax rotation	118 normal subjects	Three factors- -Space -Visual Discrimin. -Colour	Construct Validity studies led to reformulation of model
Construct Validity Age related changes	Determine if performance changes with age	Provide Content Validity	Testing for significant differences between ages	118 normal subjects aged 20 - 79 yrs.	Ability on test decreases with age	Construct validity for age changes established
Concurrent Validity Changes in C.V.A. Patients	To determine whether test was sensitive to V-P-M problems in C.V.A. patients	Are the test scores of patients, different to those of normative group	Comparison between normal subjects and patients: Levine's test for equal variance. Not sig. use F test Sig. use Welch test	-33 C.V.A. patients between ages 20 yrs. - 79 yrs, compared to -118 Normal individuals	Results showed significant differences	Construct validity demonstrated.
Inter-rater Reliability	Prove inter-rater reliability	Does the V-P-M battery demonstrate reliability between test administrators	3 O.T.s rated 6 normal individuals	6 normal people between the ages 20-79 yrs. Sample of convenience	Results showed no statistical difference between scores obtained by administrators	Inter-rator reliability demonstrated

TABLE 21.26 CONTINUED

STUDY	PURPOSE	RESEARCH QUESTION	DESIGN	SUBJECTS	RESULTS	CONTRIBUTION TO INSTRUMENT DEVELOPMENT
Inter-scorer Reliability-VMI	To determine inter-scorer reliability	Do different scorers of the VMI achieve consistency in scores on the same test.	Two Occupational Therapists scored 59 VMI tests	Every second test of normal group scored by both therapists. T test used for comparison	Scores of the two raters showed no statistical difference	Inter-scorer reliability demonstrated.
Internal consistency-Reliability	To determine test reliability with regard to content sampling	Are the items in the test consistent	Split- half reliability on tests completed by normal subjects	Pearson product moment correlation co-efficient on odd and even items	Reliability demonstrated	Tests internally consistent
Internal Consistency-Reliability	To determine the homogeneity of the test items	Are the items in the tests homogeneous	Kuder - Richardson Formula 20	Each item of test compared to total normal subjects	Reliability Demonstrated	The tests consistency of measurement demonstrated

21.13. STEP 12 - ADMINISTERING THE TEST BATTERY TO A LARGE SAMPLE OF THE POPULATION FOR THE PURPOSE OF OBTAINING NORMATIVE DATA

The following procedure should be followed:-

21.13.1. Construct the test battery as proposed in the previous section, each test containing only those items that have been found to be appropriate in terms of their difficulty levels.

21.13.2. Administer the test to one hundred normal subjects from each of the age categories mentioned between twenty years and seventy-nine years. The selection of this sample should be from all population groups and various settings in the country. Different educational levels should be accounted for with a representative sample of subjects from those who ·e received formal schooling and those who have not, to confirm the findings that education does not influence performance on this type of test. This would necessitate the maintenance of the age bands twenty to twenty- nine, thirty to thirty-nine, forty to forty-nine, fifty to fifty-nine, sixty to sixty-nine and seventy to seventy-nine years with a re-evaluation of any possible differences in performance among the age groups, educational levels and social origin. The sample should be randomly drawn from a representative sample of old age homes, retirement villages, patients without neurological deficit using the out patient departments of a variety of hospitals and healtl centres. All subjects should be independent in all aspects of activities of daily living.

21.13.3. The data should then be converted into standard scores so that the function of patients can be easily compared with that of normal individuals. In addition, activities of daily living and aspects of perception should also be compared to determine the correlation between perceptual difficulties and independence.

21.14. Conclusions

At the time that the perceptual testing material presented in this thesis was being researched there was a lack of suitable visual-perceptual-motor tests for occupational therapists to use to evaluate this type of function. When the V-P-M Battery was first described (Concha 1982) the RPAB was also unveiled (Cockburn et al 1982). Since then other tests that might be used by occupational therapists i.e. the COTNAB (Tyerman et al 1986), the LOTCA (Itzkovich et al 1990), the Arnadottir Occupational Therapy Neurobehavioural Evaluation (A-ONE) (Arnadottir 1990) and the VOSP (Warrington and James 1991) have appeared on the market. All of them originate overseas, the RPAB, the COTNAB and the VOSP in the United Kingdom and the LOTCA in Israel and the A-ONE in the USA. All of the data for the V-P-M battery had been collected prior to the appearance of the above tests. When the above mentioned tests appeared on the market, careful consideration had to be given to the need for yet another testing tool. In order to help in this decision making process, the candidate had to carefully scrutinise the components of each of the above tests, the results of their psychometric analyses, the population on which they were standardised, the adequacy of their standardisation and whether they fulfilled the needs of occupational therapists in this country. In addition the candidate evaluated patients using these tools to determine their effectiveness.

Careful consideration led the candidate to believe that completing the above steps needed to prepare the V-P-M battery for standardisation was a worthwhile exercise. (For a summary of the research on the V-P-M Battery see table 21.24). None of the above published tests had undergone the research carried out at each of the steps followed in this thesis, nor did they evaluate all aspects of V-P-M function. In addition this is the only test battery to make the distinction between motor free, motor reduced and motor enhanced tests. In using the above published tests it is, therefore, difficult to analyse the patient's problem. The aims of this thesis have therefore been fulfilled.

The task of producing a useful test battery for South African occupational therapists to use with brain damaged adults is not yet completed as the new test must be reconstructed and administered to the normative sample. The most important preparatory steps enabling the construction of a robust and comprehensive test, however have been completed. The candidate believes that once this final step is accomplished, a very valuable tool will have been provided.

One of the contributions of this thesis is the description of the criteria that could be used to diagnose different types of visual-perceptual-motor dysfunction. This will enable therapists to make careful analysis of not only the test scores, but the types of performance seen on each test. Quantitative data cannot alone provide information on a patient's behaviour, but must be supplemented by qualitative information and an analysis of this behaviour which in turn can help in the selection of appropriate treatment techniques.

One of the most important roles of the occupational therapist is to prepare the patient to participate in all aspects of daily living. The influence of perceptual dysfunction on the performance of self care activities has been described by Arnadottir (1990) but a diagnosis as recommended by her requires an experienced and skilled examiner to make the appropriate inferences and it is still not clear the degree to which perceptual problems influence the ability to perform activities of daily living in the elderly stroke patient. The links with age, perceptual problems and motor paralysis have not yet been successfully demonstrated. One of the main problems in doing this has been the lack of tests that are sensitive to age related change in normal individuals who are completely independent in their activities of daily living (ADL). The other factor that has not been considered in research dealing with the relationship of function and ADL is the compounding variable of motor paralysis i.e. hemiparesis.

The preparation of this battery of tests makes it possible, not only to measure the developmental changes of perception in the elderly but to implement much needed research into the relationship between perceptual function and the spectrum of activities of daily living. In addition it will now be possible to carry out investigations into the functions of the left and right cerebral hemispheres and the role that ageing plays in their function.

This thesis has produced a battery of tests which are:

most important preparatory steps enabling the construction of a robust and comprehensive test, however have been completed. The candidate believes that once this final step is accomplished, a very valuable tool will have been provided.

One of the contributions of this thesis is the description of the criteria that could be used to diagnose different types of visual-perceptual-motor dysfunction. This will enable therapists to make careful analysis of not only the test scores, but the types of performance seen on each test. Quantitative data cannot alone provide information on a patient's behaviour, but must be supplemented by qualitative information and an analysis of this behaviour which in turn can help in the selection of appropriate treatment techniques.

One of the most important roles of the occupational therapist is to prepare the patient to participate in all aspects of daily living. The influence of perceptual dysfunction on the performance of self care activities has been described by Arnadottir (1990) but a diagnosis as recommended by her requires an experienced and skilled examiner to make the appropriate inferences and it is still not clear the degree to which perceptual problems influence the ability to perform activities of daily living in the elderly stroke patient. The links with age, perceptual problems and motor paralysis have not yet been successfully demonstrated. One of the main problems in doing this has been the lack of tests that are sensitive to age related change in normal individuals who are completely independent in their activities of daily living (ADL). The other factor that has not been considered in research dealing with the relationship of function and ADL is the compounding variable of motor paralysis i.e. hemiparesis.

The preparation of this battery of tests makes it possible, not only to measure the developmental changes of perception in the elderly but to implement much needed research into the relationship between perceptual function and the spectrum of activities of daily living. In addition it will now be possible to carry out investigations into the functions of the left and right cerebral hemispheres and the role that ageing plays in their function.

This thesis has produced a battery of tests which are:

sensitive to age related changes.
sensitive to V-P-M problems in the adult stroke patient.
robust in terms of their psychometric characteristics.
measure components of a researched model of V-P-M function.
make the diagnosis of Visual-perceptual-motor syndromes possible.
is able to link perceptual problems with those in activities of daily living.
is able to link perceptual problems with pathology seen on Computerised Tomography (CAT scan) and Magnetic Resonance Imaging (MRI).
is able to invstigate the perceptual functions of both left and right hemispheres

- THE END -

BIBLIOGRAPHY

Adams, G.F. (1974). Cerebrovascular Disability and the Ageing Brain. London: Churchill Livingstone.

Afifi, A.A., and Azen, S.P. (1959). Statistical Analysis: A Computer Orientated Approach. New York: Academic Press.

Albert, M.S. and Heaton, R.K. (1988). Inteligence Testing. In M.S. Albert and M.B. Moss (Eds.), Geriatric Neuropsychology. New York: Guildford.

Aiken, L.R. (1996). Assessment of Intellectual Functioning, (2nd Edition). New York: Plenium Press.

Albert, M.L. (1973). A Simple Test of Visual Neglect. Neurology, 23, 658-664.

Albert, M.S. and Heaton, R.K. (1988). Intelligence Testing. In M.S. Albert and M.B. Moss (Eds.), Geriatric Neuropsychology. New York: Guilford.

Allard, F., and Bryden, M.P. (1979). The Effect of Concurrent Activity on Hemispheric Asymmetries. Cortex, 15, 5-17.

Allison, R.S. (1962). The Senile Brain - A Clinical Study. London: Edward Arnold.

Ames, L.B., Gillespie, C., Haines, J. and Illg, F.L.,(1980). The Child from One to Six - Evaluating the Behaviour of the Preschool Child. London : Hamish Hamilton.

Anastasi, A. (1968). Psychological Testing (3rd Edition). New York: MacMillan.

Anderson, E., Anderson,T.P. and Kotke, F.J. (1997). Stroke Rehabilitation: Maintenance of Achieved Gains. Archives of Physical Medicine and Rehabilitation, 58:8, 345.

Anderson, T.P., Bourestom, N., Greenberg, F.R. and Hildyard, V.G. (1974). Predictive Factors in Stroke Rehabilitation. Archives of Physical Medicine and Rehabilitation, 55:12, 545-553.

Anderson, E., and Choy, E. (1970). Parietal Lobe Syndromes in Hemiplegia. American Journal of Occupational Therapy, XXIV:I, 13-18.

Andrews, K. (1979). Perceptual Disorders in Stoke. Occupational Therapy, 42:3, 62.

Archibald, Y.M. (1978). Time as a Variable in the Performance of Hemisphere - Damaged Patients on the Elithorn Perceptual Maze Test. Cortex, Vol 14, 22-31.

Arena, R. and Gainotti G. (1978). Constructional Apraxia and Visuoperceptive Disabilities in Relation to Laterality of Cerebral Lesion. Cortex, Vol 14, 463-473.

Arenberg, D. (1978). Differences and Changes with Age in the Benton Visual Retention Test. Journal of Geriantology, 33:4, 534-540.

Arnadottir, G. (1990). The Brain and Behaviour, Assessing Cortical Dysfunction Through Activities of Daily Living. St. Louis: The C.V. Mosby Co.

Atkeson, B.M. (1978). Differences in the Magnitude of the Simultaneous and Successive Muller-Lyer Illusions from age 20-79 years. Experimental Ageing Research, Vol 4, 55-66.

Ayres, A.J. (1962). Methods of Evaluating Perceptual Motor Dysfunction. Proceedings of the WFOT Conference.

Ayres, A.J. (1972). Southern California Sensory Integration Tests Manual. Los Angeles: Western Psychological Services.

Ayres, A.J. (1980a). Southern California Sensory Integration Tests - Manual. Los Angles: Western Psychological Services.

Ayres, A.J. (1980b). Interpreting the Southern California Sensory Integration Tests. Los Angeles: Western Psychological Services.

Ayres, A.J. (1985). Developmental Dyspraxia and Adult Onset Apraxia. Torrence: Sensory Integration International.

Banus, N., and Wills, I.H. (1977). Prescriptive Teaching - Theory into Practice. Springfield, Illinois: Charles C. Thomas.

Barrett, C. (1986). In Search of Brain Behaviour Relationships in Dementia and the Luria-Nebraska Neuropsychological Battery. Occupational Therapy in Geriatrics, Vol 4, 113-139.

Basso, A., Luzzatti, C. and Spinnler, H. (1980). Is ideomotor apraxia the outcome of damage to well defined regions of the left hemisphere? Journal of Neurology, Neurosurgery and Psychiatry, 43:2, 118-126.

Baum, B. and Hall, K.M. (1981). Relationship between Constructional Praxis and Dressing in the Head-Injured Adult. Ameican Journal of Occupational Therapy, 35:7, 438-442..

Beery, K.E. and Buktenica, N.A. (1967). Developmental Test of Visual-Motor Integration Manual. Chicago: Follet Publishing Co.

Beery, K.E. (1982). Revised Administration, Scoring and Teaching Manual for the Developmental Test of Visual Motor Integration. Chicago: Follet Publishing Co.

Beery, K.E. (1989). The Developmental Test of Visual Motor Integration, Administration, Scoring and Teaching Manual, 3rd Edition. Cleveland: Modern Curriculum Press.

Beery, K.E. (1997). The Beery-Buktenica Developmental Test of Visual-Motor Integration, Administration, Scoring and Teaching Manual, 4th Edition. Presippany: Modern Curriculum Press.

Bellack, A.S. and Hersen, M. (1984). Research Methods in Clinical Psychology, New York: Pergamon Press.

Belleza, T., Rappaport, M., Hopkins, H.K. and Hall, K. (1979). Visual Scanning and Matching Dysfunction in Brain Damaged patients with drawing impairment. Cortex, Vol 15, 19-36.

Benaron, C. (1976). Occupational Therapy in the Treatment of Hemiplegia. Occupational Therapy, 39:12, 311.

Bender, L.A. (1938). A Visual Motor Gestalt Test - Its Clinical Use. American Orthopsychiatric Association Research Monograph, No 3.

Bender, M.B. and Feldman, M (1972). The so called Visual Agnosias. Brain, Vol 9, 173-186.

Benson, D.F. and Barton, M.I. (1970). Disturbances in Constructional Ability. Cortex, Vol 6, 19-46.

Benson, D.F. and Greenberg, J.P. (1969). Visual Form Agnosia. Archives of Neurology, Vol 20, 82-89

Benson, D.F. and Tomlinson, E.B. (1971). Hemiplegic Syndrome of the Posterior Cerebral Artery. Stroke, Vol 2, 559-564.

Benton, A.L. and Fogel, M.L. (1962). Three Dimensional Constructional Praxis: A Clinical Test. Archieves of Neurology, Vol 7, 109.

Benton, A.L. (1967). Constructional Apraxia and the Minor Hemisphere. Confinia Neurologica, Vol 29, 1-6.

Benton, A.L., (1969). Disorders of Spatial Orientation. In P.J. Vinken and G.W. Bruyn (Eds.), Handbook of Clinical Neurology, Vol 3, Disorders of Higher Nervous Activity. New York: John Wiley.

Benton, A.L. and Hecaen, H. (1970). Stereoscopic Vision in Patients with Unilateral Cerebral Disease. Neurology, 20: 1084-1088.

Benton, A.L. (1973). Tests of Three Dimensional Block Construction. New York: Oxford University Press.

Benton, A.L. (1974). Revised Visual Retention Test (4th Edition). New York: The Psychological Corporation.

Benton, A.L., Hannay, H.J. and Varney, N.R. (1975). Visual Perception of Line Direction in Patients with Unilateral Brain Disease. Neurology, 25 : 907-910.

Benton, A.L. Varney, N.R. and Hamsher,K. (1978). Visuospatial Judgement: A Clinical Test. Arch. Neurol.,35:364-367.

Benton, A.L. (1979). Visuoperceptive, Visuospatial and Visuoconstructive Disorders. In K.M. Heilman and E. Valenstein (Eds.), Clinical Neuropsychology. New York: Oxford University Press.

Benton, A.L., Hamsher, K. deS., Varney, N.R and Spreen. O. (1983). Contributions to Neuropsychological Assessments - A linical Manual. Oxford: Oxford University Press.

Berent, S. (1981). Laterlisation of Brain Fi iction. In S.B. Filsikov and T.J. Boll (Eds.), Handbook of Clinical Neuropsycholr jy. New York: John Wiley and Sons.

Ben-Yishay, Y., Diller, L., Gerstman, L. and Gordon W. (1976). Relationship Between Initial Competence and Ability to Profit from Cues in Brain-Damaged Individuals. Canadian Journal of Occupational Therapy, 43:4, 145-154.

Ben-Yishay, Y., Diller, L., Gertsman, L., and Haas. A. (1969). The Relationship between Impersistance, Intellectual Function and Outcome of Rehabilitation in Patients with Left Hemiplegia. Neurology, Vol 18, 852-861.

Bhavnani, G., Cockburn, J., Whiting, S. and Lincoln, N. (1983). The Reliability of The Rivermead Perceptual Assessment. Occupational Therapy, 46:1, 17-19.

Birren, J.E., Imus, H.A. and Windle, W.F., (1959). The Process of Ageing in the Nervous System. Springfield: Charles C Thomas.

Birren, J.E. (1964). The Psychology of Ageing. Englewood Cliffs: Prentice Hall.

Birren, J.E. and Schaie, K.W. (Eds.) (1977). Handbook of the Psychology of Ageing. New: York: Van Nostrand Reinhold Co.

Bisiach, E., Luzzatti, C. and Perani, D. (1979). Unilateral Neglect, Representational Schema and Consciousness. Brain, Vol 12, 609-618.

Bisiach, E., Nichelli, P. and Sala, C. (1979). Recognition of Random Shapes in Unilateral Brain Damaged Patients: A Reappraisal. Cortex, Vol 15, 491-499.

Bisiach, E. and Luzzatti, C. (1978). Unilateral Neglect of Representational Space. Cortex, Vol 14, 129-133.

Bisiach, E., Capatani, E. and Spinnler, H. (1975). Focal Hemisphere Damage in Visuoperceptual Categorisation. Journal of Neurosurgery, Psychiatry, Vol 38, 1115-1120.

Bisiach, E., and Luzzatti, C. (1978). Unilateral Neglect of Representational Space. Cortex, Vol 14, 129-133.

Boll, T.J. (1981). The Halstead-Reitan Neuropsychological Battery. In S.B. Filskov and T.J. Boll (Eds.), Handbook of Clinical Neuropsychology. New York: John Wiley and Sons.

Botwinick, J. (1981). Neuropsychology of Ageing. In S.B. Filskov and T.H. Boll (Eds.), Handbook of Clinical Neuropsychology. New York: John Wiley and Sons.

Boys, M., Fisher, P., Holzberg, C., and Reid, D.W. (1988). The CSOT Perceptual Evaluation: A Research Perspective. American Journal of Occupational Therapy, 42:2, 92-98.

Bourstom, N.C. (1967). Predictors of Long Term Recovery in Cerebro-Vascular Disease. Archives of Physical Med and Rehabil, 48:8, 415-419.

Brady, B.A. and Pribram, K.H. (1978). The Role of the Frontal and Parietal Cortex in Cognitive Processing Tests of Spatial and Sequencing Functions. Brain , Vol 101, 607-633.

Bradley, A.K. (1982). The Effectiveness of Construction and Praxis Tests in Predicting Upper Extremity Dressing Abilities. The Occupational Thrapy Journal of Research, 3:3, 184-185.

Bralley, K.P. (1982). Brief: The Effectiveness of Constructional Praxis Tests in Predicting Upper Extremeity Dressing Abilities. Occupational Therapy Journal of Research, 42:5, 184.

Brown, J. (1972). Aphasia, Apraxia and Agnosia - Clinical and Theoretical Aspects. Springfield: C C Thomas.

Bruce, V. and Green, P. (1985). Visual Perception - Physiology, Psychology and Ecology. London: Lawerence Erlbaum Associates.

Bruce, V. (1988). Recognising Faces. London: Lawerence Erlbaum Associates.

Brunnstrom, S (1970). Movement Therapy in Hemiplegia. New York: Harper and Rouw.

Burnell, D.P. (1985). Neurophysiological Approach in Psychiatric Occupational Therapy. Unpublished paper delivered at 2nd European Congress of Occupational Therapists, London.

Burr, M. and Hazen, B. (1972). Use of Television in the Rehabilitation of Stroke Patients with Perceptual Difficulties. American Journal of Occupational Therapy, Jan/March, 19-22.

Butters, N. and Barton, M. (1970). The Effect of Parietal Lobe Damage on the Performance of Reversible Operations in Space. Neuropsycholigia, 8, 205-214.

Carter, L.T., Howard, B.E. and O'Neil, W.A. (1983). Effectiveness of Cognitive Skill Remediation in Acute Stroke Patients. American Journal of Occupational Therapy, 37:5, 320-326.

Carter, L.T.,Oliveira, D.O., Duponte,J. and Lunch, S.V. (1988). The Relationship of Cognitive Skills Performance to Activities of Daily Living in Stroke Patients. American Journal Of occupational Therapy, 42:7, 449-455.

Casella, C. (1962). A Behavioural Test of Activation Theory for Hemiplegic Patients. Archieves of Physical Medicine and Rehabilitation, 43:7, 321-323.

Cassvan, A., Ross P.L., Dyer, P.R. and Zane, L. (1976). Lateralisation in Stroke Syndromes as a Factor in Ambulation. Arch Phys Med Rehabil, Vol 57, 583-587.

Cerella, J., Poon, L.W. and Fazord, J.L. (1981). Mental Rotation and Age Reconsidered. Journal of Geriantology. 36: 5, 620-624.

Christensen, A.L. (1974). Luria's Neuropsychological Investigation - Text. Copenhagen: Munksgaard.

Christensen, A.L. (1975). Luria's Neuropsychological Investigation - Manual, Copenhagen: Munksgaard.

Cockburn, J., Bhavani, A., Whiting, S. and Lincoln, N. (1982). Normal Performance on Some Tests of Perception in Adults. Occupational Therapy, 45:2, 67-68,

Cohen, D., Schaie, K.W. and Gribbin, K. (1977). The Organisation of Spatial Abilities in Older Men and Women. Journal of Geriantology,32:5, 578-585.

Colarusso, R.P. and Hammill, D.D. (1972). Motor-Free Visual Perception Test - Manual. Navto: Academic Therapy Publications.

Colombo, A., De Renzi, E. and Fagliani, P. (1976). The Occurence of Visual Neglect in Patients with Unilateral Cerebral Disease. Cortex, Vol 12, 221-231.

Comalli, P.E. (1965). Cognitive functioning in a Group of 80-90 Year Old Men. Journal of Geriantology, Vol 20, 14-17.

Concha, M.E. (1978). Brunnstrom's Apprach to the treatment of adult patients with Hemiplegia. S. A. Journal of Occupational Therapy, 8:2, 8-11.

Concha, M.E. (1982). Testing Procedures for the Delimitation of Visual Perceptual Problems in the Adult CVA Patient. Proceedings of the 5th Congress of the World Federation of Occupational Therapists, Hamburg: Germany.

Concha, M.E. (1983). Perception - Occupational Therapy in Perspective - Part I. S. A. Journal of Occupational Therapy, 13:2, 5-11.

Concha, M.E. (1984a). The Performance of Normal Adults Versus that of CVA Patients on a Test of Visual Perception. Proceedings of the New Zealand Association of Occupational Therapists Congress.

Concha, M.E. (1984b). Perception, Occupational Therapy in Perspective - Part 2. S. A. Journal of Occupational Therapy, 14:1, 5-13.

Concha, M.E. (1985). Perceptual Activities in an Experiential Learning Programme for Disadvantaged Children in Soweto. Paper presented to the SAAOT Congress - Cape Town.

Concha, M.E. (1986). Adult Performance on the Developmental Test of Visual Motor Integration. S. A. Journal of Occupational Therapy, 16:1, 11-19.

Concha, M.E. (1987). A Review of Apraxia. British Journal of Occupational Therapy, 50:7, 222-226.

Concha, M.E. (1989). Reliability and Validity Studies on the Developmental Test of Visual-Motor Integration. S.A. Journal of Occupational Therapy,19:2,17-25.

Concha, M.E. (1995). The Diagnosis of Spatial Problems in a Group of Right Hemisphere CVA Patients. S.A. Journal of Occupational Therapy, 25:2, 13-24.

Coren, S. and Girgus, J.S. (1980). Principles of Perceptual Organisation and Spatial Distortion. The Gestalt Illusions. Journal of Experimental Psychology: Human Perception and Performance, 6:3, 404-412.

Coren, S. and Ward, L.M. (1979). Levels of Processing in Visual Illusions: The Combination and Interaction of Distortion - Producing Mechanisms. Journal of Experimental Psychology: Human Perception and Performance. 5:2, 324-335.

Corlew, M.M. and Nation, J.E. (1975). Characteristics of Visual Stimuli and Naming Performance in Aphasic Adults. Cortex, Vol 11: 186-191.

Costa, L.D. (1976). Interset variability on the Raven Coloured Progressive Matrices as an Indicator of Specific Ability Deficit in Brain Lesioned Patients. Cortex, 12:1, 31-40.

Cratty, B.J. (1979). Perceptual and Motor Development in Infants and Children, Englewood Cliffs: Prentice Hall Inc.

Crawford-Nutt, D.H. (1977). The Symco Test: Research Report and Guide to its Administration and Scoring. Johannesburg: CSIR Special Report, Pers 265, UDC 159, 928, 072,.

Cristarella, M.C. (1977). Visual Functions of the Elderly. American Journal of Occupational Therapy, 31:7, 432-440.

Critchley, M. (1953). The Parietal Lobes. New York: Hafner.

Danta, G., Hilton, R.C. and O'Boyle, D.J. (1978). Hemisphere Function and Binocular Depth Perception. Brain, Vol 101, 569-589.

Davies, A.D.M. (1968). Measures of Mental Deterioration in Ageing and Brain Damage. In S.S. Chawn and K.F. Reigal (Eds.), Interdisciplinary Topics in Geriantology, Vol 1. New York: S Karger.

De Ajuriaguerra, J. and Tissot, R. (1969). The Apraxias. In P.G. Vinkun and G.W. Bruyn (Eds.), Handbook of Clinical Neurology, Amsterdam: North Holland Publishing Co.

De Bono, E. (1976). Teaching Thinking. Hofmensworth: Penguine Books.

De Cencio, D.V., Leshner, M. and Voron, D. (1970). Verticality Perception and Ambulation in Hemiplegia. Arch Phys Med Rehabil, Feb, 105-110.

De Renzi, E. and Spinnler, H. (1966). Visual recognition in Patients with Unilateral Cerebral Disease. Journal of Nervous and Mental Disease, 142, 515-525.

De Renzi, E. and Spinnler, H. (1967). Impaired Performance on Colour Tasks in Patients with Hemispheric Damamge. Cortex, Vol 3: 194-217.

De Renzi, E. and Faglioni, P. (1967). The Relationship between Visuo-Spatial Impairment and Constructional Apraxia. Cortex, Vol 3, 327-342.

De Renzi, E., Faglioni, P., Scotti, G., and Spinnler, H. (1972). Impairment in Associating Colour to Form, Concomitant with Aphasia. Brain, Vol 95, 293-304.

De Renzi, E., Motti, F. and Nichelli, P. (1980). Imitating Gestures: A Quantitative Approach to Ideomotor Apraxia. Archieves of Neurology, 37:1, 6-10.

De Renzi, E. (1982). Disorders of Space - Exploration and Cognition. New York: Wiley.

De Renzi, E. (1985). Methods of Limb Apraxia Examination and their Bearing on the Interpretation of the Disorder. In E.A. Roy (Ed.), Neuropsychological Studies of Apraxia and Related Disorders. Amsterdam: Elsevier.

Denney, N.W. and Palmer, A.M. (1981). Adult Age Differences on Traditional and Practical Problem Solving Measures. Journal of Geriantology, 36:3, 323-328.

Dennis, R. and Dennis, M. (1969). Dennis Visual Perception Scale. Los Angeles; Western Psychological Service.

Dixon, W.J. (1981). BMDP Statistical Software. Berkley: University of California Press.

Downie, N.M. and Heath, R.W. (1974). Basic Statistical Methods. New York: Harper and Row.

Dudley, J.G. (1976). Influence of selected semantic variables on word associations of aphasics. Canadian Journal of Occupational Therapy, 43:4, 155-160.

Dywan, J., Segalowitz, S.I. and Unsal, A. (1992). Speed of Information Processing, Health, and Cognitive Performance in Older Adults. Developmental Neuropsychology, 8, 473-490.

Eiman, M.C., Eiman, A.L. and Cermak, S.A. (1983). Performance of Schizophrenic Patients on a Motor-Free Visual Perception Test. American Journal of Occupational Therapy, 37:5, 327-332.

Eisner, D.A. and Schaie, K.W. (1971). Age Changes in Response to Visual Illusions from Middle to Old Age. Journal of Geriantology, Vol 26, 146-150.

Elsner, D.A. (1975). Age Simulation in Perceptual and Cognitive Functioning: Age Progression to 80 Years in a College Sample. Perceptual and Motor Skills, Vol 41, 115-118.

Elias, M.F. and Kinsbourne, M. (1974). Age and Sex Differences in the Processing of Verbal and Non-Verbal Stimuli. Journal of Geriantology , 29:2, 162-171.

Faglioni, P. and Basso, A. (1985). Historical Perspectives on Neuro-anatomical Correlates of Limb Apraxia. In E Roy (Ed.), Neurophysiological Studies of Apraxia and Related Disorders. Amsterdam: Elsevier.

Fall, C.C. (1987). Comparing Ways of Measuring Constructional Praxis in the Well Elderly. American Journal of Occupational Therapy, 41:8, 500-503.

Farkas, M.S., and Hoyer, W.J. (1980). Processing Consequences of Perceptual Grouping in Selective Attention. Journal of Geriantology , 35:2, 207-216.

Farrell, W.S. (1979). Coding Left and Right. Journal of Experimental Psychology: Human Perception and Performance, 5:1, 42-51.

Farnsworth, D. (1943). Farnsworth-Munsel 100-Hue and Dichotomous Test for Colour Vision. Journal of the Optical Society of American, Vol 33, 568-578.

Farver, P.F. and Farver, T. (1982). Performance of Normal Older Adults on Tests Designed to Measure Parietal Lobe Function. American Occupational Therapy Journal, 36:7, 444-449.

Feigenson, J.S., Fletcher, H., McDowell, F.H., Meese, P., McCarthy, M.L. and Greenberg, S.D. (1977a). Factors Influencing Outcome and Length of Stay in a Stroke Rehabilitation Unit - Part I. Stroke, 8:6, 651-656.

Feigenson, J.S., McCarthy, M.L., Greenberg, S.D. and Feigenson, W.D. (1977b). Factors Influencing Outcome and Length of Stay in a Stroke Rehabilitation Unit - Part II. Stroke, 8:6, 657-662.

Feldt, R., Helzberg, C., Hren, M. and McKenzie, J. (1979). Perception Training Manual. Ontario Society of Occupational Therapists Study Group on the Brain Damaged Adult.

Feingold, A. (1988). Cognitive Gender Differences are Disappearing. American Psychologist, 43,95-103.

Finch, F.H. and Kuhlmann, F. (1956). Kuhlmann-Finch Scholastic Aptitude Tests - Manual. Minesotta: American Guidance Service.

Fink, S.L. and Hallenbeck, C.E. (1962). Assessment of Intellectual Potential of Persons with Hemiplegia. Archieves of Physical Medicine and Rehabilitation. 43:7, 324-331.

Fisher, A., Murray, E.A. and Bundy, A.C. (1991). Sensory Integration - Theory and Practice. Philadelphia: F.A. Davis Co.

Flavell, J.H. (1963). The Developmental Psychology of Jean Piaget. New York: Van Nostrand Reinhold Co.

Fontenot, D.J. and Benton, A.L. (1972). Perception of Direction in the Right and Left Fields. Neuropsycholgeia, Vol 10: 447-452.

Fox, J.V. and Harlowe, D. (1984). Construct Validation of Occupational Therapy Measures used in CVA Evaluation: A Beginning. American Journal of Occupational Therapy. 38:2, 101-106.

Fozard, J.L., Wolf, E., McFarland, R.A. and Poddsky, S. (1977). Visual Perception and Communication. In J Birren and K.W. Schaie (Eds.), Handbook of the Psychology af Ageing. New York: Van Nostrand Reinhold Co.

Fraser, C.M. and Turton, A. (1986). The Development of the Cambridge Apraxia Battery. Occupational Therapy, Vol 8, 248-252.

Frederiks, J.A.M. (1969a). Disorders of the Body Schema. In P.G. Vinken and G.W. Bruyn (Eds.), Handbook of Clinical Neurology (Vol 4). Disorders of Seech, Perception and Symbolic Behaviour. New York: John Wiley and Sons.

Frederiks, J.A.M. (1969b). The Agnosias, Disorders of Perceptual Recognition. In P.J. Vinken and G.W. Bruyn (Eds.), Handbook of Clinical Neurology (Vol 4). Disorders of Speech Perception and Symbolic Behaviour. New York: John Wiley and Sons.

Freeman, F.S. (1962). Theory and Practice of Psychological Testing. New York: Holt, Rinchart and Winston.

Frostig, M. (1966). Developmental Test of Visual Perception - Manual. Palo-Alto: Consulting Psychologistis Press.

Frostig, M. and Maslow, P. (1973). Learning Problems in the Classroom. New York: Grune and Straton.

Fudin, R. and Masterson, C.C. (1975). Hemisphere Factors and Scanning Dynamics in the Processing of Briefly Expressed Stimuli by Human Subjects - Bibliography. Perceptual and Motor Skills, Vol 41, 299-310.

Fuller G. B. (1969). The Minnesota Perceptuo-Diagnostic Test (Revised). Clinical Psychology Monograph Supplement, No 28.

Gainotti, A., and Tiacci, C. (1970). Patterns of Drawing Disability in Right and Left Hemipshere patients. Neuropsychologia, Vol 8, 379-384.

Gane, J. (1976). Spatial Relations Testing in Occupational Therapy: Results of a Survey among Canadian Occupational Therapists. Canadian Journal of Occupational Therapy, 43:4, 161-164.

Gardner, M.F. (1982). TVPS: Test of Visual-Perceptual-Skills (Non Motor) - Manual. Seattle: Special Child Publications.

Gardner, M.F. (1988). TVPS: Test of Visual-Perceptual Skills (Non Motor) Upper-Level. San Francisco: Health Publishing Co.

Gardner, M.F. (1992). Test of Visual-Perceptual Skills (Non Motor) Upper Level - Manual. Burlington: Psychological and Educational Publications Inc.

Gaylord, S.A. and Marsh, G.R. (1975). Age Differences in the Speed of a Spatial Cognitive Process. Journal of Geriantology, 30:6, 674-678.

Gazzaniga, M.S. and Le Doux, J.E. (1978). The Integrated Mind, New York: Plenum Press.

Geschwind, N. (1965). Disconnection Syndromes in Animals and Man. Brain, Vol 88, 237-294.

Geschwind, N. and Fusillo, M. (1966). Colour-Naming Defects in Association with Alexia. Archives of Neurology, Vol 15, 137-146.

Geshwind, N. (1975). The Apraxias: Neural Mechanisms of Disorders of Learned Movement. American Scientist, Vol. 63, 188-195.

Gesell, A. (1966). The First Five Years of Life. London: Methuen and Co Ltd.

Gheorghita, N. (1980). Constructional Apraxia of Drawing in Patients with Vascular or Tumoral Injury of the Right Hemisphere. Neurologic et Psychiatrie, 18;2, 127-143.

Gibson, J.J. (1950). The Perception of the Visual World. Boston: Houghton Mifflin Co.

Gibson, C.J. (1974). Epidemiology and Patterns of Care of Stroke Patients. Archives of Physical Medicine and Rehabilitation, 55:9, 398-403.

Gillette, N.P. (1982). Nationally Speaking: A Data Base for Occupational Therapy: Documentation through Research. American Journal of Occupational Therapy. 36:8, 499-501.

Gilroy, J. and Meyer, J.S. (1975). Medical Neurology. New York: MacMillan Publishing Co.

Golden, C.J., Hammeke, T.A., and Purisch, A.D. (1980). Manual for the Luria-Nebraska Neuropsychological Battery. Los Angeles: Western Psychological Services.

Golden, C.J. (1981). A Standardised Version of Luria's Neuropsychological Tests: Quantitative and Qualititative Apprach to Neuropsychological Evaluation. In S.B. Filskov and T.J. Boll (Eds.), Handbook of Clinical Neuropsychology. New York: John Wiley and Sons, .

Golden, C.J. Purisch, A.D. and Hammeke, T.A. (1985). Luria Nebraska Neuropsychological Battery: Forms I and II - Manual. Los Angeles: Western Psychological Services.

Golden, C.J. (1987). Screening Test for the Luria-Nebraska Neuropsychological Battery: Adult and Childrens Forms, Manual. Los Angeles: Western Psychological Services.

Goldstein, K.H. and Sheerer, M. (1953). Tests of Abstract and Concrete Behaviour. In A. Weider (Ed.), Contributions to Medical Psychology (Vol 2). New York: Ronald Press.

Goldstein, G. and Shelly, C. (1975). Similaritics and Differences between Psychological Deficit in Ageing and Brain Damage. Journal of Geriantology , 30:4, 448-455.

Goodglass, H. and Kaplan, E. (1972). Assessment of Aphasia and Related Disorders. Philadelphia: Lea and Fibeger.

Goody, W. and Reinhold, M. (1963). The Sense of Direction and the Arrow Form. In E Halpern (Ed.). Problems of Dynamic Neurology. Jerusalem: Hebrew University, Hadassah Medical School.

Gottsdanker, R. (1982). Age and Simple Reaction Time. Journal of Geriantology, 37:3, 342-348.

Graham, F.K. and Kendall, B.S. (1960). Memory for Designs Test - Revised General Manual. Perceptual and Motor Skills, Vol 11, 147-188.

Grant, G.V. (1969). Fret Repetition Test, Test Administrators Manual. Johannesburg: CSIR Guide K.7.16(iv), National Institute for Personnel Research.

Grassi, J.R. (1970). The Grassi Block Substitution Test for Measuring Organic Brain Pathology (2nd Edition). Springfiled: Charles C Thomas.

Gregory, M.E. and Aitken, J.A. (1971). Assessment of Parietal Lobe Function in Hemiplegia. Occupational Therapy, July, 9-17.

Gregory, S.M. (1976). Hemi/Sphere: A Continuing Management Programme for Stroke Patients and their Families. Canadian Journal of Occupational Therapy, 43:4, 169-171.

Haese, J.B., Trotter, A.B. and Flynn, R.T. (1970). Attitudes of Stroke Patients Towards Rehabilitation and Recovery. American Journal of Occupational Therapy, 20:4, 285-289.

Halberstam, J.L. and Zavetsky, H.H. (1969). Learning Capacities of the Eldrely and Brain Damaged. Archives of Physical Medicine and Rehabilitation, 50:3, 133-139.

Hammeke, T., Golden, C.J., and Purisch, A. (1978). A Short, Comprehensive and Standardised version of Luria's Neuropsychological Tests. International Journal of Neurosciences, No 8, 135-141.

Hammill, D.D., Pearson, N.A and Voress, J.K. (1993). Developmental Test of Visual Perception (2nd Edit.), Examiners Manual. Austin: Pro-ed.

Hannay, H.J., Varney, N.R. and Benton A.L. (1976). Visual Localisation in Patients with Unilateral Brain Disease. J Neurol. Neurosurg. Psychiat., Vol 39 : 307-313.

Harshman, R., Hampson, A.E. and Barenbaun, S.A. (1983). Individual Differences in Cognitive Abilities and Brain Organization - Part I - Sex and Handedness Differences in Ability. Canadian Journal of Psychology, Vol 37:144-192.

Hardy, C.H., Rand,G. and Ritter, J.M.C. (1955). H-R-R Pseudoisochromatic Plates. Buffalo: American Optical Co.

Harlowe, D. and Van Deusen, J. (1984). Construct Validation of the St Mary's CVA Evaluation: Perceptual Measures. American Journal of Occupational Therapy, 38:3, 184-186.

Hasselkus, B.R. and Safrit, M.J. (1976). Measurement in Occupational Therapy. American Journal of Occupational Therapy, 30:6, 429-436.

Haworth, M.R. (1970). The Primary Visual Motor Test. New York: Grune and Stratton.

Hayslip, B. and Sterns, H.L. (1979). Age Differences in Relationship Between Cyrstallised and Fluid Intelligence and Problem Solving. Journal of Geriantology, 34:3, 404-416.

Hecaen, H., De Ajuriaguerra, J. et Massonnet, J. (1951). Les Troubles Visuao-Constructifs par Lesion Parieto-Occipital Droit. Encephale,Vol 40, 122-179.

Hecaen, H., and Assal, G. (1970). A Comparison of Constructive Deficits following Right and Left hemisphere lesions. Neuropsychologia, Vol 8, 289-303.

Hecaen, H. and Albert, M. (1978). Human Neuropsychology. New York: John Wiley and Sons.

Hecaen, H. (1981) Apraxia. In S.B. Filskor and T.J. Boll (Eds.), Handbook of Clinical Neuropsychology. New York: John Wiley and Sons.

Hecaen, H. and Rondot, P. (1985). Apraxia as a Disorder of a System of Signs. In E.A. Roy (Ed.), Neuropsychology: Studies of Apraxia and Related Disorders. Amsterdam: Elsevier.

Heilman, K.M. (1979). Neglect and Related Disorders. In K.M. Heilman and E. Valenstein.(Eds.), Clinical Neuropsychology. Oxford: University Press.

Heilman, K.M. and Valenstein, E. (1979). Mechanisms Underlying Hemispatial Neglect. Ann. Neurology, Vol 5, 166-170.

Heilman, K.M. and Van Den Abell, T. (1980). Right Hemisphere Dominance for Attention: The Mechanism Underlying Hemipshere Asymmetrics of Inattention (Neglect). Neurology, 30:3, 327-330.

Heiniger, M.C. and Randolph, S.L. (1981). Neuropsychological Concepts in Human Behaviour. St Louis: C.V. Mosby and Co.

Helmstadter, G.C. (1966). Principles of Psychological Measurement. London: Methuen and Co. Ltd.

Herrmann, D.J. and Van Dyke, K.A. (1978). Handedness and the Mental Rotation of Perceived Patterns. Cortex, Vol 14, 521-529.

Hochberg, J.E. (1978). Perception. Englewood Cliffs: Prentice-Hall.

Hooper, H.E. (1957). The Hooper Visual Organization Test - Manual. Los Angeles: Western Psychological Services.

Horn, J.L. (1975). Psychometric Studies of Ageing and Intelligence. In S. Aershan and A. Raskin (Eds.), Ageing, Vol II. New York: Raven Press.

Horn, J.L. and Cattell, R.B. (1966). Age Differences in Primary Mental Ability Factors. Journal of Geriantology, 21:2, 210-220.

Howell, S.C. (1972). Familiarity and Complexity in Perceptual Recognition. Journal of Geriantology, 27:3, 364-371.

Hsu, Y.T.and Nelson, D.L. (1981). Adult Performance on the Southern California Kinesthesia and Tactile Perception Tests. American Journal of Occupational Therapy, 35:12, 788-791.

Humprheys, G.W. and Riddoch, M.J. (1987). To See but Not to See - A Case Study of Visual Agnosia. London: Lawerence Erlbaum Associates.

Hung, S.S., Fisher, A.G. and Cermak, S.A. (1987). The Performance of Learning Disabled and Normal Young Men on the Test of Visual Perceptual Skills. American Journal of Occupational Therapy, 41:12, 790-797.

Huysamen, G.K. (1980). Psychological Test Theory. Published by the Author and distributed by Uitgewery Boschendal, P.O. Box 487, Durbanville, 7550.

Huysamen,G.K. (1983). Psychological Measurement, An Introduction with South African Examples. Pretoria: J.L. van Schaik.

Huysamen, M.D. (1972). Social Psychological Determinants of Patients Performance in Stroke Rehabilitation. Archieves of Physical Medicine and Rehabilitation, 53:5, 217-226.

Ishihara, S. (1964). Tests for Colour-Blindness (11th Edition). Tokoyo: Kanchara Shuppan.

Itzkovich, M., Elazar, B. and Averbuch, S. (1990). LOTCA - Loewenstein Occupational Therapy Cognitive Assessment - Manual. Pequannock: Maddak Inc.

Jacewicz, M.M. and Hartley, A.A. (1979). Rotation of Mental Images by Young and Old College Students: The Effects of Familiarity. Journal of Geriantology, 34:3, 396-403.

Jastak, J.F. and Jastak, S.R. (1965). The Wide Range Achievement Test Manual. Wilmington: Guidence Associates of Delaware.

Jenkins, P., Martin, J., Oxenham, R., Pointer, J., Pantureseu, B., Smith, M. and Habal, M. (1977). Perceptual Evaluation Manual. Ontario Society for Occupational Therapists Study Group on the Brain Damaged Adult, Toronto.

Jimenez, J., Chiarcossi A., Keltz, E. and Tapperman, A. (1976). Prerequisites for Perceptual Evaluation on Brain Damage. Canadian Journal of Occupational Therapy, 45:4, 165-167.

Johnson, R.C., Cole, R.E., Bowers, J.K., Foiles, S.V., Nikaido, A.M., Partrick, J.W. and Woliver, R.E. (1979). Hemispheric Efficiency in Middle and Later Adulthood. Cortex, Vol 15, 109-119.

Jones, B. and Santi, A. (1978). Lateral Asymmetrics in Visual Perception With and Without Eye Movements. Cortex, Vol 14, 164-168.

Jones, M. (1960). An approach to Occupational Therapy. London: Butterworth and Co.

Jongbloed, L.E., Collins, J.B. and Jones, W. (1986). A Sensorimotor Integration Test Battery for CVA Clients: Preliminary Evidence of Reliability and Validity. The Occupational Therapy Journal of Research, 6:3, 131-150.

Kaplan, J. and Hier, D.B. (1982). Visuospatial Deficits after Right Hemisphere Stroke. American Journal of Occupational Therapy, 36:5, 314-321.

Katz, N., Itzkovich, N., Averbuch, S. and Elazar, B. (1989). Lowenstein Occupational Therapy Cognitive Assessment (LOTA) Battery for Brain Injured Patients: Reliability and Validity. American Journal of Occupational Therapy, 43:2, 184-192.

Kausler, D.H. and Kleim, D.M. (1978). Age Differences in Processing Relevant versus Irrelevant Stimuli in Multiple Item Recognition Learning. Journal of Geriantology, 33:1, 87-93.

Kephart, N.C. (1960). The Slow Learner in the Classroom. Columbus: Charles E Merrill.

Kertesz, A. (1979). Visual Agnosia: The Dual Deficit of Perception and Recognition. Cortex, Vol 15, 403-419.

Kertesz, A. and Ferro, J.M. (1984). Lesion Size and Location in Ideomotor Apraxia. Brain, Vol 107, 921-933.

Kirk, S.A. McCarthy, J.J. and Kirk, W.D. (1968). Illinois Test of Psycholinguistic Abilities - Examiners Manual. Urbana: University of Illinois Press.

Kimmel, D.C. (1980). Adulthood and Ageing. 2nd Edition. New York: John Wiley and Sons.

King-Smith, P.E. and Riggs, L.A. (1978). Visual Sensitivity to controlled motion of a line or edge. Vision Research, Vol 18, 1509-1520.

Kinsbourne, M. and Berryhill, J.L. (1972). The Nature of the Interaction Between Pacing and the Age Decrement in Learning. Journal of Geriantology, 27:4, 471-477.

Kleiman, J.M. and Brodzinsky, D.M. (1978). Haptic Exploration in Young, Middle-Aged and Elderly Adults. Journal of Geriantology, 33:4, 521-527.

Klisz, D.K. (1978). Neuropsychological Evaluation of Older Persons. In M. Storandt, I.C. Siegles and M.F. Elias (Eds.), The Clinical Psychology of Ageing. New York: Plenum Press.

Knapp, M.E. (1962). Results of Language Tests of Patients with Hemiplegia. Archieves of Physical Medicine and Rehabilitation, 43:7, 317-320.

Kolb, B. and Whishaw, I.Q. (1985). Fundamentals of Human Neuropsychology (2nd Ed). New York: W H Freeman and Co.

Kolb, B. and Whishaw, I.Q. (1990). Fundamentals of Human Neuropsychology, (3rd Edition). New York: W H Freeman and Co.

Kools, S.D. and Tweedie, D. (1975). Development of Praxis in Children. Perceptual and Motor Skills, Vol 40, 11-19.

Krauss, I.K., Quayhagen, M. and Schaie, K.W. (1980). Spatial Rotation in the Elderly: Performance Factors. Journal of Geriantology, 35:2 199-206.

Krueger, L.E. and Shapiro, R.G. (1979). Letter detection with Rapid Serial Visual Presentation: Evidence against Word Superiority at Feature Extration. Journal of Experimental Psychology: Human Perception and Performance, 5:4, 657-673.

Larrabee, G.J., Levin, H.S., Huff, F.J., Kay, M.C. and Guinto, F.C. (1985). Visual Agnosia Contrasted with Visual-Verbal Disconnection. Neuropsychologia, 23:1, 1-12.

Lavy, S.. Melamed, E. and Portnoy, Z. (1975). The Effect of Cerebral Infarction on the Regional Cerebral Blood Flow of the Centralateral Hemisphere. Stroke, Vol 6, 160-163.

Le Doux, J.E. (1979). Parieto-Occipital Symptomology: The Split-Brain Perspective In M.S. Gazzaninga (Ed.), Handbook of Behaviour Neurobiology, Vol 2: Neuropsychology. New York: Plenium Press.

Lehmann, J.F., DeLateur, B.J., Flower, R.S., Warren, C.G., Arnhold, R., Schertzer, G., Hurka, R., Whitmore, J.J., Masock, A.J. and Chambers, K.H. (1975). Stroke Rehabilitation: Outcome and Prediction. Archieves of Physical Medicine and Rehabilitation, 56:9, 383-389.

Lehmkuhl, G. and Poeck, K. (1981). A Disturbance in the Conceptual Organisation of Actions in Patients with the Ideational Apraxia. Cortex, 17:1, 153-158.

Lehmkuhl, G., Poeck, K., and Willmes, K. (1983). Ideomotor Apraxia and Aphasia: An Examination of Types and Manifestations of Apraxic Symptoms. Neuropsychologia, 21:3, 199-212,

Lemlich, R. (1975). Subjective Acceleration of Time with Ageing. Perceptual and Motor Skills, Vol 41, 235-238.

Levine, D.N., Calvanio, R. (1978). A Study of the Visual Defect in Verbal Alexia - Simultanagonsia. Brain, Vol 101, 65-81.

Lezak, M.D. (1976). Neuropsychological Assessment. Oxford: Oxford University Press.

Lezak, M.D. (1983). Neuropsychological Assessment. (2nd Edition). Oxford: Oxford University Press.

Lezak, M.D. (1995). Neuropsychological Assessment (3rd Edition). Oxford: Oxford University Press.

Likert, R. and Quasha, W.H. (1970). The Revised Minnesota Paper Form Board Test - Manual. New York: Psychological Corporation.

Lincoln, N. and Clarke, D. (1986). Performance of Normal Elderly People on the RPAB: Unpublished Paper.

Little, E.and Sylvester, J. (1971). Perceptual Dysfunction and Retraining. Australian Journal of Occupational Therapy, July , 12-18.

Llorens, L.A. (1973). Activity Analysis for Cognitive-Perceptual-Motor Dysfunction. American Journal of Occupational Therapy, 27:8, 453-456.

Lorden, R., Atkeson, B.M. and Pollack, R.H. (1979). Differences in the Magnitude of the Delboeuf Illusion and Usnadze Effect During Adulthood. Journal of Geriantolog, 34:2, 229-235.

Lorenze, E.J. and Cancro, R. (1962). Dysfunction in Visual Perception with Hemiplegia: Its Relation to Activities of Daily Living. Archieves of Physical Medicine and Rehabilitation, 43:10, 514-516.

Louis, S. and McDowell, F. (1970). Age: Its Significance in Nonembolic Cerebral Infarction. Stroke, Vol 1, 449-453.

Luria, A.R., Providano-Vinarksaya, E.M. and Yarus, A.L. (1963). Disorders of Occular Movement in a Case of Simultanagnosia. Brain, Vol 86, 219-228.

Luria, A.R. (1966). Higher Cortical Functions in Man. London: Tavistock.

Luria, A.R. (1980). Higher Cortical Functions in Man (2nd Edition). New York: Basic Books.

Lyman, H.B. (1971) Test Scores and What the Mean. Englewood Cliffs: Prentice Hall.

MacQuarrie, T.W. (1953). MacQuarrie Test for Mechanical Ability. Monterey: MacGraw-Hill.

Mack, J. and Levine, R.N. (1981). The basis of Visual Constructional Disability in Patients with Unilateral Cerebral Lesions. Cortex, Vol. 17, 516-532.

Maki, R.H., Grandy, C.A. and Hauge, G. (1979). Why is Telling Rght From Left More Difficult Than Telling Above From Below. Journal of Experimental Psychology: Human Perception and Performance, 5:1, 52-67.

Marteniuk, R.G., Green, H.J., Houston, M.E., King, P.G., McPherson, B.D. and Wankel, L.M. (1975). Ageing and the Decline in Human Performance: An Interdisciplinary Study. Journal of Human Movement Studies, Vol 1, 113-114.

Martin, C.M. (1978). Verbal and Spatial Encoding of Visual Stimuli: The effects of Sex Hemisphere and Yes-No Judgements. Cortex, Vol 14, 227-235.

Marosszeky, J.E. (1972). Cortical Brain Damage and Associated Dysfunction. American Journal of Occupational Therapy, January-March. 10-11.

Maskowitz, E., Lightbody, F.E.H. and Freitag, N.S. (1972). Long Term Follow-up of the Paststroke Patient. Archieves of Physical Medicine and Rehabilitation, 53:4, April, 167-172.

McCormack, P.D. (1982). Coding of Spatial Information by Young and Elderly Adults. Journal of Geriantology, 32:1, 80-86.

McFie, J. (1969). The Diagnostic Significance of Disorders of Higher Nervous Activity. Syndromes Related to Frontal, Temporal, Parietal and Occipital Lesions. In P.J. Vinkin and A.W. Bruyn (Eds.), Handbook of Clinical Neurology, Vol 4. Amsterdam: North Holland Publishing Co.

McFie, J. (1975). Assessment of Organic Intellectual Impairment. London: Academic Press.

McGlone. J. (1978). Sex differences in Functional Brain Asymmetry. Cortex, Vol 14, 122-128.

McMenamin, P. (1976). Assessment of Visual Perceptual Problems in Relation to Self-Care Activites. Occupational Therapy, January, 6-8.

Meadows, J.C. (1974). Disturbed Perception of Colours Associated with Localised Cerebral Lesions. Brain, Vol 7, 615-632.

Meeder, D.L. (1982). Cognitive Perceptual Motor Evaluation Research Findings for Adult Head Injuries. In L.E. Trexler (Ed.), Cognitive Rehabilitation - Conceptualisation and Intervention. New York: Plenium Press.

Meier, M.J. and French, L.A. (1965). Lateralised Deficits in Complex Visual Discrimination and Bilateral Transfer of Reminiscence Following Unilateral Lobectomy. Neuropsychologia, Vol 3: 261-272.

Meyer, A. (1974). The Frontal Lobe Syndrome, The Aphasias and Related Conditions. Brain, Vol 97, 565-600.

Millar, S. (1994). Understanding and Representing Space. Theory and Evidence from Studies with Blind and Sighted Children. New York: Oxford University Press.

Miller, N. (1986). Dyspraxia and its Management. London: Croom Holm.

Mitchell, J.A. (1976). Three Dimensional Construction Tests for Children Aged 5-6 Years. American Journal of Occupational Therapy, 30:6, 362-369.

Money, J.A. (1976). A Standardised Road Map Test of Directional Sense - Manual. San Rafael: Academic Therapy Publications.

Moses, J.A. (1983). Assessment of Visual Motor Skills. In C.J. Golden and P.J. Vicente (Eds.), Foundations of Clinical Neuropsychology. New York; Plenium Press.

Nelson, T.O. and Chaiklin, S. (1980). Immediate Memory for Spatial Location. Journal of Experimental Psychology, Human Learning and Memory, 6:5, 529-545.

Neter, J. and Wasserman, W. (1974). Applied Linear Statistical Models. Homewood: Richard D Irwin Inc.

Newcombe, F. and Russel, W.R. (1969). Dissociated Visual Perceptual and Spatial Deficits in Focal Lesions of the Right Hemisphere. J. Neurol. Neurosurg. Psychiat., Vol 32: 73-81.

Newcombe, F. (1969). Missile Wounds of the Brain. London : Oxford University Press.

Newman, M. (1972). The Process of Recovery after Hemiplegia. Stroke, Vol 3, 702-710.

Ontario Study Group (1972). Manual on Perceptual Evaluation. Canadian Association of Occupational Therapists, Unpublished work.

Osterrieth, P.A. (1944). Le Test de Copie d'une Figure Complex. Archives de Psychologie, 30, 206-356; Translated by J. Corwin and F.W. Bylsma (1993), The Clinical Neuropsychologist, 7, 9-15

Ottenbacher, K.J. (1986). A Sensorimotor Integration Test Battery for CVA clients: Preliminary Evidence of Reliability and Validity. Occupational Therapy Journal of Research, 6:3, 151-156.

Ottenbacher, K.J. and Goar, D. (1986). Commentary: A Sensorimotor Integration Test Battery for CVA Clients: Preliminary Evidence of Reliability and Validity. Occupational Therapy Journal of Research, Vol 6: 151-156.

Oxbury, J.M., Oxbury, S.M., and Humphrey, N.K. (1969). Varieties of Colour Anomia. Brain, Vol 92, 847-860.

Oxbury, J.M., Campbell, D.C. and Oxbury, S.M. (1974). Unilateral Spatial Neglect and Impairments of Spatial Analysis and Visual Perception. Brain, Vol 97, 551-564.

Parks, R.W., Zec, R.F. and Wilson, R.S. (1993). Neuropsychology of Alzheirner's Disease and Other Demensias. NewYork: Oxford University Press.

Patterson, A. and Zangwill, O. (1944). Disorders of Visual Space Perception Associated with Lesions of the Right Sided Hemipshere. Brain, Vol 67, 331-358.

Peterson, P. and Wikoff, R.L. (1983). The Performance of Adult Males on the Southern California Figure-Ground Visual Perception Test. American Journal of Occupational Therapy, 37:8, 554-560.

Pinker, S. and Finke, R.A. (1980). Emergent Two-Dimension Patterns in Images Rotated in Depth. Journal of Experimental Psychology: Human Perception and Performance, 6:2, 244-264.

Poeck, K. (1982). The Two Types of Motor Apraxia. Archieves Italiennes de Biologie, Vol 120, 361-369.

Poeck, K., Lehmkhul, G. and Willmes. (1982). Axial Movements in Ideomotor Apraxia. Journal of Neurology, Neurosurgery and Psychiatry, 45:12, 1128-1129.

Poeck, K. (1983). Ideational Apraxia. J. Neurol. 230, Vol 1, 1-5.

Poeck, K. (1985). Clues to the Nature of Disruptions to Limb Praxis. In E.A. Roy (Ed.). Neuropsychological Studies of Apraxia and Related Disorders. Amsterdam: Elsevier.

Pollack, R.H. and Zetland, F. (1965). A Translation of the Measurement of Visual Illusions in Children by Alfret Binet. Perceptual and Motor Skills, Vol 20, 917-930.

Pomerantz, J.R., Lawrence, C.S., Sager, L.C. and Stoever, R.J. (1977). Perception of Wholes and of Their Component Parts: Some Configural Superiority Effects. Journal of Experimental Psychology: Human Perception and Performance, 3:3, 422-435.

Rankine-Wilson, J. (1977). Ageing - What abilities are lost. The Australian Journal of Physiotherapy, Vol 23, 100-102.

Ratcliff, G. (1979). Spatial Thought, Mental Rotation and the Right Hemisphere. Neuroscyhologia, Vol 17, 49-54.

Raven, J.C. (1965). Guide to using the Coloured Progressive Matrices. London: H.K. Lewis.

Reitan, R.M. (1962). The Comparative Psychological Significance of Ageing in Groups With or Without Organic Brain Damage. In C.Tibbitts and W. Donahue (Eds.), Social and Psychological Aspects of Ageing. New York: Columbia University.

Reynolds, C.R., Chastain, R.L., Kaufman, A.S., and McLean, J.E. (1987). Demographic Characteristics and IQ among Adults: Analysis of the WAIS-R Standardisation Sample as a Function of the Stratification of Variables. Journal of School of Psychology, 25, 223-242.

Riseman, J., Eagle, M.N., Bengamin, H., and Bernstein, L.J. (1971). Short-Term Recall in Left Hemiplegic Patients. Archieves of Physical Medicine and Rehabililtation, 52:3, 118-125.

Rose, F.C. and Capildeo, R. (1981). Stroke, The Facts. Oxford: Oxford University Press.

Rosenberg, J. and Miller, J.W. (1992). Nutritional Factors in Physical and Cognitive Functions of Eldely People. American Journal of Clinical Nutrition, 55, 1237-1243.

Rosenthal, A.M., Pearson, L., Madinila, B., Manaster, A. and Smith, C.S. (1965). Correlation of Perceptual Factors with Rehabilitation of Hemiplegic Patients. Archieves Physical Medicine and Rehabilitation, Vol 46, 461-466.

Rosman, K.D. (1986). The Epidemiology of Stroke in an Urban Black Population. Stroke, 17:5, 667-669.

Rosner, J. (1975). Test of Visual Analysis Skills. San Rafael: Academic Therapy Publications.

Roy, E.A. (1978). Apraxia: A new look at an old Syndrome. Journal of Human Movement Studies, Vol 4, 191-210.

Roy, E.A. (1985). Apraxia as a Disorder of a System of Signs. In E.A. Roy (Ed.), Neuropsychological Studies of Apraxia and Related Disorders. Amsterdam, Elsevier.

Rubens, A.B. (1979). Agnosia. In K.M. Heilman and E. Valenstein (Eds.), Clinical Neuropsychology. New York: Oxford University Press.

Salmani, A.W. and Sullivan, S.J. (1976). The Intersensory Integration of Vision and Kinesthesis for Distance and Location Cues. Journal of Human Movement Studies, Vol 2, 225-232.

Sands, E., Sorno, M.T. and Shankweil, D. (1969). Long Term Assessment of Language Function in Aphasia Due to Stroke. Archieves of Physical Medical and Rehabilitation, 50:4, 202-206.

Schaie, K.W. and Schaie, J.P. (1977). Clinical Assessment and Ageing. In J.E. Birren and K.W. Schaie (Eds.), Handbook of the Psychology of Ageing. New York: Van Nostrand, Reinhold.

Schenkenberg, T., Bradford, D.C. and Ajax, E.T. (1980). Line Disection and Unilateral Visual Neglect in Patients with Neurologic Impairment. Neurology, Vol 30, 509-517.

Semenza, C., Denes, G., D'Urso, V., Romano, O. and Montorsi, T. (1978). Analytic and Global Strategies in Copying Designs by Unilaterally Brain-Damaged Patients. Cortex, Vol 14, 404-410.

Shan-Shan, H., Fisher, A.G., and Cermak, S.A. (1987). The Performance of Learning Disabled and Normal Young Men on the Test of Visual-Perceptual Skills. American Journal of Occupational Therapy, 41:12, 790-797.

Shelton, M.D., Parsons, O.A. and Leber, W.R. (1982). Verbal and Visuospatial Performance and Ageing : A Neuropsychological Apprach. Journal of Geriantology, 37:3, 336-342.

Siegel, S. (1956). Nonparametric Statistics for the Behavioural Sciences. New York: McGraw Hill.

Siev, E. and Freishtat, B. (1976). Perceptual Dysfunction in the Adult Stroke Patient - A Manual for Evaluation and Treatment. Thorofare: Charles B Slack.

Siev, E., Freishtat, B., and Zoltan, B. (1986). Perceptual and Cognitive Dysfunction in the Adult Stroke Patient. A Manual for Evaluation and Treatment. Revised Edition. Thorofare: Slack Incorporated.

Siegler, I.C. and Botwinick, J. (1979). A Long Term Longitudinal Study of Intellectual Ability of Older Adults: The matter of Selective Subject Attrition. Journal of Geriantology, 34:2, 242-245.

Simion, F. and Bagnara, S. (1980). Laterality Effects, Levels of Processing and Stimulus Properties. Journal of Experimental Psychology: Human Perception and Performance, 6:1, 184-195.

Slosson, R.L. (1980). Slosson Drawing Co-ordination Test. New York: Slosson Educational Publications.

Smith, J.M., Bright, B. and McCloskey, J. (1977). Factor Analytic Composition of the Geriatric Rating Scale. Journal of Geriantology, 32:1, 58-62.

Smith, A. (1980). Principles Underlying Human Brain Functions in Neuropsychological Sequelae of Different Neuropathological Processes. In S.B. Filskov and T.J. Boll (Eds.), Handbook of Clinical Neuropsychology. New York: L.J.B. Wiley.

Smit, G.J. (1996). Psychometrics. Aspects of Measurement. Pretoria: Kagiso Publishing.

Smith, V. and Keen, J (1979). Visual Handicap. Clinics in Developmental Medicine, No 73. London: William Heinemann.

Smythies, J.R. (1956). Analysis of Perception. London: Routledge and Kegan Paul.

Solet, J. (1975). The Solet Test of Apraxia. Unpublished.

Springer, S.P. and Deutsch, A. (1989). Left Brain, Right Brain (3rd edition). New York: W.H Freeman and Co.

Stein, D.G., Rosen, J.J. and Butlers, N. (1974). Plasticity of Function in the Central Nervous System. New York: Academic Press.

Stephens, L.C. (1975). Introducing a Stroke Service in a General Hospital Setting. American Journal of Occupational Therapy, 29:7, 418-422.

Stern, P., Lincoln, J.C. and Robinson, M.B. (1975). Data Base for Stroke Rehabilitation Using Computerised English Text Discharge Summaries. Stroke, Vol 6, 181-186.

Stern, P.H., McDowell, F., Miller, J. and Robinson, M.B. (1971). Factors Influencing Stroke Rehabilitation. Stroke, 2:3, 213-218.

Storandt, M. (1972). Recognition Across Visual Fields Range. Journal of Geriantology, 27:4, 482-486.

Storandt, M. (1977). Age, Ability Level, and Method of Administering and Scoring the WAIS. Journal of Geriantology, 32:2, 175-178.

Storck, P.A., Looft, W.R. and Hooper, F.H. (1972). Interrelationships Among Piagetian Tasks and Traditional Measures of Cognitive Abilities in Mature and Aged Adults. Journal of Geriantology, 27:4, 461-465.

Swilhart, A.A. and Pirozzolo, F.J. (1988). The Neuropsychology of Ageing and Dimensia: Clinical issues. In H.A. Whitaker (Ed.), Neuropsychological Studies of Non Focal Brain Damage. New York: Springer-Verlag.

Sylvester, J., Lucas, S. and Sorensen, R. (1974). Review of the Parietal Lobes as a Useful Guideline in the Perceptual Assessment of the Brain Damaged Adult. Australian Journal of Occupational Therapy, July-September, 125-135.

Talland, G.A. (1965). Deranged Memory. New York: Academic Press.

Taglia, J.P. (1989). Visual perception of objects: An Approach to Assessment and Intervention. The American Journal of Occupational Therapy, 43:9,587-595.

Taylor, M.M. (1968). Analysis of Dysfunction in Left Hemiplegia Following Stroke. American Journal of Occupational Therapy, Vol 22, 512-520.

Taylor, M.M., Schaeffer, J.W., Blumenthal, F.S. and Grisell, J.L. (1971). Perceptual Training in Patients with Left Hemiplegia. Archieves of Physical Medicine and Rehabilitation, 52:4, 163-169.

Taylor, L.B. (1979). Psychological assessment of Neurosurgical Patients. In T. Rasmussen and R. Marino (Eds.), Functional Neurosurgery. New York: Raven Press.

Terman, L.M. and Merrill, M.A., (1973). Stanford-Binet Intelligence Scale. Manual for the Third Revision Form L-M. Boston: Houghton, Melin.

Thornbury, J.M. and Mistrotta, C.M. (1981). Tactile Sensitivity as a Function of Age. Journal of Geriantology, 36:1, 34-39.

Thorndike, R.L. (1982). Applied Psychometrics. Boston: Houghton Mifflin Co.

Thurstone, T.G. (1963). Primary Mental Abilities for Grades 6-9 - Examiners Manual. Chicago:I.B.M. 805 Edition, Science Research Associates Inc.

Titus, N.D., Gall, N.G., Yerxa, E.J., Roberson, W.M. and Mack, W. (1991). Correlation of Perceptual Performance and Activities of Daily Living in Stroke Patients. American Journal of Occupational Therapy, 45:5, 410-418.

Tomlinson-Keasey, and Kelly, R.R. (1979). Is Hemispheric Specialisa 'n Important to Scholastic Achievement. Cortex, Vol 15, 97-107.

Truscott, B.L., Kretschmann, C.M., Tode, J.F. and Thomas, F. (1974). Early Rehabilitative Care in Community Hospitals: Effect on Quality of Survivorship Following Stroke. Stroke, 5:5, 623-629.

Tuckman, B.W. (1975). Measuring Educational Outcomes - Fundamentals of Testing. New York: Harcourt Brace Jovanovich.

Tyerman, R., Tyerman A., Howard, P.and Hadfield C., (1986). The Chessington O.T. Neurological Assessment Battery, Manual. Nottingham: Nottingham Rehab Ltd.

Tyler, H.R. (1968). Abnormalities of Perception with Defective Eye Movements (Balints Syndrome). Cortex, Vol 4: 154-171.

Valenstein, E. and Heilman, K.M. (1979). Apraxic Agraphia with Neglect-Induced Paragraphia. Archieves Neurology, 36:8, 506-508.

Van Deusen, J.V. and Harlowe, D. (1987). Continued Construct Validation of the St Mary's CVA Evaluation: Bilateral Awareness Scale. American Journal of Occupational Therapy, 41:4, 242-245.

Van Tuijl, H.F.J.M. (1980). Perceptual Interpretation of Complex Line Patterns. Journal of Experimental Psychology: Human Perception and Performance, 6:2, 197-221.

Walsh, K.W. (1987). Neuropsychology: A Clinical Approach. New York: Churchill Livingstone.

Walton, B. (1978). Approaches to Stroke Management in the Community. Occupational Therapy, 41:7, 219-220.

Wang, P.L., Kaplan, J.R. and Rogers, E.J. (1975). Memory Functioning in Hemiplegia: A Neuropsychological Analysis of the Wechsler Memory Scale. Archives of Physical Medicine and Rehabilitation, 56:12, 517-521.

Wapner, S., Werner, H. and Comalli, P.E. (1960). Perception of Part-Whole Relationships in Middle and Old Age. Journal of Geriantology, Vol 15, 412-416.

Wapner, W., Judd, T. and Gardner, H. (1978). Visual Agnosia in an Artist. Cortex, Vol 14, 343-364.

Warren, M. (1987). Relationship of Constructional Apraxia and Body Scheme Disorders to Dressing Performance in Adult CVA. American Journal of Occupational Therapy, 35:7, 431-437.

Warrington, E.K., James, M. and Kinsbourne, M. (1966). Drawing Disability in Relation to Laterality of Cerebral Lesion. Brain, Vol 89, 53-82.

Warrington, E.K. (1969). Constructional Apraxia. In P.J. Vinken and G.W. Bruyen (Eds.), Handbook of Clinical Neurology, Vol 4. New York: John Wiley and Sons.

Warrington, E.K. and Rabin, P. (1970). Perceptual Matching in Patients with Cerebral Lesions. Neuropsychologia, Vol 8, 475-487.

Warrington, E.K. and Taylor, A.M. (1973). Contribution of the Right Parietal Lobe to Object Recognition. Cortex, Vol. 9, 152-164.

Warrington, E.K. and James, M. (1991) The Visual Object and Space Perception Battery (VOSP) - Manual. Burry St Edmonds: Thomas Valley Test Company.

Watson, R.T. and Heilman, K.M. (1983). Collosal Apraxia. Brain, Vol 106, 391-403.

Webster's New Collegiate Dictionary, (1976). Springfield : G and C Merriam Company.

Wechsler, D. (1945). Standardised Memory Scale for Clinical Use. Psychology, Vol 19, 87-95.

Wechsler, D. (1955). Wechsler Adult Intelligence Scale Manual. New York: Psychological Corporation.

Wechsler, D. (1981). WAIS-R Manual, New York: Psychological Corporation.

Weintraub, D.J. (1979). Ebinghaus Illusion: Context, Contour and Age Influence on the Judged Size of a circle admidst circles. Journal of Experimental Psychology : Human Perception and Performance, 5:2, 353-364.

Weiskrantz, L., Warrington, E.K., Sanders, M.D. and Marshall, J. (1974). Visual Capacity in the Hemianopic Field Following a Restricted Occipital Abalation. Brain, Vol 97, 709-728.

Weg, R.B. (1973). The Changing Physiology of Ageing. American Journal of Occupational Therapy, 27:5, 213-217.

Wepman, J., Moreney, A. and Seidl, M. (1975). Manual for Administration, Scoring and Interpretation of the Visual Discrimination Test. Los Angeles: Western Psychological Services.

Whiting, S., Lincoln, N., Bhanani, G. and Cockburn, J. (1985). Rivermead Perceptual Assessment Battery - Manual. Windsor: NFER-Nelson.

Williams, M. (1971). The Psychological Testing of Patients with Head Injuries. Occupational Therapy, February, 21-24.

Williams, M. (1979). Brain damage, Behaviour and the Mind. Chichester: John Wiley and Sons

Wise, L.A., Sutton, J.A. and Gibbons, P.D. (1975). Decrement in Stroop Interference Time with Age. Perceptual and Motor Skills, Vol 41, 149-150.

Witkin, H.A. (1950). Individual Differences in ease of Perception of Embedded Figures. J. Pers. Soc. Psychol., Vol 19: 1-15.

Witkin, H.A., Goodenough, D.R. and Korp. S.A. (1967). Stability of Cognitive Style from Childhood to Young Adult. J. Pers. Soc. Psychol., Vol 7: 291-300.

Wright, L.L. and Elias, J.W. (1979). Age Differences in the Effects of Perceptual Noise. Journal of Geriantology, 34:5, 704-708.

Zankel. H.T. (1971). Stroke Rehabilitation - A guide to the Rehabilitation of an Adult Patient following a Stroke. Springfield: Charles C Thomas.

Zaretsky, H.H., Brucker, B.S., Guttman, A.R. and Mete, J. (1972). Motor Response Time and Task Difficulty among aged and Brain damaged Patients. Archieves of Physical Medicine and Rehabilitation, 53:9.

THE FORMULATION AND STANDARDISATION OF A BATTERY OF TESTS OF VISUAL-PERCEPTUAL-MOTOR FUNCTION FOR THE ADULT CEREBRO - VASCULAR ACCIDENT PATIENT

Marjorie Eileen Concha

VOLUME III

A Thesis Submitted to the Faculty of Medicine, University of the Witwatersrand, Johannesburg for the Degree of Doctor of Philosophy.

Johannesburg 1998

Appendices

APPENDIX 1

TEST INSTRUCTIONS AND TEST FORMAT

1. GENERAL TEST INSTRUCTIONS

1.1. INTRODUCITION TO TEST FOR NORMAL SUBJECTS

"We are having a look at the way people see things after they have had a stroke, but for us to be able to tell if there is anything wrong, we first have to know how normal people do on the tests that we give to the patients. There is no right or wrong way to do the test, it is not an I.Q. test and I will not be measuring your performance against anybody else. You will become a number and your results will go into the computer along with the results that have been obtained from everybody else. I will then get a normal range of figures against which I can measure the patient's performance".

Eliminate Subject(S) from the study if:-

a) If S cannot read with normal reading glasses.

b) If S cannot hear test instructions.

c) If S has or has had any neurological problem.

d) If S has or has had any psychiatric disorder.

Complete questions 1-5 on the General Information Sheet.

1.2. INTRODUCTION TO TEST FOR PATIENTS

"Sometimes after a person has had a stroke, the way that they see things becomes slightly changed. We want to see if this has happened to you so that we can give you the right treatment and help you to be as independent as possible."

1.3. ORDER OF TESTS

1.3.1. General Information

APPENDIX 1

TEST INSTRUCTIONS AND TEST FORMAT

1. GENERAL TEST INSTRUCTIONS

1.1. INTRODUCITION TO TEST FOR NORMAL SUBJECTS

"We are having a look at the way people see things after they have had a stroke, but for us to be able to tell if there is anything wrong, we first have to know how normal people do on the tests that we give to the patients. There is no right or wrong way to do the test, it is not an I.Q. test and I will not be measuring your performance against anybody else. You will become a number and your results will go into the computer along with the results that have been obtained from everybody else. I will then get a normal range of figures against which I can measure the patient's performance".

Eliminate Subject(S) from the study if:-

a) If S cannot read with normal reading glasses.

b) If S cannot hear test instructions.

c) If S has or has had any neurological problem.

d) If S has or has had any psychiatric disorder.

Complete questions 1-5 on the General Information Sheet.

1.2. INTRODUCTION TO TEST FOR PATIENTS

"Sometimes after a person has had a stroke, the way that they see things becomes slightly changed. We want to see if this has happened to you so that we can give you the right treatment and help you to be as independent as possible."

1.3. ORDER OF TESTS

1.3.1. General Information

1.3.2. Test of Visual-Motor Integration (VMI)

1.3.3. Form Matching test

1.3.4. Colour Matching test

1.3.5. Part-Whole test

Other tests, i.e.:-

1.3.6. Dot-Line, Position in Space, Spatial Relations, Figure-Ground and Perceptual Constancy may be given in any order. The Dot-Line should be presented in the middle to give a variation between matching tasks and drawing tasks.

1.3.7. The last tests must be the Block/Stick/Design Construction tests.

The above order was decided on for ease of administration and to provide a variation in the tasks in order to prevent fatigue and boredom. The information on the tests appears in the order in which they are presented in the thesis:-

- Form Matching
- Test of Visual-Motor Integration
- Part-Whole test
- Perceptual Constancy test
- Figure-Ground test
- Arrows test
- Dot-Line test
- Spatial Relations test
- Position in Space test
- Block Construction I and II tests
- Stick Construction I and II tests

- Design Construction test
- Colour Matching test

A break or several breaks may be taken if the subject (S) is fatigued. If S is a patient the test must be conducted over at least two sessions, more if necessary.

GENERAL INFORMATION SHEET AND TEST RECORD

CVA PERCEPTION

1. Name: ______________________

	Year	Month	Day
2. Date of Birth			

3. Address: ____

____

____

____

Phone: ____

4. Dominance: 1. Right 2. Left

5. General Information

5.1. Present residence:

1. own home	2. aged home
3. hotel	4. child's home

5.2. Living:

1. with husband / wife	2. family
3. own	

5.3. Schooling:

1. below Std 8	2. Std 8
3. Matric	

5.4. Vocational training:

1. college	2. university
3. nil	4. other

5.5. Work:

1. clerical	2. domestic
3. fine dexterity	4. heavy manual
5. persuasive	6. professional
7. sport	

6. History of illness

6.1. Date of onset:

6.2. Side of stroke:

1. left 2. right

6.3 . Associated problems (if information available):

Diplopia 1. R side 2. L side

Stage of physical recovery (Brunnstrom 1 - 6):

Sensory loss (U.L.) 1. Yes 2. No

Emotional sequele 1. Yes 2. No

Cardiac 1. Yes 2. No

Memory 1. Yes 2. No

7. Specific Tests

7.1. Date of test:

7.2. Age at testing:

7.3. Form Matching:

accuracy score

time (secs)

7.4. VMI:

accuracy score

time (secs)

7.5. Part-Whole:

accuracy score

time (secs)

7.6. Perceptual Constancy:

accuracy score

time (secs)

7.7. Figure-Ground:

accuracy score

time (secs)

7.8. Arrows:

accuracy score

time (secs)

7.9. Dot-Line:

accuracy score

time (secs)

7.10. Spatial Relations:

accuracy score

time (secs)

7.11. Position in Space:

accuracy score

time (secs)

7.12. Blocks Construction I:

accuracy score

time (secs)

7.13. Blocks Construction II:

accuracy score

time (secs)

7.14. Stick Construction I:

accuracy score

time (secs)

7.15. Stick Construction II:

accuracy score

time (secs)

7.16. Design Construction:

accuracy score

time (secs)

7.17. Colour:

Comments:

2. SPECIFIC TEST INSTRUCTIONS

2.1. FORM MATCHING TEST

Materials

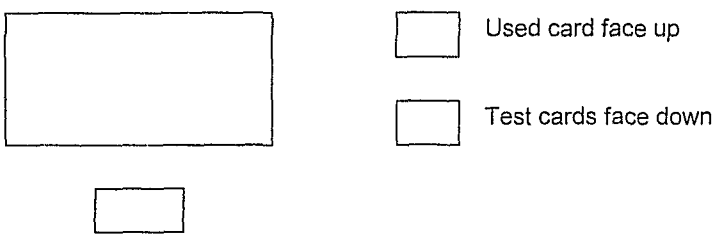
Multiple Choice Sheet with 12 Forms, Demonstration Sheet with 2 Forms, 14 Test Cards, Stop Watch, Protocol Sheet, 1 Pencil, Digital Stop Watch.

Description

Subject (S) is required to match the shape on the test card with the identical shape on the multiple choice sheet. He is required to indicate his choice by touching the correct form. S is not allowed to change his mind, i.e. his first choice is recorded.

Procedure

Examiner (E) sits to the right of S. The Demonstration Sheet is placed + 16 cm from the edge of the table in front of S. The pile of individual test cards are placed face down with demonstration number one uppermost to the right and in line with the bottom of the multiple choice sheet. The Examiner (E) places the demonstration card one face up in front of S between the edge of the table. No timing is used with the demonstration item.



Instructions are as follows:

"Now we are going to match shapes. Point to the shape that is exactly like this one". (Place demonstration card one in front of S). If S is correct. ***"That is right, we are going to do more like this."***

(Remove demonstration sheet and substitute multiple choice sheet and stick down with press stick). ***"I will show you a card with a shape on it and you must point to its exact duplicate on the sheet in front of you. The first***

one that you touch is the one that will be counted as your choice. You will be timed to see how long it takes".

If S is incorrect with first demonstration item, use the second demo card to explain what he should do. If S was correct, do not give him the second demo card but remember to place this on the used pile. Place the test card face up in between the multiple choice card and the edge of the table using the left hand, simultaneously start the stop watch with the right hand. Stop the watch the moment S touches one of the shapes on the multiple choice card. Record the number of the choice and the time taken (including fractions of a second) in the appropriate columns. Remove the used test card and zero the stop watch.

If S picks up the test card, ask him to leave the card in place and tell him that he only needs to point to its duplicate.

If S calls out the number of his choice on the multiple choice sheet, remind him that he must point to his choice and touch it. The first time the he calls out the number take the time until the number is called, however, if he continues to call the number keep on reminding him that he must touch his choice and keep the watch going until he does so.

Score

The number of correct responses made and the time taken is totalled. When the time has been added the total is brought to the nearest whole second and decimal points are dropped. A score of 5,58 is taken to 6, a score of 4,48 is taken to 5 whereas a score of 4,43 is left as 4.

The Test

The demonstration (test size) and the multiple choice sheet used in this test are shown on the next two pages. The protocol sheet follows. The multiple choice sheet has been reduced as the A4 format makes it difficult to fit into this thesis. Each of the test shapes is printed singly on a test card while the figures from which the subject chooses his response is on a single multiple choice sheet.

FORM MATCHING TEST

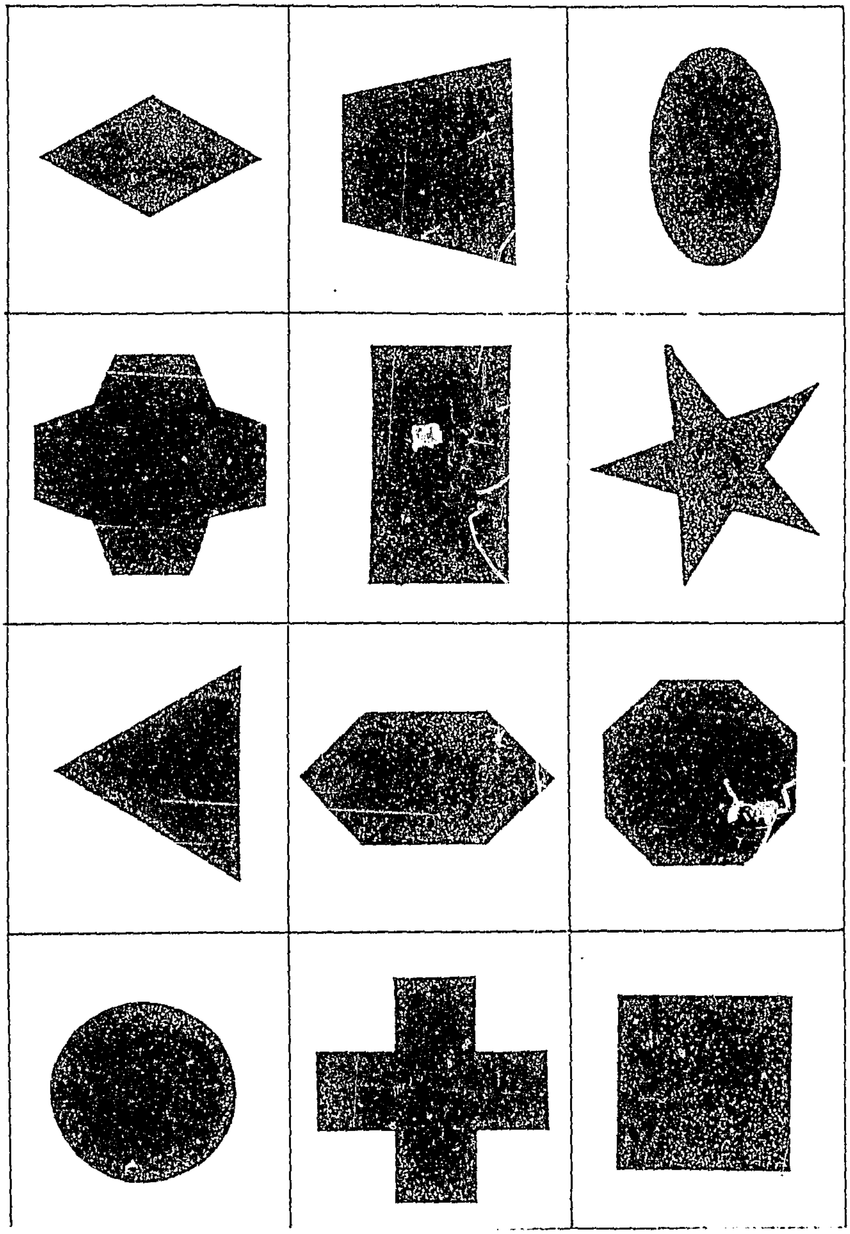
Name: ______________________ Date of Test : ______________________

Age : ______________________ Date of Birth: ______________________

Item No.	Correct Answer	Subject's Answer	Time
1	7		
2	10		
3	2		
4	3		
5	5		
6	11		
7	4		
8	1		
9	6		
10	12		
11	9		
12	8		
	TOTAL		

Accuracy Score:____________________

Time Score : No. of Secs:______________



MULTIPLE CHOICE SHEET (reduced)

2.2. TEST OF VISUAL - MOTOR INTEGRATION (VMI)

Materials

VMI Test Form as published (Beery and Buktenica 1967 and Beery 1982), 2 Protocol Sheets, Digital Stop Watch, 2 Pencils.

Description

S is required to copy the designs that are in the top block into the equivalent space in the block underneath.

Procedure

The test booklet is placed directly in front of S at a comfortable distance from the edge of the table (+ 4 cm). The booklet must remain square to the table, at no time may it be rotated. The pencil is placed at the top border of the test booklet. S is timed from the moment that he picks up the pencil until he indicates that he has completed the last design. The test must be presented with number 1 at the back of the book so that each new page is placed on top of the completed page. This is to prevent the pencil strokes from making indentations on pages still to be completed. E sits on the right of S and turns the pages for S. Instructions are as follows:-

"I would like you to copy the design that you see in the top space here (indicate with hand) into this space underneath (indicate with hand). Make it as exact a copy as you can bearing in mind the fact that you do not have a rubber or a ruler. As you finish each page I will turn to the next page for you. I am going to time you to see how long it takes but remember accuracy is more important than speed." (Note : the instructions differ from that given in the test manual for children).

Should S, at the first design, attempt to make his lines as broad as those in the test, say:

"You need not make your lines as thick as the printed line - one pencil stroke will do."

During the execution of the test E records, in the space provided on protocol sheet, the direction that lines are drawn and the order of execution plus any other interesting features of the performance of S such as rotation of body, etc.

Scoring

The designs are scored correct or incorrect and receive a rating of one or zero according to the criteria given for each figure. All the criteria must be met for a score of one to be given. The scoring is a modification of that used in the original test as standardised by Beery (1982) and is different to the 1989 version. The time taken is converted to seconds.

The test protocol sheet, a copy of the test designs and the scoring criteria follow.

Note: The test designs are printed on green paper for evaluation purposes to aviod the desigs showing through on to the next page and to remove the glare experienced with white paper. The test should be purchased from the publishers.

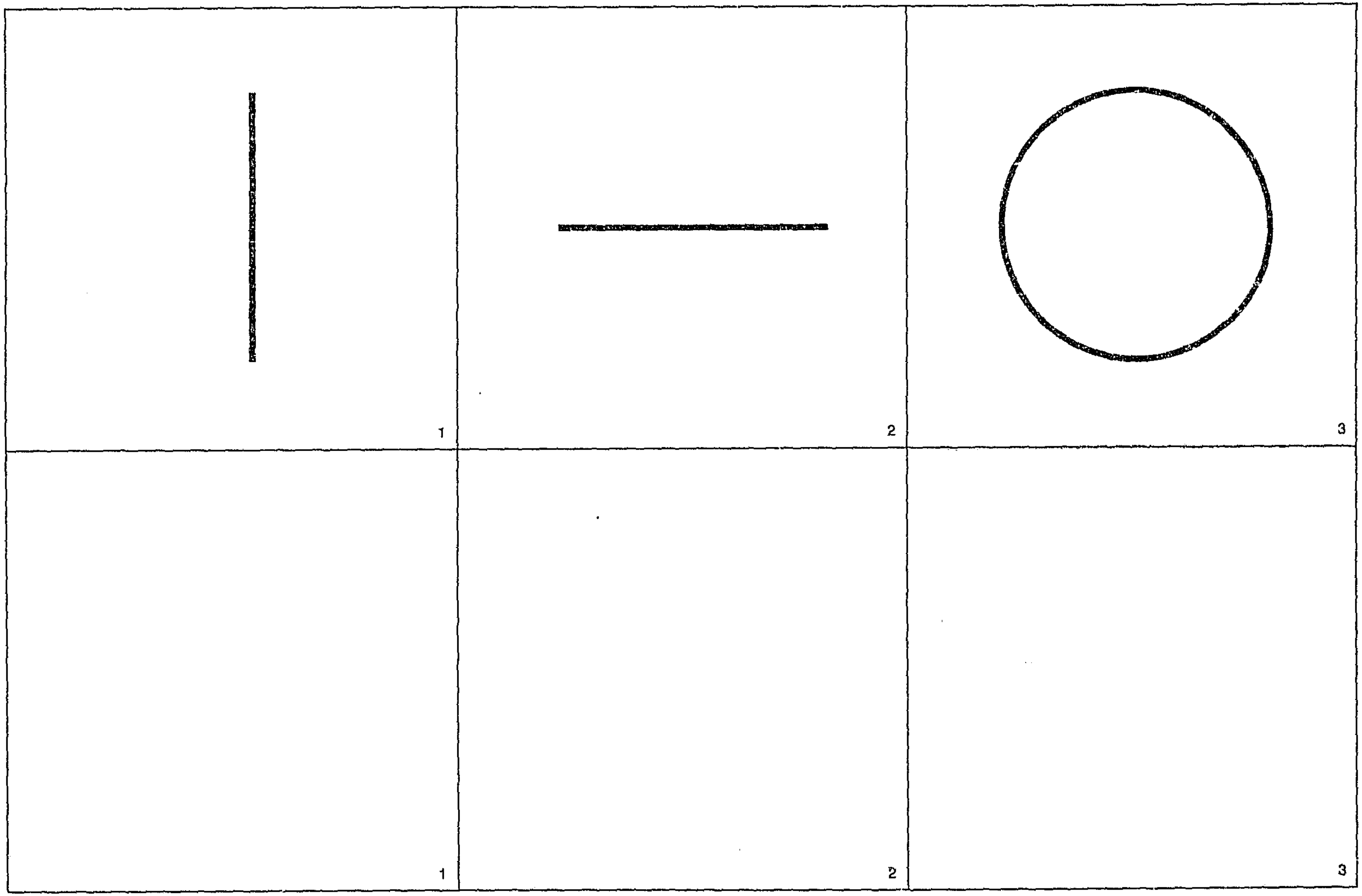
PROTOCOL SHEET

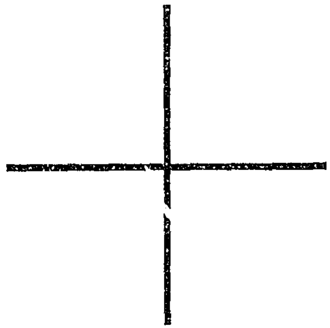
VMI TEST

Patient's Name:______________________ Date of Test: ______________________

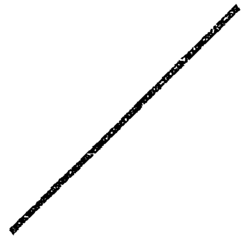
Date of Birth: ______________________ Age: ______________________

	OBSERVATION	TIME SECS	SCORE
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
13.			
14.			
15.			
16.			
17.			
18.			
19.			
20.			
21.			
22.			
23.			
24.			

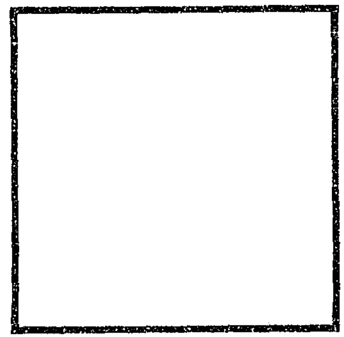

1
2
3
1
2
3



4



5

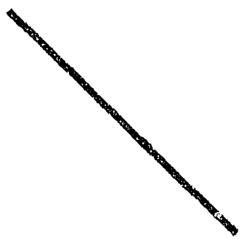


6

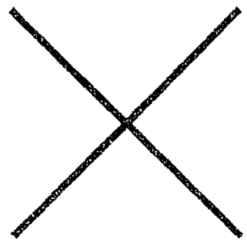
4

5

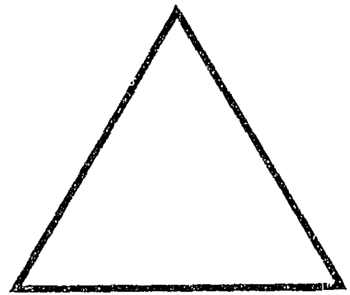
6



7



8

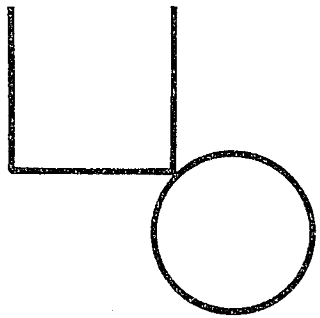


9

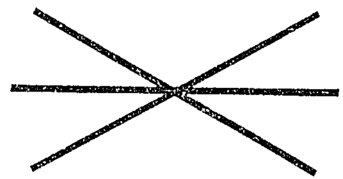
7

8

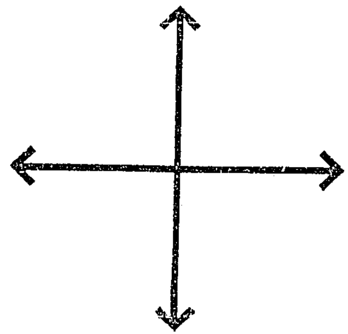
9



10



11

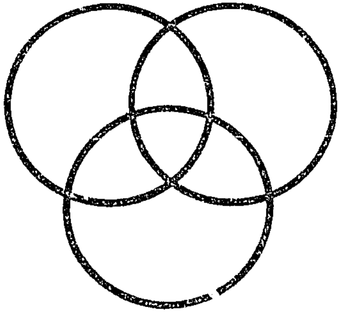


12

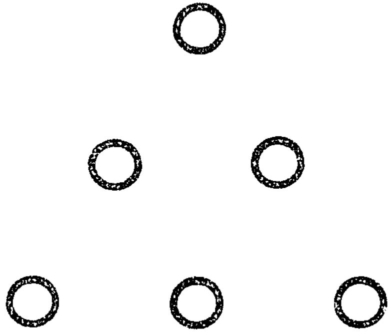
10

11

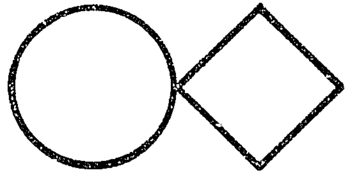
12



13



14

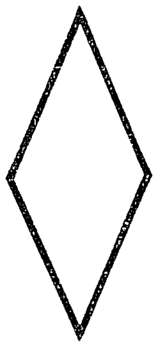


15

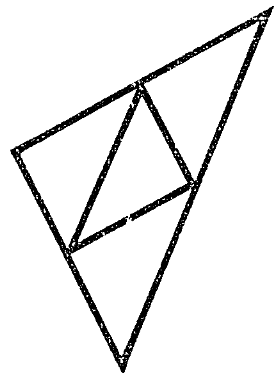
13

14

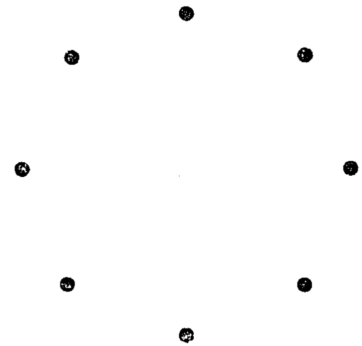
15



16



17

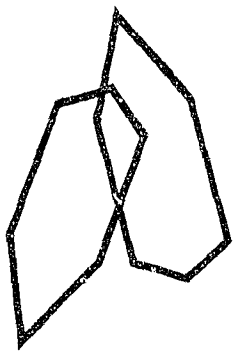


18

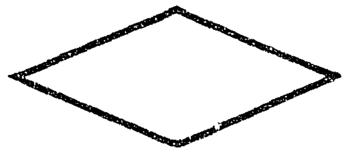
16

17

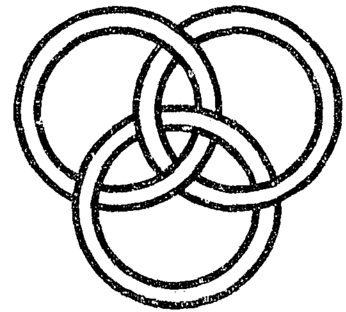
18



19



20

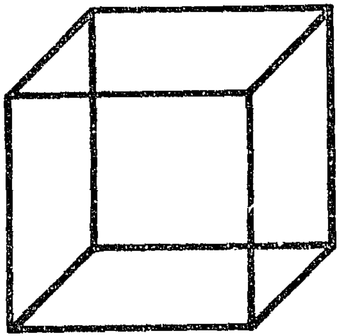


21

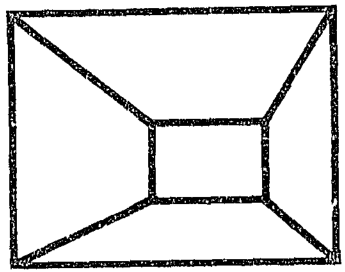
19

20

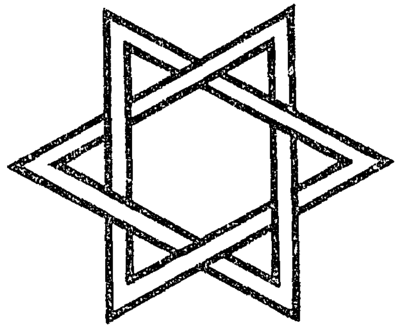
21



22



23



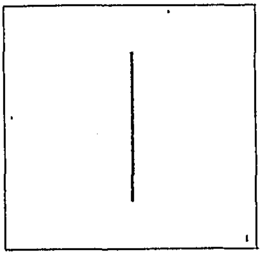
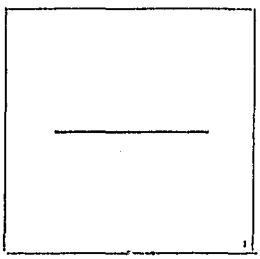
24

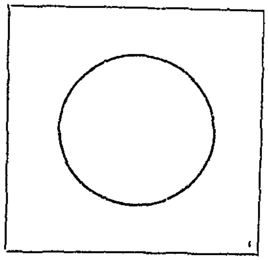
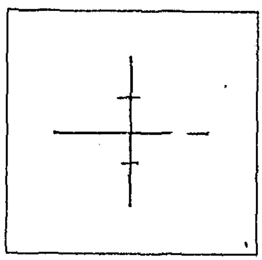
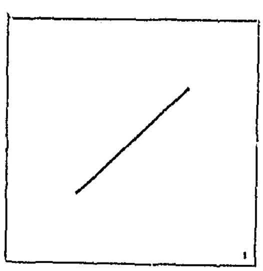
22

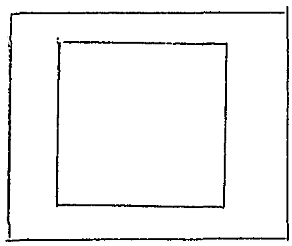
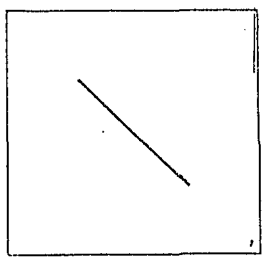
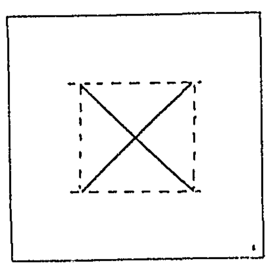
23

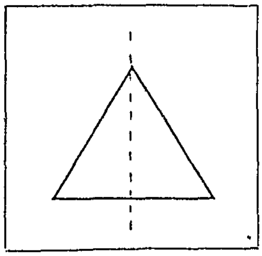
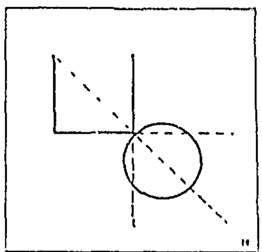
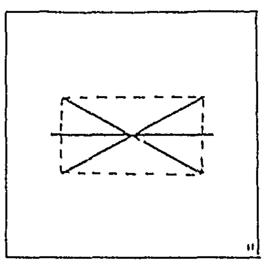
24

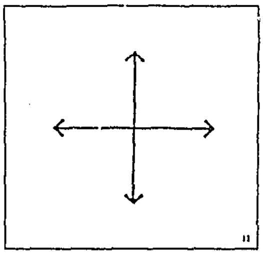
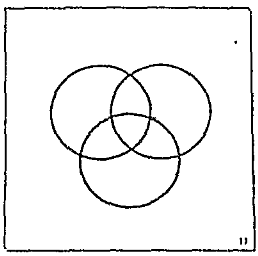
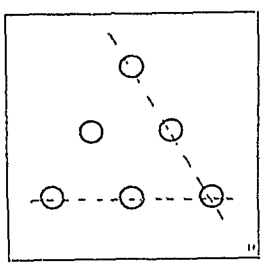
SCORING CRITERIA - VMI

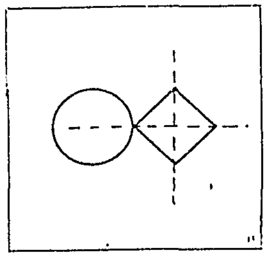
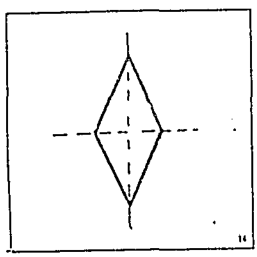
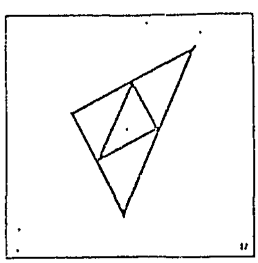
ITEM		SCORING CRITERIA
1		Predominantly vertical line (length not a criterion) No perseveration
2		Predominantly horizontal line (length not a criterion) No perseveration

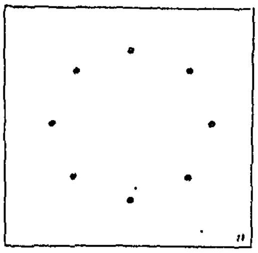
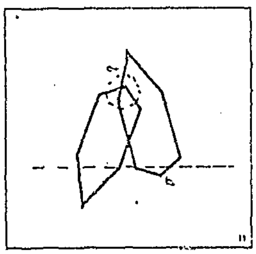
ITEM		SCORING CRITERIA
3		Circular in shape No oval or egg shapes allowed
4		*Two fully intersecting lines* Two continuous lines Each line within 20° of its correct orientation Horizontal within the middle 1/3 of the vertical
5		*A fairly straight line* Line between 110° & 160° (*read protractor* in a clockwise direction) No change of direction

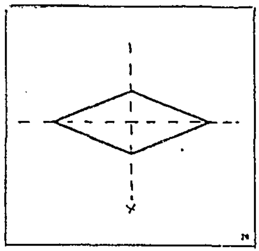
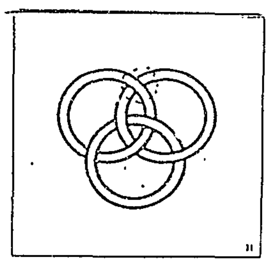
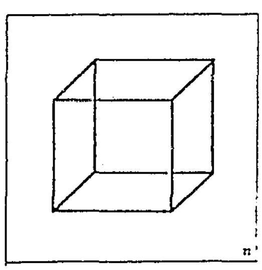
ITEM		SCORING CRITERIA
6		Four clear sides at right angles to each other Must look like a square rather than a rectangle
7		A fairly straight line Line between 20° - 70° (read protractor in a clockwise direction) No change in direction
8		Four continuous intersecting lines Lines angled between 20° - 70° i.e. when drawing a block around the X the line must fall at the corners The ends of at least two lines must fall onto the corners within 2mm

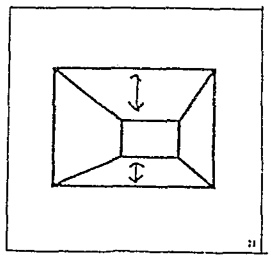
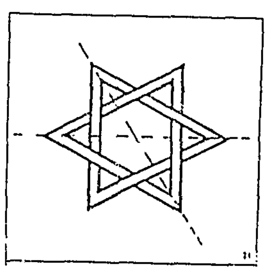
ITEM		SCORING CRITERIA
9		Three clear sides One corner higher than the others Perpendicular line dropped from apex to baseline to determine whether top corner falls within 10mm of centre of baseline
10		Circle must be below square Part of circle must be above line and to left of line as shown No separation of circle and square
11		Lines must intersect within 2mm of each other (i.e. no more than 2mm separation) Two of the cross lines fall to corner of rectangle One horizontal and two diagonal lines Horizontal must meet the side of the outlined rectangle or fall outside (not inside)

ITEM		SCORING CRITERIA
12		At least three attached arrowheads Clear vertical and horizontal lines Sharp points on arrow tips No indication of directional confusion Fairly equal length of legs Only very slight separation of arrowheads
13		Distinct overlap of three circles i.e. obvious trianglular form in the centre Once circle below the other two Central triangular form must point downwards
14		Two sides in a straight line i.e. drawn line passes through the circles (not necessarily in the middle) Correct number of circles Fairly equal spacing Baseline horizontal Circle not dots

<table>
<tr><th>ITEM</th><th></th><th>SCORING CRITERIA</th></tr>
<tr><td>15</td><td></td><td>Draw a horizontal line through tilted square as well as a vertical line:
At least one set of corners of the square must be within 2mm of horizontal or vertical (i.e. opposite each other)
Horizontal line dissects the circle
Square touches circle with closed corners
No gap or overlap of forms
Fairly equal size of circle and square
Horizontal of square within 10° of horizontal</td></tr>
<tr><td>16</td><td></td><td>Draw horizontal and vertical lines through form:
Two angles opposite each other or within 2mm of the line
Length greater than width
Four good corners
No kite shapes
Only slight dog ears allowed
Both acute angles must be 60° or less</td></tr>
<tr><td>17</td><td></td><td>There must be two triangles
Two corners of the inner triangle clearly touch the outer
Two points of the inner triangle touch within 2mm of the middle of outer triangle's side (use ruler to measure)
Left outer angle 90°
Right outer line slopes 100° or more</td></tr>
</table>

ITEM		SCORING CRITERIA
18		Distinct circle of dots Eight dots Fairly regular spacing
19		Draw a line through right lower angle of left figure: Upper point of left figure must be inside upper figure (a) Overlap must not be extreme Lower point of right figure must fall below horizontal drawn line (b) or touch horizontal line within 10mm All angles must be indicated No evidence of directional confusion

ITEM		SCORING CRITERIA
20		Draw horizontal line and vertical lines through figure: At least one set of angles must be opposite each other i.e. touching line within 2mm Four good corners Both acute angles 60° or less No obvious kites Equal length on both sides of vertical (X)
21		At least two correct 3D overlaps One circle below the other two Three complete double line circles
22		Correct number of parts Correct orientation No evidence of confusion

ITEM		SCORING CRITERIA
23		Inner rectangle in lower right corner i.e. the distance between bottom line and inner rectangle smaller than between top line and inner rectangle Outer form a parallelogram (may be a square) Inner form a horizontal rectangle Inner form clearly shifted to right No confusion or distortion - inner diagonal lines must go to corner of figures
24		At least two correct 3D overlaps Correct alignment of 1 set of corners (within 5mm of line drawn) No 30° rotations

2.3. PART - WHOLE TEST

Materials

Test Booklet, Protocol Sheet, 2 Pencils, Digital Stop Watch.

Description

S is required to select from 3 shapes given at the bottom of the page the one that will fit into the missing part of the form given. The completed shape is given as a model at the top of the page.

Procedure

E sits to the right of S. The booklet is opened to page one demonstration one, and a piece of cardboard is slipped under the page; this is to prevent the following page showing through. Instructions are as follows:-

"Here is a shape, (E indicates by pointing to the complete shape [in box] at the top of the page***), here is the same shape with a piece cut out of it.*** (E indicates middle incomplete shape). ***The missing piece is one of these*** (indicate all 3 shapes at the bottom of the page)***. Which one fits in here (indicate) to make this exactly like the shape at the top*** (indicate)***". Mark your choice.***

If S is correct:-

"Yes that is right, if you envisage a line completing the shape like this, (E draws a pencil line to complete middle shape***) you will see which shape fits into the space."***

If S is incorrect:-

"No that is not right, if you can envisage a line completing the shape like this (draw a pencil line to complete the middle shape***) you will see which shape fits in the space. Can you see that your shape does not fit, but this shape (indicate) does".*** Give any additional instructions necessary.

Turn to page 2 moving the cardboard behind the next page as you do so. ***"Now try this one. Which of these 3 shapes down here (indicate) fits in this shape to make this shape (indicate) exactly like the one at the top? Make your choice".*** When S has marked his choice:-

If S is correct:-

"You are correct. This one is a little tricky isn't it?"

If S is incorrect:-

"That one is not correct. This one is a bit tricky. Let us complete the shape. Now you can see that number two is too rounded at the top and that number three with its more flat and squashed top fits into the empty space?"

"We are going to do more like these, I will time you to see how long it takes, remember accuracy is more important than speed. As you finish each page, I will turn to the next one." The stop watch is started as soon as E has turned to page three and is left running until the last page is completed. It is stopped as S completes his mark on the shape of his choice.

N.B. Record time taken on the protocol sheet and on the outside of the test booklet.

Scoring

E writes in subject's answer onto protocol sheet and totals the number of correct responses. The item number of the correct response for each item is given on the protocol sheet. The time taken is brought to the nearest second.

The Test

The test is reproduced on the following pages. Pages are printed alongside each other for ease of presentation, however, for testing purposes each test item was printed on a separate page and made up into booklet form. The test has been reduced in size.

PROTOCOL SHEET

PART-WHOLE

NAME : ______________________ DATE OF TEST : ______________

AGE : ______________________ DATE OF BIRTH: ______________

Item No.	Correct Answer	Subject's Answer
1	2	
2	1	
3	2	
4	2	
5	1	
6	3	
7	1	
8	3	
9	3	
10	1	
11	1	
12	2	
	Total Scored	

Accuracy Score: ________________

Time (secs): ____________________

PART-WHOLE

Name: ______________________

No. Correct: ______________________

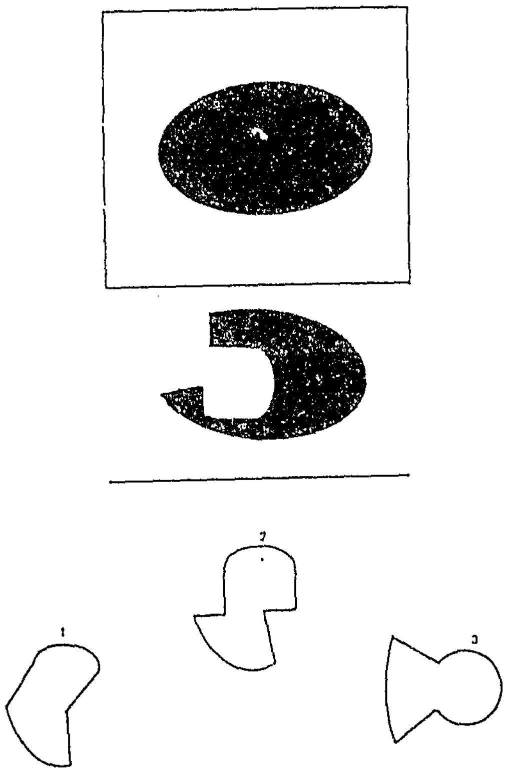
Date: ______________________

Time: ______________________

Age: ______________________

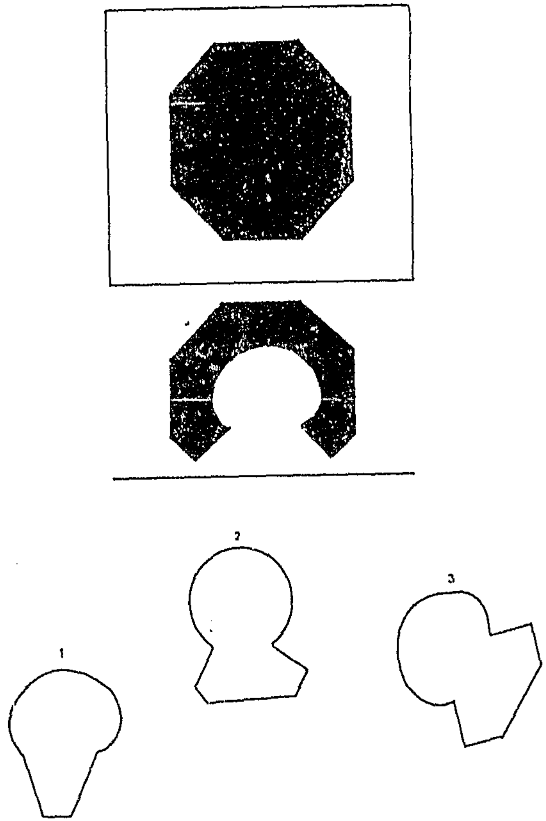
Demo 1

1

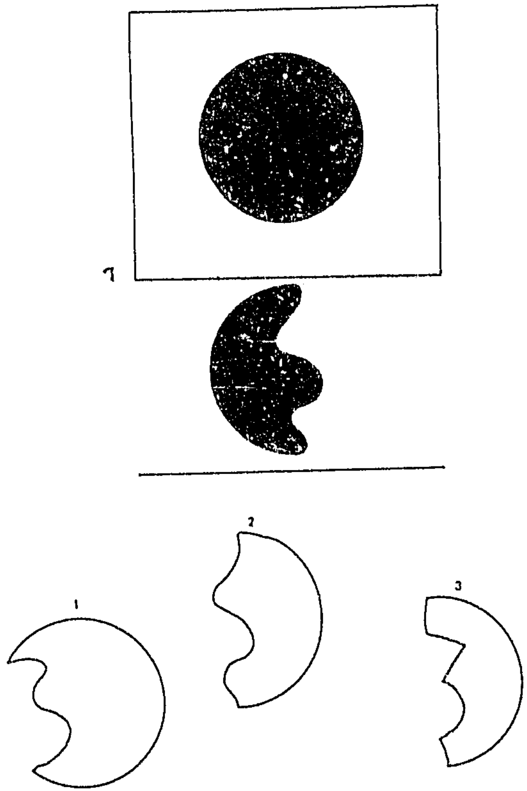


Demo 2

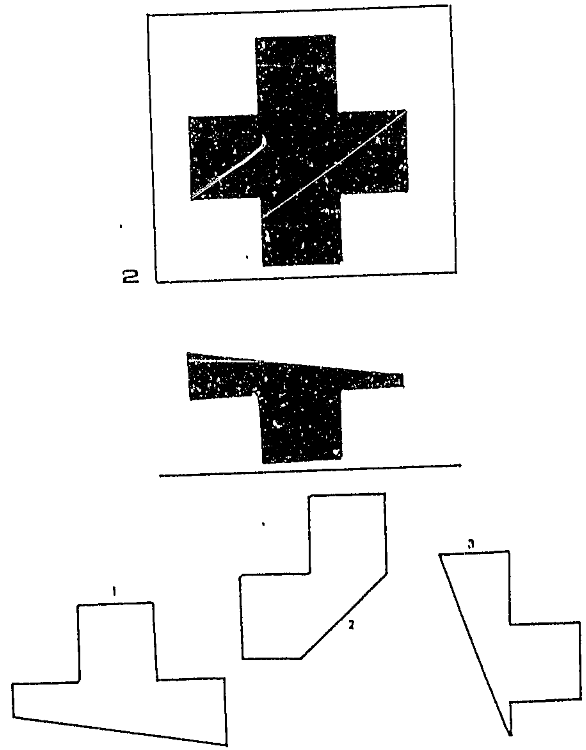
2

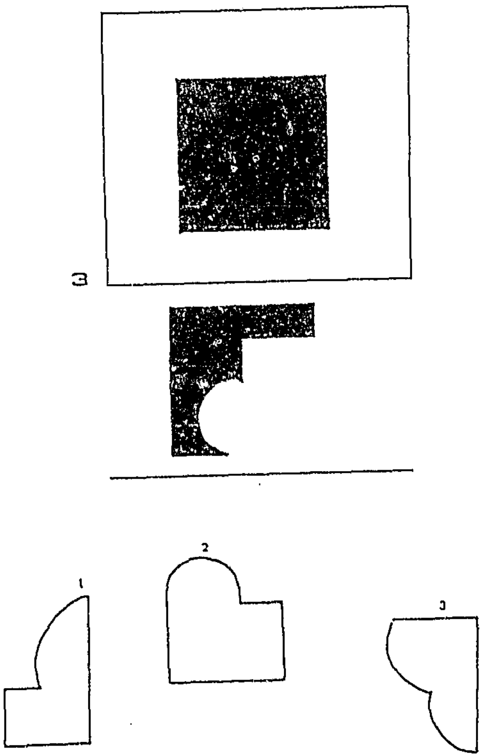


3

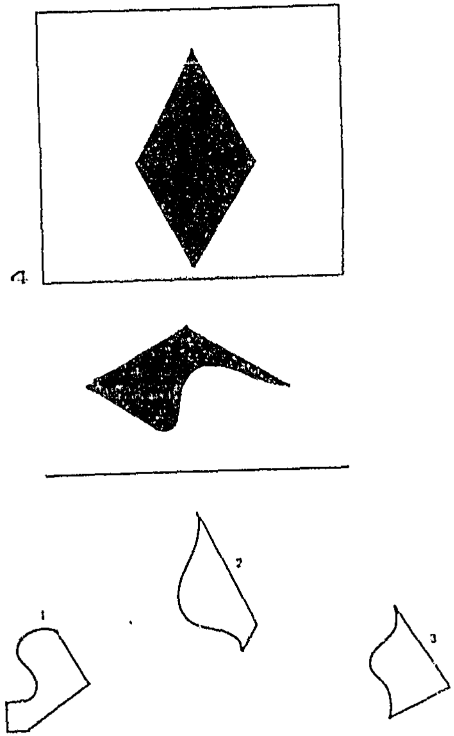


4



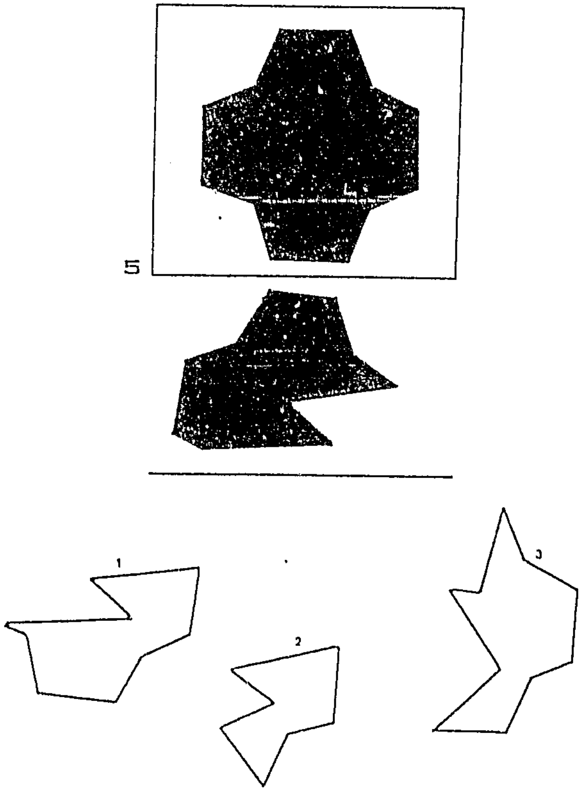


3
1
2
3

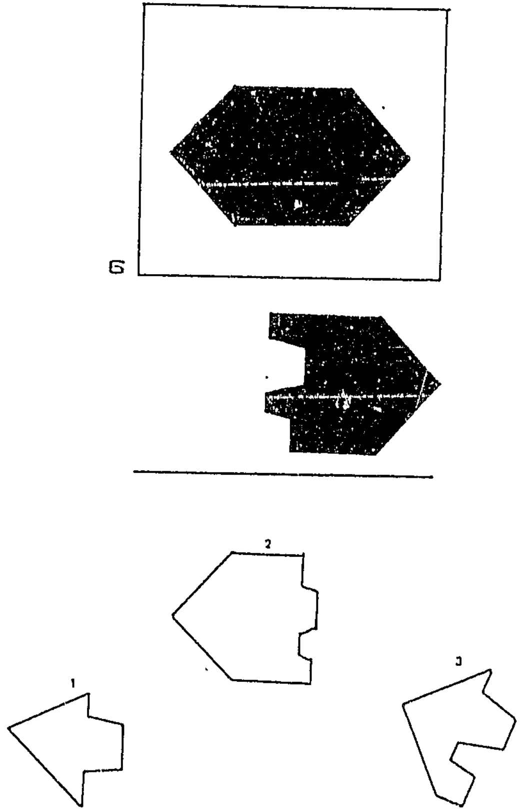


4
1
2
3

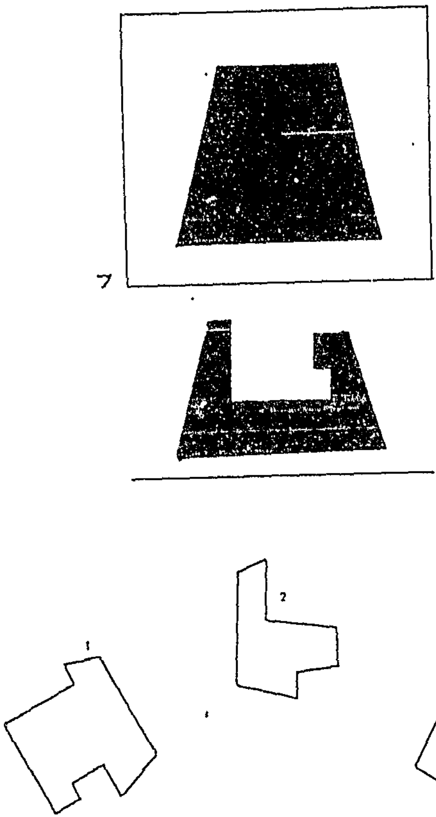
7



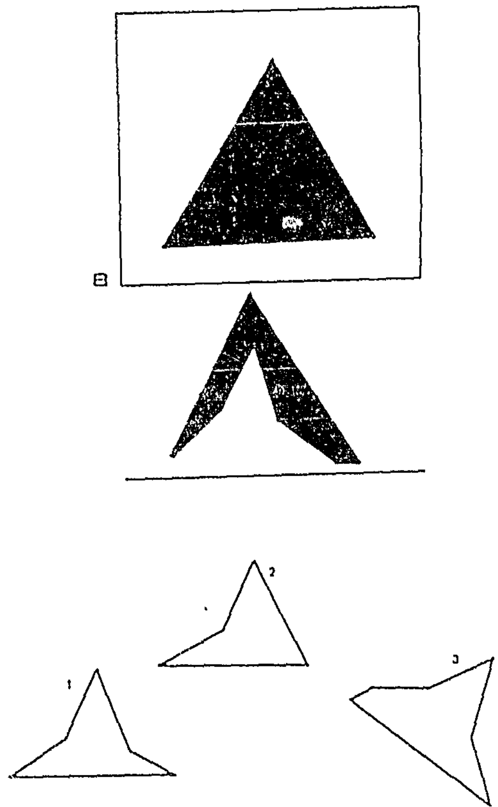
8



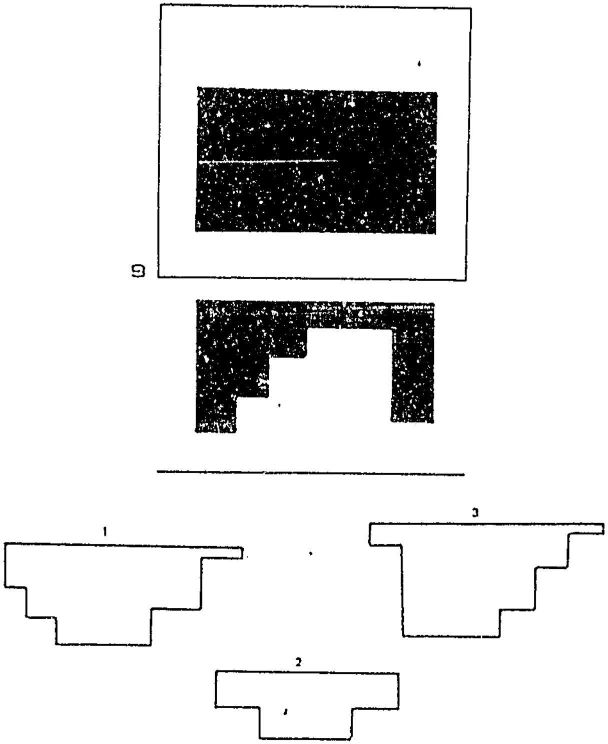
9



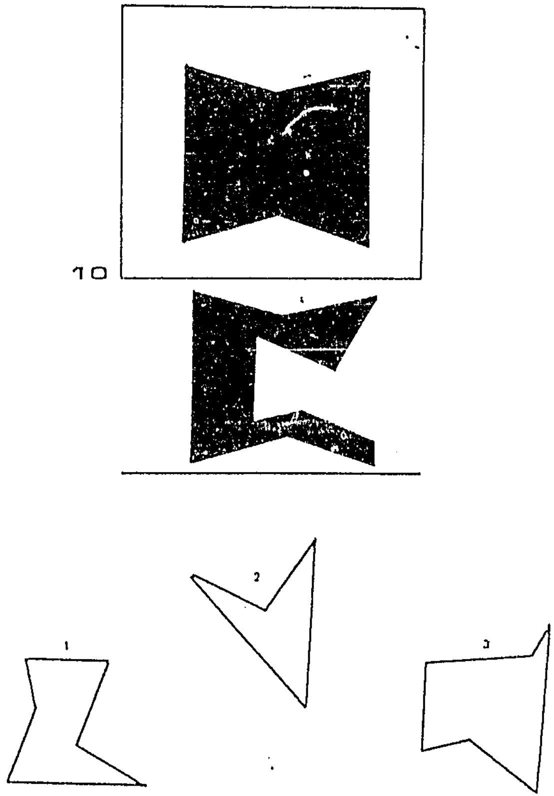
10



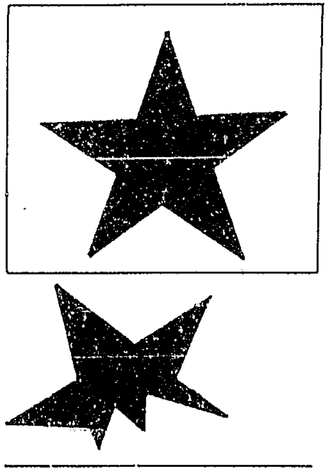
11

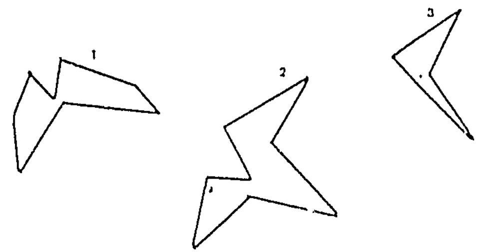


12

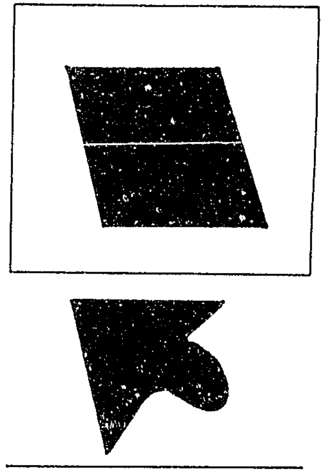


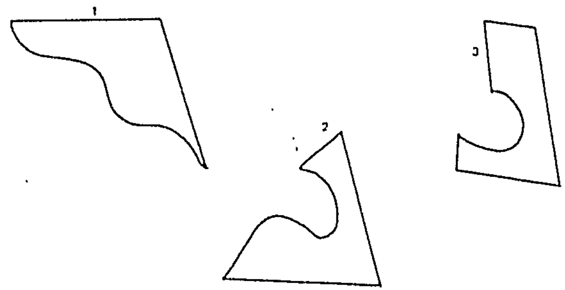
11





12





2.4. PERCEPTUAL CONSTANCY

Materials

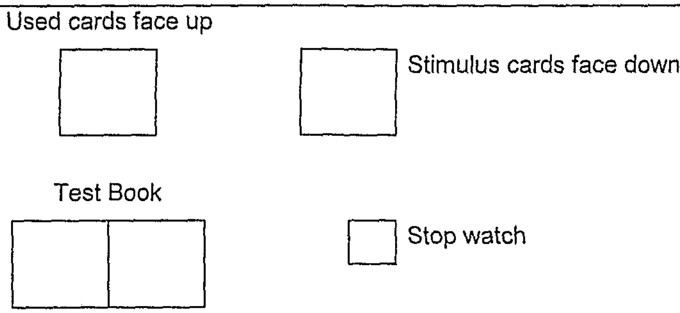
Test Booklet, Stimulus Cards, Protocol Sheet, 1 Pencil, 1 Red Felt Tipped Pen, Digital Stop Watch, Cardboard.

Description

S is required to mark all the objects on the test page that are similar to that shown on the stimulus cards. The test is divided into 3 sections, items 1-8 are animals and objects, 9-14 are shapes which must be exactly matched, items 15-20 are letters. The time taken to complete each page is recorded.

Procedure

E sits to right of S. E places a blank card between page 1 and 2, this is to prevent proceeding designs from showing through, then places booklet in front of S. Stimulus cards are placed face down to the right of the book with no one uppermost.



S is given the red pen. Turn up demonstration card number one and place it face up above the test book in the centre.

Instructions are as follows : (Items 1-8).

"I am going to show you a series of cards with pictures on, this is a chicken (fowl). I want you to mark all the chickens on the page in front of you. When you think that you have marked them all, put your pen down, that way I will know that you have finished". Allow S to complete the page, point out any mistakes made or inform S that he is correct. Turn the page so that the blank card shows, turn over demonstration number two stimulus card, then remove blank card and place it under the demonstration two test page. ***"This is a bus, I want you to mark all the buses on the page."***

"That is correct, we are going to do more like this but I am not going to tell you what it is on the card. I am going to leave that to your imagination. Again I am going to time you to see how long it takes."

Turn page with left hand, turn up card with left hand, lift page with left hand very slightly and put blank card underneath with right hand, start watch immediately with right hand. As soon as S puts pen down, stop the watch and record time.

(Items 9-14)

Turn up stimulus card of triangle, leave blank card on top of test page while giving instructions.

"Now you are going to do something different. This is a triangle, I want you to *outline* (E traces round the edge of the stimulus triangle) ***all the triangles on this page that are the same size as well as shape. They must be exactly the same size".***

Slip card under the test sheet and start watch. If S starts to tick shapes show him what it means to outline. When S has finished item nine turn to item ten. ***"Do the same here, outline all the rectangles that are the same shape and size".*** No further instructions are given after this item.

(Items 15-20)

Turn up the stimulus card with a B. Leave blank card on top of test page while giving instructions. ***"We are going to do something a little different. This is a B, I want you to mark (tick) all the Bs on the page in front of you. As it is placed on the page it must look like a B".*** Slip the blank card under the page and start the watch.

Score

Total all the correct responses and all the incorrect responses. To obtain the accuracy score subtract the total of incorrect responses from that of correct responses for each item separately. The minimum score that can be given for each item is 0 e.g. if only incorrect responses given for an item, that item would score 0. If two correct responses and one incorrect response is given, the score would be 1. Total the time taken and correct to nearest second.

The Test

The test is produced on the following pages. Please note that the stimulus card is printed on the left side of the page and the test sheet on the right. For testing purposes the test sheets were made up in a booklet form and the stimulus figures printed on separate cards. The test has been reduced in size for inclusion in this thesis.

PROTOCOL SHEET

PERCEPTUAL CONSTANCY

NAME: ____________________ DATE OF TEST: ____________________

AGE: ____________________ DATE OF BIRTH: ____________________

ITEM		NUMBER CORRECT	NUMBER INCORRECT	TOTAL	TIME
1. Horse	3				
2. Dog	4				
3. Carrots	2				
4. Giraffe	3				
5. Couch	2				
6. Comb	2				
7. Duck	3				
8. Frog	3				
9. Triangle	3				
10. Rectangle	3				
11. Circle	3				
12. Diamond	4				
13. Oval	3				
14. Square	2				
15. B	4				
16. P	4				
17. F	5				
18. M	5				
19. J	6				
20. U	6				
TOTAL					

Accuracy Score: ____________

Time : ____________

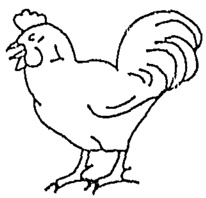
PERCEPTUAL CONSTANCY TEST

Name: ____________________ No. Correct: ____________________

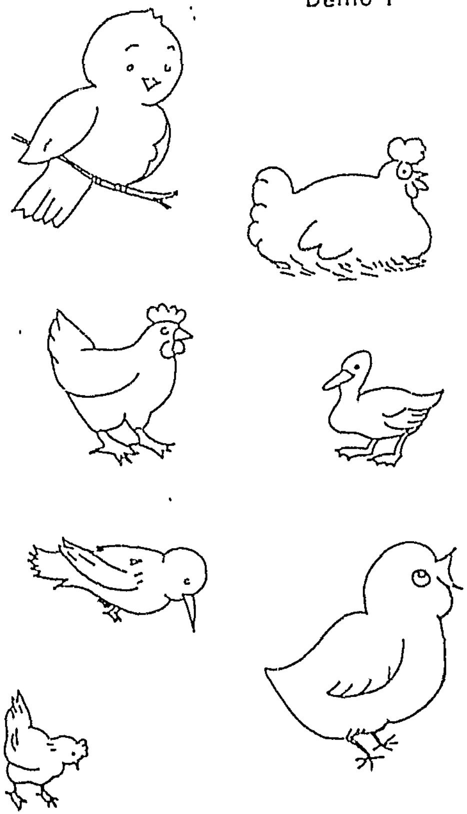
Date: ____________________ Time: ____________________

Age: ____________________

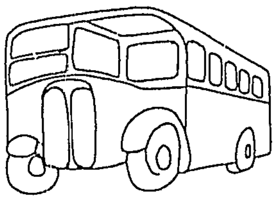
Demo 1



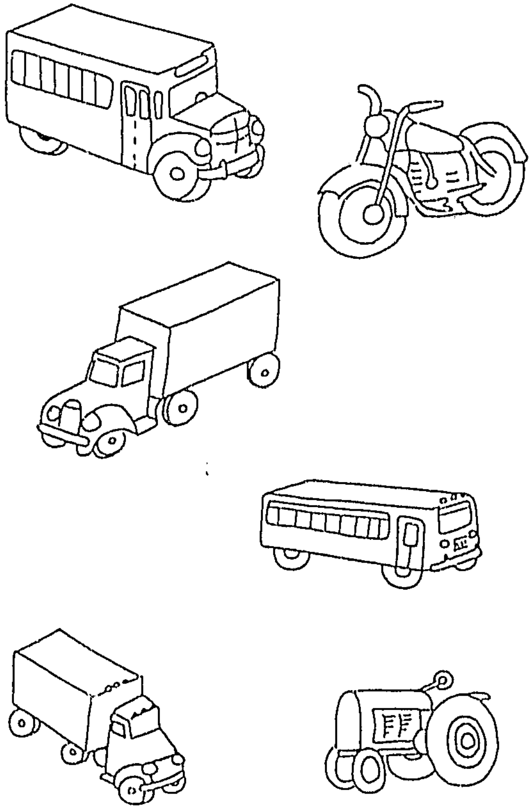
Demo 1

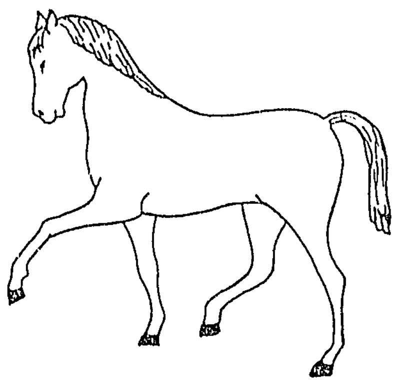


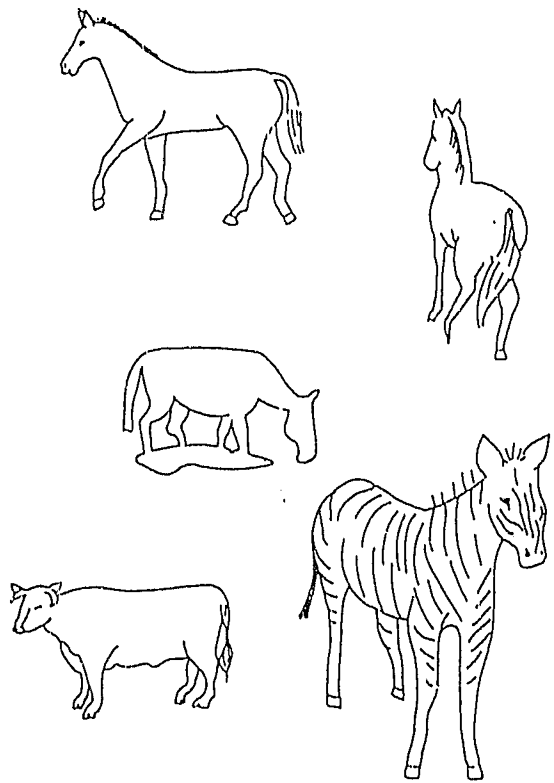
Demo 2



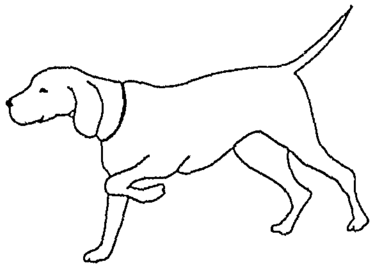
Demo 2



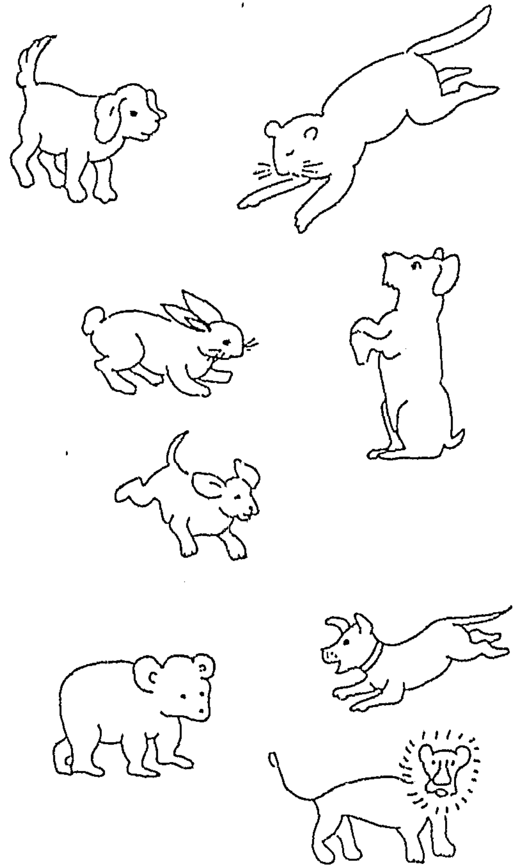




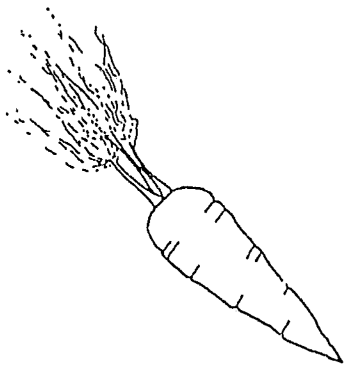
2



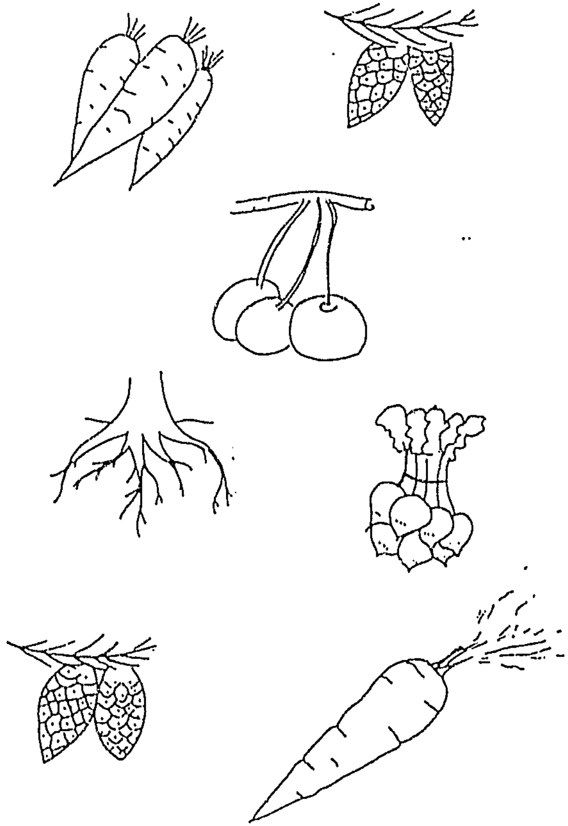
2

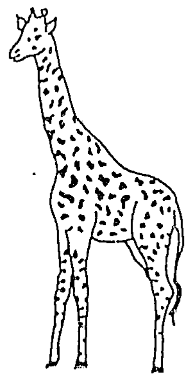


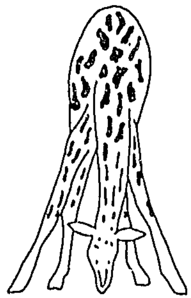
3

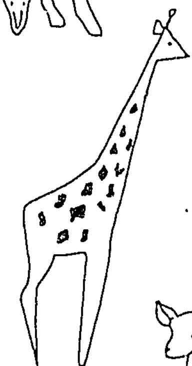


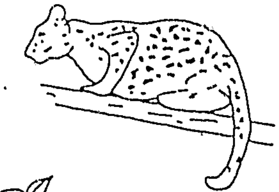
3

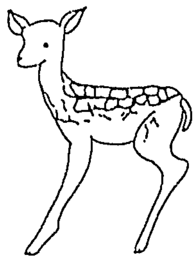




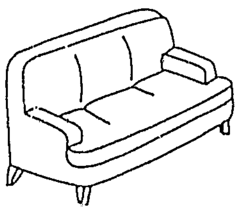




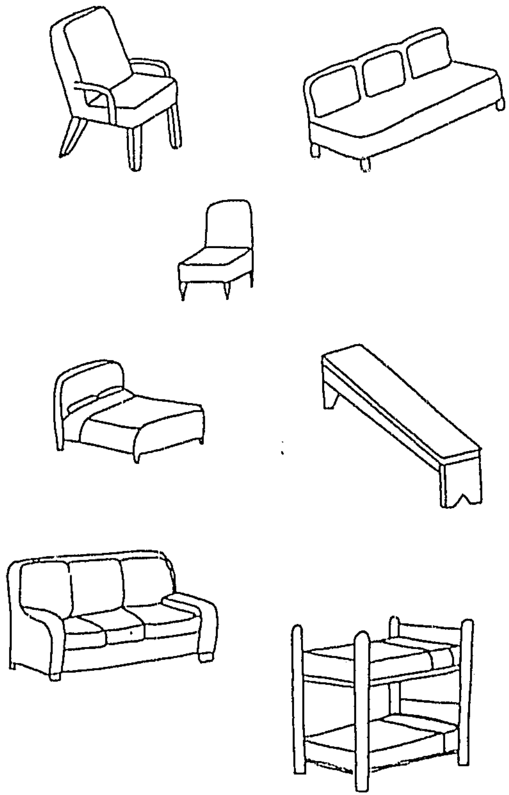




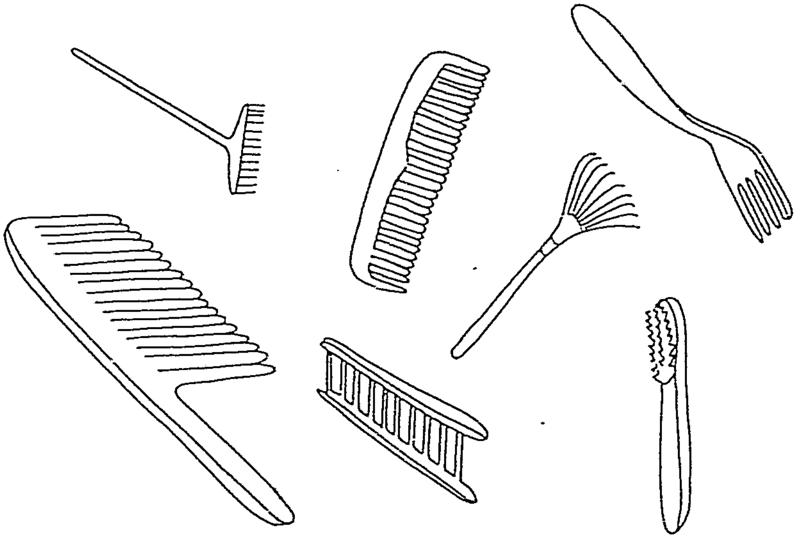
5



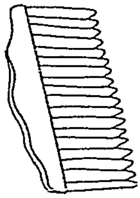
5



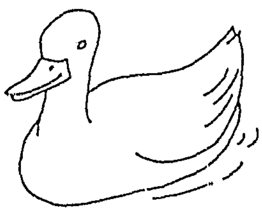
6



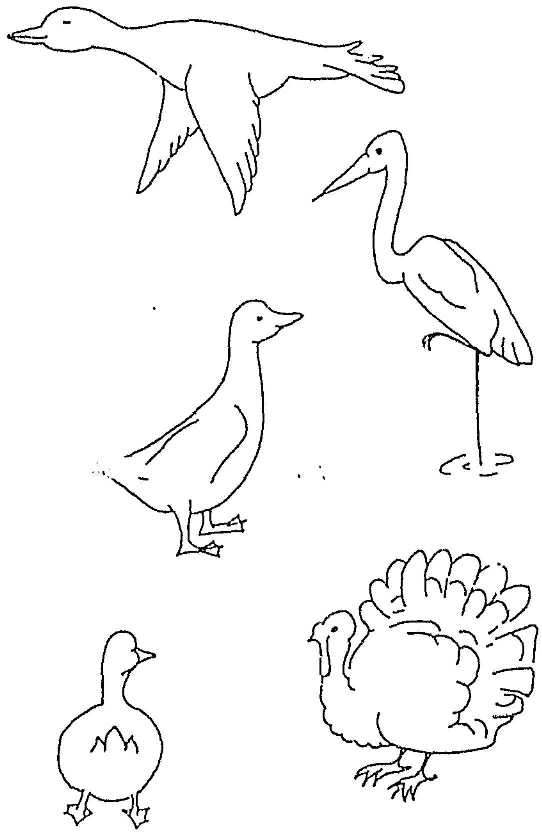
6



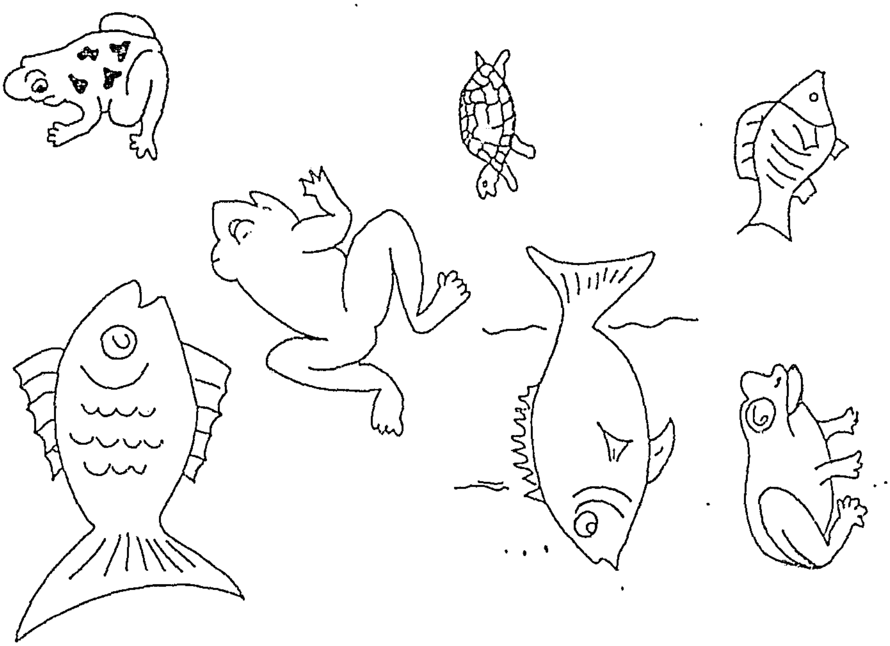
7



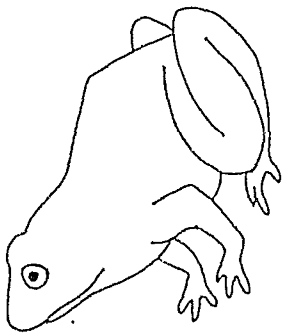
7



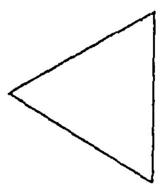
8

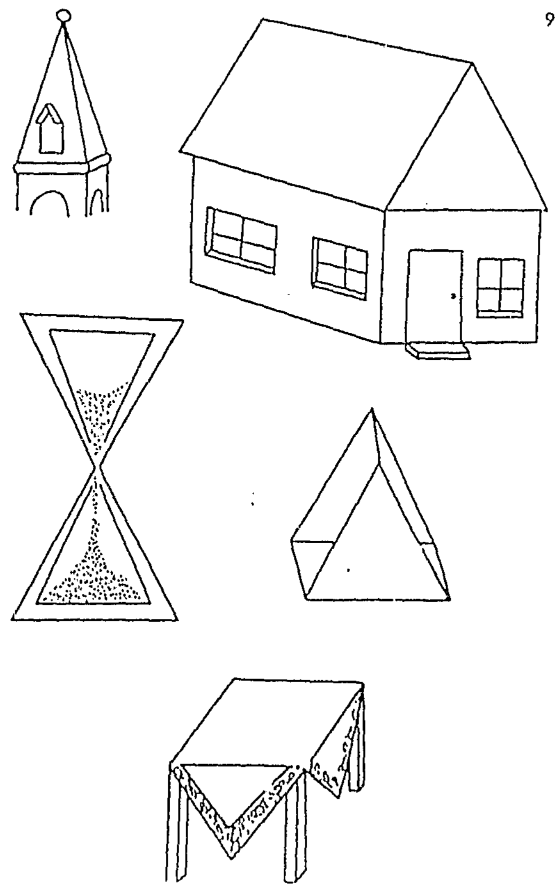


8

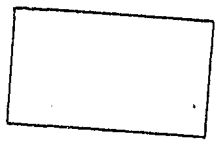


9



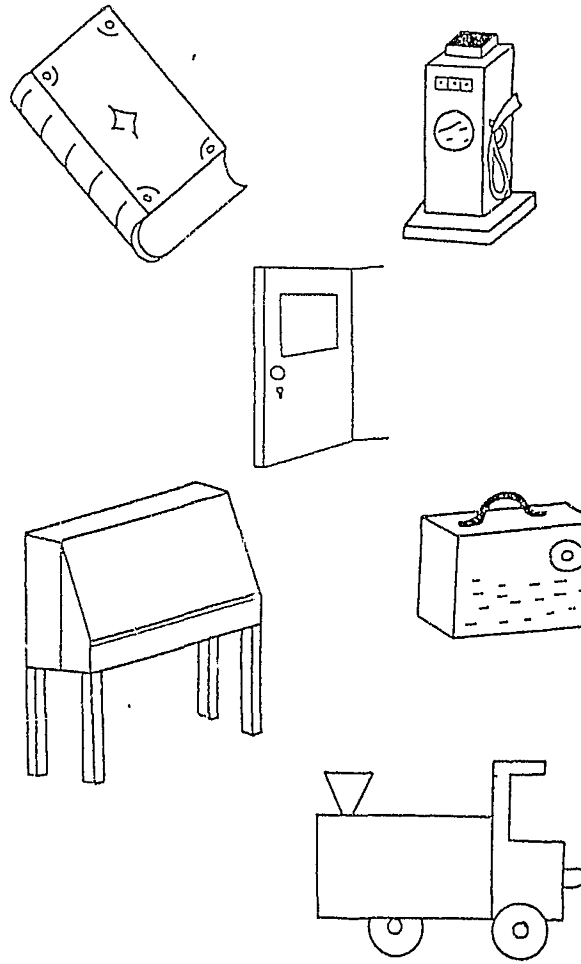


9

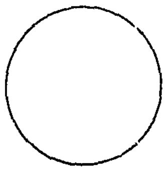


10

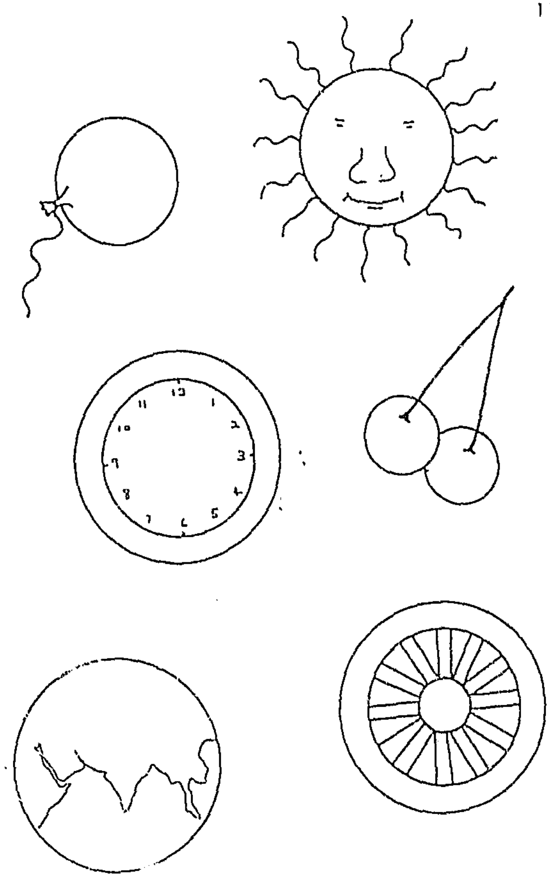
10

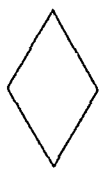


11

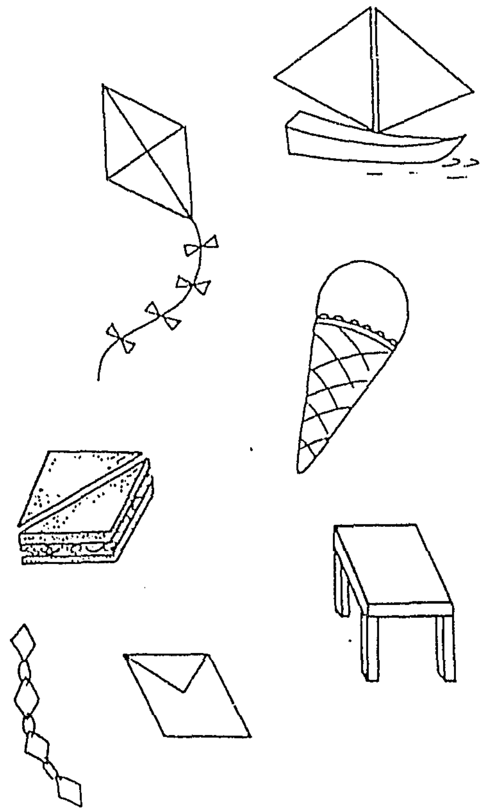


11



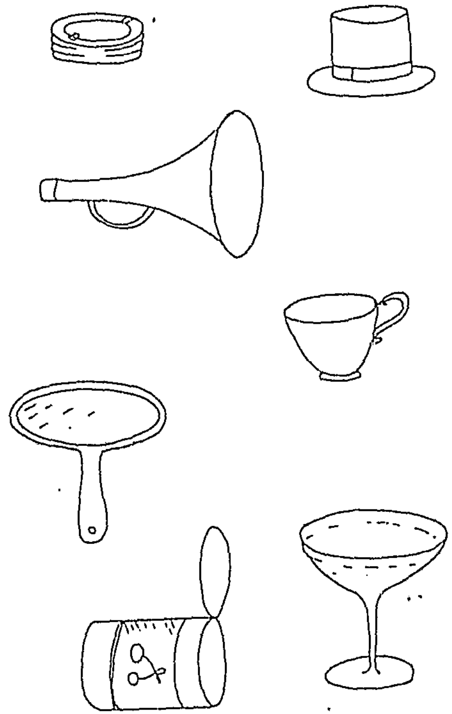


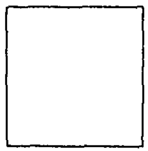
12



13

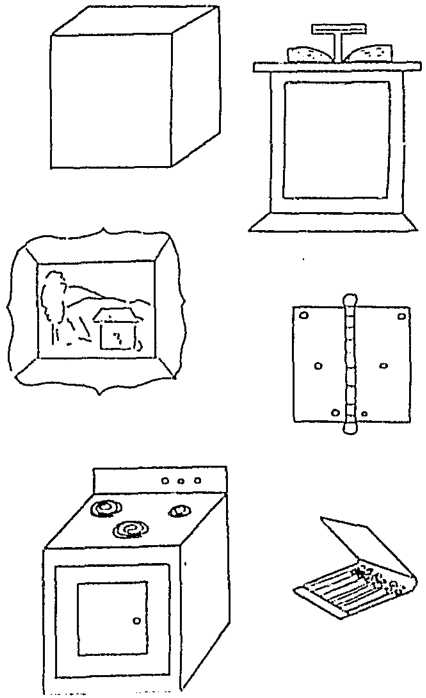
13





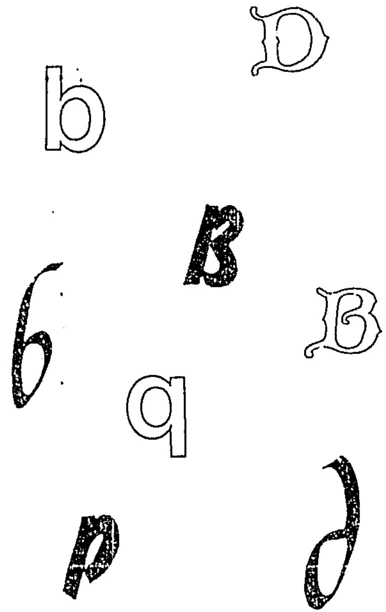
14

14



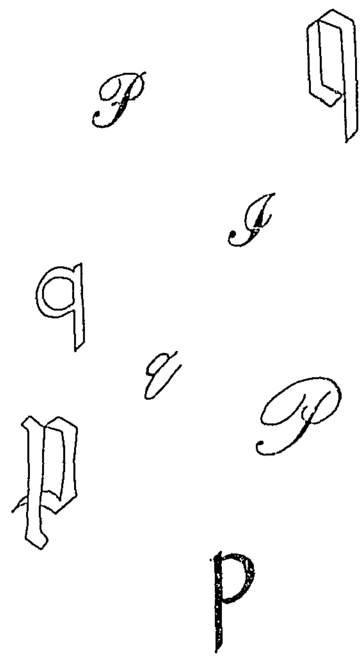
13

15



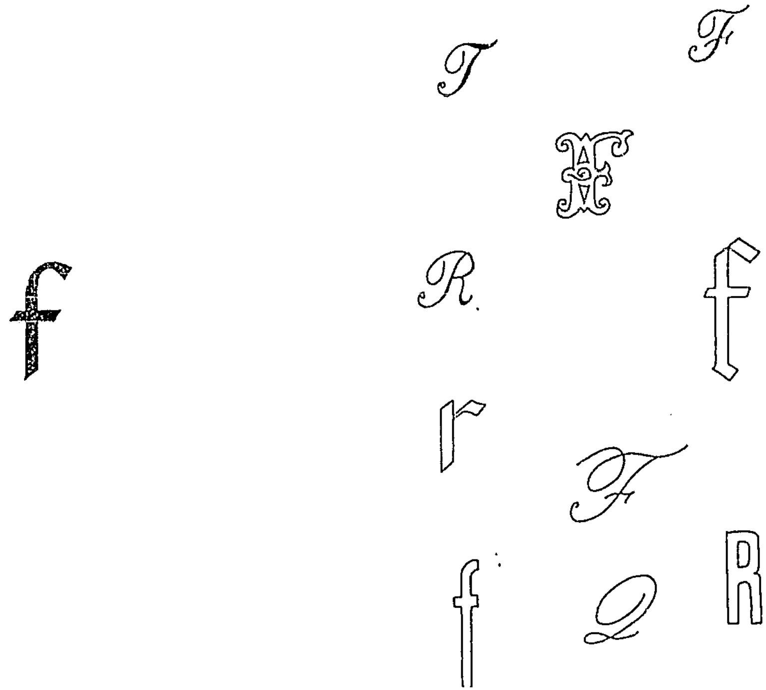
16

16



17

17



- LXVII -

M

18

18

M

M

N

M

W

N

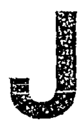
M

m

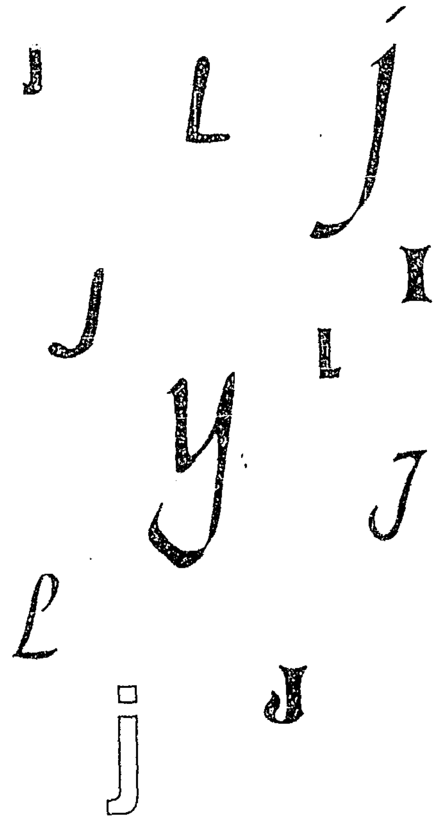
N

W

19



19



U

V u

v

W U

U

V

U

u V

V W

U

2.5. FIGURE-GROUND

Materials

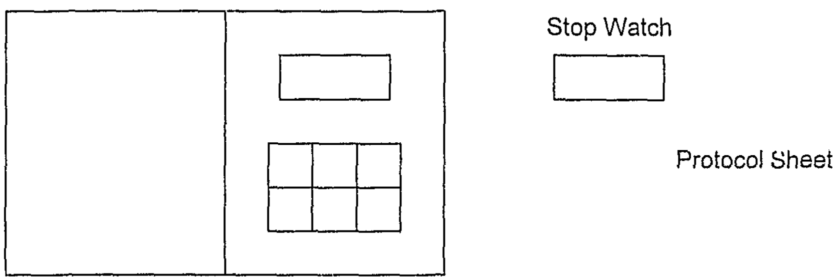
Test Book, Protocol Sheet, Digital Stop Watch, 1 Pencil.

Description

S is required to select from the multiple choice plate of 8 pictures, the 5 that are present in the hatched over plate above. The number of correct responses and the time taken for each test sheet, is recorded.

Procedure

E sits to the right of S and places the book open at the demonstration page. The protocol sheet is placed in front of E with the stop watch at the upper left hand corner.



E turns the page of the book with left hand, as the page drops over, E starts the watch with right hand which also holds the pencil. E immediately swops hands on the watch keeping left hand in place on the stop button. As S points to his choices the numbers are recorded, when he has finished, the watch is stopped and the time recorded. Watch is then zeroed. Instructions are as follows:-

Demonstration page open in front of S ***"There are 8 pictures here*** (indicatewith left hand the multiple choice plate***), 5 of them are in this scribbled over area above (indicate). I want you to point down here to the 5 pictures that you can see up here. Which of these pictures*** (indicate the multiple choice grid at the bottom***) are in the scribbled over picture".***

If S is correct:

"These are correct, we are going to do more like this. I will time you to see how long it takes, but remember accuracy is more important than speed."

If S is incorrect, point out two of the pictures he has missed or incorrectly indicated saying:

"See here is the .... and here is the ...., can you find the others (i.e. E points with right hand to design in the scribbled over plate and at the same time to the duplicate design in the multiple choice plate).

If S points to the designs in the scribbled over plate and not below, remind him that he should only point out the designs that he sees in the multiple choice plate.

If S calls out the numbers he should also be reminded to point to his choices not call the numbers. S can also be encouraged to count out loud 1, 2, 3, 4, 5 as he points should he feel that he will forget how many he has pointed out or if he seems to forget how many he has pointed to.

If S changes his mind during the test, E records all the choices and time includes all choices.

Scoring

a) Score only the first five choices made and record the number of correct responses within those five.

b) Total the number correct.

c) Total the time and bring to the nearest second.

The Test

The test sheets follow. For the purposes of testing each sheet was printed on cardboard, slipped inside a plastic cover and fixed between special covers so that it was presented in booklet form. This is the actual size of the test.

If S is correct:

"These are correct, we are going to do more like this. I will time you to see how long it takes, but remember accuracy is more important than speed."

If S is incorrect, point out two of the pictures he has missed or incorrectly indicated saying:

"See here is the .... and here is the ...., can you find the others (i.e. E points with right hand to design in the scribbled over plate and at the same time to the duplicate design in the multiple choice plate).

If S points to the designs in the scribbled over plate and not below, remind him that he should only point out the designs that he sees in the multiple choice plate.

If S calls out the numbers he should also be reminded to point to his choices not call the numbers. S can also be encouraged to count out loud 1, 2, 3, 4, 5 as he points should he feel that he will forget how many he has pointed out or if he seems to forget how many he has pointed to.

If S changes his mind during the test, E records all the choices and time includes all choices.

Scoring

a) Score only the first five choices made and record the number of correct responses within those five.

b) Total the number correct.

c) Total the time and bring to the nearest second.

The Test

The test sheets follow. For the purposes of testing each sheet was printed on cardboard, slipped inside a plastic cover and fixed between special covers so that it was presented in booklet form. This is the actual size of the test.

PROTOCOL SHEET

FIGURE-GROUND

NAME: ______________________ DATE OF TEST : ____________________

AGE : _______________________ DATE OF BIRTH : ____________________

ITEM NO.	ITEMS CORRECT	ITEMS CHOSEN	TIME	TOTAL
1	1,2,4,5,7			
2	1,2,6,7,8			
3	3,4,5,6,8			
4	1,2,5,7,8			
5	1,2,3,5,6			
6	1,2,5,6,7			
7	2,3,5,7,8			
8	2,3,4,7,8			
9	2,3,4,5,7			
10	1,2,4,7,8			
11	1,2,3,4,8			
12	2,4,5,7,8			
13	2,3,4,6,8			
14	1,3,4,5,6			
15	1,3,4,5,8			
16	2,3,4,5,6			
		TOTAL		

Accuracy Score:

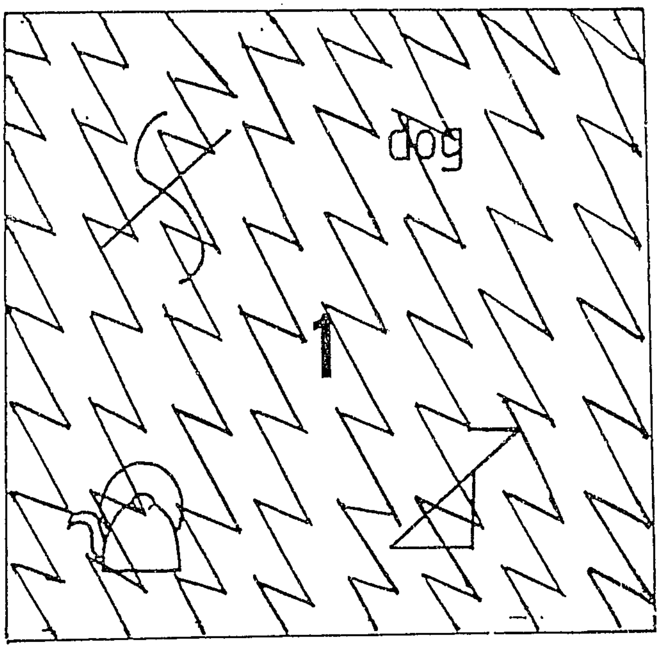
Time (secs) ___________ = _____________

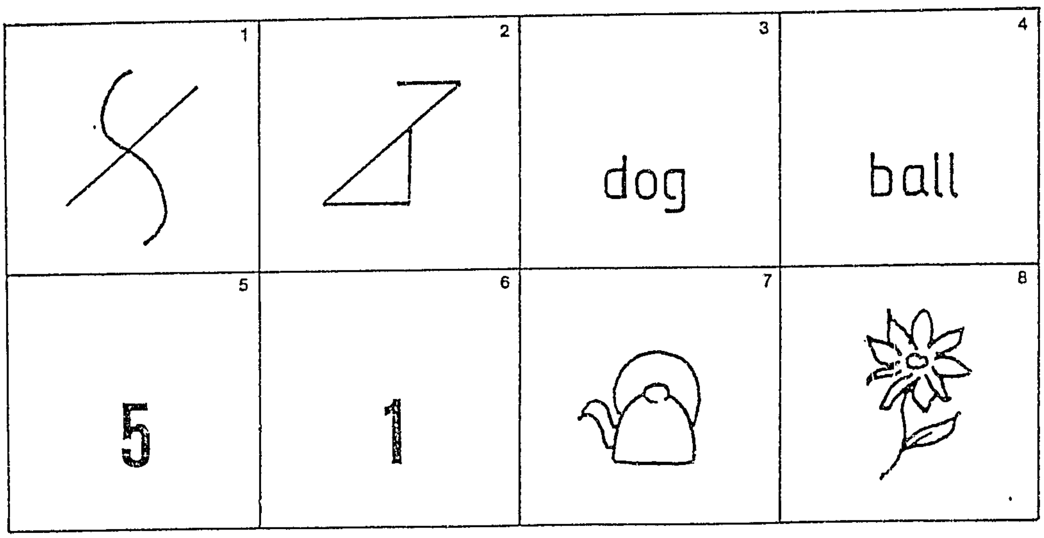
FIGURE-ROUND TEST

Name: ______________________ No. Correct: ______________________

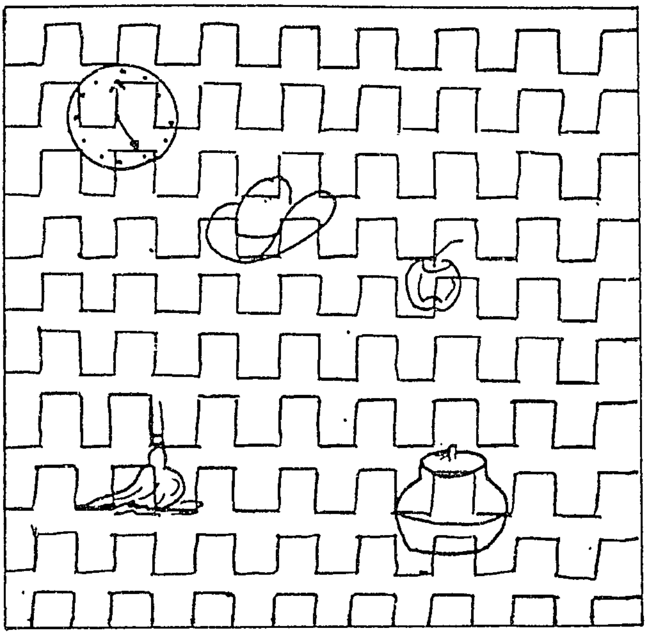
Date: ______________________ Time: ______________________

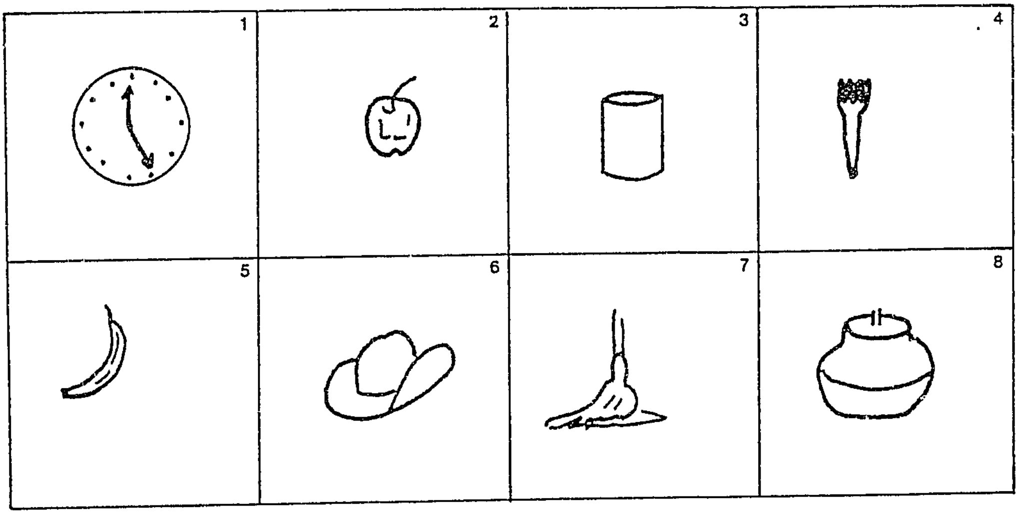
Age: ______________________

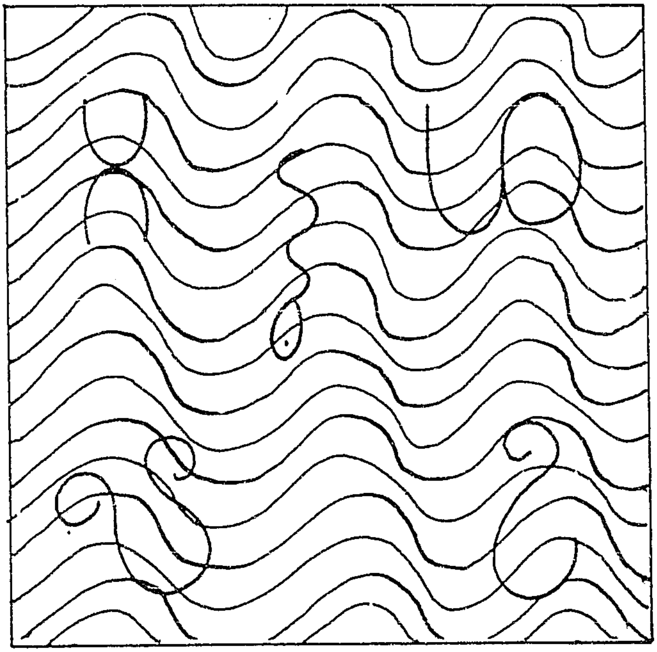


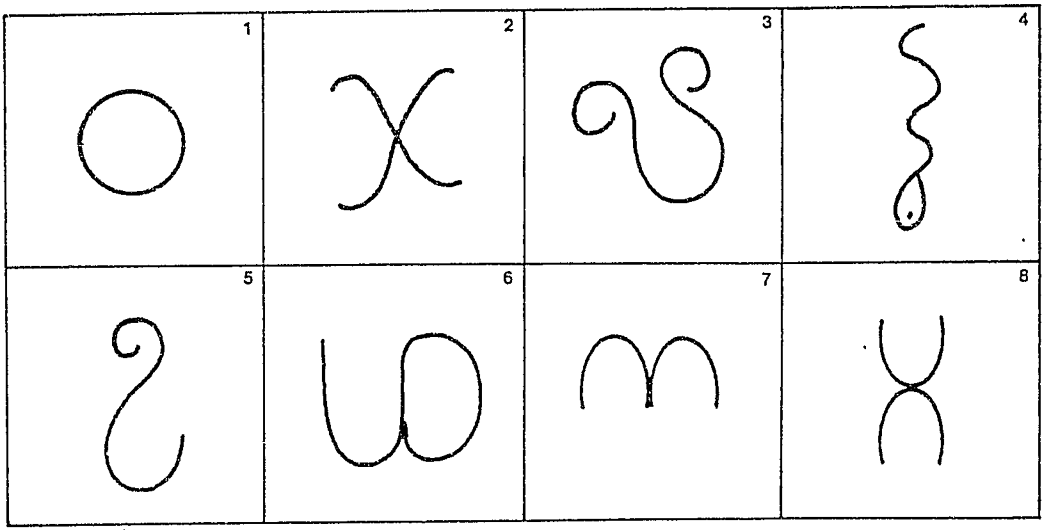


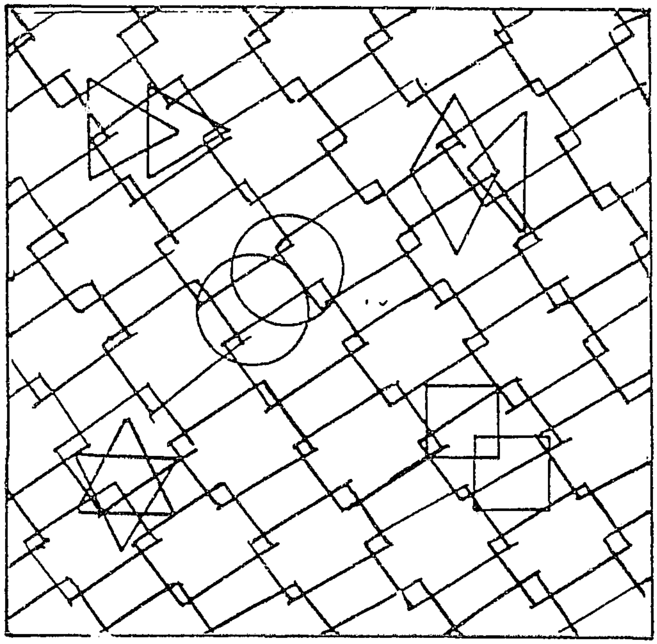
Demo

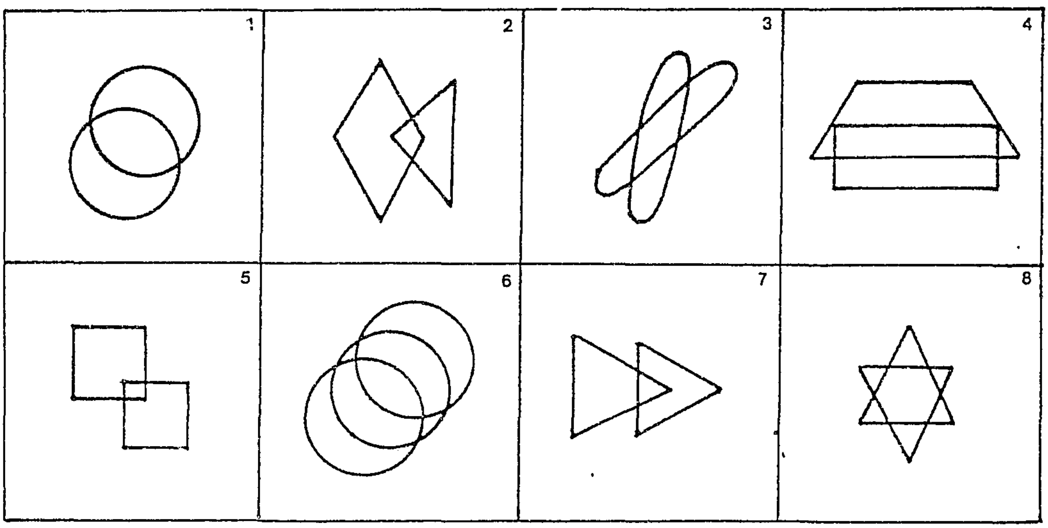


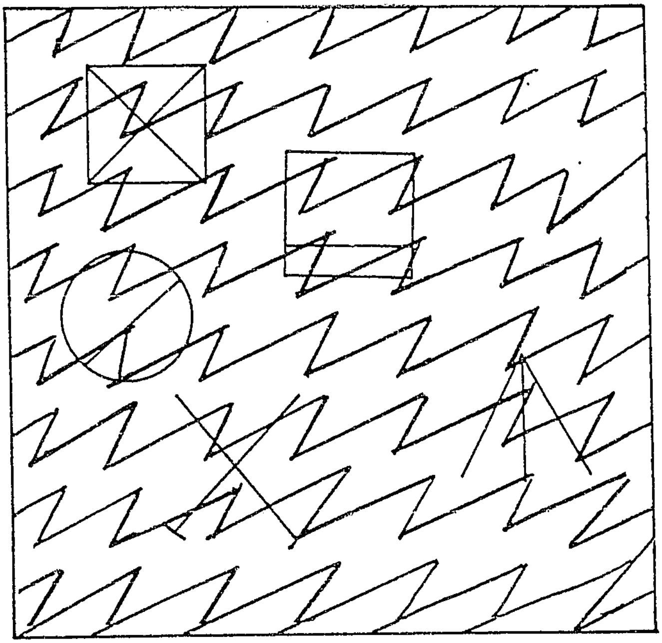

1
2
3
4
5
6
7
8

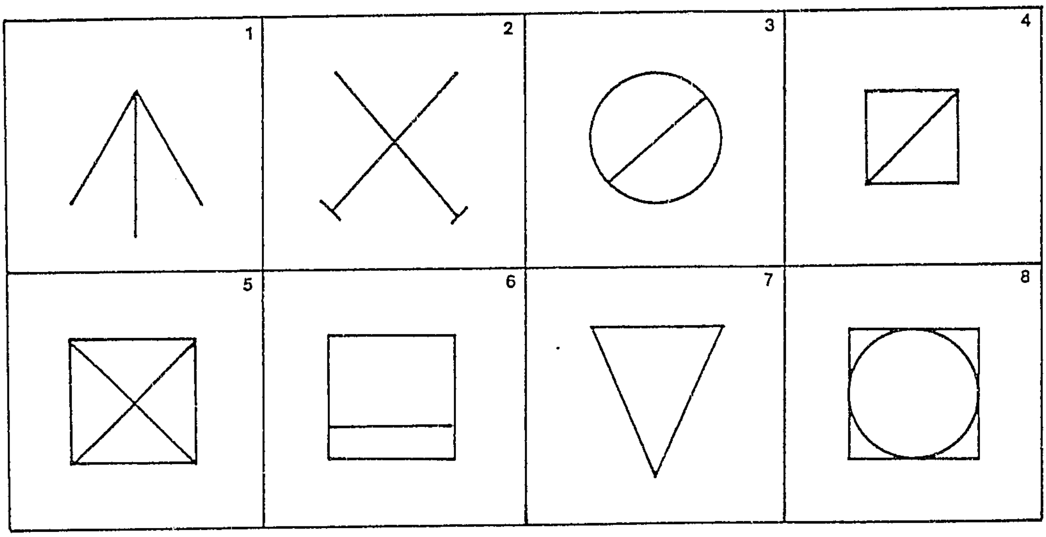


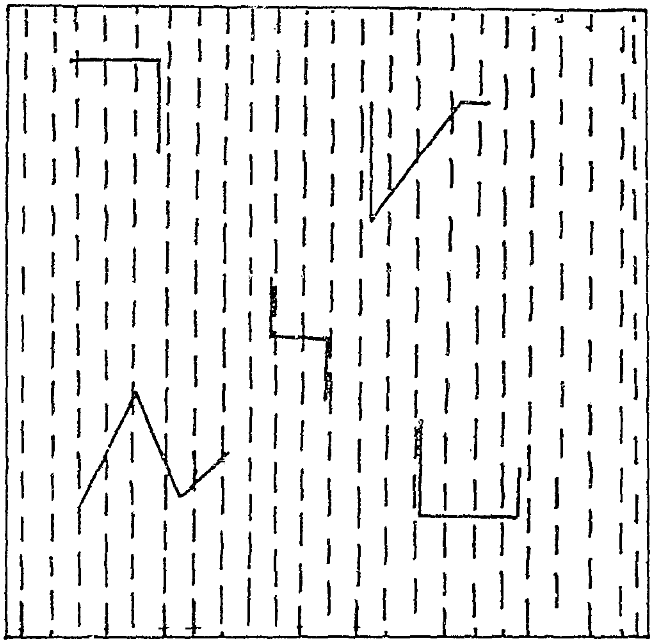

1
2
3
4
5
6
7
8

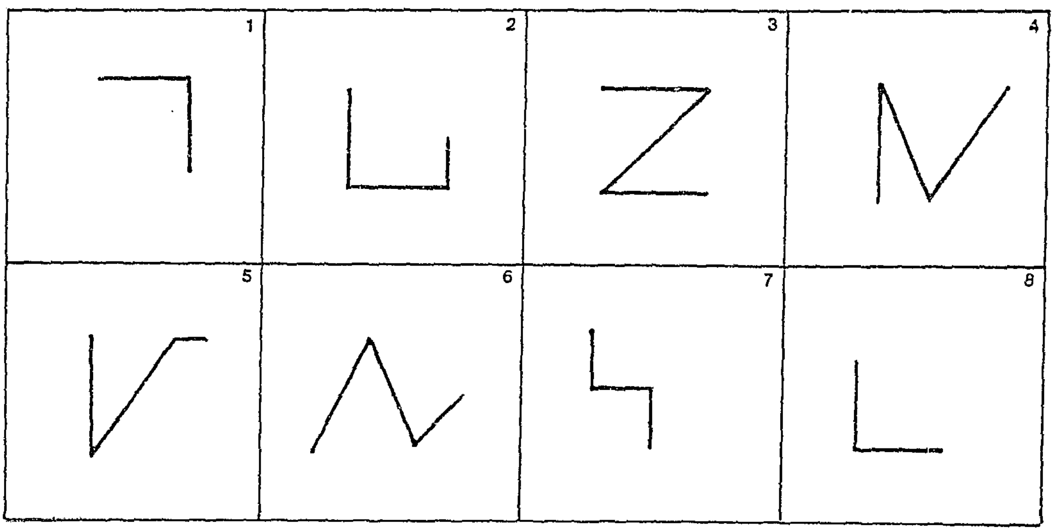



1
2
3
4
5
6
7
8

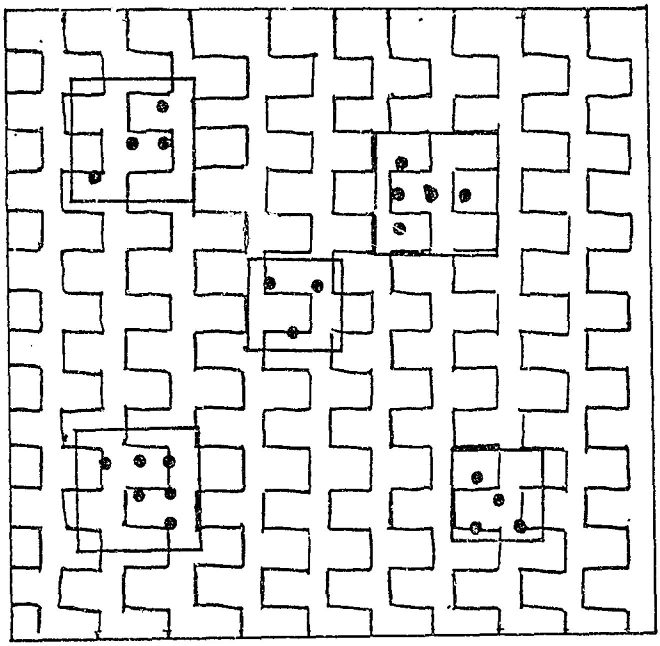


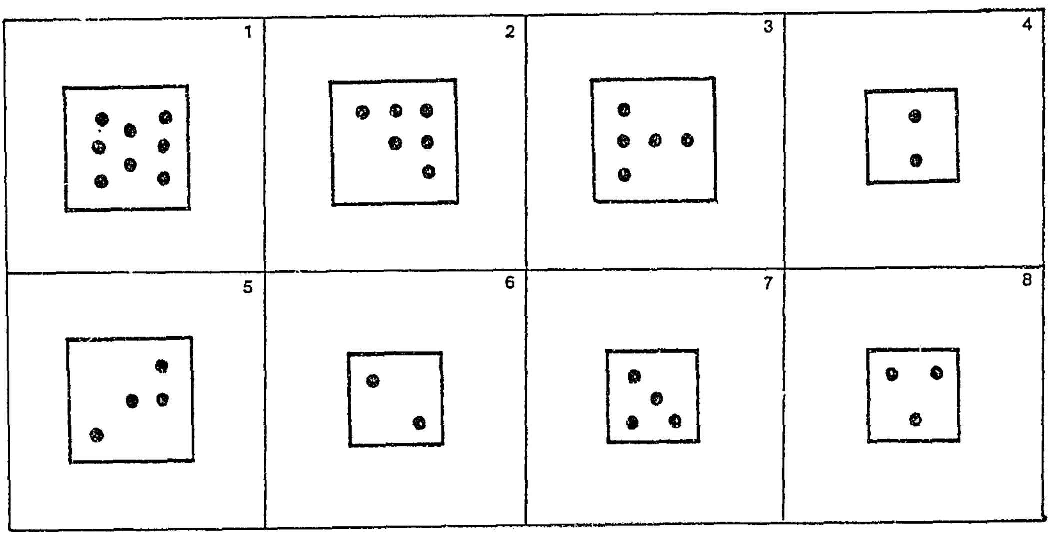

1
2
3
4
5
6
7
8

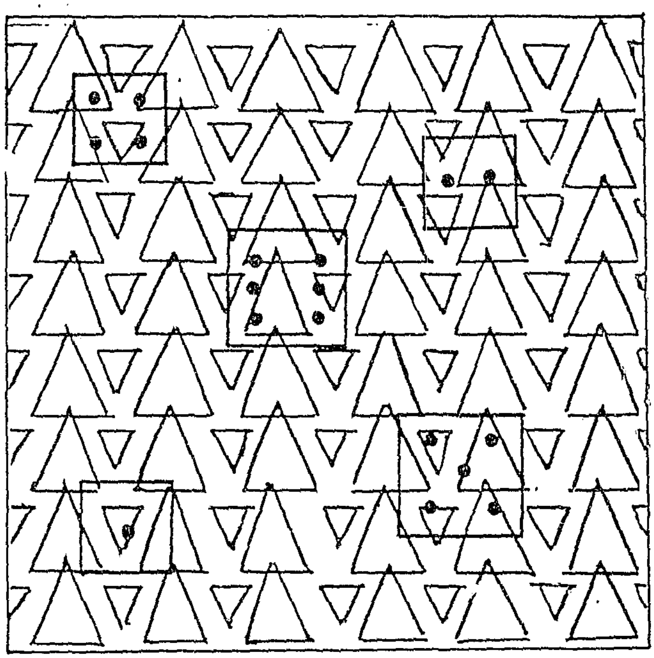


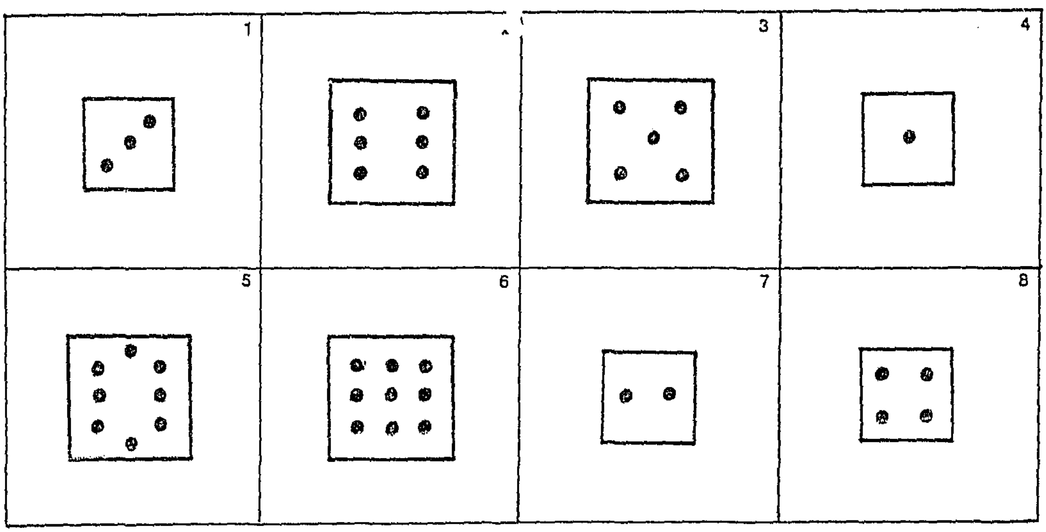

1
2
3
4
5
6
7
8

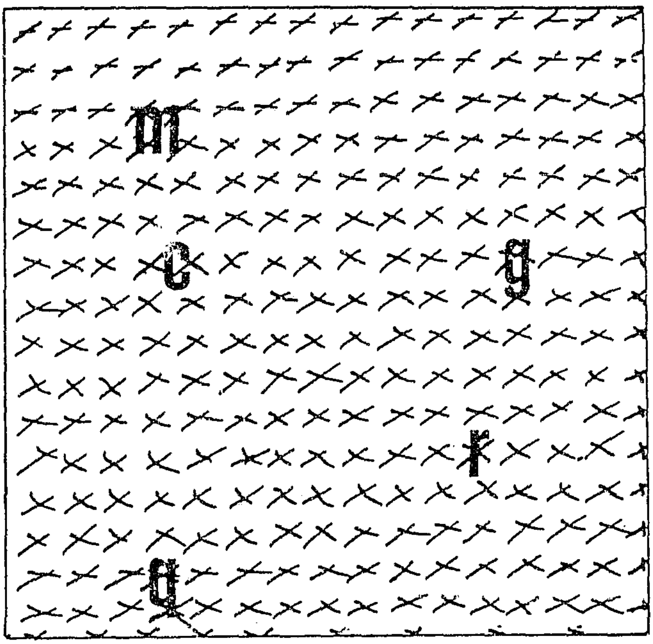
7



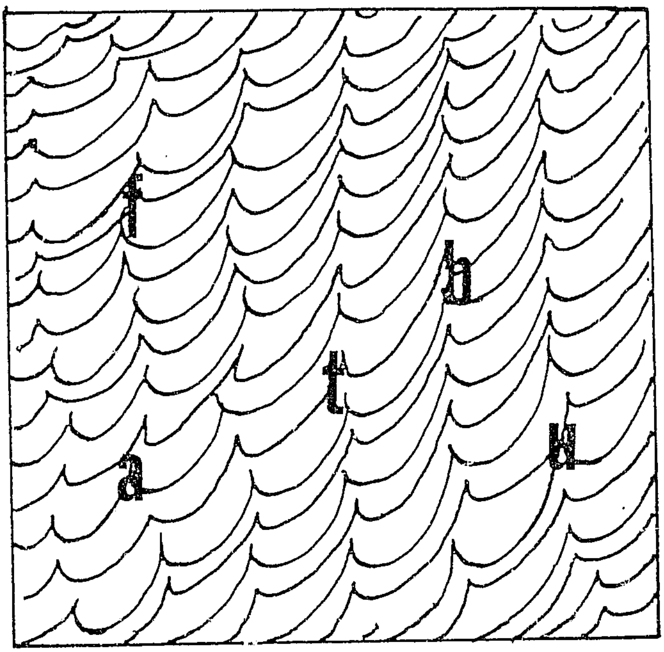




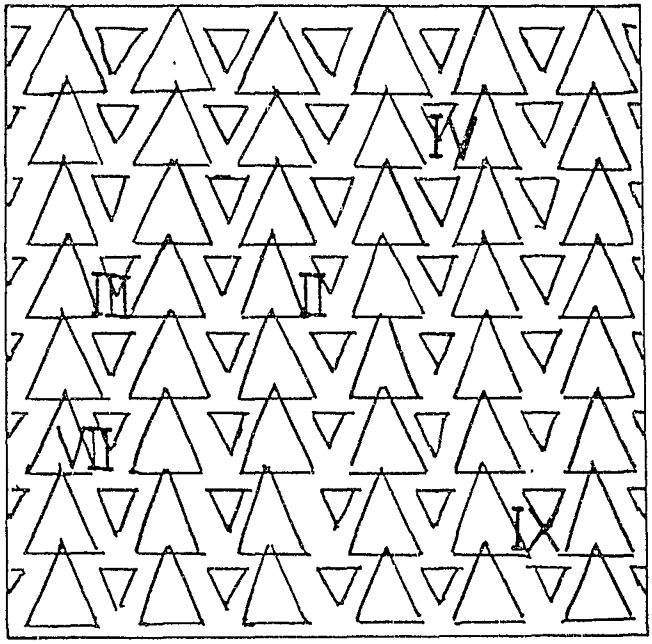

1
3
4
5
6
7
8



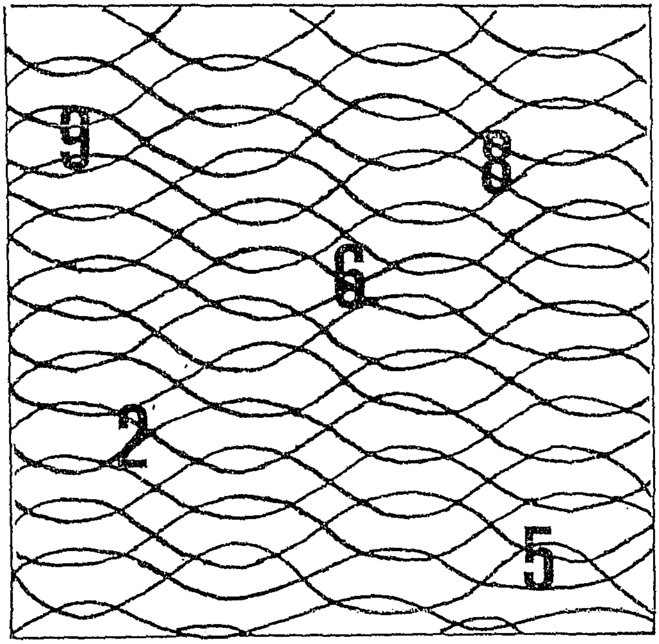
1	2	3	4
h	m	g	c
5	6	7	8
q	o	r	n



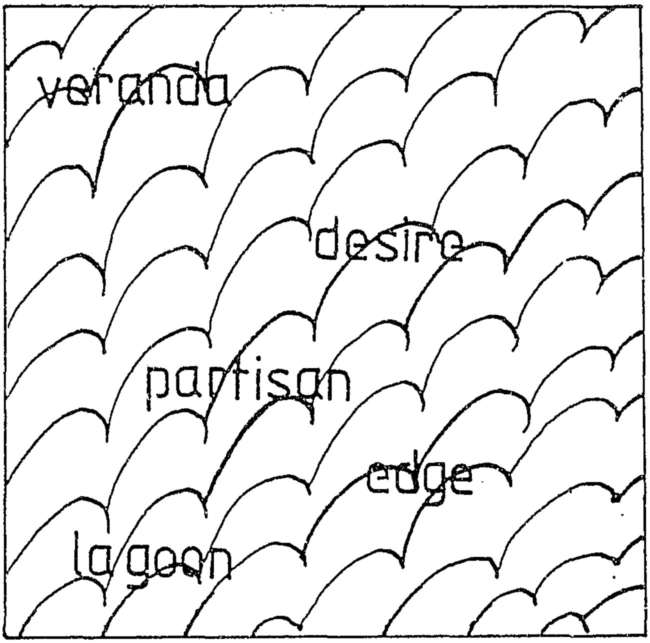
1 a	2 u	3 s	4 f
5 d	6 p	7 b	8 t



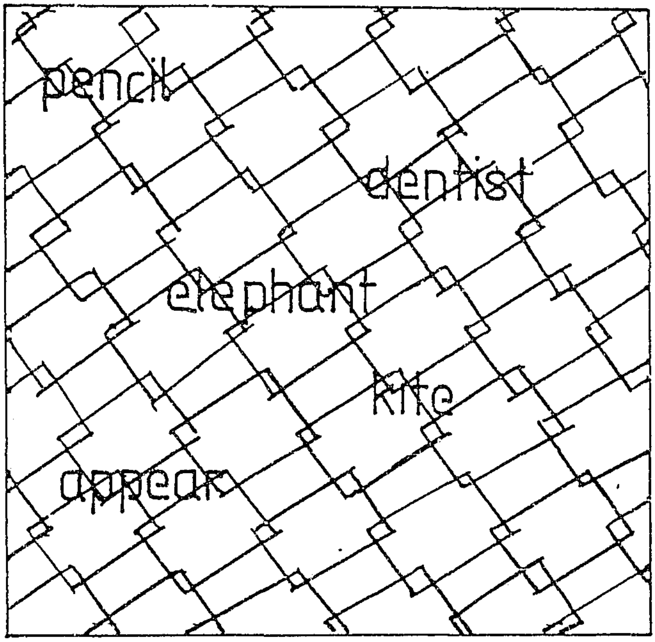
1	2	3	4
II	IX	IV	VII
5	6	7	8
VI	V	I	III



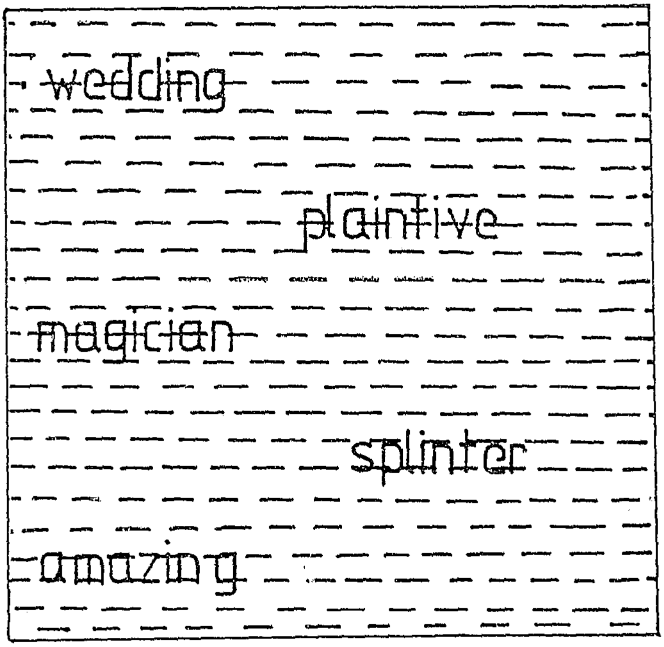
1 3	2 5	3 4	4 2
5 8	6 7	7 9	8 6



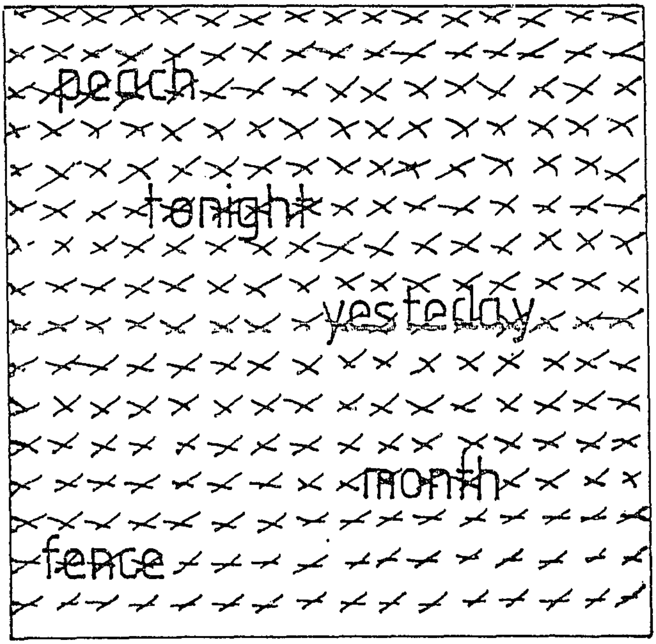
1 children	2 desire	3 lagoon	4 partisan
5 conceited	6 veranda	7 motley	8 edge



1 dentist	2 vehicle	3 kite	4 elephant
5 appear	6 pencil	7 giraffe	8 aeroplane



1 magician	2 grateful	3 wedding	4 amazing
5 plaintive	6 manager	7 friend	8 splinter



1 house	2 yesterday	3 peach	4 month
5 fence	6 tonight	7 tomorrow	8 horse

2.6. ARROWS TEST

Materials

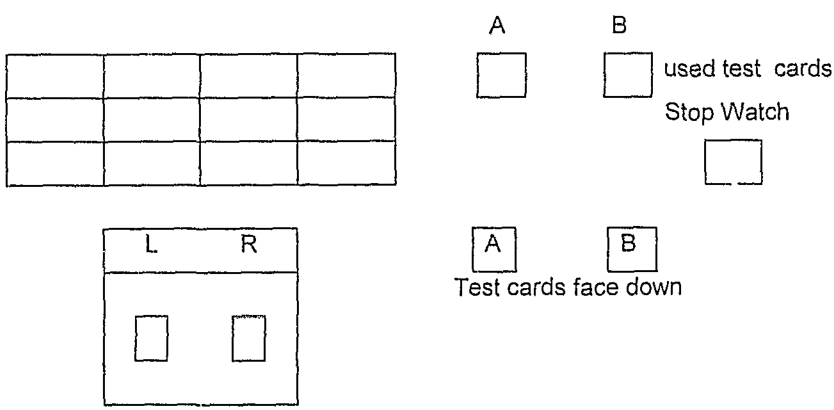
Multiple Choice Test Sheet, Multiple Choice Demonstration Card, Individual Test Cards, Protocol Sheet, Digital Stop Watch, 1 Pencil, Felt Rectangle (21 1/2cm x 15cm), Left/Right Card.

Description

S is required to match a design on the multiple choice sheet with the correct design from two alternatives. S is required to lift the correct card and place it on top of its duplicate on the multiple choice sheet. Each item is timed from the moment of exposure of each card until S indicates his choice by touching the card.

Procedure

Place the felt rectangle + 3-4 cm from the edge of the table in front of S. Stick the left/right card to the top edge of the felt with press stick. Stick the multiple choice card to the table with press stick + 4 cm above the felt rectangle. Test cards A and B are placed face down in 2 piles at the lower right border of the multiple choice card.



A and B cards are picked up simultaneously (by E) and placed face up on felt rectangle with A under the left sign and B under the right sign. They must lie straight on the felt i.e. lower edge must be parallel with edge of felt. E starts the watch immediately with right hand. Watch is stopped as soon as S touches a card. Left or right is recorded according to which card is chosen, as well as the number of the choice (see multiple choice sheet) and the time taken. Watch is then zeroed.

Cards are removed using left hand for A cards and right hand for B cards and placed face up on the two used piles. Instructions are as follows:-

Place demonstration card one A and B. ***"You are to select from these two cards*** (indicate) ***the card that has a duplicate on this*** (indicate) ***sheet. One of these cards will match one of these designs."*** Once S has indicated his choice: ***"Now pick it up like this*** (E picks left hand card up) ***and place it on top of its duplicate like this"*** (E places card on duplicate (number two) on the multiple choice sheet). E then removes cards - left hand on card on multiple choice sheet and right on (B) card on felt rectangle - and places them in two separate piles above protocol sheet. Demonstration two cards are then put in place.

"Let us try the next one - which of these two cards matches this design here (point to number one on the multiple choice sheet). ***That is right, do not touch either of these 2 cards*** (indicate) ***until you have decided which one has a duplicate, because the first one that you touch is the one that will be counted as your choice. Don't pick up a card until you are sure which one has a duplicate on the sheet in front of you. As it lies it will have a duplicate, you must not rotate them. Remember it is more important to be accurate than to be quick."*** Use as much time and explanation as is needed to get S to understand the task expected of him. Replace the demonstration multiple choice sheet with the test multiple choice sheet and stick down with press stick. Start timing with these items.

"Now we are going to do more items in the same way. Remember do not touch the cards until you have decided on the right one, then pick it up and put it on top of it's duplicate on the multiple choice sheet."

Record

Left or Right and the number of the item chosen on multiple choice sheet and the time taken in the Section B of the protocol sheet.

Section A is used only if S is unable to do Section B. If S fails the first six items, remove all the parts of Section B and place the cards for Section A in position. This section is administered in exactly the same way.

"I want you to do the same with these cards - find the one that has a duplicate on this sheet (indicate multiple choice sheet) ***when you have decided which one it is, pick up the card and place it on top of the one that is the same."***

Scoring

For an item to be scored correct, the right card must be selected and then correctly placed. Should Section A not have to be used, S automatically obtains credit for these 6 items. Total all correct answers. Total the time and bring to the nearest second.

The Test

The following pages depict the test. This is the actual size of the test.

A	=	Demonstration multiple choice sheet
B	=	Demonstration test cards
C	=	Test Multiple choice sheet
D & E	=	Test cards. Pairs are labelled 1A & B
		2A & 2B
		3A & 3B etc.

PROTOCOL SHEET

ARROWS TEST

NAME: ____________________ DATE OF TEST : ____________________

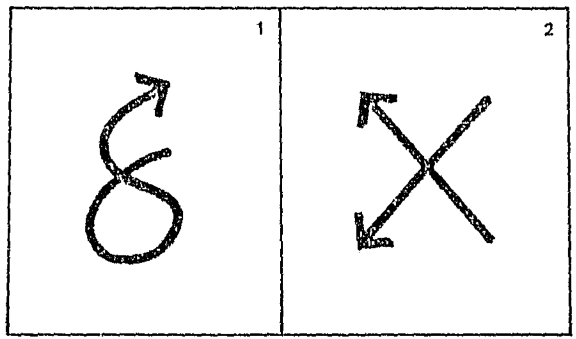
AGE : ____________________ DATE OF BIRTH: ____________________

ITEM NO.	CORRECT ANSWER	CORRECT ANSWER	RECORD R/L	RECORD ITEM	TIME	ACCURACY
A 1	6	R				
2	2	L				
3	5	L				
4	3	R				
5	1	L				
6	4	R				
B 1	1	L				
2	3	R				
3	5	L				
4	12	L				
5	14	R				
6	9	L				
7	11	L				
8	16	R				
9	8	R				
10	10	L				
11	17	L				
12	4	L				
13	6	L				
14	7	R				
15	18	L				
16	13	R				
17	2	L				
18	15	R				
		TOTAL				

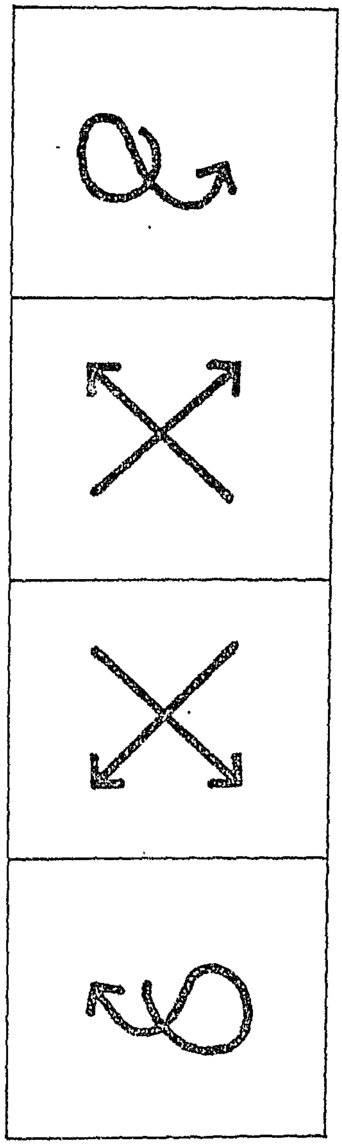
Accuracy Score: ____________________

Time (secs) : ____________________ = ____________________

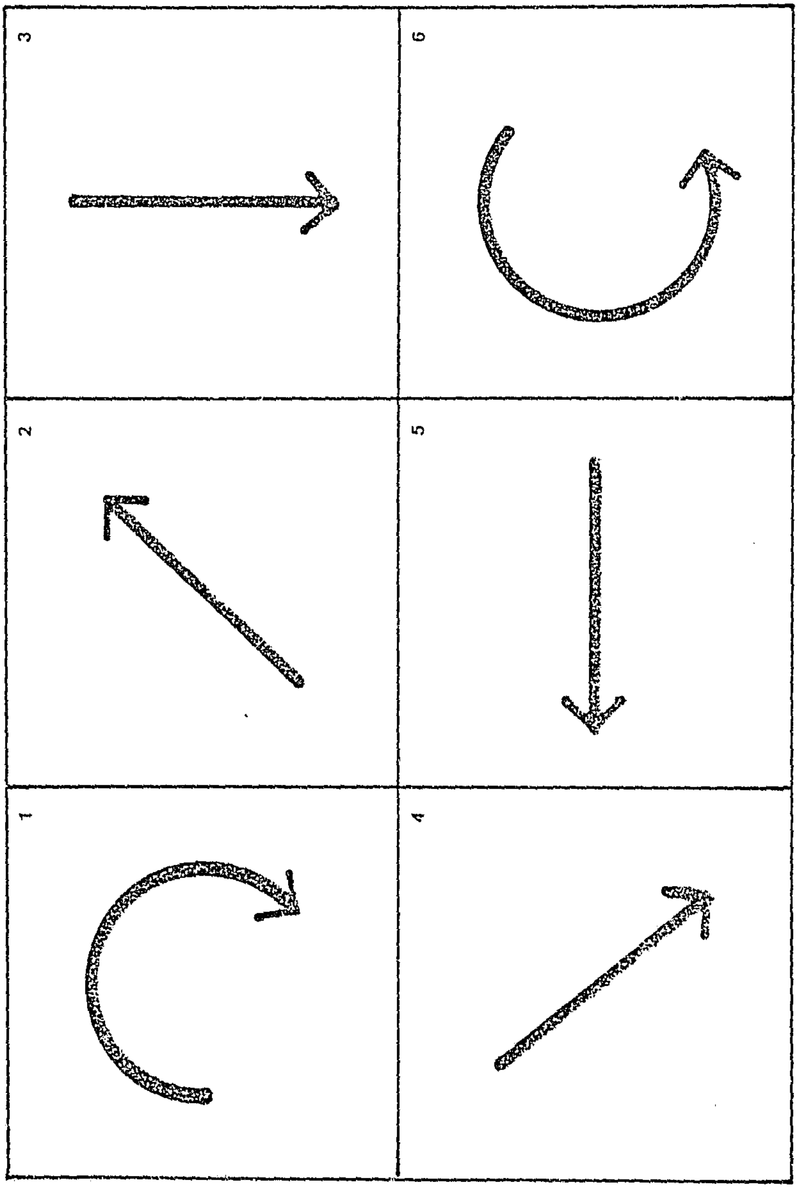
Demo



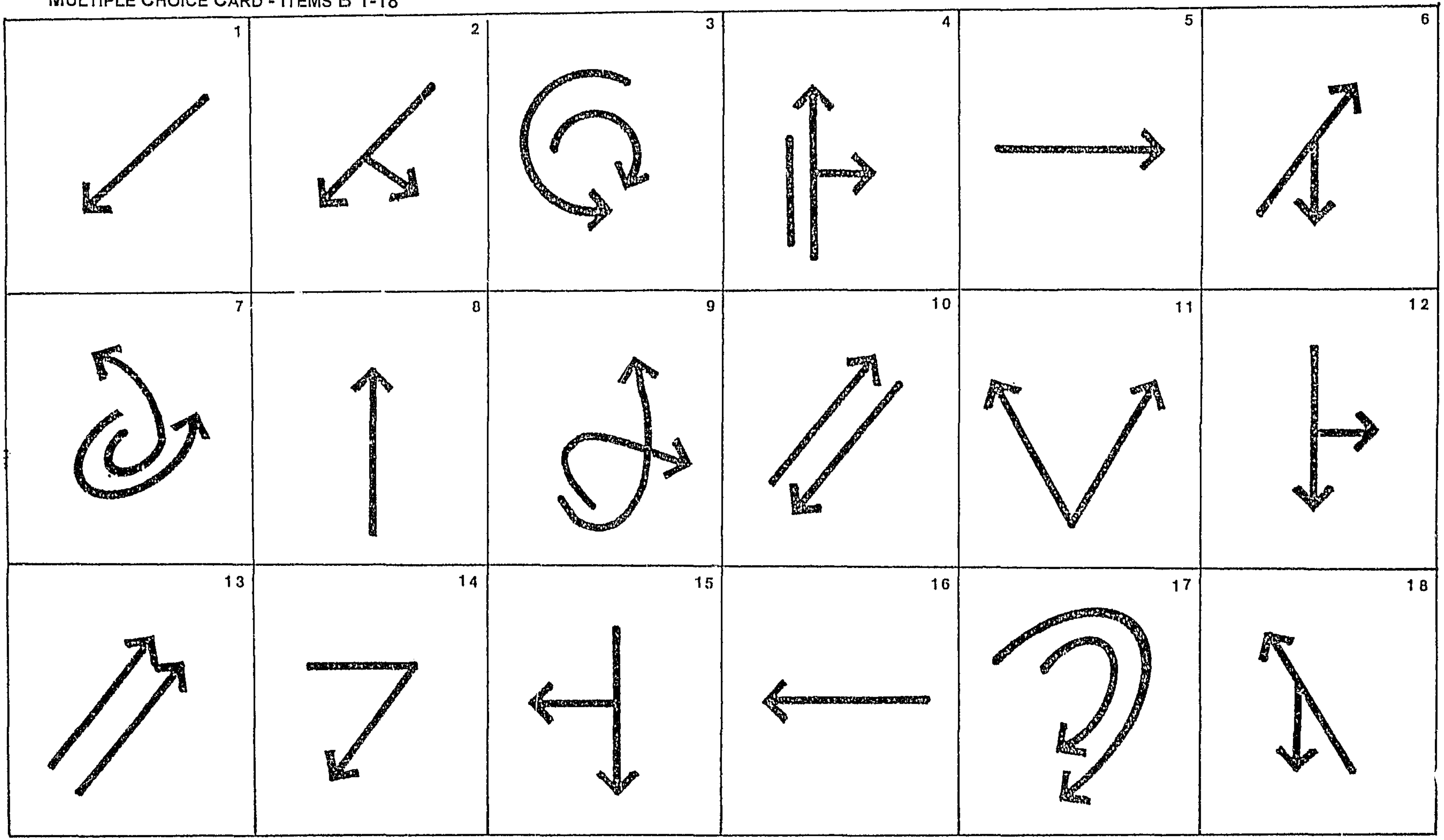
DEMONSTRATION CHOICE CARDS



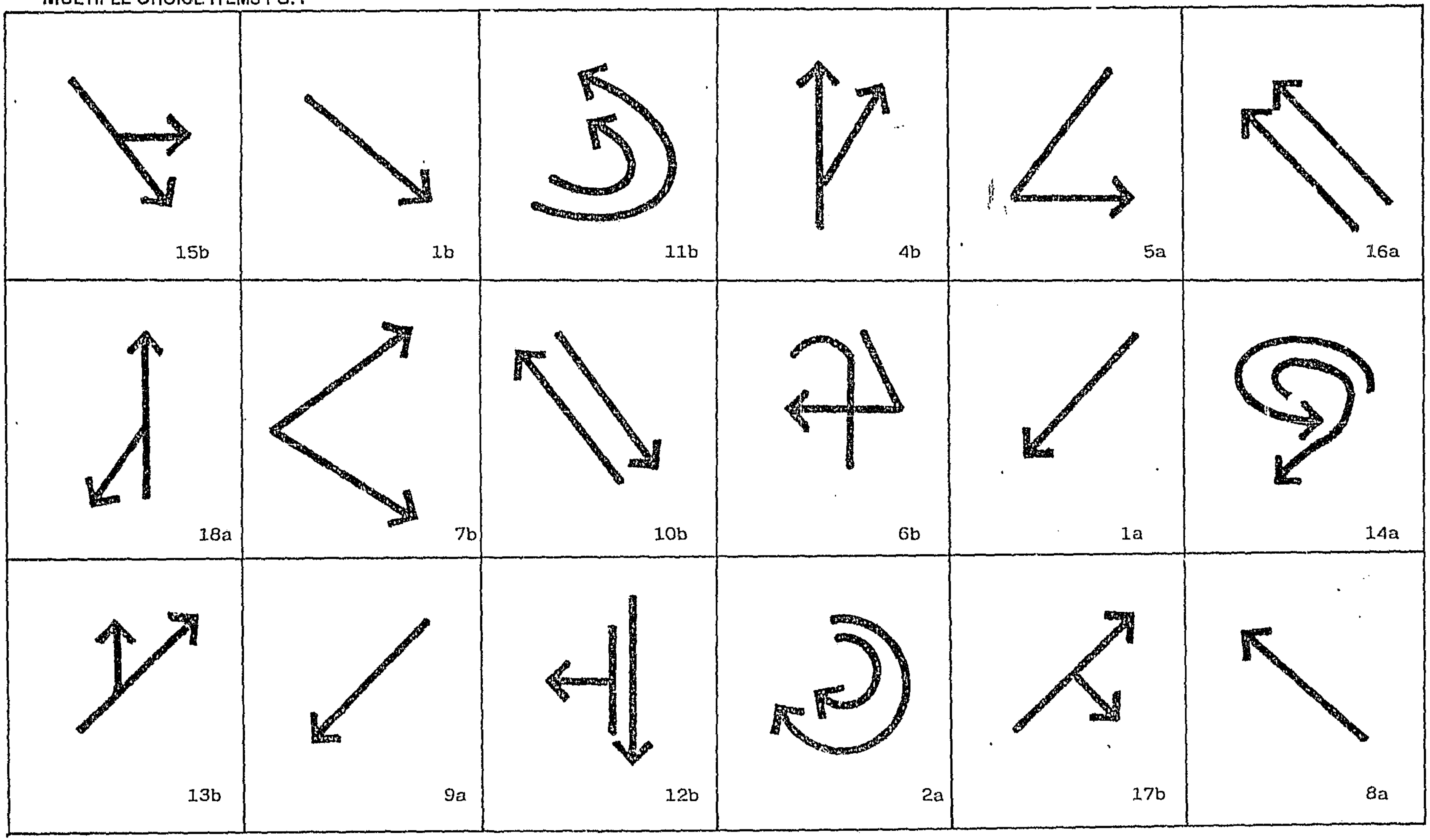
MULTIPLE CHOICE CARD - ITEMS A 1-6



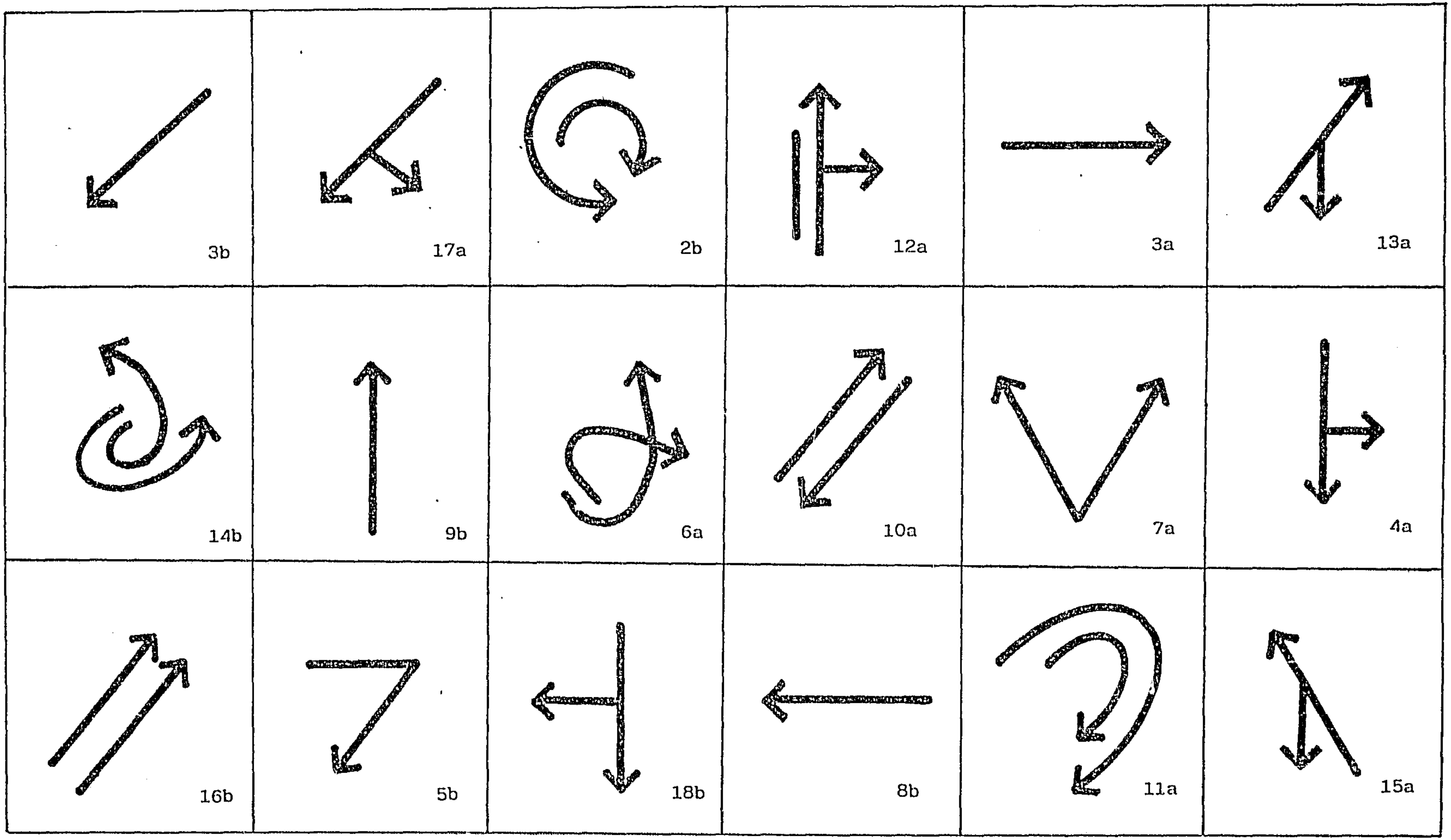
MULTIPLE CHOICE CARD - ITEMS B 1-18



MULTIPLE CHOICE ITEMS PG.1



MULTIPLE CHOICE ITEMS PG. 2



2.7. DOT-LINE TEST

Materials

Test Book, 2 Pencils, Digital Stop Watch, Protocol Sheet.

Description

S is required to draw lines between the dots depicted at the bottom of the page, thus duplicating the design at the top of the page.

Procedure

E sits to right of S. The test book is opened to page one, demonstration one and placed a comfortable drawing distance away from the S (i.e. + 4-5 cm from edge of the table) the bottom of book remaining parallel with the table edge throughout the test. A piece of cardboard is placed under the top page and moved as the test progresses. This is to prevent the succeeding designs from showing through as well as to prevent pencil impressions from the 1st design being made on the second design.

Instructions are as follows:-

"I want you to draw lines between the dots at the bottom of the page so that this design (indicate bottom configuration of dots) ***looks exactly like the design at the top of the page*** (indicate)."

After S has drawn his design.

"That is correct. If you think a line touches a dot be sure to make your line touch a dot, therefore you would not do this:-

or

(draw over S's already drawn design)

"Make your drawing as accurate as possible , keep in mind the fact that you do not have a rubber or ruler. I will not expect your lines to be perfectly straight."

If S is correct:-

"Now you are going to do more drawings like this one".

Turn to page two moving the cardboard and immediately start the stop watch. Leave the watch running until S has completed his last drawing. Stop the watch when S indicates that he has finished. As S does each drawing note any spatial neglect, directional confusion, odd ways of approaching the problem etc.

If the S neglects half the drawing, remind him to look at the whole design. If S is incorrect at the demonstration item - demonstrate saying - ***"This drawing*** (point to example) ***has a line here, therefor your drawing must have a line here to."***

<u>At Item 9</u> There are more dots in the test design than in the model. Give instructions ONLY if S asks, i.e. ***"Yes there are more dots in the bottom design, plan your lines to look exactly like the lines at the top of the page."***

<u>At Item 13</u> The test design has less dots than the model, give instruction <u>ONLY</u> if S asks, i.e. ***"Yes there are less dots, plan your lines to look exactly like the lines at the top of the page."*** If S asks if he can draw in his own dots say: ***"You can do whatever you like to make your lines look like the lines at the top of the page."***

N.B. Record time on protocol sheet and on test booklet at end of test.

<u>Scoring</u>

Record all correct designs. A transparency with the correct lines drawn in is used for items 13-16. Any design where the following occurs is scored incorrect:-

a) The dots are joined incorrectly

b) Lines do not touch the dots i.e. there is a gap between the line and the dot of more than 5 mm

c) Line overshoots the dot for more than 5 mm

d) Part of the design is missing.

The Test

The test sheets follow and they are the actual size of the test. For testing purposes they were made up into a booklet. Convert time to seconds and round off to the next highest second.

PROTOCOL SHEET

DOT-LINE TEST

NAME: ______________________ DATE OF TEST : ______________________

AGE: ______________________ DATE OF BIRTH: ______________________

	ITEM NO.	ITEM CORRECT
A	1	
	2	
	3	
	4	
	5	
	6	
	7	
	8	
B	9	
	10	
	11	
	12	
C	13	
	14	
	15	
	16	
	TOTAL	

Accuracy Score: ____________

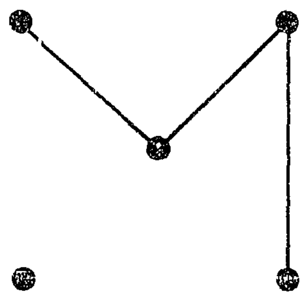
Time: (secs) ____________

THE DOT-LINE TEST

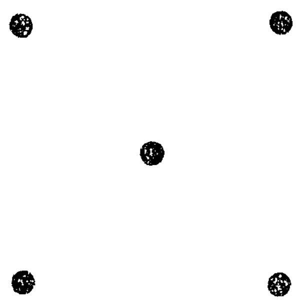
Name: ____________________ No. Correct: ____________________

Date: ____________________ Time: ____________________

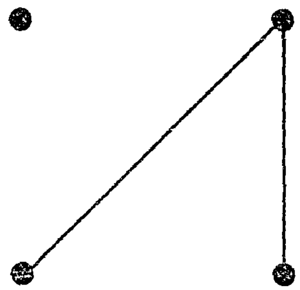
Age: ____________________



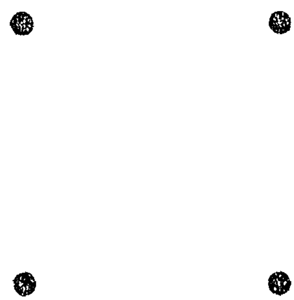
Demo



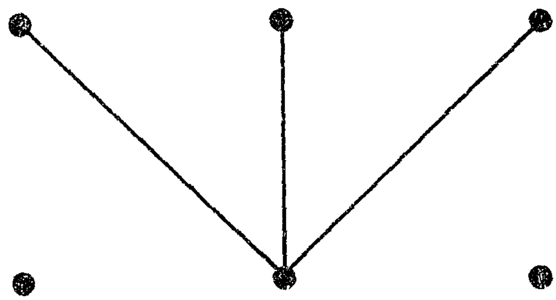
2



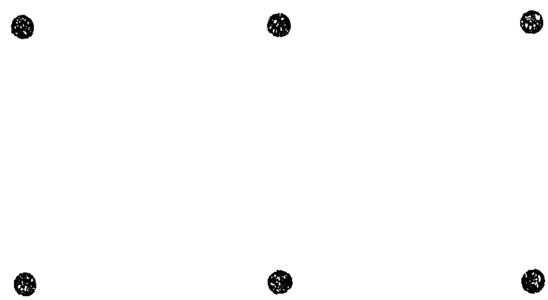
1



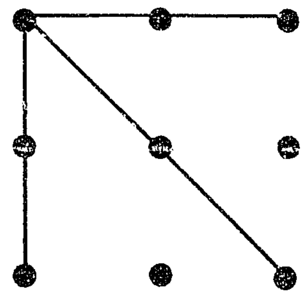
3



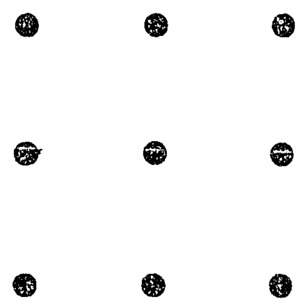
2



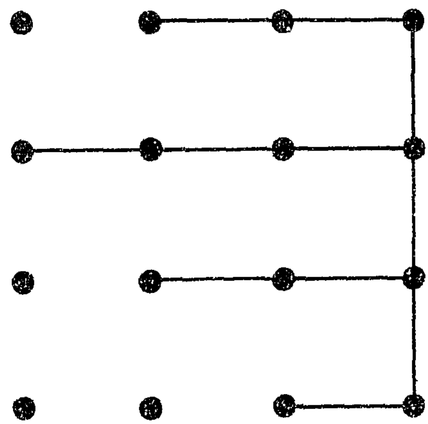
4



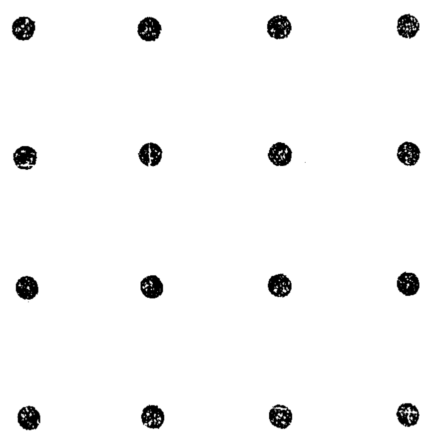
3



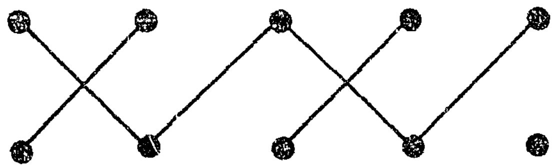
5



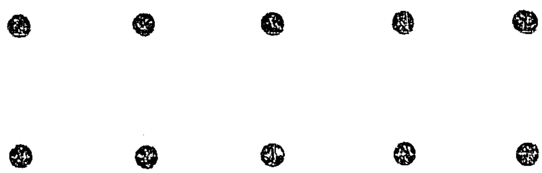
4

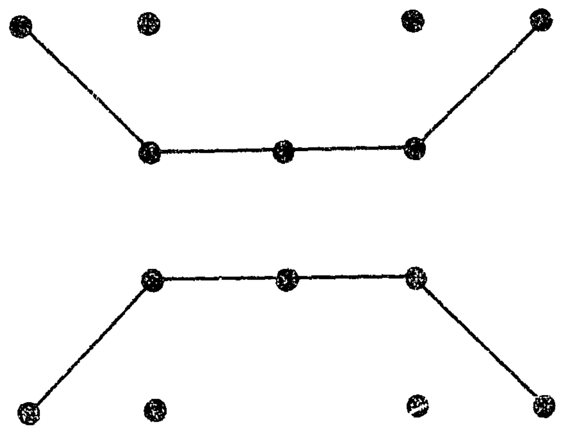


6

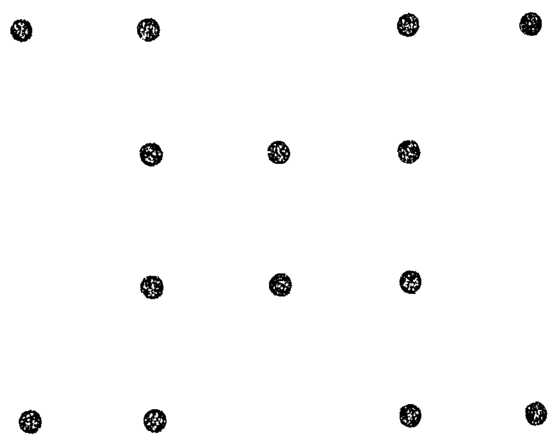


5

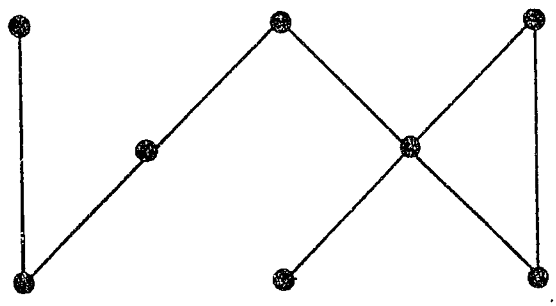




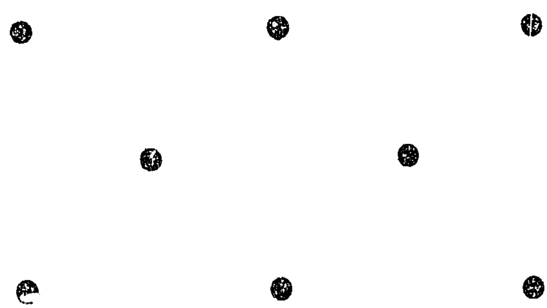
6



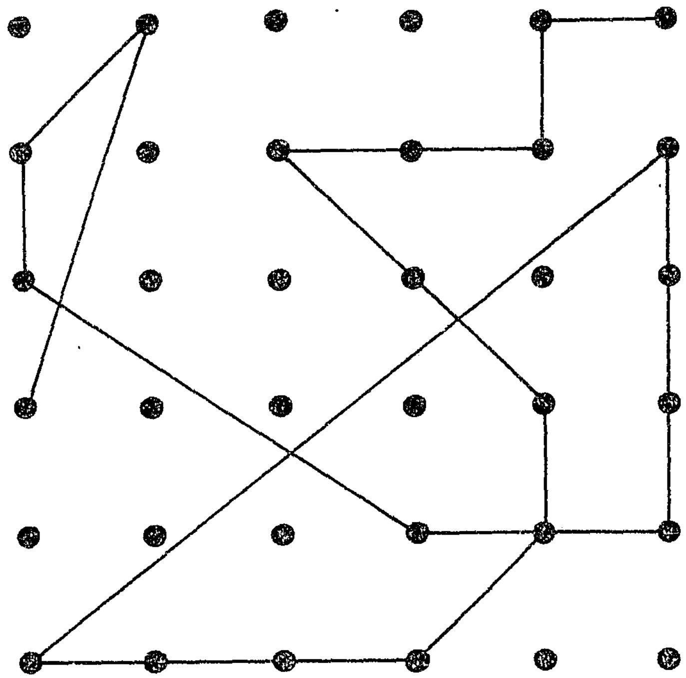
8



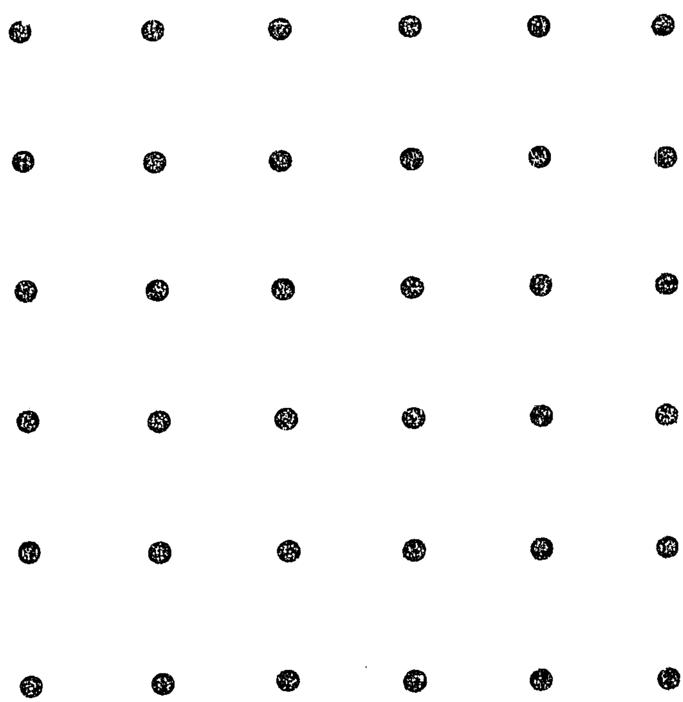
7

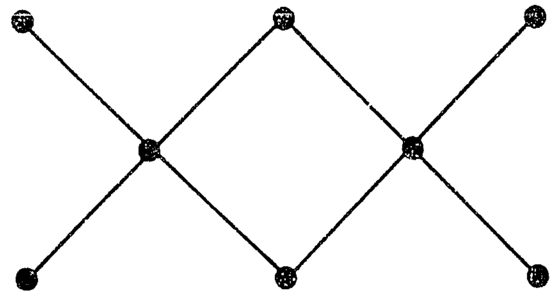


9

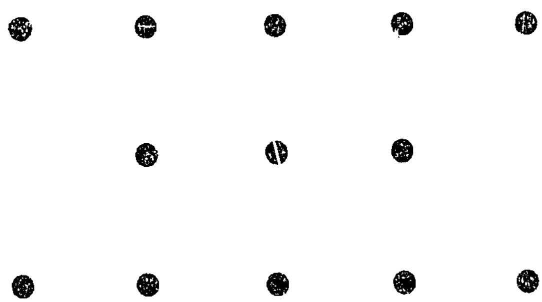


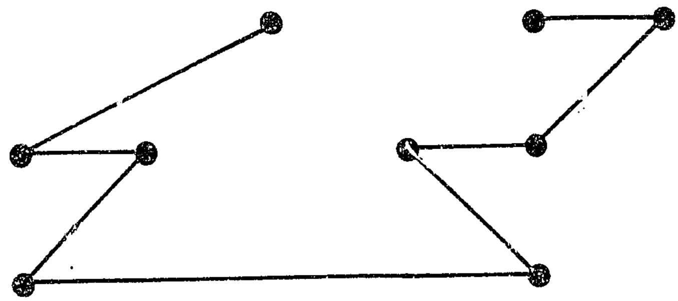
8



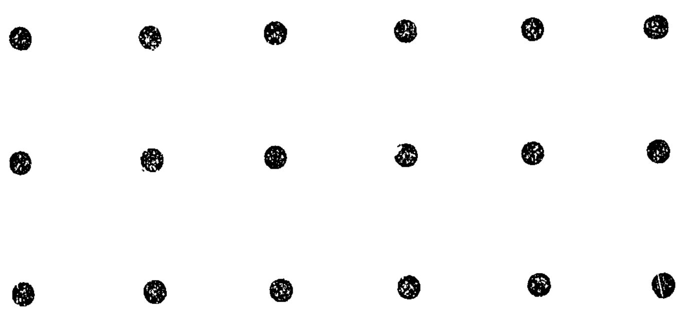


9

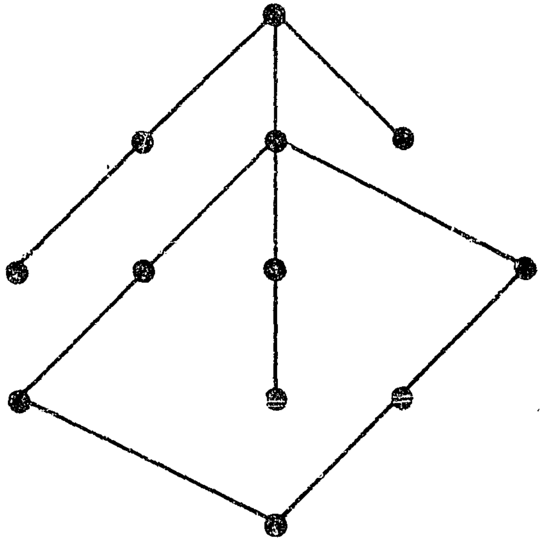




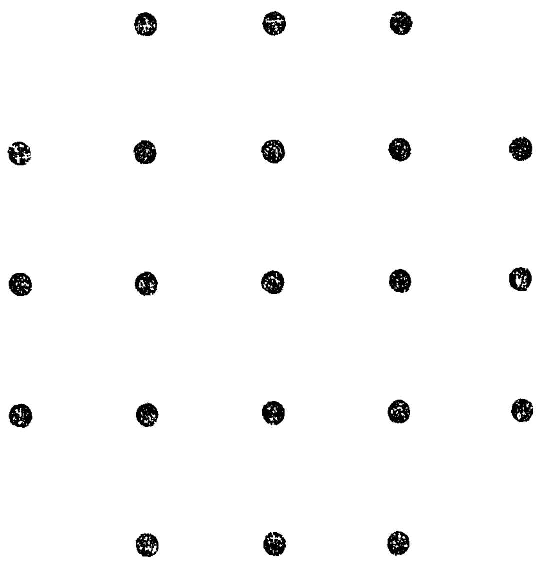
10



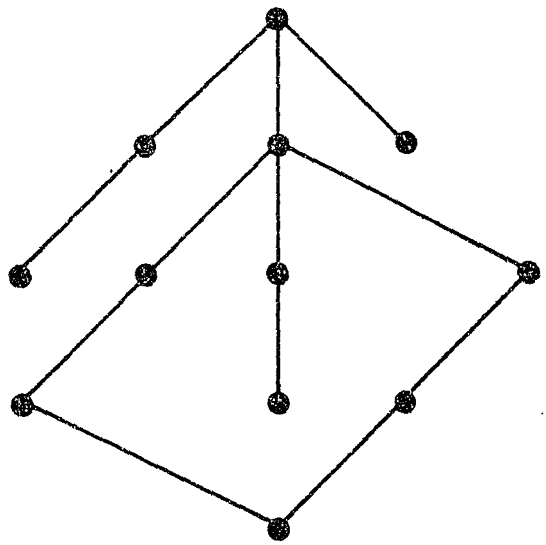
12



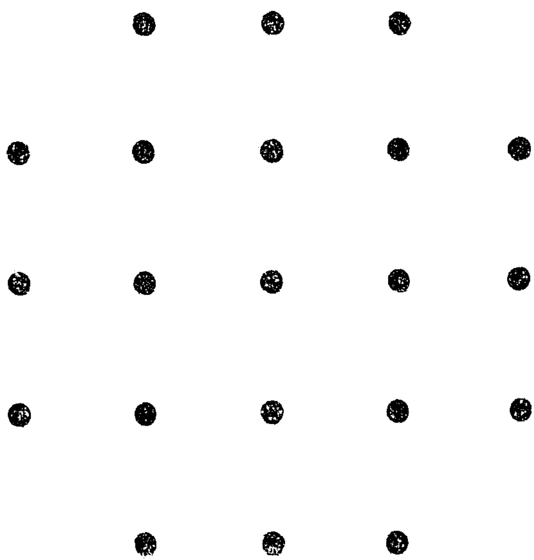
11

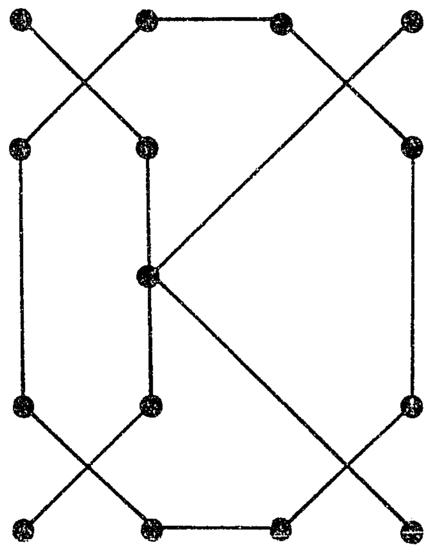


12

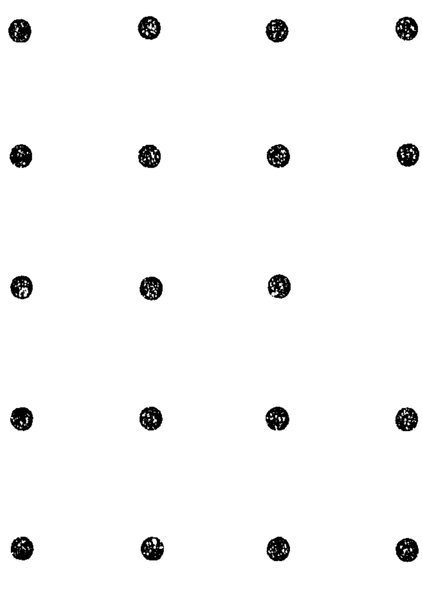


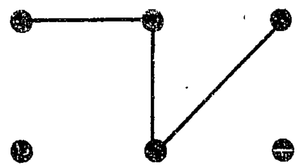
11



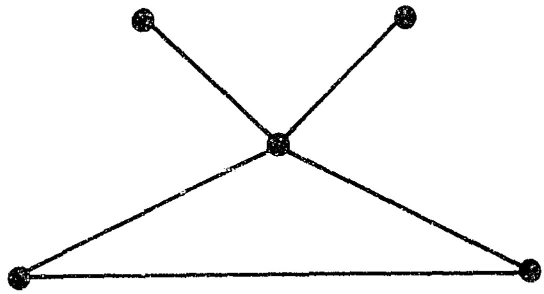


12

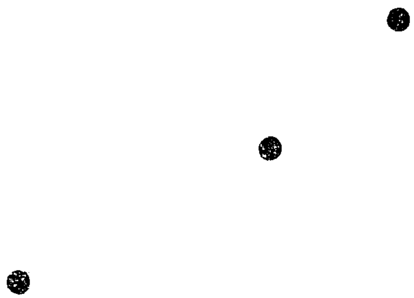




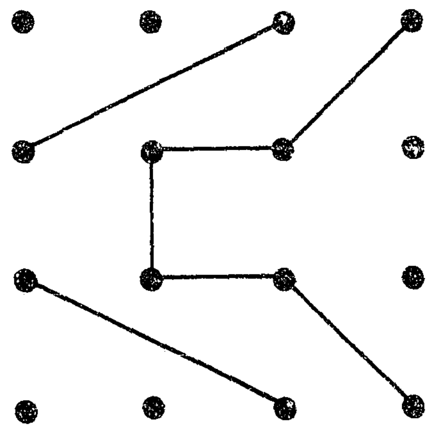
13



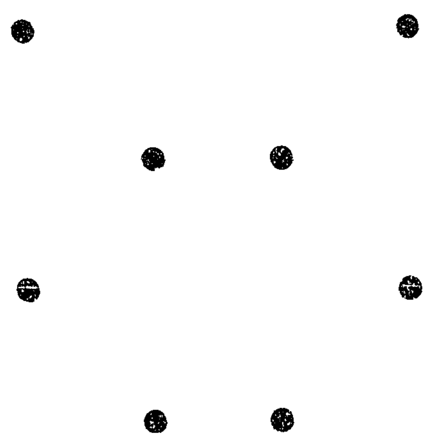
14

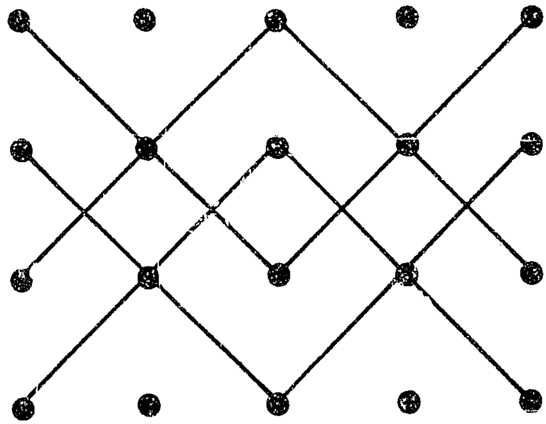


16

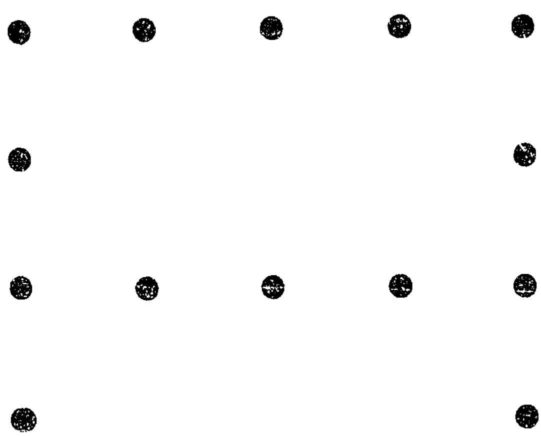


15





16



2.8. SPATIAL RELATIONS

Materials

Test Book, 2 Pencils (one for E and one for S), Digital Stop Watch, Foolscap Cardboard.

Description

S has to mark the figure that is exactly the same as the figure in the block on the left side of each row of figures.

Procedure

E sits to right of S. An A4 size piece of cardboard is placed under the first page and a small piece of cardboard over the second row of the demonstration item before the test booklet is placed in front of the subject. The test book is opened to page one - the demonstration page and the test book are placed in front of S close to the edge of the table. The cardboard between pages is to prevent proceeding designs from showing through.

Instructions are as follows:

"Look at the design in the left hand block here (point) there is one other like it in the row. I want you to put a mark on the design that is exactly the same as this design (point)." When S has made his mark, expose the lower row and say: ***"That is right, you mark the design that is the same as the one in the left box with a cross just the way this has been done."***

"Now we are going to do more like this and I am going to time you. When you have finished one row move on to the next. When you have finished the page, I will turn to the next one for you".

E turns to the next page, moving the cardboard. Once the page has been turned the stop watch is started and kept running until item 40 is completed. Time taken is recorded on the protocol sheet and on the test booklet.

If S is having difficulty concentrating on one line at a time, the cardboard with the window may be used, this covers all items except that under consideration. E moves the window from one row to the next as each row is completed.

S may be reminded at the beginning of each page that he is to mark the item that is the same as the one in the left hand block. Patients may have to be reminded of this more often.

If S chooses the wrong answer in the demonstration item explain the differences between the model and the answers, e.g. ***"The design in the box has a circle on the left at the top of the line and a square on the right side. This one*** (point to first of possible answers) ***has a circle at the bottom on the left, it is not the same"*** and so on.

Scoring

Correct answers are totalled and recorded, incorrect answers are totalled and recorded. **Note:** The number of incorrect responses is subtracted from the number of correct responses to provide the accuracy score. The time score is rounded off to the nearest second and recorded.

The Test

The test sheets follow. These sheets were made up in a booklet form for the purposes of testing.

PROTOCOL SHEET

SPATIAL RELATIONS

NAME: ______________________ DATE OF TEST :______________________

AGE : ______________________ DATE OF BIRTH:______________________

Item No.	Correct	Incorrect	Item No.	Correct	Incorrect
1			21		
2			22		
3			23		
4			24		
5			25		
6			26		
7			27		
8			28		
9			29		
10			30		
11			31		
12			32		
13			33		
14			34		
15			35		
16			36		
17			37		
18			38		
19			39		
20			40		

Accuracy Score: Total Correct: __________

Total Correct: __________ Time Secs: [ ]

TOTAL [ ]

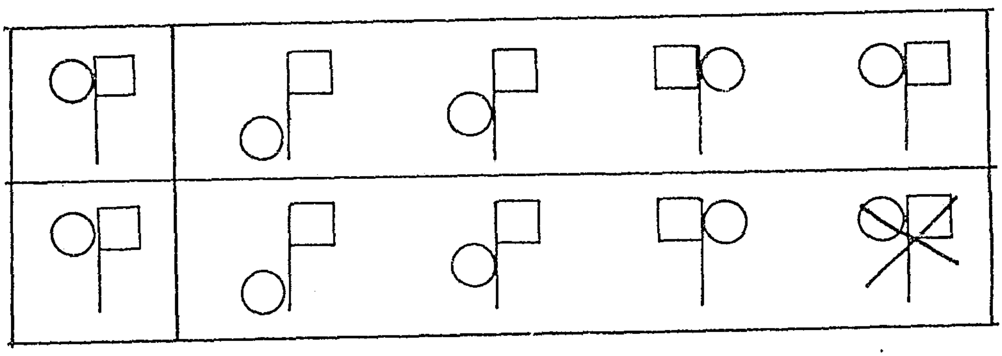
SPATIAL RELATIONS

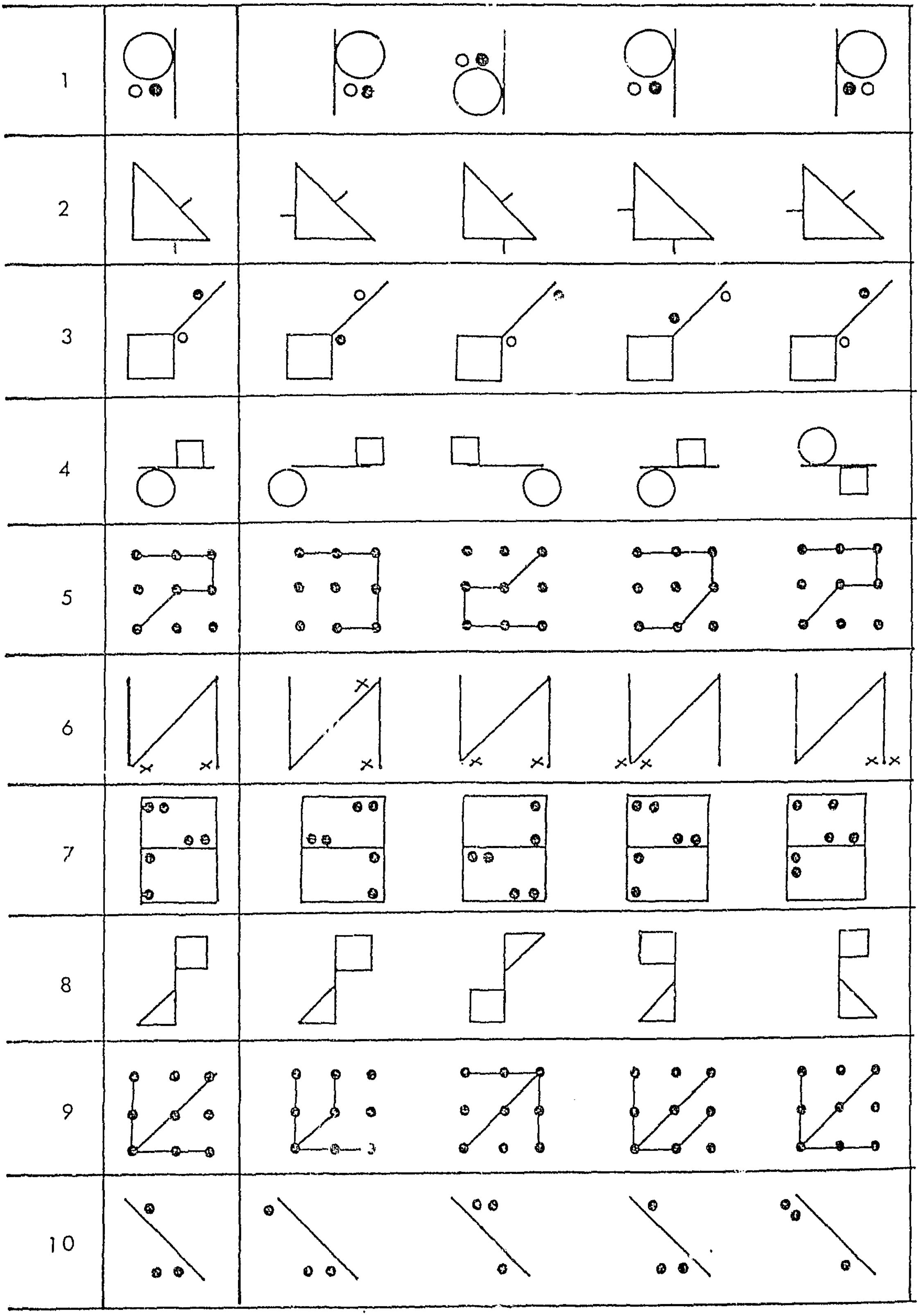
Name: ____________________ No. Correct: ____________________

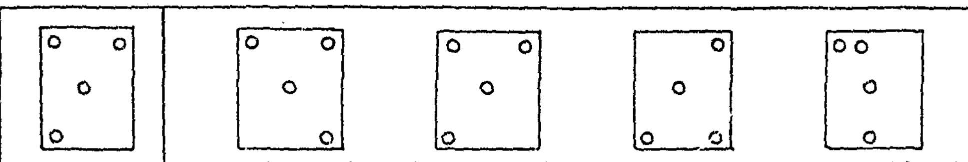
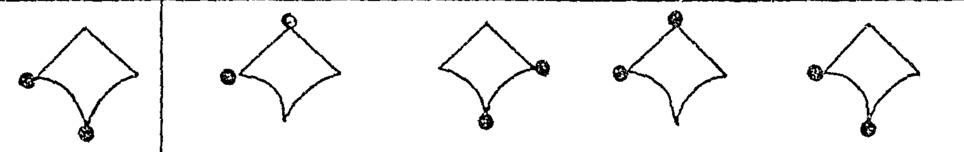
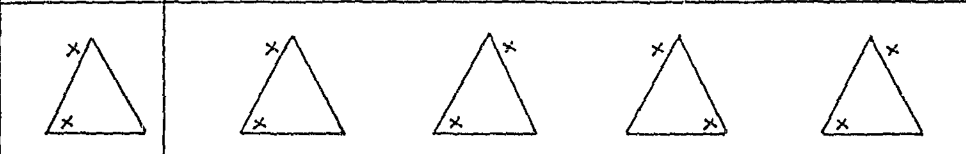
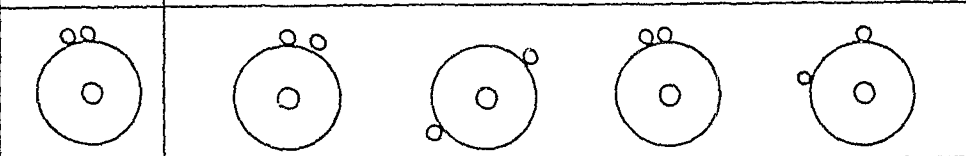
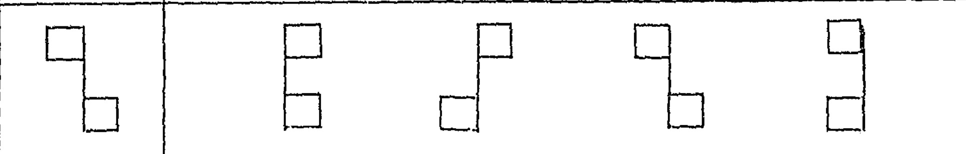
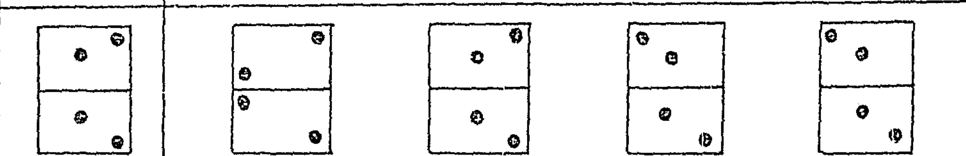
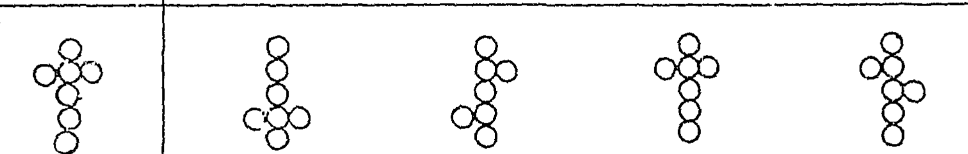
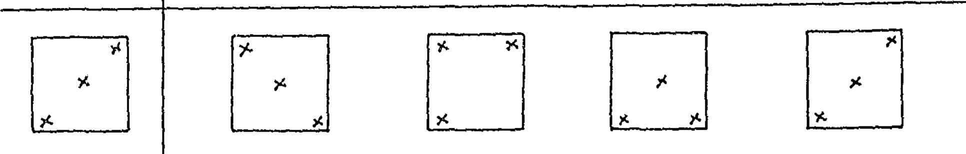
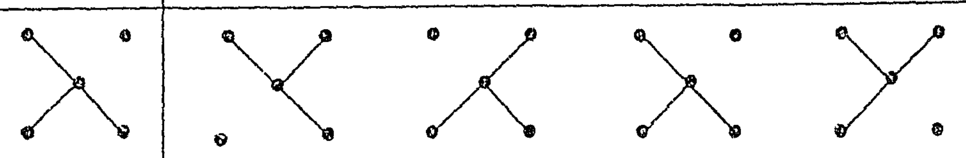
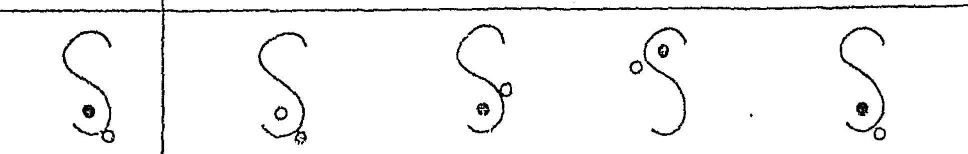
Date: ____________________ Time: ____________________

Age: ____________________

Demo




1
2
3
4
5
6
7
8
9
10

11	
12	
13	
14	
15	
16	
17	
18	
19	
20	

21	15867	15678	15867	87651	17865
22	13579	35179	13597	79513	13579
23	57 63 75	75 36 57	53 67 75	57 63 75	77 36 55
24	2 8 0 9 4	0 2 8 9 4	2 8 0 9 4	8 2 0 4 9	4 8 9 2 0
25	235689	986532	236589	235986	235689
26	97867	97678	97867	79867	76879
27	200 113 445	210 431 450	020 311 544	200 131 445	200 113 445
28	8 10 523	8 13 520	0 18 523	8 10 523	5 10 823
29	344690	344690	044693	346409	344960
30	1 0 9 8 2	0 1 9 8 2	8 2 9 0 1	1 0 9 2 8	1 0 9 8 2

31	damp	dapm	damp	pamd	admp
32	build	duilb	biuld	build	dluib
33	swallow	swalowl	sallwow	wasllow	swallow
34	pyghik	pigkih	pyghik	gikpyh	khygip
35	brought	brought	boughtr	btoughr	hroubgt
36	march	ramch	charm	march	camrh
37	fatqyup	patquyf	qyfpaut	fytpuaq	fatqyup
38	brush	bsurh	brush	shrub	hrusb
39	march	charm	mrach	march	chram
40	funnel	funelh	fenuln	lennuf	funnel

31	damp	dapm	damp	pamd	admp
32	build	duilb	biuld	build	dluib
33	swallow	swalowl	sallwow	wasllow	swallow
34	pyghik	pigkih	pyghik	gikpyh	khygip
35	brought	brought	boughtr	btoughr	hroubgt
36	march	ramch	charm	march	camrh
37	fatqyup	patquyf	qyfpaut	fytpuaq	fatqyup
38	brush	bsurh	brush	shrub	hrusb
39	march	charm	mrach	march	chram
40	funnel	funelh	fenuln	lennuf	funnel

2.9. POSITION IN SPACE TEST

Materials

Test Book, 2 Pencils, Digital Stop Watch, Protocol Sheet, Scoring Transparencies.

Description

S is required to identify all the figures in each row that are different from the figure in the left block.

Procedure

E sits to the right of S. The test booklet is opened on page one, the Demonstration page. An A4 size piece of cardboard is placed under the first page to prevent the designs on proceeding pages from showing through. There are two demonstration items, each one has two rows of figures. The second row demonstrates all the correct responses. A small strip of cardboard is placed over the second row of items of demonstration one as well as over demonstration two. When this has been done, the test book is placed in front of S, close to the edge of the table.

Instructions are as follows:-

"Look at the first figure in the row, the one in the left block here (indicate), ***there are other figures in the row that are the same although they have been rotated to a different position. There are also others that when you rotate them in your mind to the same position as this one, they are different - they are back to front and will look like this.*** (Draw a model of demonstration item one back to front above the item) ***I want you to rotate each item in your mind until it is brought to the same position as this one".*** Point to demo item in the block. ***"If it looks different reversed or back to front put a cross on it."***

When S has completed the row move the card to expose the second row of demonstration items which shows all the correct responses marked. With each design explain why S is right or wrong - use your own words. It is more important that S understands what he has to do than using exact words.

Then expose the first row of Demonstration Two saying:

"Now try this one" As S is working on Demonstration two say ***"Rotate the designs in your mind - don't flip them*** (demonstrate with hand) ***you are looking for those already flipped."*** When completed expose the second row and again explain why each item is right or wrong. When S understands what he has to do, say:-

"We are going to do some more like this. When you have finished one row move on to the next row. You have only four minutes for each page, so I will stop you when your time is up."

Turn to page 2 moving the cardboard under the page and starting the stop watch say: ***"Remember you must mark all the designs in the row that are different to the one in the left block."*** Stop S at the end of 4 minutes. If S has finished the page before 4 minutes have passed say ***"You still have more time, if you want to use it to check your answers."*** S is not forced to use the time if he does not want to. The stop watch is started anew for each page.

If S is having difficulty concentrating on one line at a time the windowed cardboard may be used. This covers all items except that under consideration. E moves the cardboard from row to row as S indicates that he has finished.

S is reminded at the beginning of each page that he is to mark all the items that are different from the one on the left. If he asks about the number of correct responses he is told that the number varies from item to item.

Scoring

A transparency on which the correct responses are marked is used to count the correct items for each row. Count the number of correct and incorrect items. **Note:** obtain the total by subtracting the number of incorrect from correct answers to get an accuracy score. There is no time score for this test.

The Test

The test sheets follow. For purposes of testing the tests were made up into booklet form.

PROTOCOL SHEET

POSITION IN SPACE

NAME: ______________________ DATE OF TEST :______________________

AGE : ______________________ DATE OF BIRTH:______________________

No.	No. correct	No. .correct	No. ..incorrect	TOTAL	No.	No. correct	No. correct	No. incorrect	TOTAL
1	2				21	2			
2	2				22	2			
3	2				23	2			
4	3				24	2			
5	3				25	2			
6	2				26	3			
7	3				27	3			
8	2				28	2			
9	3				29	2			
10	3				30	1			
11	3				31	2			
12	3				32	2			
13	2				33	1			
14	4				34	3			
15	4				35	2			
16	3				36	2			
17	4				37	3			
18	3				38	2			
19	3				39	2			
20	4				40	2			
			TOTAL					TOTAL	

Accuracy Score:______________________

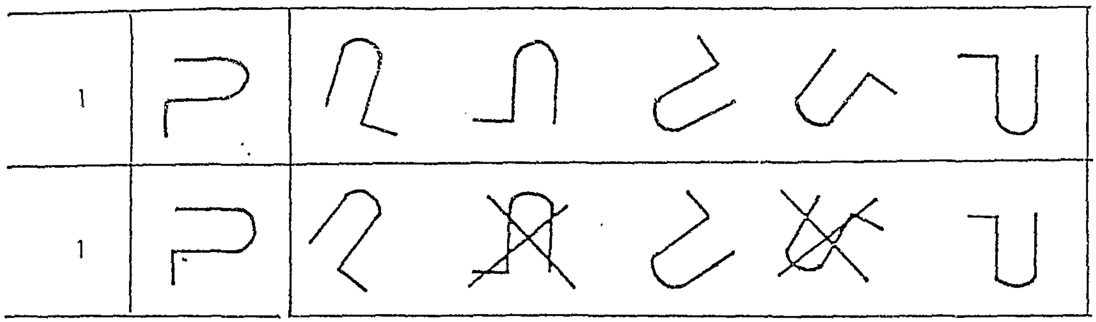
POSITION IN SPACE TEST

Name: ______________________________ No. Correct: ________________________

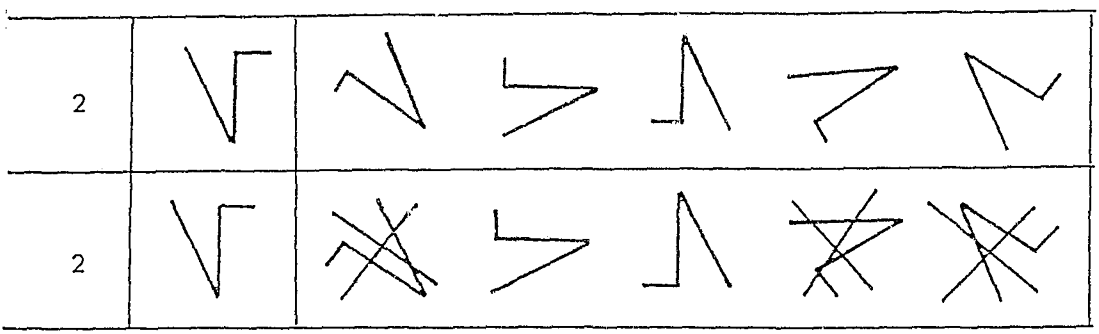
Date: ______________________________

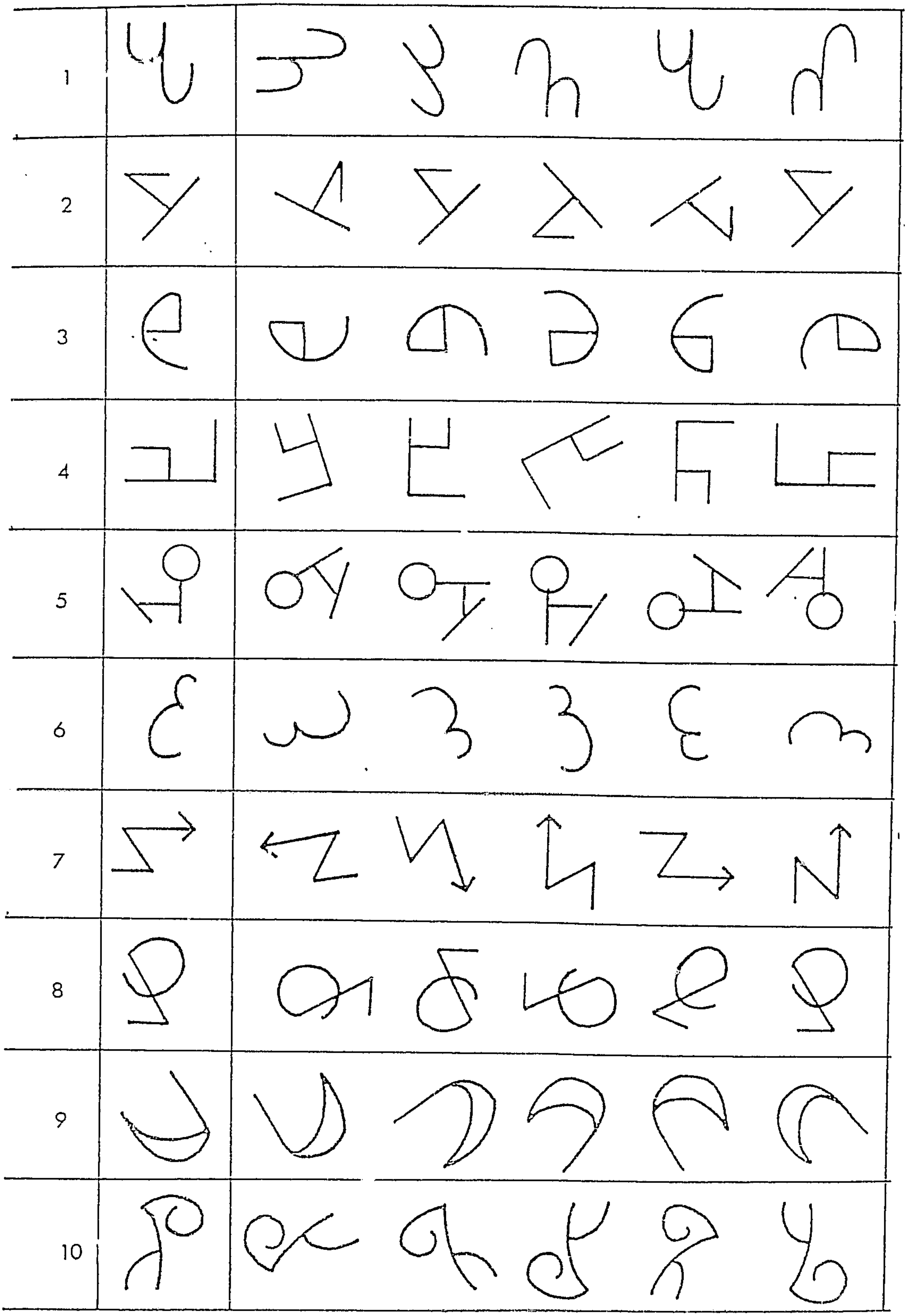
Age: ______________________________

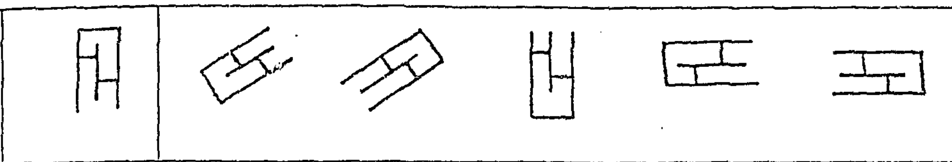
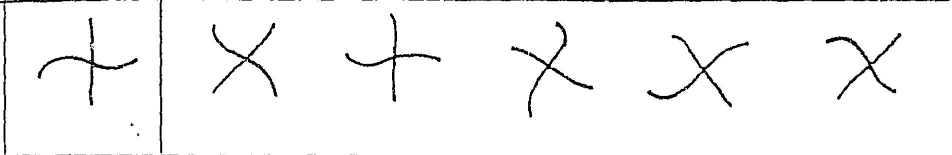
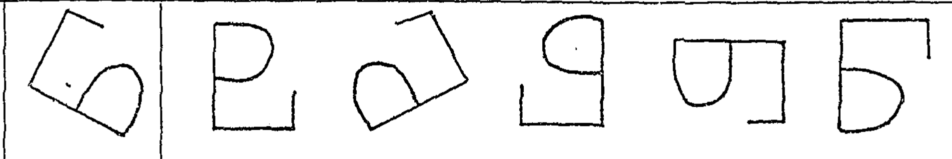
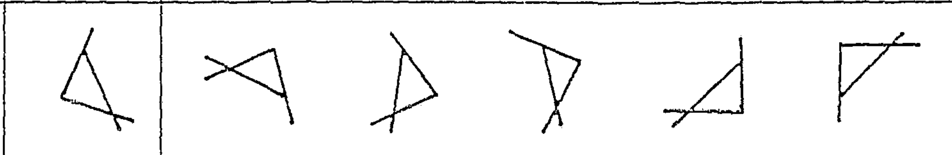
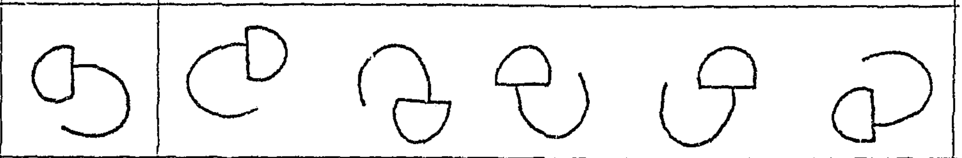
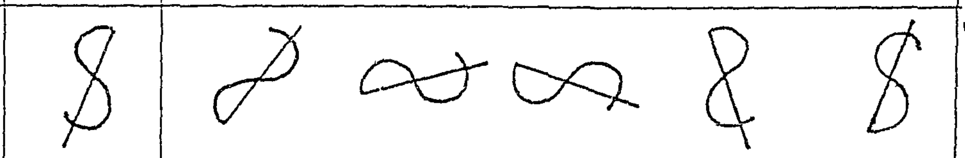
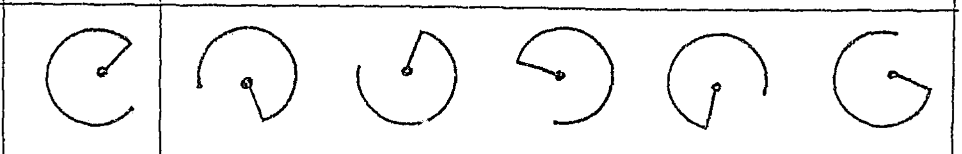
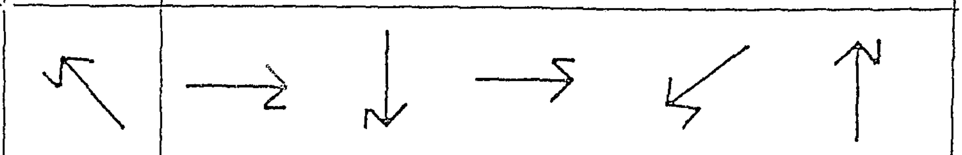
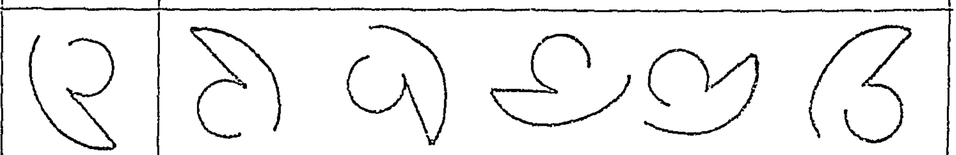
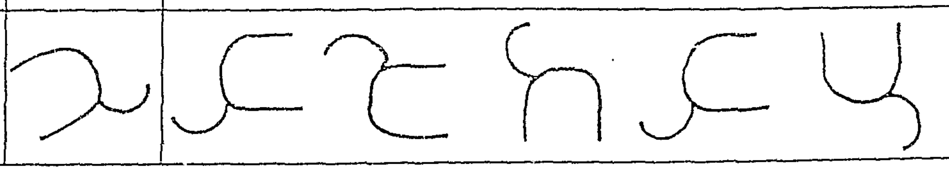
Demo 1

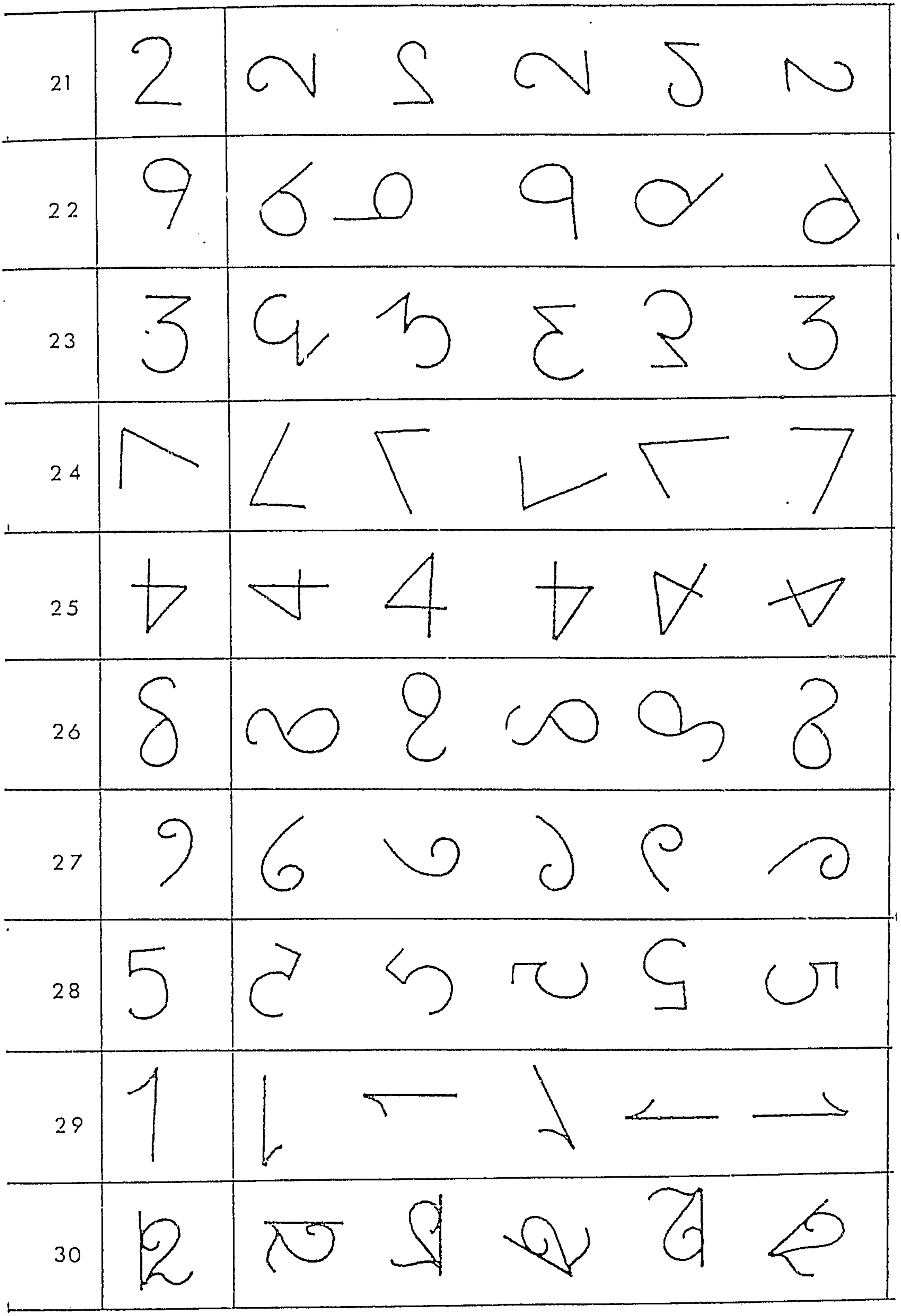


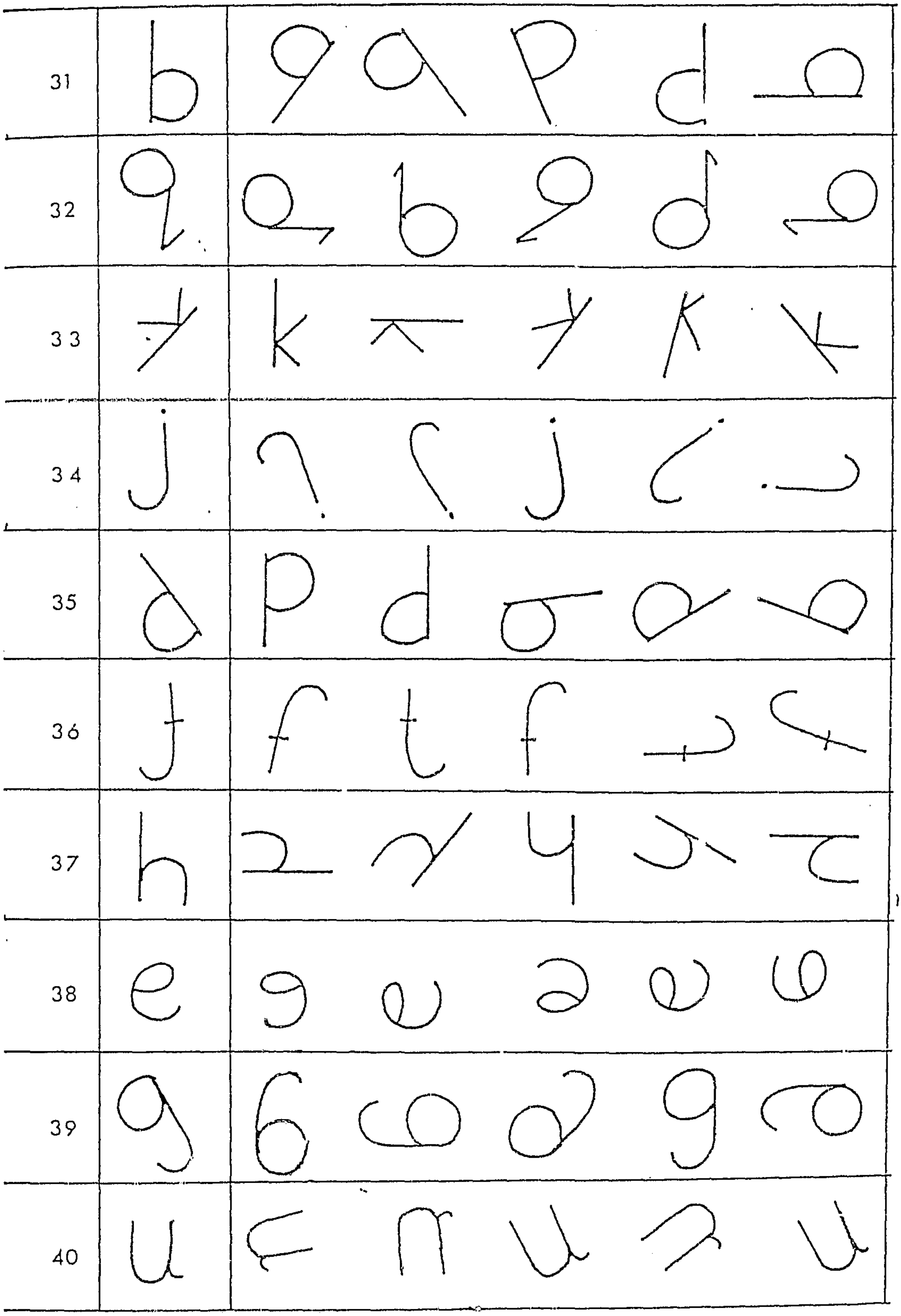
Demo 2




1
2
3
4
5
6
7
8
9
10

11	
12	
13	
14	
15	
16	
17	
18	
19	
20	


21
22
23
24
25
26
27
28
29
30


31
32
33
34
35
36
37
38
39
40

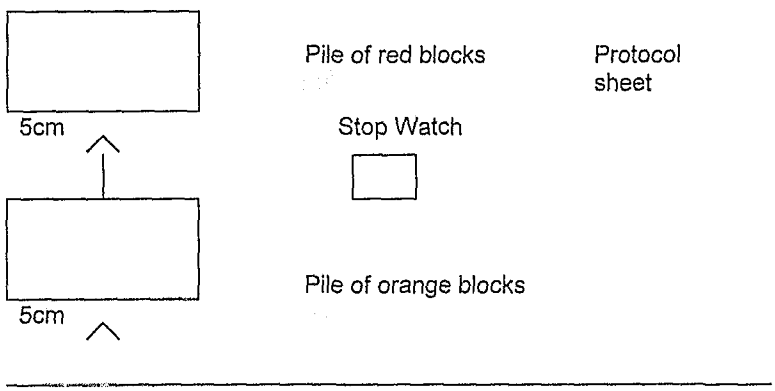
2.10. BLOCK , STICK, AND DESIGN CONSTRUCTION TESTS

Materials

Blocks (eight red, eight orange - 2 1/2 x 2 1/2 x 2 1/2 cm) key way sticks (16 blue - 7 1/2 cmx3mmx3mmx3mm), Test Cards, File to be used as a Screen, Protocol Sheet, Digital Stop Watch, Design Pieces, 2 White Felt Rectangles (21 1/2cm x 15cm). [The felt rectangles were made by covering 2 pieces of hardboard of the correct dimensions, with white felt.]

2.10.1. BlockConstruction I Test

Two felt rectangles are placed in front of S with enough room between them for the file cover to be held as a screen. The felt rectangles will be left in place for the Block Construction II, Stock Construction I and II and Design Construction Tests.



The red blocks are piled on the right side of the further-most rectangle and are for E to work with, the orange blocks are piled on the right hand side of the nearest rectangle and are for S to work with. E sits to the right of S. The block designs are constructed behind the screen as per protocol sheet. The screen is held in E's left hand while the block design is constructed on the further most felt rectangle with the right hand. The screen is removed and the stop watch started with right hand. The watch is stopped when S removes his hand from the construction indicating that he has completed his work. E then records any relevant information concerning the design, allocates a score of two, one or zero,9See record sheet for criteria), records time and zeros watch. Blocks from each construction are then returned to their respective piles.

Instructions are as follows:-

"I am going to build something with these blocks (point to red blocks***) behind this screen*** (place screen in front of S with left hand***). I want you to make an exact copy of my construction with these blocks here"*** (indicate orange blocks).

Build Demonstration One, remove screen once the construction has been completed. If S builds design correctly say ***"you must use the same number of blocks as well as building the same design."*** If S is incorrect point out his mistakes to him and get him to build the demonstration correctly. You may have to let S watch the construction being made. Once S understands what he is to do say: ***"We are going to do some more like this and I will time you for each"***

2.10.2. Block Construction II Test

Push the red blocks aside. ***"Now I am going to show you a card with a design of blocks on it. I want you to use your blocks to build the design that you see on the card."*** Place the pile of cards face down to the right of the distal rectangle. E turns the card over to lie on top of the felt rectangle and starts the stop watch at the same time. There is no trial item. Record information, score and time on protocol sheet. When the test is completed remove the cards to the right side of E. Pack the blocks away.

2.10.3. Stick Construction I Test

"Now we are going to do the same thing with the sticks. First I will build a design behind the screen which you are to copy and then I will place cards with a design of sticks for you to copy exactly using your sticks." Divide sticks up equally between E pile at right side of distal felt rectangle] and S [pile at right side of proximal rectangle. Place screen and build design as per the designs depicted on the protocol sheet. As screen is removed start stop watch. Stop the stop watch when S removes hands from his construction thus indicating that he has finished. Record information.

2.10.4. Stick II Construction II Test

E's sticks are removed and the pile of test cards put to the right of the distal rectangle. ***"Now you are to copy the design that you see on the card with your sticks. Make your design on this felt here (indicate)."*** There is no trial item. At the end of the test the sticks are packed away.

2.10.5. Design Construction Test

Coloured shapes are placed to the right of the proximal felt piece for the subject to use in his construction. The test card with the design is placed on the distal felt piece, face up.

"I am now going to give you cards with designs on and pieces for you to make the same design. The card is the same size as the felt, you must place your pieces on the felt in exactly the same way as they are placed on the card." Turn over card and start the watch. Record as previously.

Scoring

All items are scored 2, 1, or 0 according to the criteria listed on the protocol sheet. The score is totalled to give an accuracy score for each section of the test. Time is totalled and brought to the nearest second for each section of the test.

2.10.6. The Tests

The test items are shown on the protocol sheets.

each section of the test. Time is totalled and brought to the nearest second for each section of the test.

2.10.6. The Tests

The test items are shown on the protocol sheets.

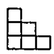
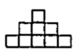
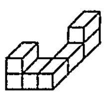
PROTOCOL SHEET

SCORING FOR BLOCK CONSTRUCTION, STICK CONSTRUCTION AND DESIGN CONSTRUCTION TESTS

NAME: ______________________ DATE OF TEST :______________________

AGE : ______________________ DATE OF BIRTH:______________________

BLOCK CONSTRUCTION I TEST (FROM MODEL)

	OBSERVATION	TIME	SCORE	P/F	SCORE
1. Tower of 6 			1. Correct construction 2. Correct number of blocks 3. Construction squared to edge of felt piece		
2. Bridge 			1. Correct construction 2. Construction squared to edge of felt piece 3. Correct number		
3. Gate 			1. Diagonal correctly placed 2. Upper blocks correctly placed 3. Construction no more than 10° rotated, i.e. slight rotation		
4. Steps 			1. Correct number of blocks 2. No more than 10° rotation 3. Correct placement		
5. Wall 			1. Correct number of blocks 2. Correct spacing 3. No more than 10° rotation		
6. L shape 			1. Front row horizontal no rotation 2. Correct number of blocks 3. Both upper blocks placed correctly		
	TOTAL			TOTAL	
				TIME	

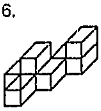
Score 2 if all 3 aspects correct

Score 1 if only 2 aspects correct

Score 0 if no aspects correct

Score 0 if reversed

BLOCKS CONSTRUCTION II TEST (FROM CARD)

	OBSERVATION	TIME	SCORE	Correct/ Incorrect	SCORE
1. 			1. Correct number of blocks		
			2. Construction horizontal - no more than 10° rotation		
2. 			1. Correct number of blocks		
			2. Construction horizontal - no more than 10° rotation		
3. 			1. Construction horizontal with edge of pad (no more than 10° rotation)		
			2. Correct placement of blocks		
			3. Correct number of blocks		
4. 			1. Front line of blocks horizontal, backline vertical		
			2. Correct placement		
			3. Correct number		
5. 			1. Horizontal		
			2. Correct number		
			3. Correct placement		
6. 			1. Horizontal		
			2. Correct number		
			3. Correct placement		
	TOTAL			TOTAL	

Score 1 if construction correct in every aspect except for rotation

Score 0 if number and or placement wrong

Score 2 if correct

Score 0 if reversed

STICK CONSTRUCTION I (FROM MODEL)

	OBSERVATION	TIME	SCORE	lCorrecr/ Incorrect	SCORE
1. 			1. Four clearly defined sides 2. Angles 90° 3. Correct orientation		
2. 			1. Three clearly defined sides 2. No rotation of horizontal		
3. 			1. Vertical component distinctly vertical 2. Open side square at $\pm 45°$ rotation 3. Right figure has sides at right angles to each other		
4. 			1. Two clear vertical - no rotation 2. Two clear horizontal- no rotation		
5. 			1. Horizontal stick must be close to the horizontal 2. Must fit on to felt rectangle 3. Right diagonal between 90° and 100° 4. Base of left diagonal level with horizontal		
6. 			1. Bottom of open ended square must be horizontal 2. Diagonal half way between 0° and 90°		
	TOTAL			TOTAL	

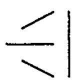
In all designs, sticks must touch or be very close (score 1 if they do not)

Score 2 if nothing wrong, 1 if one item incorrect

0 if more than 1 item incorrect

Reversals score 0

STICK CONSTRUCTION II (FROM CARD)

	OBSERVATION	TIME	SCORE	P/F	SCORE
1. 			1. Design must fit on to felt rectangle 2. Horizontal must be level with bottom of felt 3. Base of right diagonal must be level with horizontal 4. Sticks must touch		
2. 			1. All diagonals must be parallel 2. Vertical must be vertica 3. + point to bottom corner of open ended square 4. Sticks must touch		
3. 			1. Horizontal must be placed half out of open triangle 2. Vertical must be parallel with side of felt rectangle 3. Sticks must not touch		
4. 			1. Horizontals level with bottom of felt triangle 2. Bottom horizontal right end must protrude to right beyond upper horizontal 3. Sticks must touch		
5. 			1. Horizontal level with bottom edge 2. Bottom ends of sticks must be level with ends of horizontal 3. Diagonals must NOT touch horizontal		
6. 			1. Verticals must touch diagonals $\pm 1/6$ from end of stick 2. Point of roof $\pm$ over centre of horizontal 3 Straight sides and bottom 4. Sticks must touch		
	TOTAL			TOTAL	

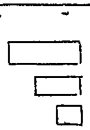
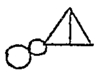
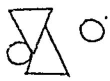
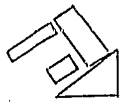
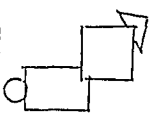
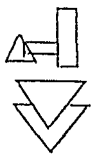
Score 2 if all correct

Score 1 if 1 incorrect

Score 0 if more than 1 incorrect

Reversals score 0

DESIGN CONSTRUCTION

	OBSERVATION	TIME	SCORE	P/F	SCORE
1. 			1. Right edges of all pieces in vertical alignment 2. Correct spacing 3. No rotations of pieces		
2. 			1. Pieces touch 2. Triangles places correctly (if trial and error for placement and then placed correct score 1) 3. Correct sequence of circles		
3 			1. Tips of triangles must overlap 2. Base of triangles horizontal 3. Blue circle touches triangles 4. Yellow circle separate		
4. 			1. Side of triangle must be horizontal 2. Correct alignment of rectangles i.e. diagonal placement 3. Triangle and rectangles must touch 4. Square correctly and must not touch		
5. 			1. Side of triangle must be parallel with edge of square 2. All overlapping and underlappings correct 3. Square must be squared to edge of felt		
6. 			1. Base of small triangle must be level with base of rectangle 2. Base of large triangles must be parallel to above 3. Right tips of triangles must be ± parallel with outer edge of rectangle		
	TOTAL			TOTAL	

Score 2 if all correct

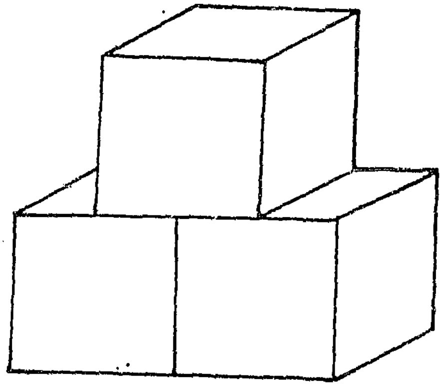
Score 1 if 1 incorrect

Score 0 if more than 1 incorrect

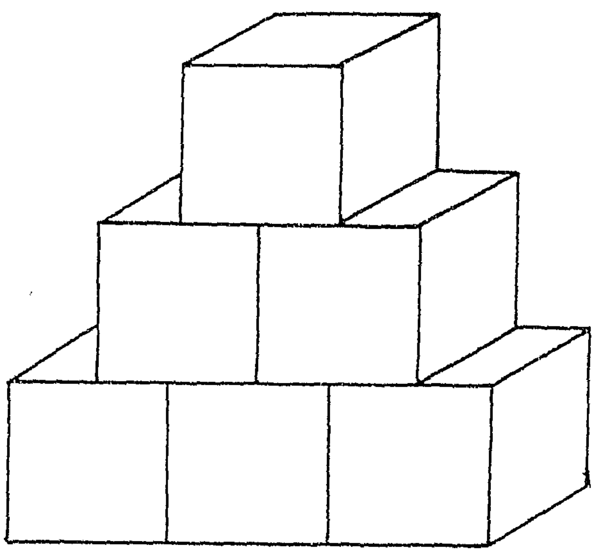
Score 0 if reversed

1

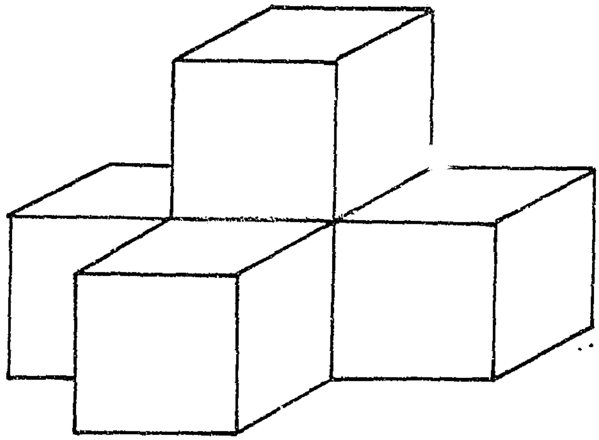
BLOCK DESIGN FROM CARD



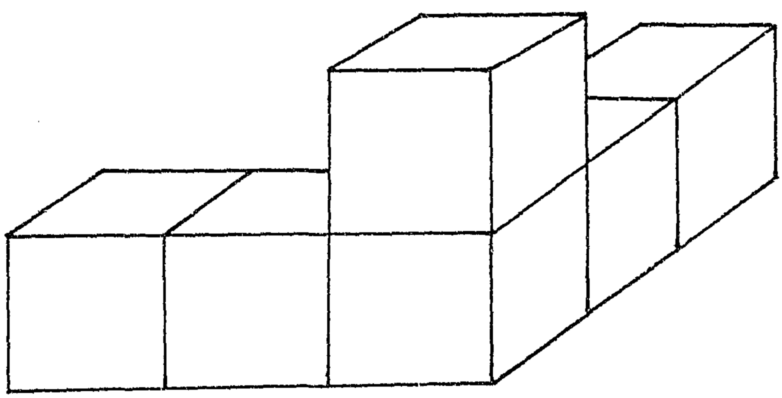
2



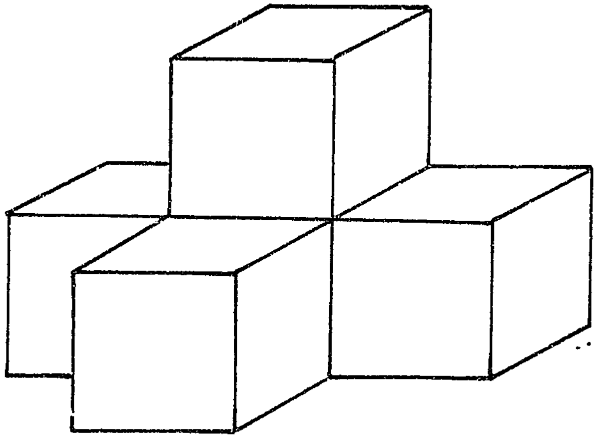
3



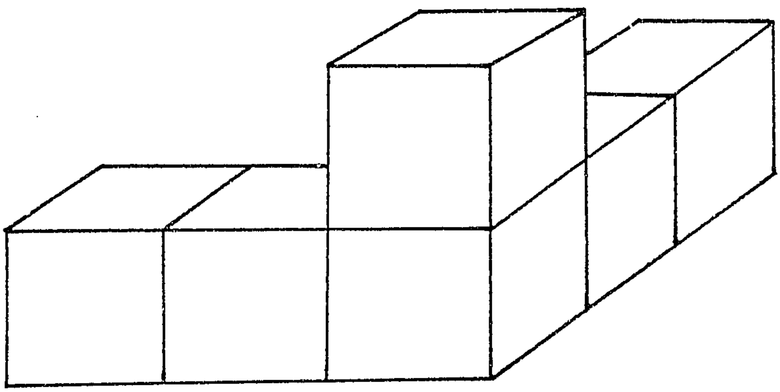
4

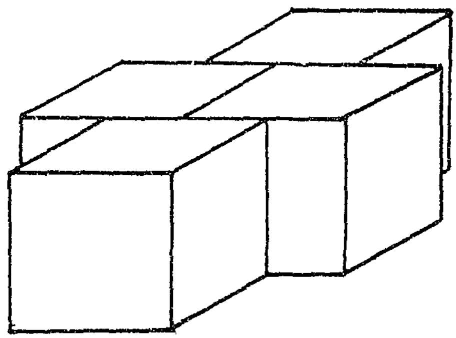


3

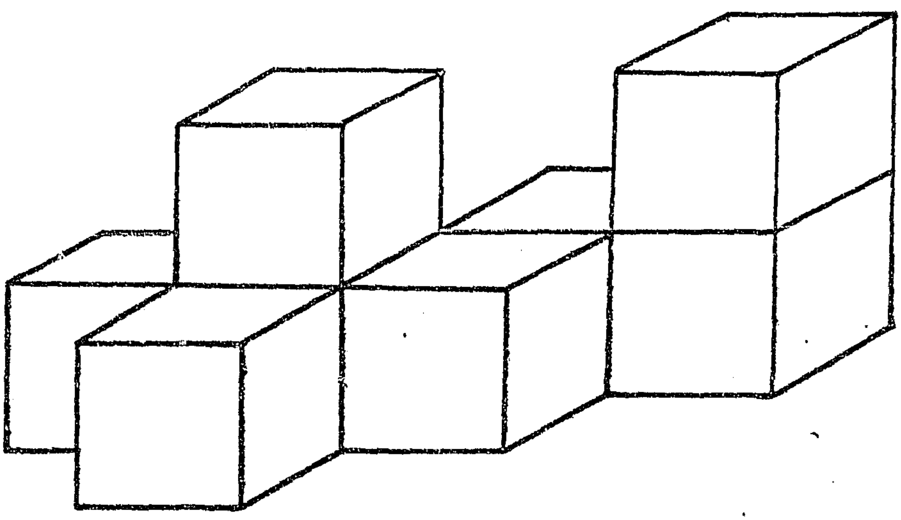


4



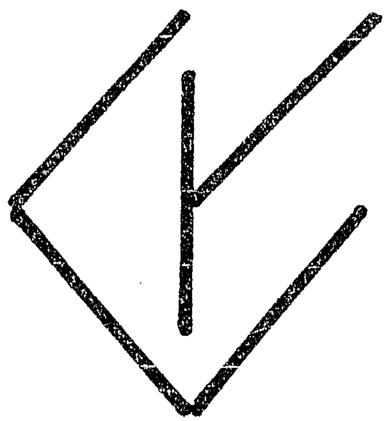


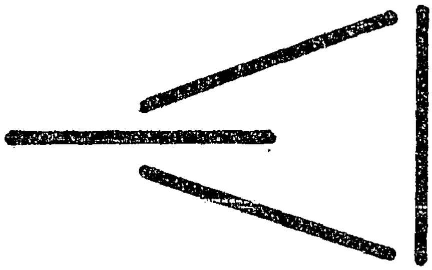
6



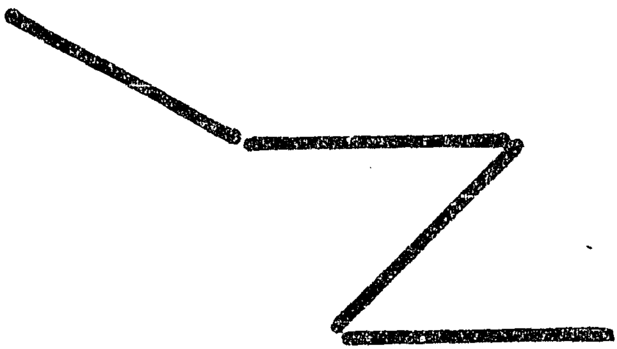
STICK DESIGN FROM CARD

8

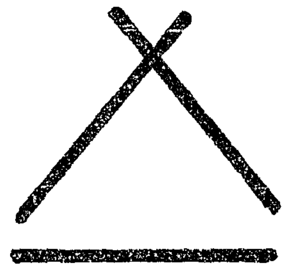




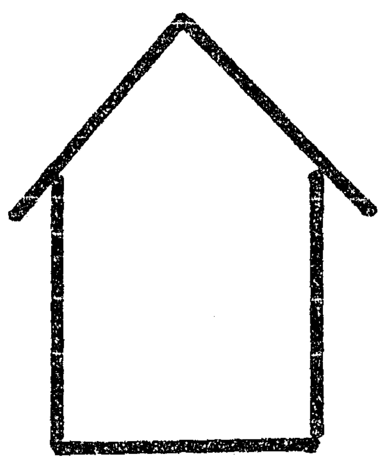
10



11



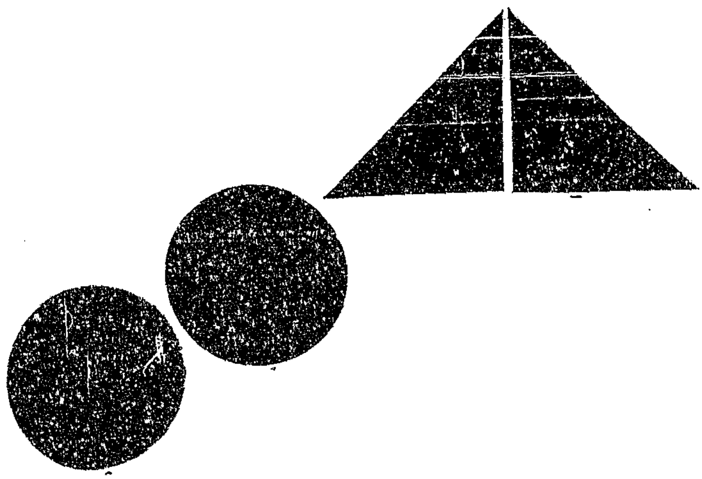
12



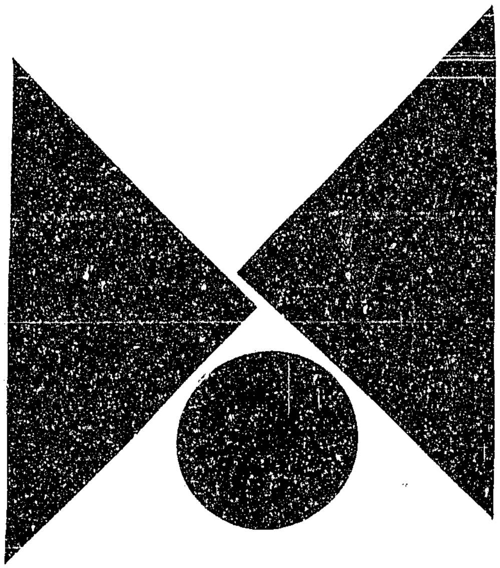
DESIGN COPYING TEST

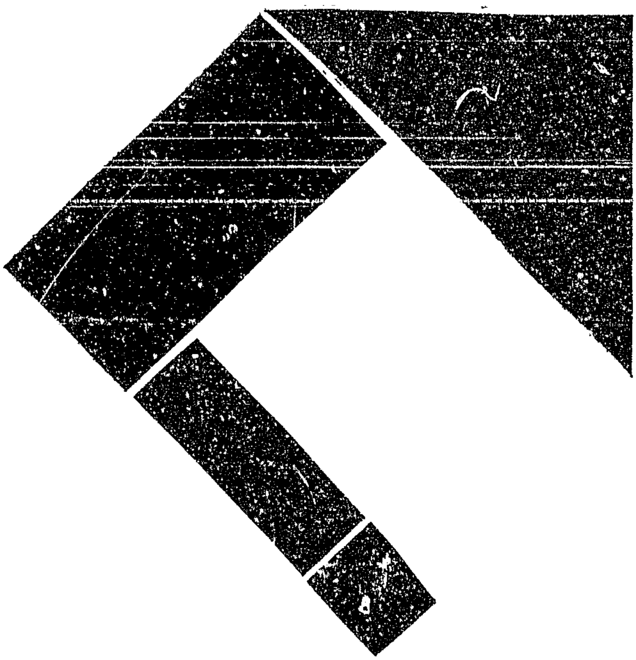
13

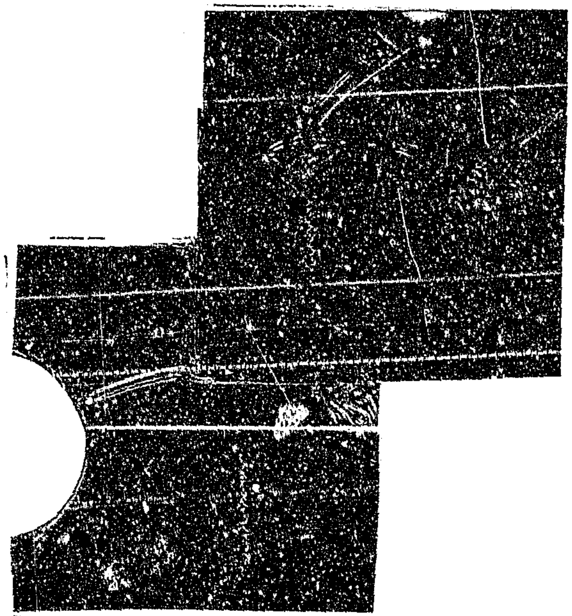
14

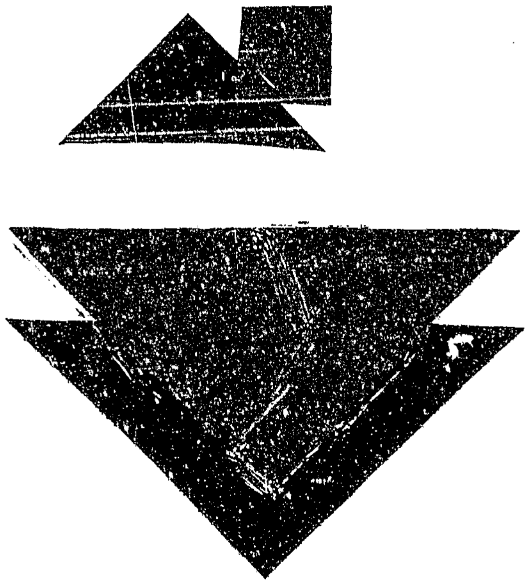


15









2.11. COLOUR MATCHING TEST

Materials

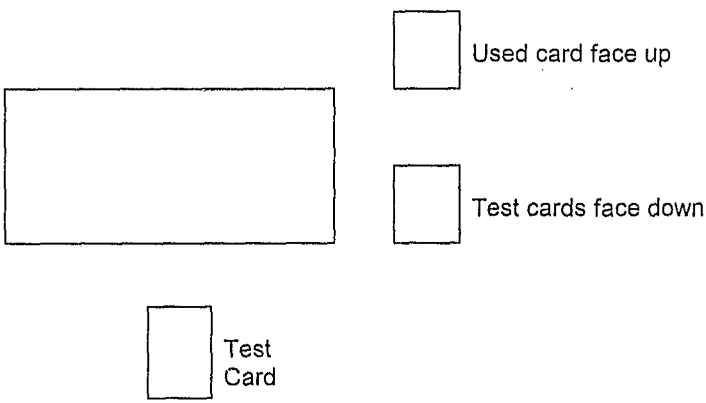
Multiple Choice Sheet, Individual Test Cards, Protocol Sheets, Digital Stop Watch, 1 pencil (for Examiner).

Description

S is required to match the colour on the test card with its exact duplicate on the multiple choice sheet. The time taken to make the correct choice is recorded.

Procedure

The multiple choice sheet of 16 colours is placed ± 16 cm from the edge of the table directly in front of S and stuck down with press stick. The individual test cards are placed face down with No.1 uppermost ± 4 cm from the lower right corner of the multiple choice sheet.



The test cards are placed one by one on the table between S and the multiple choice sheet. As each card is used, it is removed and placed face up on a pile at the upper right hand corner of the multiple choice sheet. This is to ensure that they are in the correct order for use on the next occasion. The stop watch is started with E's right hand as the test card is placed on the table with E's left hand. It is stopped as S indicates choice by pointing to the matching colour on the test sheet. The number of the test choice and the time in seconds (including fractions of second) is recorded on the record sheet.

Instructions are as follows:-

"Now we are going to match colours. I will show you one of these cards (point) ***with a colour on it. You must point to its exact duplicate on this sheet*** (indicate the multiple choice sheet). ***Do not point to a colour until you are sure that you have the correct one as the first one that you touch is the one that will be counted as your choice. I am going to time you to see how long it takes but again accuracy is more important than speed."***

There is no trial item in this test.

If S picks up the card ask him to leave the card in place and tell him that he only needs to point to its duplicate, leave watch running as this occurs.

If S calls out the number of his choice on the multiple choice sheet, remind him that he must point to his choice and touch it. The first time he does this, time it until he calls the number, however, if he continues to call the number keep on reminding him that he must touch his choice and keep the watch going until he does so.

Scoring

The number of correct responses made and the time is totalled. When the time has been added, the total is brought to the nearest whole second i.e. the decimal points are dropped. A score of 5,58 seconds is taken to 6, a score of 4,48 is taken to 5, whereas a score of 4,43 is left as 4.

PROTOCOL SHEET

COLOUR

NAME: ____________________ DATE OF TEST :____________________

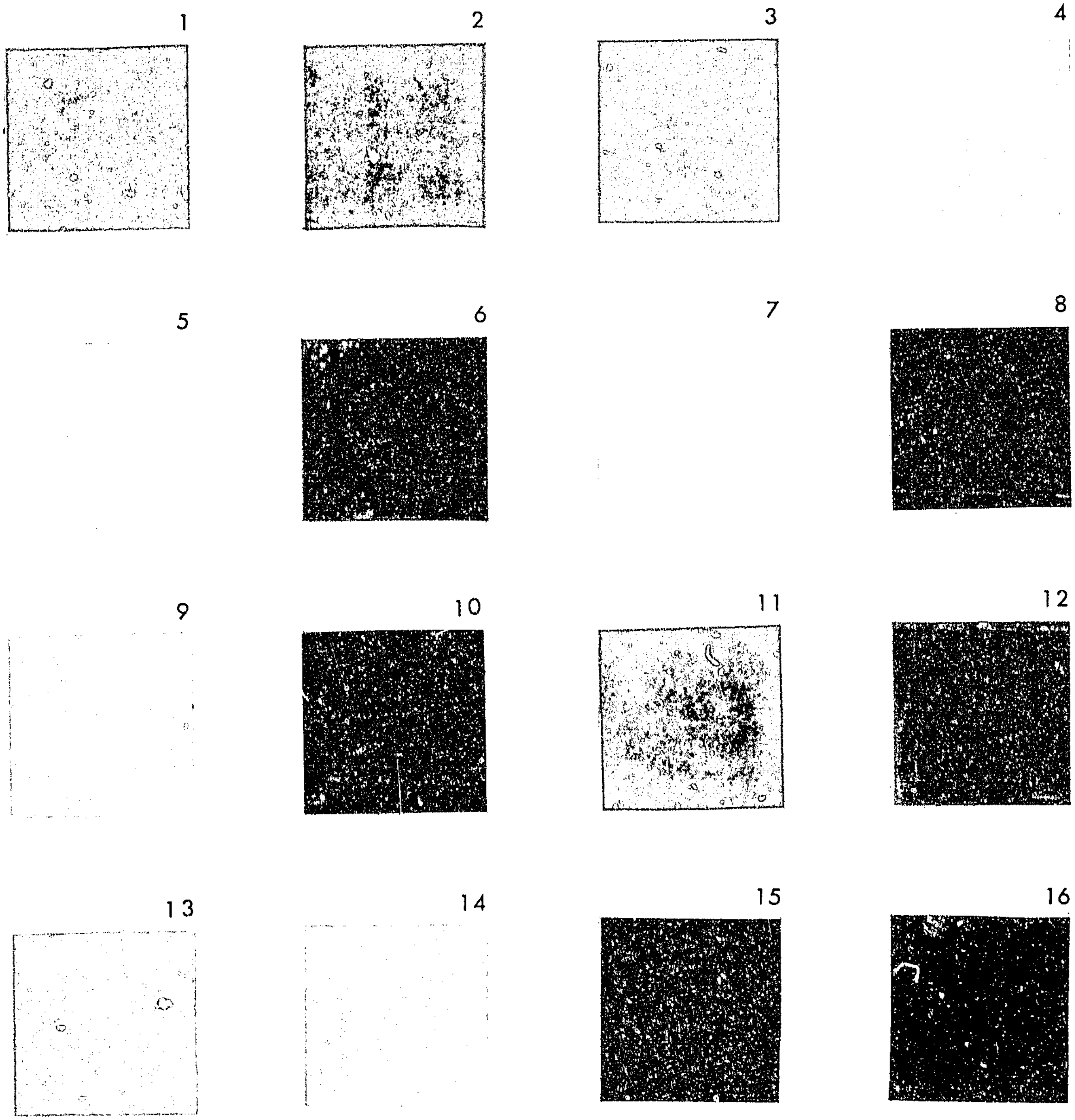
AGE : ____________________ DATE OF BIRTH:____________________

ITEM NO.	CORRECT ANSWER	SUBJECT'S ANSWER	TIME
1	14		
2	4		
3	3		
4	10		
5	6		
6	11		
7	16		
8	5		
9	7		
10	2		
11	9		
12	15		
13	12		
14	13		
15	8		
16	1		
	TOTALS		

Accuracy Score :____________________

Time (secs) : ____________________

COLOUR MATCHING TEST



APPENDIX 2

PERCENTILE TABLES

APPENDIX 2.1. PERCENTILE TABLES FOR THE FORM MATCHING TEST

Note : No accuracy percentiles were calculated as only 2 scores were obtained by the normal group i.e. eleven and twelve.

n = 118
$\bar{x}$ = 11,96
SD = 0,2

TABLE I 20-39 year olds - Form Time

n = 41
$\bar{x}$ = 17,20
SD = 4,13

SECS	%	SECS	%	SECS	%	SECS	%
11	7,3	15	39,0	19	70,7	23	92,7
12	12,2	16	51,2	20	82,9	24	95,1
13	22,0	17	53,7	21	85,4	25	97,6
14	29,3	18	58,5	22	87,8	26	100,0

TABLE II 40-59 year olds - Form Time

n = 38
$\bar{x}$ = 21,58
SD = 5,44

SECS	%	SECS	%	SECS	%	SECS	%
12	2,6	18	28,8	23	65,8	29	94,7
14	10,5	19	35,3	24	68,4	30	97,4
15	15,8	20	47,4	25	73,7	35	100,0
16	21,1	21	55,3	27	81,5		
17	23,7	22	63,2	28	89,5		

TABLE III **60-69 year olds - Form Time**

n = 19

$\bar{x}$ = 28,11

SD = 9,27

SECS	%	SECS	%	SECS	%	SECS	%
16	5,3	22	31,6	27	57,9	34	78,9
19	15,8	23	36,8	29	63,2	35	89,5
20	21,1	25	42,1	30	68,4	38	94,7
21	26,3	26	52,6	33	73,7	56	100,0

TABLE IV **70-79 years old - Form Time**

n = 20

$\bar{x}$ = 31,20

SD = 7,55

TIME	%	TIME	%	TIME	%	TIME	%
19	10,0	28	30,0	32	65,0	44	90,0
23	15,0	29	40,0	33	70,0	45	95,0
24	20,0	30	50,0	34	80,0	46	100,0
26	25,0	31	55,0	36	85,0		

APPENDIX 2.2. PERCENTILE TABLES FOR THE TEST OF VISUAL - MOTOR INTEGRATION (VMI)

TABLE I **20-39 years - VMI Accuracy**

n = 40

$\bar{x}$ = 20,52

SD = 2,61

RAW SCORE	%	RAW SCORE	%	RAW SCORE	%
11	2,5	19	22,5	23	95,0
14	5,0	20	42,5	24	100,0
15	7,5	21	57,5		
18	12,5	22	82,5		

TABLE II <u>40-59 years VMI Accuracy</u>

n = 38

$\bar{x}$ = 20,79

SD = 2,18

RAW SCORE	%	RAW SCORE	%	RAW SCORE	%
16	2,6	19	23,7	22	78,9
17	7,9	20	42,1	23	86,8
18	21,1	21	57,9	24	100,0

TABLE III <u>60-69 years VMI Accuracy</u>

n = 19

$\bar{x}$ = 18,36

SD = 3,11

RAW SCORE	%	RAW SCORE	%	RAW SCORE	%
11	5,3	17	36,8	20	63,2
14	15,8	18	52,6	21	84,2
16	21,1	19	57,9	2[illegible]	100,0

TABLE IV <u>70-79 years VMI Accuracy</u>

n = 19

$\bar{x}$ = 16,94

SD = 2,79

RAW SCORE	%	RAW SCORE	%	RAW SCORE	%
12	5,3	16	47,4	21	94,7
13	10,5	17	57,9	22	100,0
14	21,1	18	68,4		
15	31,6	19	84,2		

TABLE V **<u>20-39 years VMI Time</u>**

n = 40

$\bar{x}$ = 467,17

SD = 275,77

SECS	%	SECS	%	SECS	%	SECS	%
106	2,5	328	32,5	408	60,0	637	85,0
198	5,0	329	35,0	450	62,5	646	87,5
250	7,5	343	37,5	485	65,0	780	90,0
260	10,1	346	40,0	505	67,5	798	92,5
261	12,5	372	42,5	508	70,0	865	95,0
267	17,5	373	45,0	517	72,5	1177	97,5
280	20,0	378	47,5	518	75,0	1616	100,0
294	22,5	383	50,0	527	77,5		
297	25,0	385	55,0	530	80,0		
314	30,0	388	57,5	602	82,5		

TABLE VI **<u>40-59 years VMI Time</u>**

n = 38

$\bar{x}$ = 606,05

SD = 311,17

SECS	%	SECS	%	SECS	%	SECS	%
214	2,6	384	28,9	548	55,3	768	84,2
295	5,3	390	31,6	577	60,5	1019	86,8
328	7,9	391	34,2	589	63,2	1053	89,5
335	10,5	406	36,8	618	65,8	1152	92,1
336	13,2	423	39,5	663	68,4	1272	94,7
347	15,8	439	42,1	711	71,1	1305	97,4
358	18,4	452	44,7	718	73,7	1508	100,0
364	21,1	468	47,4	723	76,3		
367	23,7	536	50,0	729	78,9		
383	6,3	544	52,6	740	81,6		

TABLE VII **60-69 years VMI Time**

n = 19

$\bar{x}$ = 551,95

SD = 256,53

SECS	%	SECS	%	SECS	%	SECS	%
113	5,3	409	31,6	563	63,2	1002	94,7
230	10,5	411	42,1	633	68,4	1091	100,0
355	15,8	436	47,4	661	73,7		
363	21,1	525	52,6	695	78,9		
372	26,3	527	57,9	810	84,2		

TABLE VIII **70-79 years VMI Time**

n = 19

$\bar{x}$ = 786,79

SD = 431,28

SECS	%	SECS	%	SECS	%	SECS	%
364	5,3	489	31,6	658	57,9	1273	84,2
411	10,5	503	36,8	738	63,2	1285	89,5
417	15,8	527	42,1	742	68,4	1451	94,7
448	21,1	572	47,4	1016	73,7	1918	100,0
463	26,3	608	52,6	1066	78,9		

APPENDIX 2.3. PERCENTILE TABLES FOR THE PART-WHOLE TEST (P-W)

TABLE I **20-39 years - PW Accuracy**

n = 41

$\bar{x}$ = 10,22

SD = 1,54

RAW SCORE	%	RAW SCORE	%
7	2,4	10	48,8
8	19,5	11	73,2
9	34,1	12	100,0

TABLE II **40-59 years - PW Accuracy**

n = 38

$\bar{x}$ = 9,71

SD = 1,96

RAW SCORE	%	RAW SCORE	%
3	2,6	9	36,8
5	5,3	10	65,8
7	10,5	11	81,6
8	16,4	12	100,0

TABLE III **60-69 years - PW Accuracy**

n = 18

$\bar{x}$ = 8,22

SD = 2,18

RAW SCORE	%	RAW SCORE	%
4	11,1	9	72,2
6	16,7	11	77,8
7	33,3	11	100,0
8	55,6		

TABLE IV **70-79 years - PW Accuracy**

n = 20

$\bar{x}$ = 8,15

SD = 2,58

RAW SCORE	%	RAW SCORE	%	RAW SCORE	%	RAW SCORE	%
3	5,0	6	25,0	9	60,0	12	100,0
4	10,0	7	40,0	10	80,0		
5	20,0	8	50,0	11	95,0		

TABLE V **20-39 years - PW Time**

n = 41

$\bar{x}$ = 170,59

SD = 51,0

SECS	%	SECS	%	SECS	%	SECS	%
96	2,4	134	31,7	168	56,1	215	85,4
99	7,3	137	34,1	176	58,5	216	87,8
103	9,3	141	36,6	186	61,0	225	90,2
119	12,2	152	39,0	191	65,9	257	92,7
120	17,1	155	41,5	194	73,2	286	95,1
125	19,5	157	46,3	198	75,6	289	97,6
127	22,0	158	48,8	201	78,0	290	100,0
128	24,4	161	51,2	203	80,5		
132	26,8	162	53,7	204	82,9		

TABLE VI **40-59 years - PW Time**

n = 38

$\bar{x}$ = 16,58

SD = 67,42

SECS	%	SECS	%	SECS	%	SECS	%
132	2,6	169	26,3	210	55,3	278	81,6
133	5,3	176	28,9	213	60,5	280	84,2
134	7,9	177	34,2	214	63,2	293	86,8
150	10,5	180	36,8	16	65,8	297	89,5
152	13,2	182	39,5	220	68,4	304	92,1
157	15,8	185	42,1	222	71,1	307	94,7
164	18,4	193	44,7	232	73,7	349	97,4
165	21,1	202	50,0	252	76,3	457	100,0
168	23,7	206	52,6	269	78,9		

TABLE VII **60-69 years - PW Time**

n = 18

$\bar{x}$ = 253,0

SD = 117,75

SECS	%	SECS	%	SECS	%	SECS	%
149	5,6	171	33,3	250	61,1	328	88,9
154	11,1	183	38,9	258	66,7	433	94,4
155	16,7	197	44,4	286	72,2	607	100,0
159	22,2	204	50,0	294	77,8		
160	27,8	245	55,6	321	83,3		

TABLE VIII **70-79 years - PW Time**

n = 20

$\bar{x}$ = 327,45

SD = 122,64

SECS	%	SECS	%	SECS	%	SECS	%
169	5,0	243	30,0	305	55,0	460	80,0
173	10,0	249	35,0	318	60,0	471	85,0
197	15,0	252	40,0	323	65,0	486	90,0
220	20,0	272	45,0	349	70,0	522	95,0
237	25,0	303	50,0	414	75,0	587	100,0

APPENDIX 2.4. PERCENTILE TABLES FOR THE PERCEPTUAL CONSTANCY TEST (PC)

TABLE I <u>20-39 years - PC Accuracy</u>

n = 41

$\bar{x}$ = 59,96

SD = 3,50

RAW SCORE	%	RAW SCORE	%	RAW SCORE	%
51	2,4	58	26,8	64	92,7
52	4,8	59	36,6	65	95,1
54	7,3	60	51,2	66	100,0
55	12,2	61	68,3		
56	14,6	62	75,6		
57	24,4	63	85,4		

TABLE II <u>40-59 years - PC Accuracy</u>

n = 38

$\bar{x}$ = 58,47

SD = 3,99

RAW SCORE	%	RAW SCORE	%	RAW SCORE	%	RAW SCORE	%
47	2,6	54	13,2	58	47,4	62	84,2
50	5,3	55	18,4	59	57,9	63	92,1
51	7,9	56	23,7	60	68,4	64	100,0
53	10,5	57	36,8	61	71,1		

TABLE III <u>60-69 years - PC Accuracy</u>

n = 19

$\bar{x}$ = 55,94

SD = 5,91

RAW SCORE	%	RAW SCORE	%	RAW SCORE	%	RAW SCORE	%
38	5,3	53	21,1	57	52,6	60	84,2
48	10,5	54	26,3	58	63,2	62	94,7
50	15,3	55	42,1	59	78,9	64	100,0

TABLE IV <u>70-79 years - PC Accuracy</u>

n = 20

$\bar{x}$ = 54,30

SD = 5,62

RAW SCORE	%	RAW SCORE	%	RAW SCORE	%	RAW SCORE	%
42	5,0	52	40,0	57	70,0	63	95,0
47	10,0	53	50,0	58	80,0	64	100,0
50	30,0	54	55,0	60	85,0		
51	35,0	56	65,0	62	90,0		

TABLE V <u>20-39 years - PC Time</u>

n = 41

$\bar{x}$ = 271,93

SD = 65,97

SECS	%	SECS	%	SECS	%	SECS	%
142	2,4	235	26,8	263	56,1	332	82,9
176	4,8	240	29,3	264	58,5	343	85,4
191	7,3	243	36,6	267	63,4	349	87,8
197	12,2	244	41,5	279	65,9	362	90,2
217	14,6	246	43,9	280	70,7	377	92,7
220	17,1	247	46,3	282	73,2	396	95,1
227	19,5	251	48,3	300	75,6	405	97,6
229	22,0	258	51,2	326	78,0	462	100,0
233	24,4	261	53,7	331	80,5		

TABLE VI 40-59 years - PC Time

n = 38

$\bar{x}$ = 318,21

SD = 75,67

SECS	%	SECS	%	SECS	%	SECS	%
196	2,6	51	26,3	325	50,0	378	78,9
207	5,3	257	28,9	326	55,3	389	84,2
229	7,9	258	31,5	327	57,9	390	86,3
231	10,5	261	34,2	346	60,5	395	89,5
233	13,2	263	36,3	348	63,2	427	92,1
237	15,8	273	39,5	355	65,8	439	94,7
239	18,4	288	42,1	357	68,4	478	97,4
242	21,1	290	44,7	358	71,1	484	100,0
245	23,7	317	47,4	360	73,7		

TABLE VII 60-69 years - PC Time

n = 19

$\bar{x}$ = 388,79

SD = 108,85

SECS	%	SECS	%	SECS	%	SECS	%
199	5,3	316	31,5	399	57,9	519	84,2
240	10,5	320	36,8	400	63,2	526	89,5
264	15,8	332	42,1	410	68,4	542	94,7
299	21,1	347	47,4	493	73,7	560	100,0
315	26,3	392	52,6	505	78,9		

TABLE VIII 70-79 years - PC Time

n = 20

$\bar{x}$ = 532, 45

SD = 208,25

SECS	%	SECS	%	SECS	%	SECS	%
274	5,0	407	30,0	493	55,0	588	80,0
296	10,0	417	35,0	544	60,0	665	85,0
298	15,0	441	40,0	554	65,0	837	90,0
383	20,0	465	45,0	575	70,0	848	95,0
392	25,0	474	50,0	583	75,0	1115	100,0

APPENDIX 2.5. PERCENTILE TABLES FOR THE FIGURE-GROUND TEST (F-G)

TABLE I 20-39 years - F-G Accuracy

n = 41

$\bar{x}$ = 78,88

SD = 1,44

RAW SCORE	%	RAW SCORE	%
74	4,9	79	58,5
77	9,8	80	100,0
78	29,3		

TABLE II 40-59 years - F-G Accuracy

n = 38

$\bar{x}$ = 77,84

SD = 3,47

RAW SCORE	%	RAW SCORE	%	RAW SCORE	%	RAW SCORE	%
63	2,6	73	7,9	77	23,7	79	71,1
67	5,3	76	18,4	78	36,8	80	100,0

TABLE III 60-69 years - F-G Accuracy

n = 19

$\bar{x}$ = 76,74

SD = 3,74

RAW SCORE	%	RAW SCORE	%	RAW SCORE	%	RAW SCORE	%
64	5,3	74	15,8	76	42,1	79	84,2
73	10,5	75	21,1	77	52,6	80	100,0

APPENDIX 2.5. PERCENTILE TABLES FOR THE FIGURE-GROUND TEST (F-G)

TABLE I 20-39 years - F-G Accuracy

n = 41

$\bar{x}$ = 78,88

SD = 1,44

RAW SCORE	%	RAW SCORE	%
74	4,9	79	58,5
77	9,8	80	100,0
78	29,3		

TABLE II 40-59 years - F-G Accuracy

n = 38

$\bar{x}$ = 77,84

SD = 3,47

RAW SCORE	%	RAW SCORE	%	RAW SCORE	%	RAW SCORE	%
63	2,6	73	7,9	77	23,7	79	71,1
67	5,3	76	18,4	78	36,8	80	100,0

TABLE III 60-69 years - F-G Accuracy

n = 19

$\bar{x}$ = 76,74

SD = 3,74

RAW SCORE	%	RAW SCORE	%	RAW SCORE	%	RAW SCORE	%
64	5,3	74	15,8	76	42,1	79	84,2
73	10,5	75	21,1	77	52,6	80	100,0

TABLE IV <u>**70-79 years - F-G Accuracy**</u>

n = 20

$\bar{x}$ = 75,15

SD = 3,67

RAW SCORE	%	RAW SCORE	%	RAW SCORE	%
68	5,0	73	30,0	77	70,0
70	15,0	74	45,0	78	85,0
71	25,0	76	50,0	80	100,0

TABLE V <u>**20-39 years - F-G Time**</u>

n = 41

$\bar{x}$ = 194,56

SD = 36,26

SECS	%	SECS	%	SECS	%	SECS	%
125	2,4	170	31,7	196	58,5	224	82,9
139	4,9	172	36,6	200	61,0	227	87,8
154	9,8	175	39,0	202	63,4	235	90,2
159	12,2	176	41,5	209	68,3	241	92,7
160	14,6	183	43,9	210	70,7	264	95,1
164	17,1	185	46,3	214	73,2	281	97,6
166	29,5	186	51,2	218	75,6	293	100,0
167	22,0	192	53,7	219	78,0		
168	24,4	193	56,1	222	80,5		

TABLE VI 40-59 years - F-G Time

n = 38

$\bar{x}$ = 247,92

SD = 76,38

SECS	%	SECS	%	SECS	%	SECS	%
142	2,6	215	28,9	234	55,3	291	78,9
147	5,3	219	31,6	238	57,9	293	84,2
154	7,8	220	34,2	243	60,5	308	86,8
155	13,2	221	36,8	245	63,2	316	89,5
169	15,8	226	39,5	246	65,8	342	92,1
180	18,4	229	42,1	253	68,4	379	94,7
191	21,1	230	44,7	269	71,1	470	97,4
211	23,7	231	47,4	272	73,7	482	100,0
212	26,3	233	50,0	273	76,3		

TABLE VII 60-69 years - F-G Time

n = 19

$\bar{x}$ = 307,63

SD = 120,85

SECS	%	SECS	%	SECS	%	SECS	%
175	5,3	223	31,6	283	57,9	414	84,2
184	10,5	240	36,8	299	63,2	429	89,5
187	15,8	250	42,1	337	68,4	545	94,7
192	21,1	258	47,4	356	73,7	591	100,0
209	26,3	279	52,6	394	78,9		

TABLE VIII 70-79 years - F-G Time

n = 20

$\bar{x}$ = 466,70

SD = 163,70

SECS	%	SECS	%	SECS	%	SECS	%
194	5,0	382	35,0	472	60,0	595	85,0
307	10,0	388	40,0	478	65,0	635	90,0
322	15,0	422	45,0	508	70,0	654	95,0
345	20,0	423	50,0	532	75,0	940	100,0
357	30,0	440	55,0	593	80,0		

APPENDIX 2.6. PERCENTILE TABLES FOR THE ARROWS TEST (AR)

TABLE I 20-30 years - AR Accuracy

n = 41

$\bar{x}$ = 23,29

SD = 1,03

RAW SCORE	%	RAW SCORE	%
20	4,9	23	43,9
22	17,1	24	100,0

TABLE II 40-59 years - AR Accuracy

n = 38

$\bar{x}$ = 23,26

SD = 0,86

RAW SCORE	%	RAW SCORE	%
21	2,6	23	50,0
22	21,1	24	100,0

TABLE III 60-69 years - AR Accuracy

n = 19

$\bar{x}$ = 23,05

SD = 0,85

RAW SCORE	%	RAW SCORE	%
22	31,6	24	100,0
23	63,2		

TABLE IV <u>70-79 years - AR Accuracy</u>

n = 20

$\bar{x}$ = 22,30

SD = 2,20

RAW SCORE	%	RAW SCORE	%
15	5,0	22	35.0
19	10,0	23	70,0
20	15,0	24	100,0
21	20,0		

TABLE V <u>20-39 years - AR Time</u>

n = 41

$\bar{x}$ = 75,63

SD = 24,1

SECS	%	SECS	%	SECS	%	SECS	%
43	2,4	59	31,7	73	53,7	90	80,5
47	4,9	61	34,1	74	56,1	92	82,9
49	9,8	62	36,6	75	58,5	100	87,8
50	12,2	64	39,0	77	61,0	112	90,2
51	17,1	65	41,5	80	63,4	115	92,7
52	19,5	66	43,9	81	65,9	124	97,6
54	24,4	69	46,3	85	70,7	145	100,0
56	26,8	71	48,8	88	73,2		
58	29,3	72	51,2	89	78,0		

TABLE VI <u>40-59 years - AR Time</u>

n = 38

$\bar{x}$ = 83,5

SD = 21,1

SECS	%	SECS	%	SECS	%	SECS	%
44	2,6	71	26,3	85	57,9	110	84,2
52	5,3	72	28,9	86	60,5	111	86,8
56	7,9	74	31,6	87	68,4	112	89,5
57	13,2	77	42,1	88	71,1	119	92,1
60	15,8	80	44,7	90	73,7	147	97,4
61	18,4	81	47,4	94	76,3	148	100,0
64	21,1	83	50,0	91	78,9		
67	23,7	84	52,6	104	81,6		

TABLE VII <u>60-69 years - AR Time</u>

n = 19

$\bar{x}$ = 124,9

SD = 36,3

SECS	%	SECS	%	SECS	%	SECS	%
73	5,3	101	31,6	135	63,2	168	89,5
76	10,6	104	42,1	138	68,4	187	94,7
87	15,8	114	47,4	140	73,7	192	100,0
94	21,1	116	52,6	164	78,9		
98	26,3	117	57,9	165	84,2		

TABLE VIII <u>70-79 years - AR Time</u>

n = 20

$\bar{x}$ = 174,25

SD = 73,2

SECS	%	SECS	%	SECS	%	SECS	%
73	5,0	132	35,0	177	60,0	221	85,0
74	10,0	142	40,0	178	65,0	267	90,0
104	15,0	160	45,0	200	70,0	284	95,0
113	20,0	165	50,0	201	75,0	367	100,0
118	30,0	171	55,0	220	80,0		

APPENDIX 2.7. PERCENTILE TABLES FOR THE DOT-LINE TEST (D-L)

TABLE I <u>20-39 years - D-L Accuracy</u>

n = 41

$\bar{x}$ = 14,56

SD = 1,28

RAW SCORE	%	RAW SCORE	%	RAW SCORE	%
10	2,4	13	14,6	15	78,0
12	7,3	14	39,0	16	100,0

TABLE II <u>40-59 years - D-L Accuracy</u>

n = 38

$\bar{x}$ = 14,58

SD = 1,57

RAW SCORE	%	RAW SCORE	%	RAW SCORE	%
11	7,9	13	21,1	15	63,2
12	13,2	14	36,8	16	100,0

TABLE III <u>**60-69 years - D-L Accuracy**</u>

n = 19

$\bar{x}$ = 13,68

SD = 2,38

RAW SCORE	%	RAW SCORE	%	RAW SCORE	%	RAW SCORE	%
6	5,3	12	15,8	14	57,9	16	100,0
10	10,5	13	31,6	15	84,2		

TABLE IV <u>**70-79 years - D-L Accuracy**</u>

n = 20

$\bar{x}$ = 11,75

SD = 2,81

RAW SCORE	%	RAW SCORE	%	RAW SCORE	%	RAW SCORE	%
7	5,0	10	45,0	13	70,0	15	85,0
8	15,0	11	55,0	14	80,0	16	100,0

TABLE V <u>**20-39 years - D-L Time**</u>

n = 41

$\bar{x}$ = 457,93

SD = 115,37

SECS	%	SECS	%	SECS	%	SECS	%
287	2,4	396	26,8	434	53,7	509	78,0
289	4,9	404	29,3	451	56,1	517	80,5
293	7,3	408	31,7	463	58,5	544	82,9
298	9,8	410	34,1	472	61,0	558	85,4
323	12,2	414	36,6	476	63,4	561	87,8
343	14,6	418	39,0	478	65,9	646	90,2
351	17,1	423	41,5	480	68,3	648	92,7
360	19,5	428	43,9	485	70,7	689	95,1
368	22,0	431	48,8	486	73,2	735	97,6
379	24,4	433	51,2	489	75,6	767	100,0

TABLE VI **40-59 years - D-L Time**

n = 38

$\bar{x}$ = 538,18

SD = 117,40

SECS	%	SECS	%	SECS	%	SECS	%
327	2,6	478	26,3	522	55,3	607	81,6
365	5,3	486	28,9	531	57,9	634	84,2
380	7,9	489	36,8	538	60,5	647	86,8
388	10,5	493	39,5	546	63,2	652	89,5
417	13,2	498	42,1	554	68,4	697	92,1
447	15,8	514	44,7	576	71,1	716	94,7
463	18,4	516	47,4	579	73,7	745	97,4
467	21,1	519	50,0	582	76,3	968	100,0
474	23,7	521	52,6	583	78,9		

TABLE VII **60-69 years - D-L Time**

n = 19

$\bar{x}$ = 699,68

SD = 233,11

SECS	%	SECS	%	SECS	%	SECS	%
347	5,3	546	31,5	703	57,9	839	84,2
460	10,5	621	36,8	727	63,2	887	89,5
488	15,3	636	42,1	729	68,4	1169	94,7
489	21,1	652	47,4	731	73,7	1289	100,0
500	26,3	701	52,6	780	78,9		

TABLE VIII 70-79 years - D-L Time

n = 20

$\bar{x}$ = 1017,05

SD = 473,09

SECS	%	SECS	%	SECS	%	SECS	%
414	5,0	726	30,0	921	55,0	1153	80,0
566	10,0	779	35,0	1047	60,0	1400	85,0
577	15,0	794	40,0	1097	65,0	1443	90,0
587	20,0	868	45,0	1115	70,0	1769	95,0
634	25,0	895	50,0	1132	75,0	2424	100,0

APPENDIX 2.8. PERCENTILE TABLES FOR THE SPACE RELATIONS TEST (SR)

TABLE I 20-39 years - SR Accuracy

n = 41

$\bar{x}$ = 38,17

SD = 2,47

RAW SCORE	%	RAW SCORE	%
30	2,4	38	46,3
32	4,9	39	48,8
34	9,8	40	100,0
36	26,8		

TABLE II 40-59 years - SR Accuracy

n = 38

$\bar{x}$ = 38,34

SD = 2,56

RAW SCORE	%	RAW SCORE	%
36	26,3	39	44,7
38	42,1	40	100,0

TABLE III 60-69 years - SR Accuracy

n = 19

$\bar{x}$ = 38,47

SD = 1,95

RAW SCORE	%	RAW SCORE	%
32	5,3	39	57,9
36	10,5	40	100,0
38	52,6		

TABLE IV 70-79 years - SR Accuracy

n = 20

$\bar{x}$ = 35,5

SD = 4,76

RAW SCORE	%	RAW SCORE	%
22	5,0	34	30,0
28	10,0	36	60,0
30	15,0	38	70,0
32	25,0	40	100,0

TABLE V 20-39 years - SR Time

n = 41

$\bar{x}$ = 177,78

SD = 34,62

SECS	%	SECS	%	SECS	%	SECS	%
125	2,4	155	26,8	176	61,0	198	82,9
129	4,9	156	29,3	178	63,4	208	85,4
130	7,3	160	34,1	182	65,9	213	87,8
138	9,8	166	39,0	186	68,3	221	90,2
142	12,2	168	43,9	190	70,7	236	95,1
145	14,6	169	46,3	191	73,2	255	97,6
146	17,1	171	51,2	192	75,6	292	100,0
151	19,5	172	53,7	194	78,0		
154	24,4	175	58,5	195	80,5		

TABLE VI **40-59 years - SR Time**

n = 38

$\bar{x}$ = 199,61

SD = 33,36

SECS	%	SECS	%	SECS	%	SECS	%
147	2,6	179	28,7	198	55,3	221	78,9
156	5,3	181	31,6	199	57,9	225	81,6
159	7,9	184	34,2	200	60,5	227	84,2
162	13,2	185	36,3	202	63,2	231	86,8
166	15,8	186	39,5	203	65,8	248	89,5
168	18,4	188	42,1	204	68,4	265	92,1
170	21,1	189	47,4	210	71,1	267	97,4
174	23,7	190	50,0	212	73,7	282	100,0
177	26,3	194	52,6	218	76,3		

TABLE VII **60-69 years - SR Time**

n = 19

$\bar{x}$ = 269,89

SD = 74,83

SECS	%	SECS	%	SECS	%	SECS	%
164	5,3	224	31,6	267	63,2	376	89,5
184	10,5	233	36,3	293	68,4	407	94,7
185	15,8	237	42,1	311	73,7	416	100,0
194	21,1	249	52,6	313	78,9		
217	26,3	255	57,9	344	84,2		

TABLE VIII **70-79 years - SR Time**

n = 20

$\bar{x}$ = 414,45

SD = 164,90

SECS	%	SECS	%	SECS	%	SECS	%
203	5,0	300	35,0	359	60,0	566	85,0
247	10,0	311	40,0	410	65,0	625	90,0
267	15,0	333	45,0	512	70,0	742	95,0
280	20,0	350	50,0	532	75,0	750	100,0
286	25,0	352	55,0	564	80,0		

APPENDIX 2.9. PERCENTILE TABLES FOR THE POSITION IN SPACE TEST (PIS)

TABLE I 20-39 years - PIS Accuracy

n = 41

$\bar{x}$ = 71,80

SD = 26,14

RAW SCORE	%	RAW SCORE	%	RAW SCORE	%	RAW SCORE	%
3	2,4	57	22,0	78	41,5	90	80,5
8	4,9	61	24,4	79	46,3	91	87,8
12	7,3	66	25,8	80	48,8	93	92,7
16	9,8	71	29,3	83	56,1	95	95,1
22	12,2	72	31,7	85	58,5	97	97,6
38	14,6	75	34,1	86	68,3	98	100,0
48	17,1	76	36,5	88	70,7		
54	19,5	77	39,0	89	78,0		

TABLE II 40-59 years - PIS Accuracy

n = 38

$\bar{x}$ = 64,70

SD = 20,26

RAW SCORE	%	RAW SCORE	%	RAW SCORE	%	RAW SCORE	%
17	2,7	53	29,7	72	54,1	85	89,2
23	8,1	56	35,1	73	59,5	88	91,9
34	10,8	63	37.8	74	64,9	90	97,3
40	13,5	64	40,5	75	70,3	98	100,0
46	16,2	67	43,2	77	73,0		
48	21,6	68	45,9	79	75,7		
49	24,3	69	48,6	80	78,4		
50	27,0	70	51,4	81	83,8		

TABLE III 60-69 years - PIS Accuracy

n = 19

$\bar{x}$ = 40,94

SD = 23,63

RAW SCORE	%	RAW SCORE	%	RAW SCORE	%	RAW SCORE	%
4	5,6	20	27,8	41	55,6	90	83,3
6	11,1	28	33,3	43	61,1	68	88,9
15	16,7	32	38,9	47	66,7	76	94,9
19	22,2	34	44,4	57	72,2	86	100,0

TABLE IV 70-79 years - PIS Accuracy

n = 20

$\bar{x}$ = 25,95

SD = 25,22

RAW SCORE	%	RAW SCORE	%	RAW SCORE	%	RAW SCORE	%
-1	10,0	14	45,0	32	75,0	93	100,0
3	15,0	15	50,0	37	80,0		
7	30,0	20	55,0	52	85,0		
11	35,0	24	60,0	55	90,0		
13	40,0	27	65,0	72	5,0		

APPENDIX 2.10. PERCENTILE TABLES FOR THE BLOCK CONSTRUCTION I TEST (BC I)

TABLE I 20-39 years - BC I Accuracy

n = 41

$\bar{x}$ = 11,62

SD = 0,83

RAW SCORE	%	RAW SCORE	%
9	4,9	11	19,5
10	12,2	12	100,0

TABLE II <u>**40-59 years - BC I Accuracy**</u>

n = 38

$\bar{x}$ = 11,71

SD = 0,57

RAW SCORE	%	RAW SCORE	%
10	5,3	12	100,0
11	23,7		

TABLE III <u>**60-69 years - BC I Accuracy**</u>

n = 19

$\bar{x}$ = 11,37

SD = 1,30

RAW SCORE	%	RAW SCORE	%
8	5,3	10	21,1
9	15,3	11	100,0

TABLE IV <u>**70-79 years - BC I Accuracy**</u>

n = 20

$\bar{x}$ = 10,95

SD = 1,23

RAW SCORE	%	RAW SOCRE	%
9	20,0	11	50,0
10	35,0	12	100,0

TABLE V **20-39 years - BC I Time**

n = 41

$\bar{x}$ = 64,23

SD = 20,23

SECS	%	SECS	%	SECS	%	SECS	%
41	4,9	53	36,6	65	63,4	82	87,8
43	7,3	54	41,5	68	65,9	89	90,2
45	9,8	56	43,9	69	68,3	93	92,7
46	14,6	58	48,8	71	70,7	94	95,1
47	19,5	59	51,2	74	78,0	98	97,6
50	24,4	60	53,7	75	80,5	148	100,0
51	29,3	61	56,1	77	82,9		
52	31,7	63	58,5	78	85,4		

TABLE VI **40-59 years - BC I Time**

n = 38

$\bar{x}$ = 75,63

SD = 19,48

SECS	%	SECS	%	SECS	%	SECS	%
45	2,6	63	31,6	78	63,2	96	86,8
46	5,3	65	36,8	79	65,8	98	89,5
52	10,5	68	42,1	83	68,4	101	94,7
56	18,4	73	47,4	84	71,1	110	97,4
59	23,7	75	52,6	89	76,3	138	100,0
60	26,3	76	55,3	90	81,6		
61	28,9	77	60,5	91	84,2		

TABLE VII **60-69 years - BC I Time**

n = 19

$\bar{x}$ = 95,74

SD = 34,88

SECS	%	SECS	%	SECS	%	SECS	%
52	5,3	78	31,6	103	63,2	117	89,5
56	10,5	80	36,8	106	68,4	162	94,7
60	15,8	84	42,1	107	73,7	189	100,0
64	21,1	87	52,6	108	78,9		
66	26,3	97	57,9	116	84,2		

TABLE VIII **70-79 years - BC I Time**

n = 20

$\bar{x}$ = 123,85

SD = 41,55

SECS	%	SECS	%	SECS	%	SECS	%
62	5,0	103	35,0	119	60,0	164	88,0
65	15,0	111	40,0	143	65,0	184	90,0
79	20,0	112	45,0	149	70,0	193	100,0
93	25,0	115	50,0	154	75,0		
101	30,0	117	55,0	155	80,0		

APPENDIX 2.11. PERCENTILE TABLES FOR THE BLOCK CONSTRUCTION II TEST (BC II)

TABLE I **20-39 years - BC II Accuracy**

n = 41

$\bar{x}$ = 22,02

SD = 2,29

RAW SCORE	%	RAW SCORE	%
6	4,9	10	41,5
7	7,3	11	53,7
8	12,2	12	100,0
9	17,1		

TABLE II <u>40-59 years - BC II Accuracy</u>

n = 38

$\bar{x}$ = 9,87

SD = 2,17

RAW SCORE	%	RAW SCORE	%
4	2,6	9	42,1
6	10,3	10	55,3
7	13,2	11	63,2
8	23,7	12	100,0

TABLE III <u>60-69 years - BC II Accuracy</u>

n = 19

$\bar{x}$ = 9,68

SD = 2,70

RAW SCORE	%	RAW SCORE	%
4	10,5	8	31,6
5	15,8	10	52,6
7	21,1	12	100,0

TABLE IV <u>70-79 years - BC II Accuracy</u>

n = 20

$\bar{x}$ = 8,30

SD = 3,03

RAW SCORE	%	RAW SCORE	%
2	5,0	8	50,0
4	10,0	10	75,0
5	20,0	11	80,0
6	35,0	12	100,0
7	40,0		

TABLE V **20-39 years - BC II Time**

n = 41

$\bar{x}$ = 59,66

SD = 24,42

SECS	%	SECS	%	SECS	%	SECS	%
30	2,4	45	34,1	63	70,7	86	90,2
33	4,9	48	39,0	69	73,2	89	92,7
37	7,3	49	43,9	72	75,5	94	95,1
38	9,8	50	46,3	73	78,0	111	97,6
39	12,2	53	51,2	74	80,5	162	100,0
40	17,1	54	53,7	75	82,9		
42	24,4	55	56,1	77	85,4		
44	29,3	56	61,8	80	87,8		

TABLE VI **40-59 years - BC II Time**

n = 38

$\bar{x}$ = 83,39

SD = 59,94

SECS	%	SECS	%	SECS	%	SECS	%
39	2,6	53	26,3	69	57,9	101	84,2
41	5,3	54	28,9	71	60,5	110	86,8
44	7,9	56	34,2	74	68,4	123	89,5
45	10,5	58	36,8	81	71,1	126	92,1
47	13,2	6	39,5	87	73,7	131	94,7
48	18,4	63	42,1	88	76,3	311	97,4
50	21,1	64	50,0	93	78,9	316	100,0
51	23,7	67	55,3	100	81,6		

TABLE VII <u>60-69 years - BC II Time</u>

n = 19

$\bar{x}$ = 126,42

SD = 94,72

SECS	%	SECS	%	SECS	%	SECS	%
52	5,3	76	31,6	86	57,9	183	84,2
59	10,5	77	36,8	94	63,2	303	89,5
63	15,8	78	42,1	105	68,4	320	94,7
67	21,1	83	47,4	118	73,7	360	100,0
69	26,3	85	52,6	124	78,9		

TABLE VIII <u>70-79 years - BC II Time</u>

n = 20

$\bar{x}$ = 154,15

SD = 122,8

SECS	%	SECS	%	SECS	%	SECS	%
48	5,0	89	30,0	119	55,0	193	80,0
74	10,0	91	35,0	121	60,0	196	85,0
79	15,0	92	40,0	127	65,0	276	90,0
80	20,0	100	45,0	140	70,0	344	95,0
81	25,0	111	50,0	146	75,0	576	100,0

APPENDIX 2.12. PERCENTILE TABLES FOR THE STICK CONSTRUCTION I TEST (SC I)

TABLE I <u>20-39 years - SC I Accuracy</u>

n = 41

$\bar{x}$ = 11,63

SD = 0,54

RAW SCORE	%	RAW SCORE	%
10	2,4	12	100,0
11	34,1		

TABLE II <u>40-59 years - SC I Accuracy</u>

n = 38

$\bar{x}$ = 11,34

SD = 1,15

RAW SCORE	%	RAW SCORE	%
7	2,6	11	36,3
9	10,5	12	100,0
10	13,2		

TABLE III <u>60-69 years - SC I Accuracy</u>

n = 19

$\bar{x}$ = 11,26

SD = 1,10

RAW SCORE	%	RAW SCORE	%
9	10,5	11	36,8
10	26,3	12	100,0

TABLE IV <u>70-79 years - SC I Accuracy</u>

n = 20

$\bar{x}$ = 11,0

SD = 1,37

RAW SCORE	%	RAW SCORE	%
7	5,0	11	55,0
9	15,0	12	100,0
10	30,0		

TABLE V 20-39 years - SC I Time

n = 41

$\bar{x}$ = 64,80

SD = 21,34

SECS	%	SECS	%	SECS	%	SECS	%
36	2,4	54	36,6	67	65,9	87	85,4
37	4,9	56	39,8	68	68,3	89	87,8
39	9,8	57	41,5	72	70,7	92	90,2
42	12,2	59	48,8	73	73,2	100	92,7
43	10,5	60	53,7	74	75,6	111	95,1
46	22,0	61	58,5	76	78,0	114	97,6
52	26,8	63	61,0	81	80,5	121	100,0
53	31,7	65	63,4	96	82,9		

TABLE VI 40-59 years - SC I Time

n = 38

$\bar{x}$ = 66,74

SD = 16,68

SECS	%	SECS	%	SECS	%	SECS	%
19	2,6	53	23,7	71	63,2	83	89,5
39	5,3	55	28,9	74	65,8	88	92,1
40	7,9	60	31,6	75	71,1	89	94,7
47	10,5	61	34,2	76	73,7	99	97,4
49	13,2	64	39,5	78	78,9	100	100,0
51	15,8	66	50,0	79	81,6		
52	21,1	70	55,3	82	86,8		

TABLE VII 60-69 years SC I Time

n = 19

$\bar{x}$ = 84,21

SD = 25,31

SECS	%	SECS	%	SECS	%	SECS	%
48	5,3	71	31,6	85	63,2	132	94,7
49	10,5	73	36,8	90	68,4	144	100,0
51	15,8	79	42,1	91	78,9		
65	21,1	81	47,4	104	84,2		
69	26,3	84	52,6	108	89,5		

TABLE VIII **70-79 years SC I Time**

n = 20

$\bar{x}$ = 98,05

SD = 33,22

SECS	%	SECS	%	SECS	%	SECS	%
50	5,0	81	40,0	100	65,0	140	90,0
70	15,0	84	45,0	102	70,0	160	95,0
71	20,0	88	50,0	108	75,0	184	100,0
72	25,0	93	55,0	110	80,0		
76	35,0	99	60,0	127	85,0		

APPENDIX 2.13. PERCENTILE TABLES FOR THE STICK CONSTRUCTION II TEST (SCII)

TABLE I **20-39 years SC II Accuracy**

n = 41

$\bar{x}$ = 10,8

SD = 1,21

RAW SCORE	%	RAW SCORE	%
7	2,4	10	39,0
8	4,9	11	63,4
9	9,8	12	100,0

TABLE II **40-59 years SC II Accuracy**

n = 38

$\bar{x}$ = 10,47

SD = 1,41

RAW SCORE	%	RAW SCORE	%
6	2,6	10	44,7
7	5,3	11	73,7
9	21,1	12	100,0

TABLE III <u>60-69 years SC II Accuracy</u>

n = 19

$\bar{x}$ = 9,58

SD = 2,4

RAW SCORE	%	RAW SCORE	%
4	5,3	9	42,1
5	10,5	10	47,4
6	15,8	11	79,8
8	26,3	12	100,0

TABLE IV <u>70-79 years SC II Accuracy</u>

n = 20

$\bar{x}$ = 9,4

SD = 2,4

RAW SCORE	%	RAW SCORE	%
3	5,0	8	30,0
6	15,0	9	40,0
7	20,0	10	60,0

TABLE V <u>20-39 years SC II Time</u>

n = 41

$\bar{x}$ = 71,17

SD = 18,70

SECS	%	SECS	%	SECS	%	SECS	%
40	2,4	61	34,1	73	61,0	91	85,4
41	4,9	62	41,5	74	63,4	94	90,2
46	7,3	63	43,9	75	65,9	98	92,7
49	14,5	66	46,3	78	68,3	108	97,6
50	17,1	67	48,3	81	70,7	113	100,0
55	19,5	69	53,7	84	73,2		
56	22,6	71	56,1	86	78,6		
58	26,3	72	58,5	89	82,9		

TABLE VI <u>**40-59 years SC II Time**</u>

n = 38

$\bar{x}$ = 78,39

SD = 17,35

SECS	%	SECS	%	SECS	%	SECS	%
54	2,6	67	31,5	80	60,5	96	92,1
60	7,9	68	36,8	83	65,8	97	94,7
61	13,2	69	42,1	84	68,4	98	97,4
62	18,4	74	44,7	85	71,1	150	100,0
63	21,1	77	47,4	86	78,9		
65	23,7	78	50,0	91	81,6		
66	28,9	79	52,6	95	89,5		

TABLE VII <u>**60-69 years SC II Time**</u>

n = 19

$\bar{x}$ = 89,95

SD = 29,16

SECS	%	SECS	%	SECS	%	SECS	%
42	5,3	76	31,6	90	57,9	105	84,2
56	10,5	80	36,8	93	63,2	109	89,5
57	15,8	82	42,1	95	68,4	141	94,7
63	21,1	86	47,4	103	73,7	166	100,0
73	26,3	88	58,6	104	78,9		

TABLE VIII <u>**70-79 years SC II Time**</u>

n = 20

$\bar{x}$ = 120,0

SD = 68,86

SECS	%	SECS	%	SECS	%	SECS	%
57	5,0	96	35,0	106	65,0	161	95,0
66	10,0	98	40,0	112	70,0	188	100,0
75	15,0	100	45,0	113	75,0		
88	20,0	102	50,0	130	80,0		
91	25,0	104	55,0	150	85,0		

APPENDIX 2.14. PERCENTILE TABLES FOR THE DESIGN CONSTRUCTION TEST (DC)

TABLE I <u>20-39 years DC Accuracy</u>

n = 41

$\bar{x}$ = 11,02

SD = 1,13

RAW SCORE	%	RAW SCORE	%
8	8,9	11	53,5
9	12,2	12	100,0
10	22,0		

TABLE II <u>40-59 years DC Accuracy</u>

n = 38

$\bar{x}$ = 10,97

SD = 1,35

RAW SCORE	%	RAW SCORE	%
6	2,6	10	28,9
8	5,3	11	52,6
9	10,5	12	100,0

TABLE III <u>60-69 years DC Accuracy</u>

n = 19

$\bar{x}$ = 9,84

SD = 2,54

RAW SCORE	%	RAW SCORE	%
2	5,3	10	47,4
5	10,5	11	78,9
8	15,8	12	100,0
9	26,3		

TABLE IV **70-79 years DC Accuracy**

n = 20

$\bar{x}$ = 8,60

SD = 2,95

RAW SCORE	%	RAW SCORE	%
2	5,0	8	40,0
4	10,0	9	60,0
5	20,0	11	85,0
6	25,0	12	100,0
7	30,0		

TABLE V **20-39 years DC Time**

n = 41

$\bar{x}$ = 93,49

SD = 26,38

SECS	%	SECS	%	SECS	%	SECS	%
58	5	76	37	96	61	129	85
60	10	82	42	102	65	134	88
61	12	84	44	103	68	135	90
65	17	86	46	104	71	140	93
67	20	87	49	105	73	141	8
69	22	90	51	111	76	145	100
71	24	91	53	112	78		
72	27	93	56	116	81		
74	28	94	59	119	83		

TABLE VI <u>40-59 years DC Time</u>

n = 38

$\bar{x}$ = 112,45

SD = 29,64

SECS	%	SECS	%	SECS	%	SECS	%
53	2,6	96	28,9	109	52,6	132	78,9
69	5,3	97	31,6	114	57,9	133	81,6
78	7,9	98	34,2	115	60,5	138	84,2
80	10,5	99	36,8	116	63,2	141	86,8
82	13,2	100	39,5	117	65,8	142	89,5
88	15,8	101	42,1	119	68,4	148	92,1
89	18,4	102	44,7	120	71,1	147	94,7
91	21,1	104	47,4	121	73,7	187	97,4
95	26,3	108	50,0	123	76,3	202	100,0

TABLE VII <u>60-69 years DC Time</u>

n = 19

$\bar{x}$ = 143,89

SD = 44,46

SECS	%	SECS	%	SECS	%	SECS	%
78	5,3	127	36,8	144	68,4	244	94,7
85	10,5	128	42,1	146	73,7	255	100,0
110	15,8	132	47,4	162	78,9		
121	26,3	133	52,6	165	84,2		
123	31,6	138	57,9	178	89,5		

TABLE VIII <u>70-79 years DC Time</u>

n = 20

$\bar{x}$ = 160,70

SD = 37,95

SECS	%	SECS	%	SECS	%	SECS	%
111	5,0	136	35,0	166	60,0	226	95,0
118	10,0	137	40,0	168	70,0	254	100,0
126	15,0	139	45,0	169	75,0		
131	20,0	141	50,0	193	85,0		
133	30,0	165	55,0	207	90,0		

APPENDIX 2.15. PERCENTILE TABLES FOR THE COLOUR MATCHING TEST (COL)

TABLE I **20-39 years COL Accuracy**

n = 41

$\bar{x}$ = 14,71

SD = 1,45

RAW SCORE	%	RAW SCORE	%	RAW SCORE	%
11	7,3	14	36,6	16	100,0
13	17,1	15	61,0		

TABLE II **40-59 years COL Accuracy**

n = 38

$\bar{x}$ = 15,08

SD = 1,02

RAW SCORE	%	RAW SCORE	%	RAW SCORE	%
12	2,6	14	23,7	16	100,0
13	7,9	15	57,9		

TABLE III **60-69 years COL Accuracy**

n = 19

$\bar{x}$ = 14,0

SD = 1,53

RAW SCORE	%	RAW SCORE	%	RAW SCORE	%
10	5,3	13	31,6	15	89,5
12	15,8	14	52,6	16	100,0

TABLE IV **70-79 years COL Accuracy**

n = 20

$\bar{x}$ = 14,45

SD = 0,83

RAW SCORE	%	RAW SCORE	%
13	10,0	15	90,0
14	55,8	16	100,0

TABLE V **20-39 years COL Time**

n = 41

$\bar{x}$ = 32,76

SD = 13,24

SECS	%	SECS	%	SECS	%	SECS	%
17	4,9	26	43,9	37	70,7	51	87,8
20	12,2	27	51,2	38	73,2	53	90,2
21	17,1	28	53,7	39	75,6	54	92,7
22	19,5	29	58,5	41	78,0	57	95,1
23	22,0	32	63,4	42	80,5	65	97,6
24	29,3	34	65,9	43	82,9	72	100,0
25	36,6	36	68,3	44	85,4		

TABLE VI **40-59 years COL Time**

n = 38

$\bar{x}$ = 46,66

SD = 17,32

SECS	%	SECS	%	SECS	%	SECS	%
18	2,6	35	28,9	43	55,3	57	84,2
26	5,3	37	31,6	44	57,9	69	86,8
27	7,9	38	36,8	45	63,2	72	89,5
30	13,2	39	39,5	48	65,8	73	92,1
31	15,8	40	42,1	49	68,4	78	94,7
32	18,4	41	47,4	54	71,1	86	97,4
33	21,1	42	52,6	55	76,3	97	100,0

TABLE VII <u>60-69 years COL Time</u>

n = 19

$\bar{x}$ = 55,58

SD = 32,79

SECS	%	SECS	%	SECS	%	SECS	%
27	5,3	37	26,3	44	52,6	82	84,2
30	10,5	38	31,6	45	57,9	85	89,5
31	15,8	41	36,8	46	68,4	122	94,7
36	21,1	42	42,1	54	78,9	152	100,0

TABLE VIII <u>70-79 years COL Time</u>

n = 20

$\bar{x}$ = 65,20

SD = 24,68

SECS	%	SECS	%	SECS	%	SECS	%
34	5,0	45	30,0	62	60,0	86	85,0
39	10,0	54	40,0	69	65,0	94	90,0
42	15,8	55	45,0	74	70,0	100	95,0
44	25,0	59	55,0	78	80,0	134	100,0

APPENDIX 3

INDIVIDUAL PATIENT PROFILES'

PATIENT 1

Sex: Female Age: 68 years and 6 months
Date of Onset of Stroke: March
Date of Test: July
Period of time between onset and test: 4 months
Diagnosis: Left Hemiplegia

Percentile Equivalents for Accuracy and Time Scores

TEST	ACCURACY SCORE	%	TIME SCORE	%
FORM	12	100	62	80
VMI	12	10*	540	60
P-W	6	16,7	293	77
PC	46	6*	600	100*
F-G	56	2*	880	100*
AR	21	28	441	100
D-L	7	4*	660	50
SR	16	0*	689	100*
PIS	9	12*		
BC I	8	5*	162	95*
BC II	0	5*	443	100*
SC I	11	37	133	95*
SC II	4	5*	121	90*
DC	3	7*	187	90*
COL	10	5*	76	80

* Below cut off score

Results

VMI Simple figures were executed correctly, mistakes were made once designs with two shapes were combined. There was neglect of portion of the design, not always the left side (see item 10). Lack of gestalt (item 14 and 18), poor angles and direction (16), lack of perspective.

P-W All mistakes occurred on the left and the centre items, however, some of the items located on the left and in the centre were correct.

AR Mistakes made were located on either the left side of the multiple choice sheet or had a left test card.

F-G Visual neglect was demonstrated. Words were better perceived than the other designs.

D-L All items, except number eight, where the number of dots in the model equalled that in the test were scored correctly. They were, however, executed in a fragmented way. None of the designs where the test had a different number of dots to the model were scored correctly. Space visualisation and distance estimates were a problem as well as direction.

SR Patient had difficulty with space relationships demonstrating reversals in all mistakes.

PIS This was a difficult test for patient to complete.

Construction Construction from the 2D model was extremely difficult for the patient.

COL Mistakes occurred on the left side of the multiple choice sheet.

Summary

This patient demonstrated a number of perceptual problems particularly in the more abstract spatial tasks. Left neglect compounded the problem

PATIENT 2

Sex: Female Age: 53 years and 5 months
Date of Onset: February
Date of Test: October
Period of time between onset and test: 8 months
Diagnosis: Left Hemiplegia

Percentile Equivalents for Accuracy and Time Scores

TEST	ACCURACY SCORE	%	TIME SCORE	%
FORM	11	2,6*	88	100*
VMI	7	2*	960	85*
P-W	5	5,3*	509	100*
PC	44	2*	840	100*
F-G	51	2*	1332	100*
AR	4	2*	344	100*
D-L	3	2*	480	27
SF	-1	0*	522	100*
PIS	untestable			
BCI	3	2*	276	100*
BCII I	4	2,6*	202	95*
SCI	7	2,6*	218	100*
SCII	0	2*	247	100*
DC	4	2*	170	95*
COL	13		110	100*

* Below cut off score

Results

FORM The one mistake was in the left visual field.

VMI Left out portions of diagrams on the left side of the page. Showed lack of gestalt, poor planning and directional problems as well as poor space relationships.

P-W Mistakes were not due to visual field neglect as correct answers were selected from the left.

PC Left neglect influenced results. However, there were also problems of form constancy resulting in a poor score on the test.

AR This test was difficult for the patient to do and she was the only patient to whom the first six items were administered. There appeared to be a

	definite problem with directionality, possibly left neglect and figure-ground perception problems
D-L	The patient left out components of designs both on the left side and in the middle. She had a problem with the gestalt, even when the design was accurately completed, the method of tackling the drawing is splintered.
SR	The patient found this test difficult, she chose the reversed designs.
PIS	Patient could not do this test at all.
Construction	These tests were as difficult as the matching tests and showed space relationships, directional and position in space problems.
COL	The mistakes were all within the left visual field.

Summary

This patient showed severe problems with form - overall contour, directional concepts, position in space and space relationships and some left neglect of the visual field.

PATIENT 3

Sex: Female Age: 21 years and 11 months
Date of Onset: August
Date of Test: August
Period of time before onset and test : 3 weeks
Diagnosis: Left Hemiplegia

Percentile Equivalents for Accuracy and Time Scores

TEST	ACCURACY SCORE	%	TIME SCORE	%
FORM	12	97,6	16	57,2
VMI	19	22,5	294	22,5
P-W	9	34,1	168	56,1
PC	61	68,3	216	14
F-G	77	9,8*	240	91
AR	24	100	136	98*
D-L	12	7,3*	438	55
SR	36	26,8	172	53,7
PIS	80	48,8		
BC I	12	100	84	88
BC II	8	12,2*	69	73,2
SC I	11	34,1	76	78
SC II	11	63,4	66	46,3
DC	10	22,0	106	74
COL	13	17,1	39	75,6

* Below cut off Score

Results

VMI Although the patient scored within normal limits,the patient experienced problems with angles, the designs were poorly executed and the work was sloppy.

PC Problems with size constancy were noted.

D-L Distance estimates were a problem.

COL Mistakes not due to unilateral neglect.

Summary

This patient did not have many problems. Failures were due mainly to poor concentration and lack of attention.

PATIENT 3

Sex: Female Age: 21 years and 11 months
Date of Onset: August
Date of Test: August
Period of time before onset and test : 3 weeks
Diagnosis: Left Hemiplegia

Percentile Equivalents for Accuracy and Time Scores

TEST	ACCURACY SCORE	%	TIME SCORE	%
FORM	12	97,6	16	57,2
VMI	19	22,5	294	22,5
P-W	9	34,1	168	56,1
PC	61	68,3	216	14
F-G	77	9,8*	240	91
AR	24	100	136	98*
D-L	12	7,3*	438	55
SR	36	26,8	172	53,7
PIS	80	48,8		
BC I	12	100	84	88
BC II	8	12,2*	69	73,2
SC I	11	34,1	76	78
SC II	11	63,4	66	46,3
DC	10	22,0	106	74
COL	13	17,1	39	75,6

* Below cut off Score

Results

VMI Although the patient scored within normal limits,the patient experienced problems with angles, the designs were poorly executed and the work was sloppy.

PC Problems with size constancy were noted.

D-L Distance estimates were a problem.

COL Mistakes not due to unilateral neglect.

Summary

This patient did not have many problems. Failures were due mainly to poor concentration and lack of attention.

PATIENT 4

Sex: Male Age: 48 years and 11 months
Date of Onset: January
Date of Test: August
Period between onset and test: 7 months
Diagnosis: Left Hemiplegia caused by C.V.A. during coronary bypass.

Percentile Equivalents for Accuracy and Time Scores

TEST	ACCURACY SCORE	%	TIME SCORE	%
FORM	12	97,4	23	65,8
VMI	19	23,7	305	6
P-W	9	36,8	188	43
PC	58	47,4	333	58
F-G	75	15*	325	90*
AR	23	50,0	124	93*
D-L	16	100	487	30
SR	38	42	340	100*
PIS	55	30		
BC I	12	100	111	98*
BC II	12	100	104	85
SC I	12	100	92	95*
SC II	9	21,1	90	79
DC	9	10,5	139	85
COL	11	2	51	70

* Below cut off score

Results

VMI No perceptual problems were noted but the patient did show lack of attention and sloppy copying as a result.

Construction Lack of ability to produce accurate and neat work which caused the failure in the Design Construction test.

COL Mistakes were not due to hemianopia but to lack of attention.

Summary

The patient did not attend to detail, his concentration was poor and this led to failure in the Figure-Ground test and the Colour Matching test. No perceptual problems were evident.

PATIENT 5

Sex: Female Age: 35 years and 11 months
Date of Onset: March
Date of Test: April
Period between onset and test: 1 month
Diagnosis: Left hemiplegia

Percentile Equivalents for Accuracy and Time Scores

TEST	ACCURACY SCORE	%	TIME SCORE	%
FORM	12	97,6	21	85,4*
VMI	16	10*	341	30
P-W	11	73,2	116	10
PC	55	12,2*	323	76
F-G	75	6*	379	96*
AR	24	100	96	83
D-L	11	5*	415	38
SR	36	26,8	201	83
PIS	51	90		
BC I	Dis	Dis		
BC II	Dis	Dis		
SC I	Dis	Dis		
SC II	Dis	Dis		
DC	Dis	Dis		
COL	11	7,3*	28	53,7

* Below cut off score Dis = Discharged

Results

VMI Mistakes are not perceptual in nature but rather show a carelessness and lack of attention to detail.

P-W Only one mistake made which was located on the left side.

PC The only problem was in the constancy of size where more space visualisation is necessary in the execution of the task.

D-L Poor planning of task when the number of dots are not the same as the model. Distance estimates disturbed, no directional problems, but rather space relationship problems and space visualisation problems.

COL All five mistakes made were in the left column.

Summary

This patient's problems were mild, some failures occurred on day one of testing, but she performed much better on day two and was discharged before testing could be completed.

PATIENT 5

Sex: Female Age: 35 years and 11 months
Date of Onset: March
Date of Test: April
Period between onset and test: 1 month
Diagnosis: Left hemiplegia

Percentile Equivalents for Accuracy and Time Scores

TEST	ACCURACY SCORE	%	TIME SCORE	%
FORM	12	97,6	21	85,4*
VMI	16	10*	341	30
P-W	11	73,2	116	10
PC	55	12,2*	323	76
F-G	75	6*	379	96*
AR	24	100	96	83
D-L	11	5*	415	38
SR	36	26,8	201	83
PIS	51	90		
BC I	Dis	Dis		
BC II	Dis	Dis		
SC I	Dis	Dis		
SC II	Dis	Dis		
DC	Dis	Dis		
COL	11	7,3*	28	53,7

* Below cut off score Dis = Discharged

Results

VMI Mistakes are not perceptual in nature but rather show a carelessness and lack of attention to detail.

P-W Only one mistake made which was located on the left side.

PC The only problem was in the constancy of size where more space visualisation is necessary in the execution of the task.

D-L Poor planning of task when the number of dots are not the same as the model. Distance estimates disturbed, no directional problems, but rather space relationship problems and space visualisation problems.

COL All five mistakes made were in the left column.

Summary

This patient's problems were mild, some failures occurred on day one of testing, but she performed much better on day two and was discharged before testing could be completed.

PATIENT 6

Sex: Female Age: 23 years and 5 months
Date of Onset: October
Date of Test: December
Period between onset and test: 2 months
Diagnosis: Left hemiplegia result of anaesthetic

Percentile Equivalents for Accuracy and Time Scores

TEST	ACCURACY SCORE	%	TIME SCORE	%
FORM	12	97,6	22	87,8*
VMI	11	2,5*	604	83
P-W	7	2,4*	263	95*
PC	57	24,4	310	76
F-G	79	58,5	223	82
AR	21	12*	86	72
D-L	8	2*	782	100*
SR	32	4,9*	363	100*
PIS	-2	1*		
BC I	11	0*	147	99*
BC II	9	17,1	146	98*
SC I	9	2*	130	100*
SC II	8	4,9*	164	100*
DC	Dis	Dis		
COL	11	7,3*	28	53,7

* Below cut off score Dis = Discgarged

Results

VMI Some odd mistakes that don't link up with other mistakes were made. The patient made comments such as "going completely wrong therefore not going to draw it." She recognised the designs that were not correct and moved her arm over the design before she attempted to draw. She squashed designs onto upper corner of the box, and disturbed spatial relationships of drawings were seen (see items 13, 14 and 15). All these are signs of a drawing apraxia.

D-L Errors of spatial positioning were seen. The patient gave up easily and would not even try items twelve and thirteen. Designs were completed in a fragmented way. The patient appeared to know when she was going wrong but could not get it correct and therefore gave up.

PIS Found the test very difficult, was very slow and did not complete page in the given time.

Construction Made minor mistakes but did not experience the problems that were seen in the drawing tasks.

<u>Summary</u>

The patient seemed to have a problem with spatial relationships and space visualisation. She demonstrated some of the signs of apraxia in the drawing tests which she found very difficult. She managed the construction tasks (except for the Stick Construction II Test).

This patient was diagnosed as having a drawing apraxia and spatial problems.

PATIENT 7

Sex: Female Age: 65 years and 2 months
Date of Onset: September
Date of Test: January
Period between onset and test: 3 months
Diagnosis: Left Hemiplegia

Percentile Equivalents for Accuracy and Time Scores

TEST	ACCURACY SCORE	%	TIME SCORE	%
FORM	12	84,2	52	98*
VMI	11	5,3*	756	80*
P-W	8	55,6	606	95*
PC	42	7*	717	100*
F-G	untestable			
AR	23	31	947	100*
D-L	8	5*	1216	95*
SR	18	5*	809	100*
PIS	5	8 *		
BC I	10	21,1	267	100*
BC II	1	10*	307	90*
SC I	8	10*	179	100*
SC II	6	15,8	249	100*
DC	10	47,4	305	100*
COL	5	5*	199	100*

* Below cut off score

Results

VMI Patient worked from right to left and had to be reminded to complete the design on the left. Parts of the designs were missing, this was not on the left but in the centre of the page.

P-W Of the five answers located on the left side, this patient obtained three wrong and of the four located in the middle, one was incorrect. All those located on the right (three) were correct. It seemed that the difficulty with part-whole perception was related to left hemianopia and left visual neglect.

PC The patient perseverated, seemed to "shut off" after a while and had to be brought back to the task.

F-G The patient was extremely slow and found the test very difficult. Only four correct responses were made within the first six items and the patient appeared very tired, testing was therefore discontinued and the test was not completed.

AR — The cards of the four items incorrectly scored were located on the left. It did not appear, therefore, that left neglect influenced her performance on this test

D-L — Lines were redrawn several times, designs were completed in a segmented fashion, patient did not see the gestalt. Accuracy of drawings markedly decreased when cues changed and the number of dots in the design to be completed did not match that of the model. Distance estimates were faulty as well as spatial relationships and directional concepts. No evidence of left neglect in this test.

SR — Reversals occurred, window card used to assist as patient jumbled rows and got confused.

PIS — Very slow, did not complete each page - managing ± 5 items per page window card used to stop patient confusing rows.

Construction — Found construction from card more difficult than from the model. Additional blocks and sticks were used in construction and the patient's construction was build on top of the model.

COL — Patient correctly answered items in the right two columns, 37,5% of those located in the left two columns were incorrect. In addition, this patient described changes to the colour of objects in her environment (see chapter on colour agnosia) and could be said to have achromatopsia.

Summary

Patient had a severe spatial problem seen in both motor and non-motor tasks, this is linked to a moderate constructional apraxia. The patient also has signs of achomatopsia and left neglect. Simultanagnosia should be investigated due to the mistakes made in the centre of the page in some instances.

PATIENT 8

Sex: Male Age: 49 years and 5 months
Date of Onset:: November
Date of Test: January
Period between onset and test: 2 months
Diagnosis: The cortical angiogram done on the patient demonstrated destruction of the middle cerebral artery

Percentile Equivalents for Accuracy and Time Scores

TEST	ACCURACY SCORE	%	TIME SCORE	%
FORM	12	97,4	27	85
VMI	15	2*	456	45
P-W	8	16,4	280	84,2
PC	57	36,8	296	16
F-G	75	12*	496	100*
AR	22	21,1	153	100*
D-L	8	7*	440	14
SR	32	10*	227	84,2
PIS	27	8*		
BC I	10	5,3*	92	85
BC II	8	23,7	81	71,1
SC I	6	2*	89	94,7*
SC II	10	44,7	87	79
DC	10	28,9	155	93*
COL	14	23,7	58	85

* Below cut off score

Results

VMI Patient worked from right to left and had to be reminded to complete the left design. Mistakes made were fairly subtle. Difficulty was experienced with angles. Perspective was lacking.

P-W All the incorrect responses had the correct answers located on the left side of the multiple choice sheet.

AR Only two items were incorrect, one of which was located on the left side of multiple choice sheet.

D-L Seven of the sixteen diagrams showed left neglect. There was also a problem with distance estimates and planning of designs when clues were not all present. No directional mistakes.

SR The patient made four errors on this test - reversed the designs.

PIS	Patient was extremely slow and did not complete each page. He made few errors in his choices but did not find all the correct choices. Lack of flexibility and difficulty in manipulating spatial concepts.
Construction	Block I - the configuration was correct but alignment was not i.e. the design was rotated. Block II - designs were rotated. Sticks I and II - failure was due to poor accuracy i.e. sticks not joining. Designs showed similar problems with rotation.
COL	The two mistakes made were both on the left side of the multiple choice sheet.

<u>Summary</u>

This patient had a left field neglect for which he sometimes compensated by turning his head. He also had some difficulty with spatial manipulation. There was some anomaly of size and articulation which according to Peterson and Zangwilll (1944) are symptoms of spatial disorder. Rotation of diagrams is a common feature in drawing and construction activities of right brain damaged individuals with space problems which were demonstrated by this patient.

PATIENT 9

Sex: Female Age: 64 years and 11 months
Date of Onset: November
Date of Test: April

Period between onset and test: 6 months

Diagnosis: Left Hemiplegia

Percentile Equivalents for Accuracy and Time Scores

TEST	ACCURACY SCORE	%	TIME SCORE	%
FORM	7	0	32	90*
VMI	5	2	1214	100*
P-W	untestable	-		
PC	36	2	1270	100*
F-G	untestable			
AR	untestable			
D-L	1	1	1083	90*
SR	0	0	941	100*
PIS	untestable	0		
BC I	2	0	361	100*
BC II	0	0	385	100*
SC I	0	0	135	95*
SC II	0	0	222	100*
DC	0	0	260	100*
COL	9	5	89	90*

* Below cut off score

Results

FORM All the mistakes were located in the two left columns of the multiple choice sheet The patient was very impulsive using only one clue to select her choice. However, if told to slow down and look again she could find the correct shape.

VMI The patient found this test extremely difficult. The first six simple diagrams indicated that the patient could perceive the model shape, however, it was very difficult for her to drawn them. Extreme perseveration was a feature of her performance. Left sided neglect was obvious in the designs with more than one shape. She started working on the right side of the page. Verbal cues had to be used to stop her perseverating. She showed classic symptoms of apraxia. She waved her hand in the shape of the design over the design before attempting to execute it. There was constant visual referral between the model and her work. The patient could name aspects of design i.e. item 15, this was the circle and the diamond.

P-W The patient could not grasp the requirements for the execution of this test and was unable to do it.

PC The patient managed some aspects of this test, although the size constancy was impossible. Left neglect also influenced the results.

F-G The patient was untestable.

AR The patient was unable to do this test. The first item was correct, but after that all items were incorrectly identified.

D-L All the above comments apply to the patients performance on the D-L test. She seemed to see elements of the model but was unable to put hers in the same place.

SR Again the patient used only one clue in the model to select her answer. She, however, managed to obtain ten correct answers but as the scoring system took away wrong from right, she scored zero.

PIS This test was impossible for the patient to execute.

Construction The constructions were extremely difficult for the patient to do, she demonstrated all the features of a constructional apraxia as enumerated by Critchley (1952) i.e. she placed her blocks and sticks on top of the model, she constantly moved blocks around and had to be stopped. There was no correct spatial placement and more blocks and sticks than necessary were used.

COL All mistakes were located within the left 2 columns. However, two of the eight answers on the left were correctly indicated. Difficulty in matching different hues of a colour was more obvious than left neglect.

<u>Summary</u>

This patient demonstrated a severe constructional apraxia with concomitant spatial problems. Problems were also demonstrated in the areas of unit and sub-units of form, perceptual constancy, directionality and figure-ground perception. Her severe left sided neglect exacerbated her problems and she lacked the mental flexibility and memory to execute most tasks. This patient was severely handicapped.

PATIENT 10

Sex: Male Age: 36 years and 0 months
Date of Onset: September
Date of Test: September
Period of time between onset and test: 3 weeks
Diagnosis: Left Hemiplegia

Percentile Equivalents for Accuracy and Time Scores

TEST	ACCURACY SCORE	%	TIME SCORE	%
FORM	12	97,6	72	100*
VMI	6	1*	194	78*
P-W	10	1*	529	73,2*
AR	13	1*	320	100*
PC	51	2,4*	556	100*
D-L	5	1*	936	100*
F-G	71	4*	585	100*
SR	22	1*	457	100*
PIS	16	9,8*	-	-
BC I	11	19,5	186	100*
BC II	7	7,3*	162	10*
SC I	7	1*	89	87,8*
SC II	2	2,4*	125	
DC	7	7*	153	100*
COL	12	5*	277	100*

* Below cut off score

Results

VMI Angles proved to be difficult for the patient as well as getting the correct number of dots, spacing, length of line and size of drawing. The simple designs were correct. The patient had difficulty in synthesising more complicated designs as well as the spatial relationships within these designs.

AR The patient could not match the arrows, he rotated the test card in an attempt to match the card correctly. These problems linked with directional problems seen in the VMI. He also demonstrated visual inattention.

D-L The patient omitted dots in the design and demonstrated a piece-meal approach to completing his designs. The problem was not one of directionality but one of analysis and spatial relationships. Visual inattention was also demonstrated.

SR The choice made was the reverse of the model.

Construction The block constructions copied from the model depicted on the card demonstrated spatial relationship problems. Sticks showed many directional problems as well as spatial relationship problems. Designs demonstrated spatial relationship problems in that the underlap and overlap were too deep.

Summary

Patient had definite directional and spatial relationship which were demonstrated in both motor and non-motor tasks.

PATIENT 11

Sex: Male Age: 58 years and 0 months
Date of Onset: July
Date of Test: September
Period between onset and test: 2 months
Diagnosis: Left Hemiplegia following middle cerebral artery infarct

Percentile Equivalents for Accuracy and Time Scores

TEST	ACCURACY SCORE	%	TIME SCORE	%
FORM	12	97,4	25	73,7
VMI	18	21,1*	585	63
P-W	7	10,5*	252	76,3
PC	44	2*	402	90*
F-G	73	7,9*	362	93*
AR	13	2*	281	100*
D-L	13	21,1	576	71,1
SR	34	10,5*	325	100*
PIS	39	11*		
BC I	12	100	114	98*
BC II	10	55,3	97	79
SC I	7	2,6*	101	100*
SC II	8	14*	117	98*
DC	10	28,9	146	90*
COL	12	2,6*	91	98*

* Below cut off score

Results

PC The shape component of the test was a problem. This could be due to an apparent concentration deficit.

AR The patient was very impulsive - impatient to get on with the task.

PIS Impulsivity was again demonstrated in the selection of answers.

Construction Poor concentration and general inattention led to poor alignment of sticks and blocks.

Summary

It appeared that this patient's test taking behaviour was governed by an attention deficit and poor concentration. The patient was also quickly fatigued.

PATIENT 12

Sex: Male Age: 60 years and 8 months
Date of Onset: October
Date of Test: April
Period of time between onset and test: 6 months
Diagnosis: Left Hemiparesis

Percentile Equivalents for Accuracy and Time Scores

TEST	ACCURACY SCORE	%	TIME SCORE	%
FORM	12	84,2	27	57,9
VMI	16	21,1	477	50
P-W	10	77,8	211	± 53
PC	50	15,3	563	100*
F-G	77	52,6	405	80
AR	20	20	98	26,3
D-L	12	15,8	680	50
SR	30	5*	365	85
PIS	4	5,6*		
BC I	12	100	118	90*
BCII	12	100	124	78,9
SC I	12	100	103	79
SCII	5	10,5*	117	90*
DC	10	47,4	164	±83
COL	11	7*	4[illegible]	52,6

* Below cut off score

Results

AR The first four items were incorrect then he suddenly seemed to get a better understanding of the task and performed within normal range.

D-L Poor concentration led to unnecessary mistakes.

SR Mistakes in the second half of the test were probably due to fatigue and poor concentration.

PIS The patient found this test very difficult, he was very slow.

COL - Mistakes did not seem to be due to left neglect but were due to problems in distinguishing the different hues.

Summary

Case where apparent poor concentration and high fatigue levels influenced test results.

PATIENT 13

Sex: Female Age: 43 years and 11 months
Date of Onset: June
Date of Test: February
Period between onset and test: 2 years
Diagnosis: Left Hemiplegia

Percentile Equivalents for Accuracy and Time Scores

TEST	ACCURACY SCORE	%	TIME SCORE	%
FORM	11	2,6*	24	68,4
VMI	13	2*	227	30
P-W	5	5,3*	62	2
PC	53	10,5*	321	49
F-G	75	16	212	26,3
AR	22	21,1	102	79
D-L	10	7*	355	3
SR	38	42,1	267	97,4
PIS	45	16		
BC I	10	5,3*	101	94,7
BC II	12	100	91	77
SC I	11	36,3*	109	100
SC II	8	13*	104	98
DC	8	5,3*	143	90
COL	10	2*	22	3

* Below cut off score

Results

VMI Accuracy was forfeited at the expense of speed. It seemed as though she could not be bothered with detail e.g. the left arrow head of design 12, she also did not attempt the double lines in designs 21 and 24. Some angles were also poorly executed. Problems did not appear to be perceptual in nature but rather one of focus of attention and concentration.

P-W She selected predominantly the test items located on the left test due to poor ability to visually scan the page.

F-G In this test as well as in other tests she seemed to take one clue and used that clue to make a judgement.

D-L The designs where the number of dots in the test equalled those in the model, were executed correctly however, when the number of dots differed, parts of the design were left out and dots linked incorrectly. Space visualisation was poor.

Construction	Careless mistakes led to failure.
COL	Mistakes were not due to left neglect but to difficulties in distinguishing colour hue.

Summary

It appeared that visual inattention led to the failure experienced in many of the tests. Poor space visualisation was present.

PATIENT 14

Sex: Male Age: 55 years and 0 months
Date of Onset: November
Date of Test: January
Period between onset and test: 2 months
Diagnosis: Left Hemiplegia

Percentile Equivalents for Accuracy and Time Scores

TEST	ACCURACY SCORE	%	TIME SCORE	%
FORM	12	97,4	20	47,4
VMI	14	2*	582	63
P-W	10	65,8	137	8
PC	58	47,4	327	57,9
F-G	76	18,4	526	100*
AR	24	100	129	93
D-L	13	21,1	475	24
SR	34	10,5*	312	100*
PIS	45	16*		
BC I	9	5*	91	84,2
BC II	9	42,1	86	72
SC I	11	36,3	82	86,8
SC II	10	44,7	80	60,5
DC	7	3*	158	95
COL	14	23,7	43	55,3

* Below cut off score

Results

VMI Direction of slanting lines was poor. Spatial relationships of lines was also poor.

D-L Part of the designs were missing. Length of lines and their location at the end point of the line in relation to the dots were poor.

Construction Blocks were poorly aligned and additional blocks added to the constructions.

Summary

Test results indicated space relation and position in space problems.

PATIENT 15

Sex: Male Age: 55 years and 2 months
Date of Onset: September
Date of Test: March

Period of time between onset and test: 6 months

Diagnosis: Left Hemiplegia

Percentile Equivalents for Accuracy and Time Scores

TEST	ACCURACY SCORE	%	TIME SCORE	%
FORM	11	2,6*	87	100*
VMI	13	2,6*	55	57
P-W	7	10,5*	215	64
PC	50	5,3*	463	95*
F-G	50	2,6*	970	100*
AR	11	1*	366	100*
D-L	5	7*	1109	100*
SR	34	10,5*	410	100*
PIS	3	2,0*		
BC I	7	5,0*	155	100*
BC II	1	2,0*	174	95*
SC I	9	10,5*	117	100*
SC II	5	2,0*	13	98*
DC	5	2,0*	199	100*
COL	10	2*	119	100*

* Below cut off score

Results

FORM The one mistake that was made by the patient on this test was in the bottom left hand corner.

VMI Problems experienced were with direction of lines and angles. On only two of the VMI designs did left visual neglect influence the results of the test.

P-W All choices that were located on the right side of the page were correct. It seemed therefore that failure could be related to visual neglect.

PC Failure was linked to visual neglect.

F-G Failures were not linked to field neglect in this instance - correct responses were located on both sides of the visual field. However, the patient did not remember which choices he had already made.

AR	There was no pattern of failure within the left visual field, failures occurred on both sides of the multiple choice sheet as well as with both left and right choices of test card. Patient attempted to turn cards around to make them match. Failure here linked to the directional problems seen in the VMI.
D-L	The patient neglected the left side of ten out of the sixteen designs. Drawings were done in a fragmented way, no line followed through i.e. he could not plan or follow the line all the way through to its proper location.
SR	The patient had difficulty in understanding what to do.
PIS	The patient found the concept of rotation in the mind very difficult.
Construction	The patient did not get thet number of blocks and sticks correct particularly in the construction executed from a card. The direction of the sticks and cubes were also incorrect and the constructions were slightly rotated.
COL	All the mistakes that were made occurred on the left side of the multiple choice plate.

Summary

This patient failed all the tests. He had a neglect of his left visual field which influenced the results on several of the tests. He had problems with all space perception in particular directionality which influence all other space concepts. It was six months since the onset of this patient's stroke and he was still severely handicapped as a result of his perceptual problems.

PATIENT 16

Sex: Female Age: 75 years and 9 months
Date of Onset: August
Date of Test: October
Period between onset and test: 2 months
Diagnosis : Left Hemiplegia

Percentile Equivalents for Accuracy and Time Scores

TEST	ACCURACY SCORE	%	TIME SCORE	%
FORM	12	100	37	86*
VMI	10	5*	833	96*
P-W	5	20	376	72
PC	44	7	922	96*
F-G	58	5*	833	96*
AR	16	7	385	95*
D-L	3	5*	967	57
SR	34	30	1001	100*
PIS	10	32		
BC I	9	20	279	100*
BC II	8	50	285	92*
SC I	8	10*	347	100*
SC II	0	0*	383	99*
DC	Untestable			
COL	13	10*	78	80

* Below cut off score

Results

VMI Lines tended to be shaky and did not join up.

AR The patient said that he was unable to "see" three of the diagrams on the multiple choice sheet. This did not appear to be left neglect - but visual inattention.

D-L The lines were shaky and parts of the design were missing. This could be due to left neglect as the missing part was always on the left. The patient found the complex figure very difficult. The patient could not do the test at all when the number of dots in the model and the example did not correspond. This could be due to visual inattention. Severe spatial, co-ordination and planning problems were also noted. The patient seemed to "shut of" sporadically.

PIS The patient was very slow, this was the main reason for the lower scores. The patient did, however, obtain a score that was within normal limits for this test.

Construction — Inco-ordination made all the construction tests attempted difficult, but the patient did make some correct constructions. Most designs were done by trial and error - she saw that it was not correct and tried to rectify it. The patient was discharged before the Design Construction test could be completed.

<u>Summary</u>

The mistakes made by the patient appeared to be due to left neglect, visual inattention and inco-ordination affecting the right hand. However, problems in space perception which involved motor action as well as poor figure-ground perception, were also noted. The space perception problems were noted in the tests that evaluated directionality.

PATIENT 17

Sex: Male Age: 64 years and 6 months
Date of Onset: May
Date of Test: June
Period between onset and test: 1 month
Diagnosis: Left Hemiplegia

PERCENTILE EQUIVALENTS FOR ACCURACY AND TIME SCORES

TEST	ACCURACY SCORE	%	TIME SCORE	%
FORM	12	84,2	52	95*
VMI	14	15,8	582	64
P-W	10	77,8	472	95*
PC	53	21,1	551	96*
F-G	80	100	427	89*
AR	24	100	164	79
D-L	14	57,9	1027	90*
SR	40	100	494	100*
PIS	81	96		
BC I	12	100	215	100*
BC II	11	80	149	80*
SC I	8	10,0*	195	100*
SC II	5	5*	165	98*
DC	9	26,3	259	100*
COL	16	100	125	95*

* Below cut off score

Results

VMI The patient drew very wavy lines. Work appeared to be careless, no perceptual problem was obvious but lines did not link up accurately. It seemed to be a co-ordination problem rather than apraxia as there were no other signs of apraxia other than the wavy lines.

D-L Lines very "wavy". Seemed to be a problem of inco-ordination.

Construction Poor co-ordination led to slight inaccuracies in construction. Particularly in the stick tasks as they were difficult to handle. This accounted for the poor score in the Stick Construction tests.

Summary

The problem seemed to be poor co-ordination, motor tasks scored more poorly than non-motor tasks for this reason. In addition the time taken to complete the tests was below normal.

PATIENT 18

Sex: Male Age: 30 years and 6 months
Date of Onset: September
Date of Test: January
Period between onset and test: 4 months
Diagnosis: Left Hemiplegia

PERCENTILE EQUIVALENTS FOR ACCURACY AND TIME SCORES

TEST	ACCURACY SCORE	%	TIME SCORE	%
FORM	12	97,6	51	100*
VMI	18	12,5*	966	96*
P-W	10	48,8	754	100*
PC	58	26,8	577	100*
F-G	75	6*	654	100*
AR	24	100	418	100*
D-L	13	14,6*	1421	100*
SR	40	100	699	100*
PIS	56	20		
BC I	12	100	139	98*
BC II	10	41,5	189	100*
SC I	12	100	148	100*
SC II	10	39	174	100*
DC	10	22	295	100*
COL	15	61	207	100*

* Below cut off score

Results

VMI The faults that the patient made were subtle. The patient concentrated hard to try to get the end product accurate.

F-G In this test the patient scored poorly due to possible visual inattention.

D-L The patient made some careless mistakes like leaving out bits of a design. This could be due to visual inattention.

SR As in the above tests, the patient was very slow, checked and rechecked his work. This could be due to problems with visual attention or a poor perceptual memory.

Summary

The patient's problems seemed to be due to visual inattention. This was demonstrated most clearly on the F-G test and the two drawing tests. Speed of performance was very slow. The patient did not seem to have perceptual problems

PATIENT 19

Sex: Female Age: 67 years and 10 months
Date of Onset: August
Date of Test: September
Period between onset and test: 1 month
Diagnosis: Medical examination queried right middle cerebral artery infarct causing a left hemiparesis

PERCENTILE EQUIVALENTS FOR ACCURACY AND TIME SCORES

TEST	ACCURACY SCORE	%	TIME SCORE	%
FORM	12	84,2	37	90*
VMI	18	52,6	597	64
P-W	6	16,7	289	73
PC	56	46	304	24
F-G	75	21,1	288	58
Ar	24	100	136	64
D-L	12	15,8	592	33
SR	38	52,6	233	36,8
PIS	42	57		
BC I	12	100	117	89,5*
BC II	12	100	131	80
SC I	12	100	104	84,2
SC II	11	79,8	101	69
DC	10	47,4	169	85*
COL	16	100	59	79

* Below cut off score

Results

VMI The few mistakes made by the patient were subtle - no specific problem was discernible.

P-W Random mistakes were made with no pattern emerging.

D-L The mistakes that were made were not due to a specific problem.

Summary

This patient seemed to have no V-P-M problems as all the scores fell within the normal range.

PATIENT 20

Sex: Female Age: 69 years and o months
Date of Onset: June
Date of Test: September
Period between onset and test: 3 months
Diagnosis: Left hemiplegia

PERCENTILE EQUIVALENTS FOR ACCURACY AND TIME SCORES

TEST	ACCURACY SCORE	%	TIME SCORE	%
FORM	12	84,2	26	52,6
VMI	17	36,8	870	85*
P-W	9	72,2	288	74
PC	57	52,5	527	91*
F-G	77	52,6	328	64
AR	22	31,6	154	75
D-L	11	13*	793	80
SR	40	100	314	79
PIS	8	12*		
BC I	11	100	120	91*
BC II	11	70	124	79
SC I	11	36,8	126	90*
SC II	8	26,3	151	95*
DC	6	12*	268	100*
COL	16	100	35	16

* Below cut off score

Results

VMI — Mistakes that were made were not due to inacurate perception of the design but due to an inability to drawt the direction of the lines correctly. She was aware of her mistakes and redrew lines to try to get the angle correct. However, the test score was still within normal limits.

D-L — There were no problems on this test until the section where estimates of distance and space visualisation were needed.

PIS — The patient had difficulty in rotating the designs in her mind - said that she could not do it, consequently she got side tracked by meaningless differences such as the thickness of a line.

Construction — Mistakes that were made were due to an inability to position pieces in space correctly.

Summary

Analysis of the mistakes made on each test seemed to indicate that the problems that the patient had with the VMI, Dot-Line, and PIS tests were in the area of space visualisation. There may also have been a slight dyspraxia.

PATIENT 21

Sex: Male Age: 68 years and 2 months
Date of Onset: March
Date of Test: August
Period between onset and test: 5 months
Diagnosis: Left hemiparesis

PERCENTILE EQUIVALENTS FOR ACCURACY AND TIME SCORES

	ACCURACY SCORE	%	TIME SCORE	%
FORM	11	15,8	49	95*
VMI	11	5,3*	890	90 *
P-W	5	14 *	412	90*
PC	35	5*	1007	100*
F-G	54	5*	1262	100*
AR	8	0	405	100*
D-L	5	5	2129	100*
SR	14	0*	985	100*
PIS	Untestable			
BC I	7	5*	176	96*
BC II	4	10,5*	270	85
SC I	8	10*	195	100*
SC II	2	5	221	100*
DC	1	5*	222	100*
COL	12	15,8	93	90*

* Below cut off score

Results

FORM The one mistake that was made was in the left column.

VMI The patient demonstrated severe directional problems e.g. angles on designs were distorted. There were also gross spatial relationship problems.

P-W The patient experienced a great deal of difficulty but the mistakes made did not seem to be due to a left neglect as they were scattered equally among the three alternatives.

PC The patient also had difficulty with this task. The form constancy items were impossible for the patient to do.

F-G The mistakes that were made with the items containing familiar symbols i.e. letters, numbers and words had as many mistakes as the meaningless items. The problem appeared to be one of difficulty in holding the item in the mind while a search was carried out to find the correct match. In addition he could not remember which item had already been located.

AR Many mistakes were made but these could not be contributed to left neglect as mistakes occurred in all rows and both sides. The problem, however could be one of visual inattention.

D-L Problems with the direction of lines were noted. Parts were also missing, and there was loss of gestalt. The mistakes made were not due to left neglect as mistakes were made on both sides of the visual field. The patient constantly referred back to the model and could not manage at all when the dots on the model did not correspond in number to those in the test. The problem was not one of left visual neglect but of spatial relationship and space visualisation.

SR The patient had a great deal of difficulty with this test, failure was not due to neglecting the left visual field but was one of spatial relationships.

PIS The patient found this test impossible. This was to be expected in view of severe difficulties experienced on simpler tests.

BC I The construction was untidy with poor relationship of blocks to each other.

BC II The ability to visualise the number of blocks in the design affected his performance.

SC I The relationship of sticks to each other was incorrect.

SC II The number of sticks was correct, but there were poor relationships among the sticks constituting the design. The patient left out sticks and placed the remainder with poor relationships to each other.

DC There were extremely poor relationships between design pieces and both position in space and space relationships problems were seen.

COL All the mistakes that were made were in the left two columns.

Summary

This patient appeared to have problems in all spheres of visual-perceptual-motor function. Ability to perceive the position in space and the relationship between objects as well as visualising these relationships was severely impaired. This affected his motor activity. However, his motor performance did not show features of apraxia. He also had problems of perceptual constancy and figure-ground perception.

PATIENT 22

Sex: Female Age: 50 years and 3 months
Date of Onset: January
Date of Test: August
Period between onset and test: 7 months
Diagnosis: Right middle cerebral artery clipped when an aneurism was discovered. This left the patient with a left hemiplegia and expressive dysphasia. A CAT scan showed brain atrophy of right frontal and temporal lobes.

PERCENTILE EQUIVALENTS FOR ACCURACY AND TIME SCORES

TEST	ACCURACY SCORE	%	TIME SCORE	%
FORM	12	94,4	45	100*
VMI	13	2*	470	48
P-W	7	10,5*	387	100*
PC	45	2*	381	80*
F-G	70	7*	654	100*
AR	16	2*	563	100*
D-L	9	7*	724	95*
SR	32	10*	679	100*
PIS	8	2*		
BC I	6	5*	151	100*
BC II	4	2,6*	147	95*
SC I	9	10,5*	142	100*
SC II	3	2	190	98*
DC	2	2	238	100*
COL	16	100	90	98*

* Below cut off score

Results

VMI Severe problems with planning the direction of the lines resulted in the angles being incorrectly executed. However the score was within the range considered normal.

AR The patient had difficulty with this test, this would correspond to the difficulty that she experienced with directional concepts on the VMI and the Dot-Line tests.

D-L The patient fragmented the designs, therefore lost track of where she was and completed the design incorrectly. This applied particularly to the section of the test where the dots in the model and the dots in the test did not correspond. She seemed to have a particular problem with distances.

SR She chose the reversed design, however all letters and words were correct.

Summary

This patient showed directional problems in the drawing tests (VMI, D-L) as well as in tests that had no motor component (AR). Space relations, position in space and space visualisation were also a problem. Scores in construction tasks where visualisation was necessary were slightly lower than other construction tests.

It seemed therefore that the patient's problems were directionality, spatial relationships, space visualisation and figure-ground perception. There was however a difference in the manifestation of these problems between drawing tasks and construction tasks, the construction tasks being easier for the patient to execute.

PATIENT 23

Sex: Male Age: 33 years and o months
Date of Onset: March
Date of Test: July
Period between onset and test: 3 months
Diagnosis: Left hemiplegia, after insertion of a pacemaker.

PERCENTILE EQUIVALENTS FOR ACCURACY AND TIME SCORES

TEST	ACCURACY SCORE	%	TIME SCORE	%
FORM	12	97,6	22	87,8*
VMI	17	10*	864	94*
P-W	10	48,8	240	91*
PC	57	24,4	550	100*
F-G	75	6,0*	609	100*
AR	23	43,9	187	100*
D-L	13	14,6*	1298	100*
SR	40	100	377	100*
PIS	49	18		
BC I	12	100	173	100*
BC II	9	17,1	135	98*
SC I	12	100	119	98*
SC II	11	63,4	115	100*
DC	11	53,5	285	100*
COL	10	7*	29	58,5

* Below cut off score

Results

VMI Difficulty was seen in planning diagonals. The designs drawn were very small and there seemed to be a problem with transposition.

D-L Demonstrated a problem with transposition.

PIS The patient said that he found this test difficult, however performance was on the lower edge of normality.

COL Failure not due to left neglect but one of difficulty in distinguishing colour hue.

Summary

Problems experienced by this patient were not easy to diagnose. A possible drawing apraxia seemed to exist along with a figure- ground problem.

PATIENT 24

Sex: Male Age: 43 years and 8 months
Date of Onset: February
Date of Test: February

Period between onset and test: 2 weeks

Diagnosis: Left hemiplegic

PERCENTILE EQUIVALENTS FOR ACCURACY AND TIME SCORES

TEST	ACCURACY SCORE	%	TIME SCORE	%
FORM	12	97,4	43	100*
VMI	18	21,1	693	69
P-W	10	65,8	333	95*
PC	62	84,2	406	90*
F-G	78	36,8	710	100*
AR	24	100	115	90*
D-L	16	100	746	98
SR	40	100	350	100*
PIS	27	9,0*		
BC I	12	100	123	99*
BC II	10	55,3	107	85
SC I	10	13,2*	121	100*
SC II	10	44,7	127	95*
DC	12	100	164	93*
COI	15	57,9	62	85

* Below cut off score

Summary

This patient had no problems with visual-perceptual-motor function apart from the difficulty seen on the PIS test and thus with space visualisation. The low score in the Stick Construction I test was attributed to test fatigue. The patient was physically weak and slow in executing most tests.

PATIENT 25

Sex: Female Age: 72 years and 6 months
Date of Onset: February
Date of Test: February

Period between test and onset: 2 weeks

Diagnosis: Left hemiplegic

PERCENTILE EQUIVALENTS FOR ACCURACY AND TIME SCORES

TEST	ACCURACY SCORE	%	TIME SCORE	%
FORM	12	100	75	45,5
VMI	8	5*	570	46
P-W	8	50	382	99*
COL	11	4*	92	88*

* Below cut off score

Summary

Testing was discontinued due to the fact that the patient appeared to be confused at times. She was orientated for person, place and time when testing began, but this fluctuated. The patient's concentration was extremely poor, it took 4 sessions to complete 4 tests. She was also hyper-distractible.

This patient's problems demonstrated that testing should only begin when the patient's condition is well stabilised. It has been suggested that the Form Matching test be used as an indicator of the patients ability to undergo testing. However, in this case the Form Matching test was not an accurate guide to the patient's mental state as she succeeded on this test but was unable to complete the other tests in the battery.

PATIENT 26

Sex:	Female	Age:	70 years and 6 months
Date of Onset:	June		
Date of Test:	July		
Period between onset and test:		3 weeks	
Diagnosis:	Left hemiplegic		

Summary

This patient was untestable. On the first two tests she stated that she could not see and felt ill. Unfortunately she was discharged before her condition enabled testing to be resumed.

Although no results were obtained for analysis, patient number twenty-six was included in the sample to demonstrate the importance of a stable physical condition as a pre-requisite to perceptual testing.

PATIENT 27

Sex: Male Age: 75 years and 10 months
Date of Onset: August
Date of Test: September
Period between onset and test: 1 month
Diagnosis: Left hemiparesis

PERCENTILE EQUIVALENTS FOR ACCURACY AND TIME SCORES

TEST	ACCURACY SCORE	%	TIME SCORE	%
FORM	6	0*	297	100*
VMI	10	5*	1180	80
P-W	4	10*	691	100*
PC	6 discont	0*	151	Dis
F-G	6 dicont	0*	462	Dis
AR	Untestable			
D-L	1 discont	0*	338	Dis
SR	-5	0*	1080	100*
PIS	Untestable			
BC I	4	0*	379	100*
BC II	2	5*	380	98*
SC I	6	5*	501	92*
SC II	0	0*	282	100*
DC	Untestable			
COL	8	10*	370	100*

* Below cut off score

Results

Form All the mistakes were on the left two columns of the multiple choice sheet.

VMI The patient waved his arm over the model - a sign of apraxia and needed to be reminded to draw his own design. He had difficulty in holding the pencil - did not seem to know how to. He needed constant reminders to complete the left design.

P-W The patient found the concept very difficult to visualise. He kept putting his mark on the model not on his choice. Needed constant reminders to do the task correctly.

AR The ptient was unable to do this test due to L neglect.

F-G In executing this test it was apparent that the left neglect came into play when the patient tried to focus his attention (left inattention syndrome).

D-L The patient could not translate what he saw into appropriate action. He could not get his hand onto the appropriate dot to begin thus demonstrating an apraxia. Testing discontinued as patient was frustrated by his inability to carry out the task.

COL All mistakes made were on left side of multiple choice test.

Summary

It appeared that this patient had severe visual-perceptual-motor problems. The following being manifested

1. Severe visual neglect and visual inattention which affected his performance on tests such as the Figure-Ground, Perceptual Constancy, Form and Colour Matching tests

2. Problems were experienced in all spheres of space perception.

3. The patient was apraxic which effected his drawing ability and his constructional ability.

4. He was dependant in activities of daily living in spite of good physical recovery.

Patient 28

Sex: Female Age: 75 years 0 months
Date of onset : March
Date of test : April
Period between onset and test: 1 month
Diagnosis: Large intra-cerebral haemorrhage in the parietal occipital area with extensions into the posterior horn of lateral ventricle and extending into the right occipital area - territory of the post-cerebral artery.

PERCENTILE EQUIVALENTS FOR ACCURACY AND TIME SCORES

TEST	ACCURACY SCORE	%	TIME SCORE	%
FORM	0			
VMI	2 Dis			
P-W	Untestable			
PC	Untestable			
F-G	Untestable			
AR	Untestable			
D-L	Untestable			
SR	Untestable			
PIS	Untestable			
BC I	Untestable			
BC II	Untestable			
SC I	Untestable			
SC II	Untestable			
DC	Untestable			
COL	7	10*	191	100

* Below cut off score

Summary

The ability of this patient to execute the test was very poor and on all tests, except the Colour Matching test the patient was found to be untestable or testing had to be discontinued. As the results were felt to be totally unreliable they were not included in the analysis of patients' data or the comparison between patients and normal subjects.

In view of the massive infarct, this patient's test results were not surprising, although her motor stage was at stage 5 of Brunnstrom stages of recovery she was wheelchair bound and dependant in all forms of self care due to her visual-perceptual-motor problems. She was discharged to nursing care at an early stage in the recovery process.

Patient 28

Sex: Male Age: 61 years and 9 months
Date of onset: July
Date of test: July
Period between onset and test: 3 weeks
Diagnosis: Left Hemiplegia

PERCENTILE EQUIVALENTS FOR ACCURACY AND TIME SCORES

TEST	ACCURACY SCORE	%	TIME SCORE	%
FORM	12	84,2	39	
VMI	22	100	720	80
PW	11	100	599	95*
PC	51	17*	698	100*
F-G	80	100	417	90*
AR	17	15	449	
D-L	15	84,2	1126	
SR	Discharged			
PIS	78	86		
BC I	Discharged			
BC II	Discharged			
SC I	Discharged			
SC II	Discharged			
DC	Discharged			
COL	15	89,5	194	100*

* Below cut off score

Summary

This patient did not have a perceptual problem although the time taken to complete the tests was longer than for the normal group. As the patient was apparently functioning well he was discharged prior to the completion of the tests.

Patient 30

Sex: Male Age: 58 years and 6 months
Date of onset: June
Date of test: July
Period between onset and testing: 1 month
Diagnosis: Left Hemiplegia

PERCENTILE EQUIVALENTS FOR ACCURACY AND TIME SCORES

TEST	ACCURACY SCORE	%	TIME SCORE	%
FORM	12	97,4	26	76
VMI	19	23,7	589	63
PW	10	65,8	208	50
PC	Discharged			
F-G	73	7,9*	468	96*
AR	Discharged			
D-L	11	7,9*	802	99*
SR	Discharged			
PIS	Discharged			
BC I	Discharged			
BC II	Discharged			
SC I	Discharged			
SC II	Discharged			
DC	Discharged			
COL	14	23,7	68	85

* Below cut off score

Summary

The patient was discharged before a complete assessment was carried out, it was therefore difficult to judge whether failure on the Dot-Line test and Figure Ground test were due to problems or fatigue on the day of testing.

Patient 31

Sex: Female Age: 72 years and 0 months
Date of onset: April
Date of test: May
Period between onset and testing: 1 month
Diagnosis: Haemorrhage in capsule of right basal ganglia Right middle cerebral artery.

PERCENTILE EQUIVALENTS FOR ACCURACY AND TIME SCORES

TEST	ACCURACY SCORE %	%	TIME SCORE	%
FORM	12	100	133	100*
VMI	14	21	1179	80
PW	5	20	559	97*
PC	Discharged			
F-G	Discharged			
AR	Discharged			
D-L	9	25	1743	95*
SR	38	70	960	100*
PIS	Discharged			
BC I	Discharged			
BC II	Discharged			
SC I	Discharged			
SC II	Discharged			
DC	Discharged			
COL	16	100	205	100*

* Below cut off score

Summary

The small number of tests executed did not allow a full evaluation, however no problems were found in those aspects tested, only an increase in the time taken to complete the tests.

Patient 32

Sex: Female Age: 61 years and 8 months
Date of onset: July
Date of test:: September
Period between onset and testing: 2 months
Diagnosis: Left Hemiplegia

PERCENTILE EQUIVALENTS FOR ACCURACY AND TIME SCORES

TEST	ACCURACY SCORE	%	TIME	%
FORM	11	15,8	38	94,77*
VMI	15	19	526	53
PW	7	33,3	268	68
PC	55	42,1	511	79
F-G	74	15,8	513	90*
AR	Discharged			
D-L	11	14	780	78,9
SR	38	52,6	314	79
PIS	Discharged			
BC I	Discharged			
BC II	Discharged			
SC I	Discharged			
SC II	Discharged			
DC	Discharged			
COL	16	100	90	90*

* Below cut off score

Summary

It did not appear that this patient suffered from any V-P-M problems. In some instances, though, the time taken to complete the tests was abnormally long.

Patient 33 .

Sex: Female Age: 34 years and 2 months

Date of onset: September

Date of test: January

Period between onset and testing: 4 months

Diagnosis: L Front Parietal Bleed with involvement of L capsule

PERCENTILE EQUIVALENTS FOR ACCURACY AND TIME SCORES

TEST	ACCURACY SCORE	%	TIME SCORE	%
FORM	12	97,6	29	100*
VMI	17	10,0*	365	40
PW	8	19,5	327	100*
PC	44	2,0*	604	100*
F-G	63	4,0*	941	100*
AR	Discharged			
D-L	11	4,0*	847	100*
SR	Discharged			
PIS				
BC I	Discharged			
BC II	Discharged			
SC I	Discharged			
SC II	Discharged			
DC	Discharged			
COL	16	100	72	98*

* Below cut off score

Summary

It was difficult to make a definitive diagnosis from these results although the patient appeared to have problems with perceptual constancy and figure-ground perception as well as with both drawing tests which indicated a spatial problem.

APPENDIX 4

SUMMARY OF HEMISPHERIC DYSFUNCTION

	LEFT		RIGHT
1.	Language and Arithmetic		
	Verbal		Visuo-spatial
a)	Problem with coding data into verbal symbols which the hemisphere manipulates and stores as verbal concepts. The formation of verbal concepts involves the breakdown of percepts into meaningful elements (analysis) the search for similarities in meaning (conceptual abstraction) the labelling of similar elements (coding) and the categorisation of coded elements for storage.	a)	Problems with manipulating and storing information as visual or spatial or non-verbal sounds.
b)	Lesions give rise to: - reading problems which stem from deficits of visual recognition, organisation and scanning - occipital lobes. - Comprehension deficit - parietal lobe. - Auditory memory - frontal lobe. - - Aphasia.	b)	- Impaired reading as a result of impaired object perception, figure/ ground and spatial problems.
c)	Writing defects result from inability to recall the visual image of the required symbol - Agraphia.	c)	Writing defects arise from an apraxia, as well as space and form defects.
d)	Calculation effected if it involves verbal material. Inability to do mental arithmetic.	d)	Acalculia - disability as a result of the spatial ordering of the numbers.

	LEFT		RIGHT
2.		**Apraxia**	
a)	Constructional apraxia is bilateral but appears in different forms: Programming and execution of movement is disturbed. Drawings become simplified.	a)	Constructional apraxia seen in visual spatial defects, poor orientation to diagonality, fragmentation of drawings. Constructional apraxia occurs almost twice as frequently in right sided lesions in conjunction with vestibular and occulomotor disorders.
b)	Ideomotor - patients perform poorly to command and imitation but improve with use of actual object.	b)	Dressing apraxia.
c)	Ideational apraxia. Sometimes there is the inability to perform a sequence of movements using a real object.		
6.		**Processing / Organising**	
	Processing is conceptual in nature - e.g. apples and oranges are alike because they are fruit.		Processing is done on basis of structural organisation - e.g. apples and oranges are alike because they are round.
7.	Gerstmann's Syndrome - acalculia, agraphia, finger agnosia, left-right spatial disorientation.	7.	Left sided field neglect seen in: - double-tactile stimuli. Patient will ignore stimulus on left. - ignoring left side of body - hemisomatagnosia. - denial of left sided hemiplegia - anosagnosia.

	LEFT		RIGHT
8.	Left-right disorientation. Confusion as to meaning of left and right on ones own body (in association with aphasia) may invoke a somato-sensory defect.	8.	Inability to recognise faces (prosopagnosia).
9.	**Space Perception**		
			Impairment of topographical or spatial thought.
			Loss of perspective.
	Order of completing task disturbed.		Loss of spatial relationships between parts.
	Poverty of detail.		Fragmentation.
			Presence of unwanted details.
			Rotation of figures.
	Analyses spatial and other information.		Constructs perceptual wholes from fragmented or incomplete sensory data. Synthesising activity is also seen in depth perception, perspective and perceptual constancy.
		10.	Amusia.
		11.	Body Image disturbance
		12.	Part-Whole relations
13.	**Emotional Problems**		
	a) Patients report depression more often.		a) Patients are euphoric more often.
	b) Show anxiety as well as catastrophic reactions following head injury. Patient over-sensitive to impairments and has a tendency to exaggerate		b) Tend to deny or make light of their disability. Less likely to be aware of mistakes and less likely to be dissatisfied with themselves. They may

his disabilities. He is however able to compensate and make satisfactory adjustments to his disability.

therefore appear to be free of emotional disturbance, however, their diminished appreciation for defective performance may result in childlike behaviour (pg. 58 Lezak). Fewer right lesions become depressed. These patients set unrealistic goals for themselves, they would then become depressed as a result of this. Their diminished capacity for self awareness diminishes their sensitivity to others, they therefore become difficult to live with. Thus depression in right sided lesions takes longer to develop as it is a reaction to secondary consequences rather than immediately perceived disabilities. However when it does develop it is more chronic, more debilitating and more resistive to intervention.

APPENDIX 5

PUBLISHED WORK IN SUPPORT OF THIS THESIS

ARTICLE	PAGE
Concha, M.E. (1987). A Review of Apraxia. British Journal of Occupational Therapy, 50:7, 222-226.	CCLX
Concha, M.E. (1986). Adult Performance on the Developmental Test of Visual-Motor Integration. S. A. Journal of Occupational Therapy, 16:1,11-19. **	CCLXV
Concha, M.E. (1989). Reliability and Validity Studies on the Developmental test of Visual-Motor Integration. S. A. Journal of Occupational Therapy, 19:2, 17-25. **	CCLXX
Concha, M. E. (1995). The Diagnosis of Spatial Problems in a Group of Right Hemisphere C.V.A. Subjects. S.A Journal of Occupational Therapy, 25:2, 13-24. **	CCLXXV

** Journals approved by the Department of national Education for subsidy purposes.

A Review of Apraxia

by

Marjorie E Concha, BSc(OT)

Head, Department of Occupational Therapy, University of the Witwatersrand, Johannesburg

Constructional, ideomotor and ideational apraxia are described in order to demonstrate their distinguishing characteristics. Tests were constructed to be able to distinguish between constructional apraxia and spatial problems in patients suffering from a CVA. The results of evaluating 15 right hemisphere CVA patients on the tests were analysed to determine the patient's problem. The test scores and test taking behaviour of two patients are presented to demonstrate that the difference between constructional apraxia and spatial problems cannot be diagnosed through test scores alone. Further, some of the effects of apraxia on the everyday function of the patient is described.

DEFINITION

Before one can discuss apraxia, one needs to have a working definition. Apraxia, therefore, in the context of this paper, may be described as 'an impairment of the ability to carry out purposeful movement by an individual who has normal primary motor skills, that is, strength, reflexes and coordination, and has no marked sensory or intellectual disturbances'.[1]

HISTORY

The term apraxia was first used by Steinthal in 1871, but it is Liepman who received the credit for describing apraxia as a clinical entity. Much discussion about the nature of apraxia has taken place between that time and today. However, major contributions to the classification of the different types of apraxia were made by Pick in 1905 who introduced the distinction between ideomotor and ideational apraxia, and Kleist who in 1912 was the first one to refer to the phenomenon of a constructional apraxia. He initially referred to it as optic apraxia but the terminology was changed in conjunction with Strauss in 1934. More recently, workers such as Zangwill in 1944, De Ajuriaguerra in 1960 and Hecāen in 1960 have added substantially to the understanding of constructional apraxia.

Over the years, many types of apraxia have been described. For example, Luria has enumerated the varieties of frontal, kinaesthetic, dynamic and optic spatial apraxia,[2] and Hecāen has described melokinetic, unilateral limb and buccofacial apraxia.[1] However, on reviewing the literature it seemed that ideomotor, ideational and constructional apraxia incorporated all the symptoms that are compatible with the definition already given. In contrast, the others are distinguished by the difficulty of defining the limits between them and primary motor, sensory or psychomotor defects and by their sequential character or unilateral aspect.

The basis of understanding apraxia is the understanding of the concept of praxis. Praxias are movement combinations that are acquired. These movement combinations, once learned, become automatic and the patterns are laid down as motor engrams in the brain. A simple example of a praxis is learning to catch a ball, that is, holding out one's arms in supination rather than reflexly holding them over the face as protection. The laying down and reuse of motor engrams is essential to the occupational therapy process in which both old and new skills are used.

A movement combination is, of necessity, spatial in character, that is, the limb moves through space. A movement sequence, therefore, has two components. The first is a decision-making component or cognitive component, which is that part of the process which decides on the sequence of the action and, therefore, the muscles which need to be involved to execute the movement. The second component is a perceptual one in which the visual and spatial information that is necessary for the cognitive process is provided. A spatial component is, therefore, an essential basic part of any movement pattern. De Ajuriaguerra and Tissot[3] have described the development of praxias or motor engrams to be based on the Piagetian concept of the development of a space structure and have linked types of apraxia to each of the developmental levels.

Before examining the different types of apraxia it may be helpful to examine, in simplified form, the neurological basis of praxias.

It appears that it is the left parietal lobe that stores motor engrams for the control of all purposeful, skilled movement. When a movement is to be performed, impulses are generated in the parietal lobe and travel to the premotor cortex on the left and thence to the motor cortex. Impulses generated in this way activate the right side of the body; therefore, for skilled movement patterns to take place on the left side of the body, impulses must cross from the left premotor cortex to the right premotor cortex via the corpus callosum.

Movements can be initiated in several ways, for example, by commands (that is, through the medium of language) or by imitation, or they can be self-initiated.

Should a command or instruction be given to perform a certain series of movements, such as 'catch the ball', the auditory stimuli are first interpreted in the secondary auditory cortex.

This area is connected to the premotor cortex via the parietal lobe where the relevant motor patterns are generated according to the verbal instructions given. Because the language centre and the motor planning centre are both located on the left side of the brain, it is conceivable that both defects will be seen together. Many apraxic patients are also aphasic and in this instance the language disorder is often difficult to distinguish from the apraxic disorder.[4] Even when a movement is self-generated, that is, it is done in a response to thinking, this route is vital because thinking is done in language, thus the pathway for planned motor action is disturbed.

However, should a movement be initiated through imitation, that is, initiated through a visual stimulus, a different route is utilized. This time the stimulus is generated in the visual cortex from where it is relayed via the left parietal lobe to the premotor centre. Should the visual stimulus have spatial connotations, the whole process becomes more complicated because the stimulus must be interpreted on the right side of the brain before crossing to the left premotor cortex. Thus lesions of the right side of the brain may affect the spatial component of movement.

Lesions of the left parietal area also cause some disturbances in the spatial ordering of movement but, because this is the nondominant hemisphere for spatial function, these disturbances are not as marked as when the lesion is on the right side. Performance is qualitatively impaired depending upon the hemisphere involved.

Warrington[5] compared the drawings of patients with left-sided and right-sided lesions. Those with left-sided lesions tended to simplify drawings while those with right-sided lesions had problems with the proportion, articulation and spatial relationships of the drawings.

This is a simplistic view of the neuroanatomical basis of apraxia, but it serves to help us understand the mechanism behind the various types.

TYPES OF APRAXIA

Ideational apraxia

Ideational apraxia is defined as the inability to perform a sequence of movements using a real object (Solet J, unpublished observations). Patients with ideational apraxia are also unable to perform correct motor patterns in response to language.[4] In addition, ideational apraxia has been described as the inability to put the elements of a sequence of movements together in the required order, although the individual elements can be executed correctly.

The most well known example of this is the patient who can t a match but cannot take the next step of putting the match to the candle. It is therefore a disturbance of the basic ability to manipulate objects in a required sequence.

Thus, ideational apraxia is a defect in Piaget's first stage of developing a space structure, that is, in the manipulation of objects.

Ideomotor apraxia

Ideomotor apraxia is defined as the impairment of symbolic or expressive gestures and/or the utilization of an object in its absence (Solet J, unpublished observations). This defect in the space structure centred on one's own body (the second stage of Piaget's development of a space structure) is demonstrated in symbolic gestures such as waving goodbye and making the sign of the cross.

Hecăen[1] suggests that there is a progressive difficulty for the person who has an ideomotor apraxia, from expressive gestures with more or less symbolic value, for example, waving goodbye, to that of making gestures which are meaningless, such as positions of the hand and body. This type of apraxia is usually not seen in spontaneous activity; therefore, it is looked for in special tests of verbal command or itation.

The performance of a patient with ideomotor apraxia typically improves when he uses an object, because the use of an object limits the number of potential movements that he can perform as well as providing additional sensory input.

Ideomotor apraxia has also been described as the inability to carry out individual elements of a sequence of acts while being able to carry out the whole sequence correctly. The level of ideation necessary for the sequence is, therefore, preserved.[1]

Constructional apraxia

Constructional apraxia refers to any type of performance in which parts are put together or articulated to form a single entity or object. Thus it implies an organizing activity in which spatial relations among the component parts must be accurately perceived if these parts are to be synthesized into the desired unity.

Constructional apraxia is, therefore, defined as a disorder of formative activities in which the spatial part of the task is disturbed. Critchley[6] says that patients with constructional apraxia will have some type of defective orientation in space, a defect which may not emerge until a motor task is attempted within a visual sphere. Constructional apraxia corresponds to a defect in Piaget's third stage of developing a space structure, that is, of objective Euclidean space.

According to Critchley,[6] Mayer-Gross specified that constructional apraxia involved the activity space within the sphere of the hands and fingers and appears to involve a difficulty in changing the hand from being a component of personal space into a tool manipulated within the extrapersonal space.

Critchley[6] has enumerated the types of difficulty that may be seen in drawing and construction tasks in apraxic patients, such as the following:

1. The copy may be smaller than the original
2. Lines drawn by the patient may be tremulous or wavy
3. There may be errors of articulation
4. The patient superimposes his copy on the model or very close to the model
5. Directional changes may be seen in the lines and there may be reversals
6. There may be perseveration.

Apraxia has, therefore, become a very complex syndrome to define and circumscribe. It was Dejarine who pointed out in 1914 that it was easier to say what an apraxia is not than to say what it is.

TESTS OF APRAXIA

For the testing of constructional apraxia, there are a variety of copy forms and construction-type tests available, such as Benton's three-dimensional constructional praxis test,[7] Rey's complex figure test,[8] and the three-dimensional copying and cube copying and right/left copy shapes of the Rivermead test battery.[9] All have some normative data for ages from 16 to 69 years. However, none of these tests distinguish between the various age groups between 16 and 69.

Lezak,[8] Luria[2] and Critchley[6] describe free drawing tests such as draw-a-daisy, clock and sun. These are non-standardized, although Lezak[8] does provide a scoring scale for drawing a bicycle.

The Solet test of apraxia is an extensive test for ideomotor and ideational apraxia drawn up by an occupational therapist. Scoring criteria are presented to help in the determination of dysfunction (Solet J, unpublished observations*).

THE STUDY

In view of the fact that Schilder stated that apraxia can be due to a fault in the transposition of the conception of space to manual activity without the conception of space being in itself disordered (Critchley[6]) and that no existing test battery evaluates this concept, the author felt it to be important to construct a test whereby visual-spatial problems could be evaluated through construction and drawing tasks as well as through matching-type tasks which evaluate spatial function without motor output. The test constructed, therefore, includes block, stick and design construction tasks as well as a dot-to-dot test and a 'copy form' test. The copy form test is Beery's test of visual motor integration.[10] Two motor free tests, that is, a spatial relations test and position in space test, are also included.[11] These tests are described in detail elsewhere.[11]

These tests were administered to a group of 118 normal individuals between the ages of 20 and 79 years in order to verify if age-related changes took place as enumerated by Farver and Farver [12] and Cristarella.[13]

For each of the subtests, the mean and standard deviation were calculated for each 10-year age category. It is noteworthy that the mean accuracy score decreased with age, while the time taken to complete the test increased with age (see Table 1).

The differences between the age groups are reported elsewhere.[14] However, in most instances there was a marked drop off in function at approximately 60 years of age as can be seen in Table 2 for constructional-type tasks and Table 3 for

**A copy of the Solet test is available from Jo Solet, 5 Channing Road, Newton Centre, Mass. 0215A, USA, or from the author.*

Table 1. Mean scores and standard deviation (SD) for construction and motor free tests

Test	20-29 Mean	20-29 SD	30-39 Mean	30-39 SD	40-49 Mean	40-49 SD	50-59 Mean	50-59 SD	60-69 Mean	60-69 SD	70-79 Mean	70-79 SD
Beery	20.7	2.9	20.3	2.5	20.9	2.4	20.7	2.0	18.4	3.1	16.9	2.8
Dot-line	14.3	1.6	14.8	0.8	14.8	1.7	14.4	1.4	13.7	2.4	11.7	2.8
Spatial relations	38.2	2.0	38.1	2.9	38.2	2.2	38.5	2.4	38.5	1.9	35.5	4.8
Position in space	72.2	28.3	71.4	24.6	65.2	18.5	64.2	22.1	40.9	23.6	25.9	25.2
Blocks combined	22.3	2.4	21.8	2.2	21.7	2.2	21.5	2.7	20.8	3.2	19.2	3.6
Sticks combined	22.3	1.4	22.6	1.4	22.0	2.4	21.6	2.0	20.8	3.2	20.3	3.2
Designs	10.9	1.2	11.1	1.0	11.3	0.9	10.7	1.6	9.8	2.5	8.6	2.9

Table 2. People with a score less than or equal to the indicated cutpoint value in the various age categories — constructional-type tests

Test	Score: Cutpoint	Score: Maximum	Age categories: 20-29	30-39	40-49	50-59	60-69	70-79	p
Beery	19	24	21.1	23.8	26.3	21.1	57.9	84.2	0.0000***
Dot-line	14	16	45.0	33.3	31.6	42.1	57.9	80.0	0.0017**
Blocks I	11	12	10.0	28.6	10.5	36.8	21.1	50.0	0.0124*
Sticks combined	21	24	20.0	14.3	26.3	31.6	52.6	60.0	0.0004***
Designs	10	12	30.0	14.3	21.1	36.8	47.4	60.0	0.004**

*p<0.05, **p<0.01, ***p<0.001

Table 3. People with a score less than or equal to the indicated cutpoint value in the various age categories — motor free tests

Test	Score: Cutpoint	Score: Maximum	Age categories: 20-29	30-39	40-49	50-59	60-69	70-79	p
Spatial relations	36	40	25.0	28.6	31.6	21.1	10.5	60.0	0.0024**
Position in space	63	100	25.0	23.8	42.1	33.3	83.3	90.0	0.0000***

**p<0.01, ***p<0.001

motor free tasks. Unbroken lines indicate the age levels between which no statistical differences exist in the accuracy values. Percentiles were calculated for each age category to enable comparisons to be made between patients who had suffered a cerebrovascular accident (CVA) or other type of brain injury and the normal individual.

The test battery has not yet been submitted for the final standardization procedure because various items are to be eliminated on the basis of the item analysis, validity and reliability studies. Comparisons between the performance of 15 patients and that of the control (normal) group were made as part of the construct validity studies. It is these comparisons that are interesting in the diagnosis of constructional apraxia and, for this purpose, the test results of 15 patients will be analysed and two specific cases discussed. The test battery used in this study was not for the evaluation of ideational or ideomotor apraxia but only for the evaluation of constructional apraxia.

Results

Of the 15 patients, only one patient performed poorly on constructional tasks (that is, between the 2nd and 10th percentiles) and above the 26th percentile on spatial tasks not requiring motor planning, thereby meeting Schilder's criterion that apraxia is due to a fault in the transposition of the conception of space to manual activity (Critchley[6]).

Nine of the patients performed below the 15th percentile in all tests. Three of these were said to be apraxic as well as having problems in the conception of space because they demonstrated some of Critchley's signs of apraxia,[6] such as perseveration.

Three of the patients performed poorly on motor free spatial tasks and within normal limits on the construction and drawing tasks. These patients could, therefore, be said to have a problem of space visualization which improved with object utilization.

Two of the patients tested were found to be within normal limits on all tests performed.

In patients with lesions of the right side of the brain, it is difficult to separate out those who have spatial problems plus apraxia and those who have only spatial problems because both groups perform poorly on both matching-type tests and motor tests. Two patients who did poorly on all tests are therefore discussed.

Specific cases

Miss C, a 64-year-old woman, suffered a CVA, involving the right middle cerebral artery. She was seen 3 months later when she was referred to the outpatient department of the Johannesburg Hospital. She was found to have a severe left hemiplegia, being at Brunnstrom stage 2 of recovery in the upper limb and stage 3 in the lower limb. She also had a left spatial neglect due to a visual field defect, as well as the neglect of one half of her extrapersonal space. She was totally dependent in all forms of self-care and could not participate in any form of recreational activity. Testing was extremely difficult and she performed poorly in every test that she completed, falling between the 1st and 5th percentiles in both visual motor and matching tests. Not only was she found to have a severe spatial problem, but this problem was compounded by a severe constructional apraxia. I present her [illegible]use she demonstrated very clearly some of the characteristics of constructional apraxia enumerated by Critchley.[6]

The Beery test[10] showed severe perseveration. Miss C crowded her drawings into the corner and her copy of the designs was smaller than the original (Fig.1). She also showed a characteristic which has been noted in apraxic patients, that is, she waved her arm over the original design in an attempt to plan the movement before actually executing the drawing.

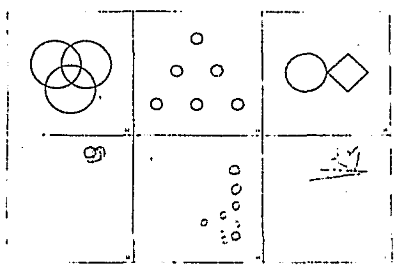


Fig.1. Apraxic patient's drawing (first patient).

Block copying showed very clearly the patient's changes in mind. The first effort had elements that showed that she could perceive something of the spatial characteristics. However, the constant reordering and changes of mind in the execution of the tasks produced a construction that did not resemble the original design.

All activities that the patient engaged in were complicated by the patient's left-sided neglect, a symptom which Critchley[6] names as belonging to the syndrome of a constructional apraxia.

An interesting fact about this patient is that she performed well on the Solet test of apraxia, which evaluates the presence of ideomotor and id[illegible]ion l apraxia. There was, therefore, no evidence of these varieties of apraxia in her behaviour. Her inability to dress and participate in other forms of activities of daily living was, therefore, probably due to her severe spatial and apraxic problems.

The second patient, a 49-year-old man who had suffered a right-sided CVA one month prior to evaluation, performed poorly on constructional tasks as well as the motor free tasks. However, the mistakes seen in the drawing tests were due firstly to visual neglect of the left space and secondly to subtle

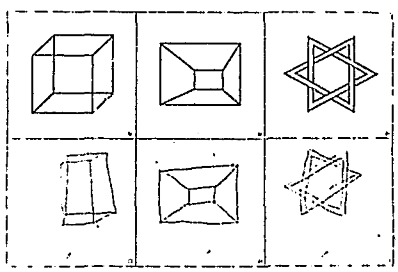
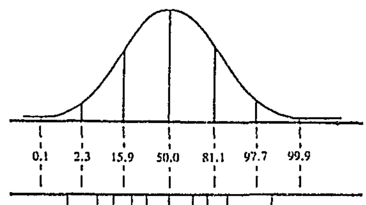


Fig.2. Drawings by a patient with spatial problems (second patient).

mistakes in the accuracy of his copying (Fig.2). It is interesting to note that the relationship of this patient's scores to the normal individual markedly improves when he is compared with the 70-year-old group (Fig.3). This bears out Botwinick's finding that brain damage in the young adult can be equated with approximately 30 years of ageing.[15]



A	Beery 2.0 Dot-line 5.0 Space rel. 2.6 Sticks 5.0 PIS 9.0 Blocks 13.2	Designs 30		30-59 years
B	Dot-line 15.0	Beery 31 Space rel. 25 Blocks 35 Sticks 18	PIS 65 Designs 70	70-79 years

Fig.3. Test scores for the second patient. A — when compared with the 30-59 year old group; B — when compared with the 70-79 year old group.

The previous patient's score remained extremely low even when compared with the older age group. One could, therefore, presume a more debilitating effect when the older individual undergoes trauma to the CNS.

The types of mistake made by the second patient did not show the characteristics of apraxia, other than the omission of parts due to his hemianopia and some anomaly of size and articulation. These, according to Pattersen and Zangwill,[16] are technical errors seen in drawings which can indicate disordered spatial thought.

It appears, therefore, that constructional apraxia can only be diagnosed by analysing the type of behaviour manifested during test performance; it cannot be diagnosed through test scores alone.

It appears also that constructional apraxia is a symptom of a lesion to the right side of the brain whereas ideational and ideomotor apraxia occur in left-sided lesions.

DISCUSSION

In evaluating the importance of apraxia vis-à-vis visual-spatial problems without apraxia, it appears that the patient who has a constructional apraxia is very much more handicapped, particularly if he does poorly on both space visualization and constructional tasks. This handicap extends into all spheres of life and the patient is unable to execute simple activities of daily living.

The patient with spatial problems may have difficulty with tasks that require spatial judgement, for example, orientating his clothes so that he can put them on; once orientated he is able to dress himself, although he may have problems with buttons and shoelaces. He usually does not have the problems with eating or brushing his teeth and hair that are due to spatial disorders. The problems that he experiences in these activities are the result of his paresis. The patient with spatial problems may have difficulty with reading and arithmetic due to the spatial disordering of letters and numbers and he has difficulty with spatial placement on paper together with reversal of the figures. In the gross motor sphere, he may have difficulty in spatially orientating himself to his environment (topographical disorientation). He may also have difficulty in carrying out activities that need spatial planning, such as board games and crafts, and there may be difficulty in translating what is seen in the form of instructions into the execution of the activity.

The patient with an ideomotor apraxia is not very limited because the lack of symbolic gestures would not affect everyday function. However, the patient with an ideational apraxia could have gross limitations of function. This is the patient who puts his food in his ear, cannot comb his hair or brush his teeth because he uses the wrong end of the brush or puts the brush in the wrong place. He cannot dress himself and he is totally dependent. Usually this is associated with aphasia and the patient and his family need emotional support. Fortunately, this severe state does not usually last and there are degrees of handicap.

The patient with the constructional apraxia may more easily be able to do automatic activities such as feeding himself, blowing his nose and drinking from a cup. Speech is intact, which enables the therapist to explain the problem and to instruct the patient. However, the patient with a constructional apraxia has all the problems experienced by the patient with a spatial problem, but the perseveration, the inability to initiate an action and the changes in mind once a movement is started make it impossible to carry out all activities of daily living which require any planning.

Treatment for a patient with spatial problems should be geared to his level of spatial deficits. Practising tasks which include directional, position in space and spatial concepts, both in the three-dimensional sphere and in the two-dimensional sphere, should improve his functional ability.

Patients with ideational apraxia should have their tasks broken down into small steps, each of which is practised and perfected before they are put together in sequence. The process of backward chaining is helpful

Both ideational and constructional apraxia require a great deal of sensory input to help guide the movements; thus, simple resisted activities should form a basis to treatment. Cues and guidelines should be given to help the patient with spatial ordering, for example, garments should be marked so that the patient recognizes the front or the back.

It is hoped that the foregoing will help to determine the origin of the patient's problems and thereby the strategy to be used for therapy.

Acknowledgement

I wish to thank the Human Sciences Research Council for making it possible for this paper to be presented at the 2nd European Congress, London, 1985.

References

1. Hecàen H. Apraxias. In: Filskov SB, Boll TJ, eds. *Handbook of clinical neuropsychology*. New York: John Wiley, 1981.
2. Luria AR. *Higher cortical functions in man*. New York: Basic Books, 1980.
3. De Ajuriaguerra J, Tissot R. The apraxias. In: Vinken PJ, Bruyn GW, eds. *Handbook of clinical neurology*. Amsterdam: North Holland Publishing, 1969.
4. Heilman VM. Apraxia. In: Heilman KM, Valenstein E, . *Clinical neuropsychology*. New York: Oxford University Press, 1979.
5. Warrington EK. Constructional apraxia. In: Vinken PJ, Bruyn GW, eds. *Handbook of clinical neurology*. New York: Wiley, 1969.
6. Critchley M. *The parietal lobes*. New York: Hafner, 1953.
7. Benton AL, Hamsher K de S, Varney NR, Spreen O. *Contributions to neuropsychological assessments*. Oxford: Oxford University Press, 1983.
8. Lezak MD. *Neuropsychological assessment*. Oxford: Oxford University Press, 1983.
9. Whiting S, Lincoln N, Bhavnani G, Cockburn J. *Rivermead perceptual assessment battery*. Windsor: NFER-Nelson, 1985.
10. Beery K. *Developmental test of visual motor integration*. Chicago: Follet Publishing, 1982.
11. Concha ME. Testing procedures for the delimitation of visual perceptual problems in the adult CVA patient. *Proceedings of the Eighth International Congress of the World Federation of Occupational Therapists, Hamburg*. Bergen/Dummie: Verband des Beschaftigungs und Arbeitstherapeuten, 1982.
12. Farver PF, Farver T. Performance of normal older adults on tests designed to measure parietal lobe functions. *Am J Occup Ther* 1982; 36(7): 444-49.
13. Cristarella MC. Visual functions of the elderly. *Am J Occup Ther* 1977; 31(7): 432-40.
14. Concha ME. The performance of normal adults versus that of CVA patients on a test of visual perception. *Proceedings of the New Zealand Association of Occupational Therapists Congress*. Auckland: NZAOT, 1984.
15. Botwinick J. Neuropsychology of ageing. In: Filskov SB, Boll TJ, eds. *Handbook of clinical neuropsychology*. New York: Wiley, 1981.
16. Pattersen A, Zangwill O. Disorders of visual space perception associated with lesions of the right-sided hemisphere. *Brain* 1944, 67: 331-58.

- CCLXV -

ADULT PERFORMANCE ON THE DEVELOPMENTAL TEST OF VISUAL MOTOR INTEGRATION

by M. E. Concha

Occupational therapists working with patients that have suffered a Cerebro-vascular Accident, have found that perceptual problems magnify the difficulties that these patients experience with activities of daily living. The methods of evaluating these perceptual problems have not been standardised and the results are accordingly unreliable. Therefore therapy cannot be directed towards the specific areas of malfunction. A battery of tests for visual – perceptual function was drawn up by the author[1] to evaluate the extent to which perceptual problems influence day to day function and to provide a standard means of administering, scoring, and judging the results of the tests. The Developmental Test of Visual Motor Integration (VMI) by Keith E Beery[2] was selected to form part of this battery.

The VMI was administered to a normal group of people between the ages of 20 – 79 years in order to provide normative data against which patients' test results could be evaluated. The data show that perceptual function in the normal individual decreases with age.[3] Occupational therapists should therefore analyse the performance of patients in relation to the function expected of the relevant age group.

THE TEST

One of the classic means of testing the ability of a patient to perceive shape, spatial relations and direction is through the copying of forms and designs.

Accurate copying ability is dependent on the ability to accurately perceive the designs to be copied as well as an intact motor system. A copy forms test, therefore, evaluates a

Professor M.E. Concha
Head: Department of Occupational Therapy
University of the Witwatersrand

combination of visual input and motor output and is known as a test of visual motor integration.

The Developmental Test of Visual Motor Integration by Keith Beery[2] provides a sequence of twenty-four geometric forms arranged from the simple to the complex. Beery states that the test can be used with adults as well as children, but was primarily designed for assessing sensorimotor development in pre-school and early grade level children.[2] The 1982 version of the test provides standard scores, percentiles and age equivalent scores for ages four through to thirteen years. The figures given for the thirteen year olds are said to serve for older age groups as well. Although occupational therapists in South Africa have found the Developmental Test of Visual Motor Integration to be an extremely valuable instrument in the evaluation of visual motor function in both children and adults, no scores for the adult population or information on the clinical use of the test have been described in the literature.

OTHER TESTS OF VISUAL MOTOR FUNCTION

Several other paper and pencil tests are available for the evaluation of function in the adult, some of which have normative data.

CCLXVI

Many of these tests have a memory component, for example, the Memory for Designs Test by Graham and Kendall[4] and the Visual Retention Test by Benton[5]. The designs in these two tests could well be used to analyse visual motor problems and the Visual Retention Test does purport to assess visual perception and visual constructive abilities in Form C of the test. However, the memory component in the other Forms as in the Graham and Kendall test, distorts the analysis of visual-motor problems.

Other design copying tests that do not include memory are available, the most well known and well researched of these being the Bender-Gestalt Test[6]. Bender herself called this a Visual-Motor Gestalt Test, but over time it has come to be known as the Bender-Gestalt Test[7]. There are different versions for the administration of this test and the"... variables that can be scored are numerous and equivocal and their dimensions ... often difficult to define ..."[7] This has resulted in a profusion of scoring systems, which together with the fact that the test is a well known psychological instrument used by psychologists for diagnostic purposes, makes it unsuitable for use by the occupational therapist.

The Minnessota Perceptuo-Diagnostic Test[8] makes use of two of Wertheimer's Gestalt designs which are also used in the Bender Gestalt Test. The particular Designs were used because of their ability to produce rotations in pathological conditions as well as yielding some information on visual motor performance. The standardisation data available is similar to that of the VMI (i.e. 5 – 13 years) but it is felt that two designs are restrictive in terms of the information that they can provide about motor planning and spatial concepts.

Reys Complex Figure Test[7] is one of the more suitable tests for occupational therapists to use in the evaluation of visual motor performance in the adult as it contains normative data on 60 adults in the age range of 16 – 60 years. The combination of figures and direction of lines make the evaluation of directional confusions, fragmentation and spatial problems possible. However, the test consists of only one design, so one mistake can be compounded and the desirability of a test beginning with simple items and ending with more complicated and difficult items, is lost. The published data on Reys Complex Figure Test does not differentiate between performance in the different age ranges, but a study carried out by Kaplan and Heir[9] found that normal subjects younger than 68 years performed better on the test than those older than 68 years ($p<.01$). Normative data, however, are not provided.

The Slosson Drawing Co-ordination Test[10] was designed to identify individuals with perceptual disorders where eye-hand co-ordination is involved. The test uses several figures from the Standford-Binet Intelligence Test and scoring is based on 3 repetitions of each of the designs.

Normative data are provided for ages 1 – 12 years and a reliability study included data from individuals aged 4 – 52 years. However, it is felt to be inappropiate for occupational therapists to use figures from the Standford-Binet Test.

The most recenty published test which was "specifically designed for use by Occupational Therapists'"[11] is the R/L Copy Shapes sub-test of the Rivermead Perceptual Assessment Battery. Sixty-nine normal subjects aged 16 – 69 years were used to obtain the normative data. In this test no significant relationship was found to age but correlation was established between R/L Copy Shapes and the Mill Hill Vocabulary Scale, as well as with the Synonyms Test. Accordingly, the final determination of a perceptual deficit is based on estimating the patient's pre-morbid intelligence level. This requirement is not always easily fulfilled.

Numerous tests of free drawing are described by Lezak[7] Critchley[12] and Luria,[13] and include such items as drawing a daisy, bicycle, sun and clock. These tests are quick determinants of gross perceptual defects. However, the absence of a model can change the test from that of perceiving something to be copied into one of recalling a picture in the mind. This type of assessment cannot therefore, be compared to that of the VMI Test.

Lezak[7] has developed a 20 point scoring system for the bicycle drawing test which could be used as a pre- and post-treatment evaluation. Kolb and Whishaw[14] provide means and standard deviations for this task for ages 20 – 29 years and 30 – 50 years as well as for age groups between 2 – 19.

The analysis of the various available tests showed that the VMI could be a valuable assessment tool for the following reasons:–

- It taps visual motor integrity in the sphere of visual analysis of overall contour of shape.
- It provides different designs presented in a graded way from simple to complex thus meeting one of the criteria for good test design.
- Some of the designs are fairly complex thus making them suitable and challenging for adults.
- The variety of designs makes it possible to evaluate different aspects of perceptual function such as directionality and spatial concepts.
- Comparison can be made between the results of this test and motor free tests which can aid in the diagnosis of apraxia.
- The designs are not widely used in other tests and the full potential of the VMI as an assessment tool has not been exploited.

Thus it was felt that the provision of normative data for the different age groups between 29 – 79 years could make the test additionally useful for the evaluation of function in the adult patient.

RESEARCH METHODS

Participants

One hundred and seventeen subjects were recruited from the Johannesburg area. The age distribution is seen in Table I.

Of the 117 subjects, thirty-eight were males and seventy-nine were females. As no statistical difference was found between the scores of males and females the two groups of scores were combined. The mean age was 49,83 (SD 17,39). The subjects varied in socio economic and educational status. The mean number of years in school being 11.35 (SD 1.10) with the minimum being 8 years and the maximum 12 years.

All subjects were required to have no known neurological or psychiatric problems and be completely independent in activities of daily living. All subjects were caucasian.

Procedure

The VMI was administered as part of a battery of tests for the evaluation of Visual-Perceptual-Motor function. The test instructions were modified to make them more suitable for the adult population. (Instructions and scoring procedure can be obtained from the author).

All other criteria for administration remained the same, i.e. the test booklet could not be rotated during the execution of the test and subjects were not permitted to erase their drawings. In addition, the time taken to complete the test was recorded. The criteria for scoring each item was also slightly altered in an attempt to eliminate as much subjectivity as possible.

Results

The mean and standard deviation for both time and accuracy scores was calculated for each age group (see Table II).

It is noteworthy that the mean accuracy score decreased with age, while time taken to complete the test increased with age.

In order to ascertain whether the differences in the scores between the age groups were statistically significant, the scores were analysed using the BMDP computer programme. The statistical analysis was carried out by the Institute of Biostatistics (Transvaal Branch) of the Medical Research Council.

ACCURACY SCORES

Value counts were performed on the accuracy scores for each age group and tables constructed in which the figure equal to and less than the 50% level was calculated. When the tables were X x K with K>2, the Pearson Chisquare Test was used with (K - 1) degrees of freedom. When the tables were 2 x 2 and the sample range small enough, Fisher's exact probabilities were calculated and for the larger samples the Chisquare Test was used after applying Yates' correction.[15]

The percentage of persons with a score less or equal to the indicated cut point value for

TABLE I: NUMBER OF SUBJECTS PER AGE GROUP

Age group	20-29	30-39	40-49	50-59	60-69	70-79	
	19	21	19	19	19	20	= 117

-CCLXVII-

TABLE II: MEANS AND STANDARD DEVIATIONS FOR BOTH TIME AND ACCURACY SCORES FOR EACH AGE GROUP

A. ACCURACY SCORES

	20-29	30-39	40-49	50-59	60-69	70-79
MEAN	20,68	20,38	20,89	20,69	18,37	16,95
S.D.	2,81	2,48	2,42	1,97	3,11	2,80

B. TIME SCORES

	20-29	30-39	40-49	50-59	60-69	70-79
MEAN	418,95	510,81	683,90	528,21	551,95	706,79
S.D.	158,65	308,47	379,64	205,22	256,53	431,28

the VMI can be seen in Table III. Unbroken *lines indicate the age levels between which* no difference exists. The Pearson Chisquare Test demonstrated that there was a significant difference among the age groups at (P = 0,0000). Further analysis showed the following:–

- Fisher's exact test demonstrated no difference between the accuracy scores of ages 60 – 69 and 70 – 79. These two age categories were therefore grouped together for further analysis.
- The Pearson Chisquare Test showed that *there was no difference* between the scores for each of the age categories 20 – 29, 30 – 39, 40 - 49, and 50 – 59 years. Thus the scores of these age categories were also grouped together for further analysis.
- A highly significant difference between the accuracy scores of the two groupings now formed, i.e. the 20 – 59 year olds, and the 60 – 79 year olds at the 0.001 (P = 0,0000) level of significance was found using Fisher's exact test. (See Table III)

It therefore appears that there is a "drop off" *at about 60 years of age, in the ability to copy* forms on paper. However, as other tests in the battery of which the VMI forms part, showed a slightly different picture, it was decided to group the ages according to the overall grouping for the calculation of percentile ranks.

Percentile ranks were therefore computed from the raw scores for the age categories 20 – 39, 40 – 59, 60 – 69 and 70 – 79 (see Tables IV, V, VI, and VII). Percentile ranks were calculated to enable comparison to be made between the performance of patients who have *suffered a CVA* or other types of brain injury and the normal individual.

TIME SCORES

The mean time scores (see Table II) for the various age groups were tested for significant differences using the Bonferroni Test which gives the significant p value comparisons of all pairs of means.

The analysis of the time scores showed that only the scores obtained for the 20 – 29 year

TABLE III: PERCENTAGE OF PERSONS WITH A SCORE EQUAL TO THE INDICATED CUT-
POINT VALUE IN THE VARIOUS AGE CATEGORIES FOR THE VMI

SCORE		AGE CATEGORIES						P
Cut-Point 19	Max 24	20-29	30-39	40-49	50-59	60-69	70-79	0,0000 P<0,001

TABLE IV

VMI ACCURACY PERCENTILES

20–39 yrs

No. = 40

x̄ accuracy = 20,52

S.D. = 2,61

Raw Score	Percentile
11	2,5
14	5,0
15	7,5
18	12,5
19	22,5
20	42,5
21	57,5
22	82,5
23	95,0
24	100,0

TABLE VI

VMI ACCURACY PERCENTILES

60–69 yrs

No. = 19

x̄ = 18,36

S.D. = 3,11

Raw Score	Percentile
11	5,3
14	15,8
16	21,1
17	36,8
18	52,6
19	57,9
20	63,2
21	84,2
22	100,0

old group differed significantly from that of the 70 – 79 *year old group and only at the 5%* level of significance. (P = 0,002).

However, the four age groupings previously described were again used for the compilation of percentiles. In regrouping the scores, although the younger age group now included the 30 – 39 year olds, the time scores still differed from that of the 70 – 79 year olds at the 5% level (P = 0,0067). Percentiles were calculated for each of the age categories 20 – 39 years, 40 – 59 years, 60 – 69 years and 70 – 79 years (see Tables VIII, IX, X, XI).

TIME/ACCURACY RATIOS

As two scores were obtained for the test, an accuracy and a time score, it was felt that a combination of the two scores would provide an overall picture of the functional level of each age group. The ratio was calculated by dividing the time score by the accuracy score.

Again simultaneous comparisons of all pairs of means were carried out on the ratios using the Bonferroni test. This procedure indicated that the age groups between 20 – 59

TABLE V

VMI ACCURACY PERCENTILES

40–59 yrs

No. = 38

x̄ accuracy = 20,79

S.D. = 2,18

Raw Score	Percentile
16	2,6
17	7,9
18	21,1
19	23,7
20	42,1
21	57,9
22	78,9
23	86,8
24	100,0

TABLE VII

VMI ACCURACY PERCENTILES

70–79 yrs

No. = 20

x̄ = 16,94

S.D. = 2,79

Raw Score	Percentile
12	5,3
13	10,5
14	21,1
15	31,6
16	47,4
17	57,9
18	68,4
19	84,2
21	94,7
22	100,0

TABLE VIII VMI TIME PERCENTILES 20–39 yrs			
Secs.	Percentile	Secs.	Percentile
[illegible]	2,5	388	57,5
198	5,0	408	60,0
250	7,5	450	62,5
260	10,0	485	65,0
261	12,5	505	67,5
267	17,5	508	70,0
280	20,0	517	72,5
294	22,5	518	75,0
297	25,0	527	77,5
314	30,0	530	80,0
328	32,5	602	82,5
329	35,0	637	85,0
343	47,5	646	87,5
364	40,0	780	90,0
372	42,5	798	92,5
373	45,0	865	95,0
378	47,5	1117	97,5
383	50,0	1616	100
385	55,0		

years differed in time/accuracy ratio scores from the elderly, i.e. 70 - 79 year old group as follows:

20 – 29 years at the 1% level (P = 0,0002)
30 – 39 years at the 5% level (P = 0.0016)
50 – 59 years at the 5% level (P = 0,0014)

Thus it can be seen that scores in which the time taken to complete the tests is included,

TABLE IX VMI TIME PERCENTILES 40–59 yrs			
Secs.	Percentile	Secs.	Percentile
214	2,6	439	42,1
295	5,3	452	44,7
328	7,9	468	47,4
335	10,5	536	50,0
338	13,2	544	52,6
347	15,8	548	55,3
358	18,4	577	60,5
364	21,1	589	63,2
367	23,7	618	65,8
383	26,3	663	68,4
384	28,9	711	71,1
390	31,6	718	73,7
391	34,2	723	76,3
406	36,8	729	78,9
423	39,5	740	81,6

TABLE X VMI TIME PERCENTILES 60–69 yrs	
Secs.	Percentile
113	5,3
230	10,5
355	15,8
363	21,1
372	26,3
409	31,6
411	42,1
436	47,4
525	52,6
527	57,9
563	63,2
633	68,4
661	73,7
695	78,9
810	84,2
880	89,5
1002	94,7
1091	100

show greater differences between the age groups than if only accuracy or time are used. It is interesting to note that there was no difference between the 40 – 49 year olds and the 70 – 79 year olds. This was thought to be due to the fact that, although the 40 year old group was the more accurate group, they achieved this accuracy by being very slow in the completion of the test.

When the ratio scores were combined to form the four groups previously mentioned, the differences were as follows:

20 – 39 years and 70 – 79 year P = 0,0004 (1% level of significance)

TABLE XI VMI TIME PERCENTILES 70–79 yrs			
Secs.	Percentile	Secs.	Percentile
364	5,3	658	57,9
411	10,5	738	63,2
417	15,8	742	68,4
448	21,1	1016	73,7
463	26,3	1066	78,9
489	31,6	1273	84,2
503	36,8	1285	89,5
527	42,1	1451	94,7
572	47,4	1918	100
608	52,6		

40 – 59 years and 70 – 79 years P = 0,0056 (5% level of significance)

DISCUSSION

The results of testing normal individuals across a wide spectrum of ages, show that older adults tend to score less well than younger adults, on tests of perceptual function. This is demonstrated in Table II where it can be seen that there is a decrease in the accuracy scores with increasing age. Statistical analysis of the results of the VMI show a significant difference between the scores obtained for the 20 – 59 year old group and those obtained for the 60 – 79 year old group. This finding is confirmed by Botwinick[16] who states that older adults tend to score less well in tasks requiring fluid intelligence, i.e. perceptual function, but scored much the same as younger adults in tasks of crystallized intelligence, i.e. verbal function.

It appears that tests that measure crystallized intelligence are similar to those that measure left hemisphere function and those that measure fluid intelligence are similar to tests of right hemisphere function. Klisz[17] found that tests that best differentiate the young from the older adult are also those that are sensitive to right hemisphere damage. The VMI test appears to be a test of right hemisphere function in that it taps spatial constructive ability.

Schaie and Schaie[18] maintain that tests of old people may look like those of right hemisphere patients and this is confirmed in the examples of the VMI test completed by a normal 70 year old (see Fig. I) when compared to that completed by a right sided CVA patient (see Fig. II). The tests completed by normal elderly individuals showed fragmentation, loss of perspective and incomplete drawings just as did those of the patients. These types of mistakes were also found by Farver and Farver[19] who found statistically significant age effects in drawings done from command. Although this type of test is not directly comparable with the VMI, they also found that there was poor reproduction of angles, loss of perspective and rotations and errors of spatial relations.

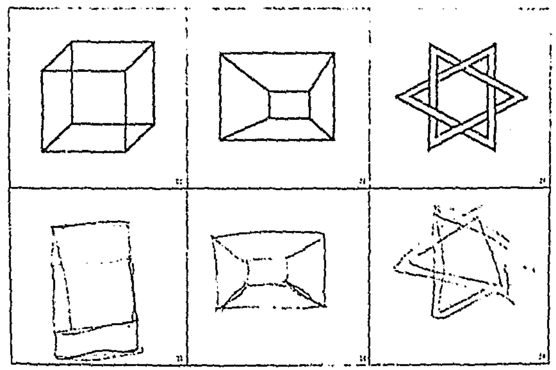


Figure I: Normal individual aged 70 years

-CCLXVIII-

Studies appearing in the occupational therapy literature are inconsistent regarding the effects of aging on tasks involving skills of visual motor integration. Both Taylor[20] and Whiting et al[11] found no age related changes in their copy form tests whereas Kaplan and Hier[9] found that there were age related changes from the age of 68 years on Reys Complex Figure Test. Kaplan and Hier also found that there was no evidence for an age x diagnosis effect on this test, thus suggesting that "the greater visuo-spatial deficits found in the older right hemisphere damaged patients are due to the effect of age on visuo-spatial ability . . ."[10]

Some studies on the relationship between perception and activities of daily living have indicated that visual spatial defects in patients do correlate with poor ability in self care tasks.[21, 22] Again, there is some disagreement on this question. Rosenthal et al[23] found that there was not a significant correlation between the severity of perceptual deficit and the degree of improvement during rehabilitation. Kaplan and Hier[19] found a significant negative correlation between the amount of improvement in self care scores made during rehabilitation and perceptual deficits.

CONCLUSIONS

The above findings indicate that the relationship of visuo-motor defects and the role that age plays in these defects need to be further researched in relation to the performance of activities of daily living. The importance of habit formation, test familiarity and the early establishment of motor engrams for everyday activity needs to be evaluated with relation to performance in complex unfamiliar visuo-motor tasks such as the VMI. The difference in function between normal individuals in VMI tasks make it essential that we examine the relationship of these tasks to the activities of daily living of an older patient.

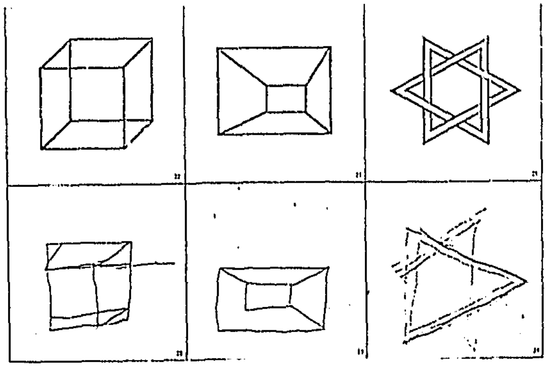


Figure II: C V A Patient aged 70 years

REFERENCES

1. Concha, M.E. Testing Procedures for the delimitation of Visual Perceptual Problems in the adults CVA patient, Proceedings of the Congress of the World Federation of Occupational Therapists, Hamburg 1982.
2. Beery, K.E. Developmental Test of Visual Motor Integration, Chicago: Follette Publishing Co, 1982.
3. Concha, M.E. The performance of normal adults versus that of CVA patients on a test of visual perception, Proceedings of the Conference of the New Zealand Association of Occupational Therapists, August, 1984
4. Graham, F. K. and Kendall, B.S. Memory for designs test – Revised General Manual, Perceptual and Motor Skills, 1960, 11, 147 – 188.
5. Benton, A.L. Visual Retention Test, New York: Psychological Corporation, 1955.
6. Bender, L A. A visual Motor Gestalt Test – its clinical use, American Orthopsychiatric Association Research Monograph, No. 3, 1983.
7. Lezak, M.D. Neuropsychological Assessment, New York: Oxford University Press, 1983.
8. Fuller G. The Minnesota Perceptuo-Diagnostic Test (Revised) Clinical Psychology, Monograph Supplement No. 28, July 1969.
9. Kaplan, J. and Hier, D.B. Visuospatial defects after right hemispheric stroke, A.M.J.O.T., 1982, 36:5, 311 – 321.
10. Slosson, R.L. Slosson Drawing Co-ordination Test, New York: Slosson Educational Publications, 1980.
11. Whiting, S., Lincoln, N., Bharnani, G., Cockburn, J., Rivermead Perceptual Assessment Battery – Manual, Windsor: NFER – Nelson, 1985.
12. Critchley, M. The Parietal Lobes, New York: Hafner, 1953.
13. Luria, A.R. Higher Cortical Functions in Man, New York: Basic Books, 1980.
14. Kolb, B. and Whishaw, I.Q. Fundamentals of Human Neuro-psychology, New York: W.H. Freeman, 1985.
15. Downie, N.M. and Heath, R.W. Basic Statistical Methods, New York: Harper International, 1974.
16. Botwinick, J. Neuropsychology of Ageing in the Handbook of Clinical Neurapsychology, Edited by Filskov, S.B. and Boll, T. New York: J. Wiley, 1981.
17. Klisz, D.K. Neuropsychological Evaluation in older persons in The Clinical Psychology of Ageing, Edited by Sterandt, M. Seigler, I.C. and Elias, M.F. New York: Plenium Press, 1978.
18. Schaie, K.W. & Schaie, J.P. Clinical Assessment and Ageing in the Handbook of the Psychology of Ageing, Edited by Birren, J.E. & Schaie, K.W. New York: van Nostrand Reinhold, 1977.
19. Farver, P.F. and Farver, T. "Performance of Normal Older Adults on Tests Designed to Measure Parietal Lobe Functions", A.M.J.O.T., 1982, 36: 7, 444-449.
20. Taylor, M.M. Analysis of Dysfunction in left hemiplegia following stroke, A.M.J.O.T., 1965, 22: 512-520.
21. Anderson, T.P. Bourestom, N., Greenberg, F.R., Hildyard, V.G. Predictive Factors in Stroke Rehabilitation, 1974, Arch. Phys. Med. Rehabil., 1974, 55: 545-553.
22. Lorenze, E.J. Cancro, R. Dysfunction in Visual Perception with hemiplegia: Its Relation to Activities of Daily Living, Arch. Phys. Med. Rehabil., 1962, 43: 514-517.
23. Rosenthal, A.M. Pearson, L. Medenila, B. Manaster, A. Smith, C.S. Correlation of Perceptual factors with rehabilitation of hemiplegic patients. Arch. Phys. Med. Rehabil., 1965, 46: 461-466.

RELIABILITY AND VALIDITY STUDIES ON THE DEVELOPMENTAL TEST OF VISUAL-MOTOR INTEGRATION

M.E. Concha

SUMMARY

The developmental Test of Visual Motor Integration (VMI) (1) is often used for the evaluation of perceptual function in adult brain injured patients although it was designed for evaluating visual motor function in children. The author obtained normative data on one hundred and sixteen normal individuals between the ages of twenty and seventy-nine years, so that adult function could be more appropriately assessed.

However, for a test to be valuable, it needs not only normative data such as percentile ranks against which patient performance can be judged, but it must also be shown to be a reliable and valid measure of the function that it purports to measure. Therefore it is essential to know how reliable and valid a test is. Reliability and validity studies were therefore carried out on the VMI.

The reliability co-efficients on the test with adults ranged from $r = 0,53$ to $r = 0,81$ which indicates a moderate degree of reliability in the measurement of visual-motor function. Inter-rater reliability was also demonstrated.

The validity studies examined the relationship of score to age and score to diagnosis and provided adequate information on the validity of the test as a measure of age-related changes as well as visual perceptual motor problems in the adult stroke patient. Examples of patient tests are used to confirm this validity. Content validity was provided by a group of fifteen occupational therapists.

M.E. Concha B.S.c (O.T.) Witwatersrand
Head, Department of Occupational Therapy
University of the Witwatersrand

The Developmental Test of Visual Motor Integration (VMI) by Keith Beery (1) was chosen as part of a battery of tests constructed by the author for the measurement of visual perceptual function in adult brain injured patients. The VMI provides a sequence of twenty four geometric forms which the subject is required to copy. Although specifically drawn up to provide a measure of visual-perceptual-motor function in children, the test has also been used for the evaluation of perceptual ability in adults although there are no normative data to provide a measure against which patient performance can be judged. The author therefore tested one hundred and sixteen normal individuals between the ages of twenty and seventy-nine years in order to determine whether increasing age influenced performance on this test and to obtain percentiles against which the ability of patients who had suffered a CVA, could be evaluated. The results of this study have been previoulsy presented and the percentiles provided (2). In essence this study demonstrated that the older age group (the sixty to seventy-nine year old group) made more mistakes on the test than did the younger age group (the twenty to fifty-nine year old group), a statistically significant difference in the raw scores obtained by the two groups being found.

The provision of normative data such as percentiles, against which patient performance can be measured, is not enough to convince the user of the value of a test. For a test to be useful it must be shown to be a reliable and valid measure of the skills that it purports to evaluate. This article therefore presents the results of the reliability and validity studies carried out on the Developmental Test of Visual Motor Integration on an adult population.

Reliability and validity are intimately linked to each other, the validity of a test being limited mathematically by the reliability of the test (3).

The reliability of a test refers to the "reproduce-ability" of a set of test results. Therefore a test that is highly reliable is one which will yield consistent results. Validity refers to the ability of a test to measure the skills that it is intended to measure (3).

METHOD

Subjects

The subjects used to obtain the data on which the reliability and validity studies of the VMI were carried out, were:

(a) one hundred and sixteen normal individuals between the ages of twenty and seventy-nine years. The details concerning their selection and composition are reported elsewhere (2).

(b) thirty three individuals who:- had suffered a right-sided CVA not more than six months prior to being tested; had received no occupational therapy testing or treatment for perceptual problems prior to the study; were orientated for person, time and place; consented to being tested and were between the ages of twenty and seventy-nine years.

Test Reliability and Validity

The raw scores obtained by the individuals tested were divided into two groups:

a) those scores obtained by the twenty to fifty-nine year olds (normal subjects = 79, patients = 17) and b) those obtained by the sixty to seventy-nine year olds (normal subjects = 38, patients = 16). These were the age groups between which statistical differences existed in the scores obtained by the normal group ($p<0.001$) (2).

Reliability and validity were calculated for each of these age groups.

Test Reliability

According to Tuckman (3), no measurement instrument gives a result that is a perfect reflection of the property being measured. If an individual is measured twice under the same conditions, identical measurements will not be obtained each time. *Reliability is the expression of the degree to which repeated measures on the test give consistent results.* However, when a test is administered many factors contribute to the error component of an individual's score e.g. fluctuations in concentration, emotional status and health of the individual taking the test. The smaller the error component and the degree to which these factors influence the score the more reliable is the test instrument.

Split-halves (a), Kuder-Richardson Formula 20 (b) and the inter-rater reliability (c) were computed in the study. Test-retest reliability was not determined as various conditions affect the technique and limit its effectiveness. Downie and Heath state that "At the present time, this method is infrequently used when determining the reliability of paper and pencil tests" (4;237).

In addition, an item analysis (d) was carried out. This was done to determine the effectiveness of each item in determining who can do well on the test and who cannot do well, thus the internal consistency of the test was examined.

a) *Split half reliability – In this method, the* scores for all the odd and even items were totalled separately and a Pearson Product Moment Correlation Co-efficient computed between the two sets of scores. The resulting reliability co-efficient was corrected for the shortening effect of splitting the test in half by using the Spearman Brown formula (4). This method provides a co-efficient of internal consistency.

b) Kuder-Richardson Formula 20 – This *method estimates reliability by comparing* scores on the test items themselves, in essence considering each item as test in itself thus providing a co-efficient of correlation (3).

c) Inter-rater Reliability – A test must not only *show reliability of results* within one testee but must be shown to be reliable if different people administer and score the test. That is, administration and scoring criteria must be such that the same individual tested by different people will yield the same results. Thus the correlation between the scores obtained by different examiners and scores was investigated.

- Reliability between examiners

  For this purpose, three examiners evaluated *the same six individuals. A random table was* drawn up by the statistician for the testing of the six individuals and a dice was used to determine which individual was to be seen by each examiner on the first occasion. The testing took place at the same time, and on the same day for three consecutive weeks. Freedman's two way analysis of variance was used to establish whether there was a difference in the scores obtained by the three examiners.

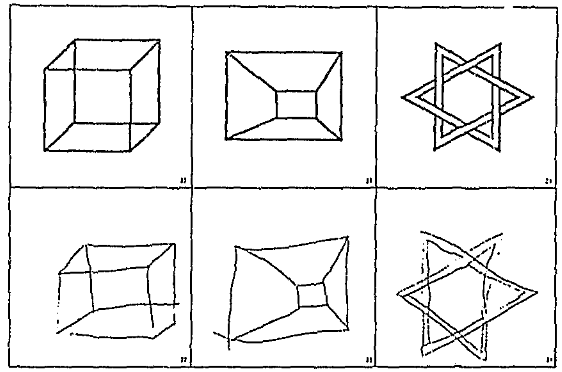


Fig. 1 Test of twenty year old CVA patient

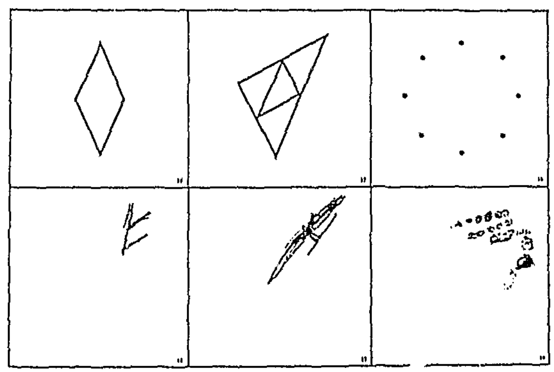


Fig. 2 Apraxia

This method was used in preference to the Correlation Co-efficient as analysis of variance is a more accurate way of determining differences.

- **Reliability between scorers**

  Due to the possible difficulty in scoring the VMI, (i.e. each item had to be carefully scrutinised to determine whether the individual completing the test met all the criteria for passing each item) inter-scorer reliability was sought.

  An independent occupational therapist was taught the scoring criteria for pass and fail on each item. Fifty-seven tests were randomly selected and scored by this therapist, these scores were compared with those obtained by the author using the test (5).

d) **Item Analysis** – this consisted of determining the discriminatory level of each item to determine whether the item could discriminate between those who did well in the test and those who did not do well. Two methods were used to evaluate the discriminatory level of each item i.e. testing the difference between two proportions and a correlation approach.

Testing for significant differences between two proportions was done by comparing the percentage or proportion of individuals who answered an item on the test correctly in the group obtaining high scores (i.e. upper 27%) with the proportion of individuals answering the item correctly in the group obtaining a low score (i.e. lower 27 %) (4). Fisher's Exact Test was used for this purpose. If the difference was significant, then the item was accepted as one which discriminates.

In contrast, the correlation approach shows the relationship of the responses to the total test score using the correlation co-efficient i.e. "it shows how well the item is doing what the test itself is doing" (4: 261). Flanigan's method of reading the estimated biserial co-efficient of correlation between the item and the total test score where the item has been restricted to the lowest and highest 27% of the total score distribution, was used. As Flanigan's is often taken as an estimate of the Pearson r, the significance of the Pearson r was used to test the significance of Flanigan's r (4).

Test Validity

Test validity refers to the ability of a test to measure what it is intended to measure (3) and was important in determining the suitability of the test for the measurement of function in the adult patient. Two types of validity were examined i.e. content (a) and construct (b)

a) **Content validity** – Huysamen (6) states that content validity should be sought by obtaining the opinion of experts in the field regarding the content of the test. In this instance the test was administered to fifteen occupational therapists who were asked to rate the test on a 0-5 scale according to how well they found the test measured nine defined skills. On this scale, zero indicated that a test did not evaluate a particular skill, whereas five indicated that a test evaluated a particular skill extremely well. A mean score of 3,75 or more indicated that the test was a very much better than average assessment of the defined skill as this was the upper quartile of the range of scores. A mean score of 2,5 or more indicated a better than average assessment of the defined skill as the score was greater than the mean and also the median value.

The fifteen Occupational Therapists had been trained in the field of perceptual testing and treatment and had more than one year's experience in this area.

b) **Construct Validity** – This refers to the extent to which the scores of a test correlate with other scores to which it can be expected to be related (3). The following relationships were investigated:- the relationship of score to age, score to diagnosis, the relationship of the VMI to other tests in the battery (4).

- **The relationship of score to age** was evaluated to determine whether the VMI was a valid differentiation of the performance ability of different ages.
- **The relationship of score to diagnosis** was investigated by comparing the scores obtained by the CVA patients with those of the normal group. This was done to determine whether the *Developmental Test of Visual Motor Integration* could determine visual-perceptual-motor dysfunction in this type of patient. The Welch Test was used to establish whether there were statistically significant differences between the scores obtained by the patients and the normal group.
- **The Relationship of the VMI to other Tests in the battery** – A correlation matrix between all the tests in the Visual-Perceptual-Motor (V-P-M-) Battery was constructed. The other tests are described in a previous article (8). A factor analysis was then carried out to determine the practical validity of the test. A test is said to have practical validity if it seems to be a good measure of some dimension that has

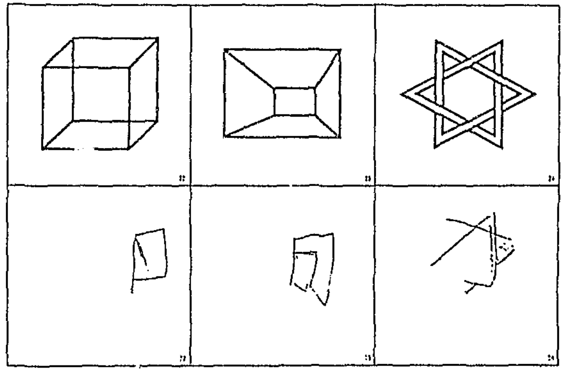


Fig. 3 Test of sixty year old CVA patient

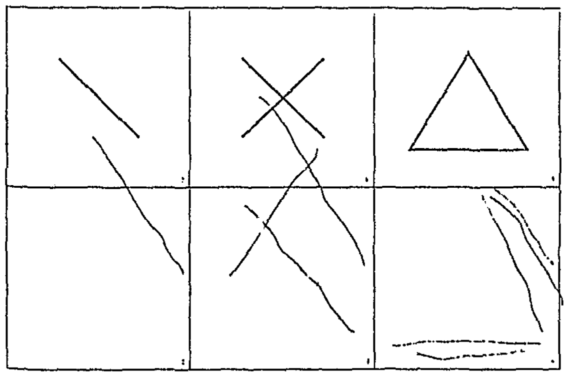


Fig. 4 Problems in overall contour

TABLE I - ITEM DISCRIMINATION

	DIFFERENCE BETWEEN TWO PROPORTIONS		CORRELATION APPROACH	
	Fisher's Exact Test		Flangan's r	
Item no.	*20-29 yrs*	*60-69 yrs*	*20-59 yrs*	*70-79 yrs*
1-7	No discrim.	No discrim	No discrim	No discrim
8	0,3433	0,0325*	,57***	,73***
9	No discrim.	No discrim.	No discrim.	No discrim.
10	0,6060	0,4737	,52***	,51***
11	1,0	0,5820	,09	,40**
12	0,0002***	0,0055**	,78***	,70***
13	No discrim.	No discrim.	No discrim.	No discrim.
14	0,1069	No discrim.	,55***	No discrim.
15	0,0670	0,0198*	,68***	,63***
16	0,000***	0,0198*	,78***	,63***
17	0,3433	0,0108*	,51***	,74***
18	No discrim.	0,4737	No discrim.	,51***
19	0,0014**	0,0198*	,72***	,63***
20	0,000 ***	0,1698	,82***	,42**
21	0,0122*	0,0055*	,45***	,70***
22	0,0013**	0,0698	,69***	,51***
23	0,6965	0,0573	,30*	,56***
24	0,0000***	0,0007**	,68***	,84***

*$p<0,05$ **$p<0,00$ ***$p<0,001$

been isolated or identified through a factor analysis (7). The name of the factor is dependent on the subjective judgement of the *reseacher who inspects* the nature of the tests loading on the same factor and labels the factor accordingly. (5).

In this study an exploratory analysis was carried out therefore no marker variables were included.

RESULTS

Reliability

- Split-half reliability studies on the results obtained from the normal group of individuals provided a correlation co-efficient of $r=0,72$ for the age group twenty to fifty-nine years and $r=0,81$ for the age group sixty to seventy-nine years. Beery (1) reported split-half correlations on children that ranged from $r=0,66$ - 0,93 with a median of $r=0,79$.

- The Kuder Richardson Formula 20 provided correlations fo $r=0,53$ for the age group twenty to fifty-nine years and $r=0,69$ for the older age group.

Reliability co-efficients for the VMI therefore ranged from $r=0,53$ to $r=0,81$ with a median of 0,705. This would indicate a moderate degree of correlation between the items on the test and a borderline level of acceptable reliability. It is interesting that the reliabilty co-efficients are higher in the older age group.Taking out those items that are too easy, and those that show no ability to discriminate between those who can do the test and those who cannot do the test, should improve the reliability.

- **Inter-Rater Reliability** - no statistical difference was found between the results obtained by each of three examiners on six individuals ($p=0,7470$) or between the two scorers of the tests ($p=0,3092$). The test could therefore be said to have both inter-examiner and inter-rater reliability.

- **Item Discrimination** - Table I lists each item together with the degree of difference in performance found between those individuals obtaining an overall high score and those obtaining an overall low score. This is shown for the normal group completing the test. Flanigan's r used in the correlational approach is not as reliable as the Fisher's Exact test used *for testing differences between two proportions*. The discrimination level obtained for each item by testing for differences between proportions is *therefore a more accurate way* of determining the discriminative ability of the item. In the case of the VMI test for adults, items 1-7, *9*, 13, *14*, *18*, *and 23 have little or* no discriminative ability and therefore should be eliminated from any further version of the test.

TABLE II - CONTENT VALIDITY OF THE VMI

PERCEPTUAL SKILL	MEAN RATING
Form as mass	1,6
Overall contour of form	3,9***
Sub-units of form	2,4
Perceptual constancy	0,86
Colour	0
Directionality	2,9***
Space relationships	2,6**
Position in space	2,0
Figure ground	1,3

Median/mean 2,5 = average ability to evaluate patient's skill
** <2,5 = *better than average* ability to evaluate patient's skill
***Upper quartile <3,75 = very much better than average ability to evaluate patient's skill

Validity

- **Content Validity** - The VMI was shown to be a very much better than average test of evaluating overall contour (a mean score of 3,9 being obtained on the therapist's rating) and a better than average method of evaluating directionality (mean = 2,9) and spatial re*lationships* (mean = 2,6) with a motor base. The VMI could therefore be said to be a valid method of evaluating visual motor inte*gration in the field of* overall contour of form (Table II) in the opinion of the occupational therapists.

- **Construct Validity**
i) The relationship of score to age has already been discussed (2) but the VMI does appear to be a valid means of determining age related changes in visual-perceptual-motor function.
ii) The relationship of score to diagnosis, that is, perceptual problems in patients with a right hemisphere lesion. For both the younger and the older group of patients there *was* a statistically significant difference between the scores obtained by the normal individuals and those obtained by the patients *(see Table III)*. It is interesting to note that the differences achieved greater significance in the younger group. This could be due to the *fact that there is a natural* decline in perceptual ability in the elderly, therefore brain damage does not have the same consequences *for perceptual function in* the older patient as it does in the younger patient. The tests completed by the patients were examined to es*tablish the type of dysfunction* demonstrated:
a) The younger patient's problems in executing *the tests (see fig.1) are not* as obvious as those observed in the older age group (see fig. 3).
b) *Adults between the ages of forty and* sixty-nine years showed a high incidence of the type of errors that could indicate apraxia (see fig. 2).

TABLE III - *DIFFERENCES* BETWEEN ACCURACY SCORES OBTAINED BY PATIENTS AND NORMAL SUBJECTS - VMI

AGE GROUP	p VALUE
20-59 years	$p=0,0000$***
60-69 years	$p=0,0003$***
	***$p<0,001$

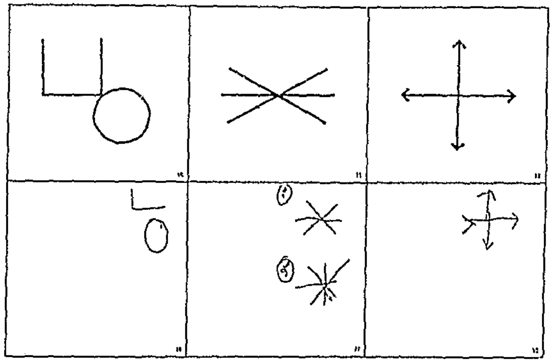


Fig. 5 Problems of directionality

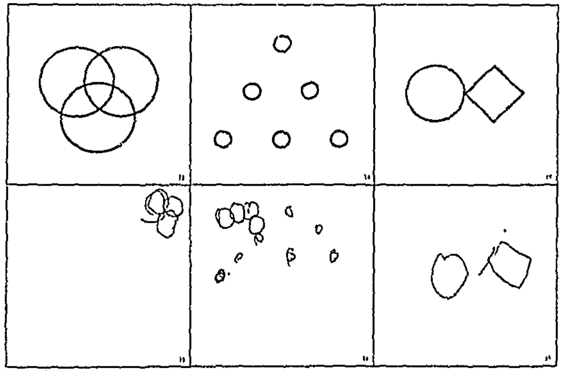


Fig. 6 Problems with spatial relationships

c) *The test of visual motor integration* was administered for the specific purpose of evaluating the skill of "overall contour" i.e. the subject is required to analyse the elements that make up the form and to reproduce these to form an outline. A patient's inability to do this is *illustrated in fig.4.*

d) The VMI was said to be a better than average measure of directionality as rated by the fifteen occupational therapists. *Problems with the ability to plan* the correct directional orientation of lines are seen in Fig. 4 and 5.

e) The VMI was said to be a better than average measure of *the ability to detect spatial relationships* among stimuli as rated by the fifteen occupational therapists. Problems with determining spatial relationships among the constituent parts are illustrated in Fig. 6.

f) Constructional apraxia in the field of drawing is clearly illustrated in *Fig. 2* which demonstrates *perseveration.* The VMI requires a high level of visual perception and motor planning and therefore is suitable for *evaluating the presence of a drawing* apraxia.

iii) The relationship of the VMI *to other tests* in the battery - the exact results of the factor analysis are not reported here as an understanding of the results is dependent upon *knowledge of the other* test in the battery. It however appears that the VMI forms part of a group of tests that measures *constructional and spatial ability as defined* by the author.(8)

CONCLUSIONS

The Development Test of Visual-Motor Integration was found to be a valid measure of age-related changes in perceptual functions as well as a measure of *function in CVA patients.* Thus construct validity was established. Content validity was adequately established by fifteen occupational therapists. It was also *proved possible to diagnose* various perceptual problems through qualitative analysis of the drawings made by the pat ents.

The ability of the test to provide consistent scores within an individual varied although reliability on the whole was at a reasonable level. This should *improve* once those items that do not discriminate between good and bad performance are removed. The test was shown to have *inter-rater (administrator)* and inter-scorer reliability.

It seems therefore that the VMI, although constructed to measure function *in children, is also a reasonably valid and reliable* method of measuring function in the adult. There are currently no tests normative on South African population data which are available to the occupational therapist for measuring perceptual function in the adult. The VMI should prove a useful clinical test and *should help in directing* therapy more appropriately. The clinical diagnosis of various problems should prove helpful in this respect.

REFERENCES

1. *Beery,* K.E. Development Test of Visual Motor Integration, Chicago: Follet Publishing Co. 1982.

2. Concha, M.E. Adult Performance on the Development *Test of Visual Motor* Integration, South African Journal of Occ. Therapy: 16:1, 11-19, 1986.

3. Lyman, H.B. Test scores and What They Mean, Englewood *Cliffs: Prentice* Hall, 1971.

4. Downie, N.M. and Heath, R.W. *Basic Statistical Methods;* New York: Harper and Row, 1974.

5. Afifi, A.A. and Azen, S.P. Statistical Analysis: A Computer Oriented Approach, New York: Academic Press, 1959.

6. Huysamen, A.K. Psychological Test Theory, distributed by Uitgewery *Boschendal,* 1980.

7. Allan, J.C. Learning about Statistics, Johannesburg: *Mac Millan South Africa,* 1982.

8. Concha, M.E. Testing *Procedures for the Delimitation* of Visual Perceptual Problems in the Adult CVA patient. Procedings of the Congress of the World Federation of Occupational Therapists Hamburg, Germany, 1982.

9. Concha, M.E. A *Review* of Apraxia, British Journal of Occupational Therapy: 50:7, 222-226, 1987.

☆ ☆ ☆ ☆ ☆

THE DIAGNOSIS OF SPATIAL PROBLEMS IN A GROUP OF RIGHT HEMISPHERE CVA SUBJECTS

M.E. Concha

ABSTRACT

Spatial problems in adult patients are difficult to deliniate on account of the normal changes which occur during the ageing process. This difficulty is enhanced by the different terms used in the literature to describe adult dysfunction.

This article is based on a study aimed at the classification of spatial problems and the development of visual-perceptual-motor tests which take into account the normal ageing process. These tests are then used in the evaluation of problems in adult CVA patients. The clinical features of spatial dysfunction are also discussed.

To determine if the tests were useful in the diagnosis of spatial problems they were administered to 118 normal individuals whose ages varied from twenty to seventy nine years, and twenty seven CVA patients in the same age group.

Statistical analysis of the test results of normal individuals indicated that three of the four tests were sensitive to the changes that occur in spatial function with increasing age, a drop in the function occurring at approximately 60 years of age. All tests showed a statistical difference between the scores obtained by the younger normal subjects and the younger patients. Reliability of the tests varied between $r = 0,43$ and $r = 0,92$. Content validity was established for three out of the four tests.

M.E Concha
Head, Occupational Therapy Department
University of the Witwatersrand

INTRODUCTION

Critchely (1953) states that Spatial Disorientation as a syndrome is difficult to delineate due to the fact that different terms are used to describe a single problem. Thus, poor localisation of stimuli in space, right-left confusion, constructional apraxia, amnesia for routes and locations, poor drawing and impaired performance on tests of mental transformations, are some of the terms used to describe spatial problems.

This study was therefore aimed at providing a definition and classification of spatial constructs which were used in the compilation of a visual-perceptual-motor (V.P.M.) battery of tests to be used for the measurement of function in the adult.

The battery of tests is in a preliminary form having undergone the following stages of development:-

1. Review by experts in the field to determine the construct validity.
2. Collection of data on a pilot group normal individuals between the ages of twenty and seventy nine years and a group of CVA patients in the same age category. This was done to determine whether the tests were sensitive to perceptual decline with age and perceptual problems in CVA patients.
3. Compilation of validity and reliability data as well as the analysis of individual items to help in the final compilation of a useful test.

For the purpose of this study, spatial disorientation was defined as a defect that interferes with the ability to determine, through vision, the position and relationship of objects or points in space in relation to oneself.

The components of spatial perception were divided and classified according to the three categories described by Kolb and Whishaw (1985). The first category is that of **BODY SPACE** which involves the localisation of parts of the body. This aspect of space function will not be discussed here due to its reliance on an intact somato-sensory system rather than the visual system. The second category is that of **GRASPING SPACE** (or subjective space) which refers to the space around the body in which objects can be seen and sometimes touched and manipulated. The visual system and the manipulation of objects with the hands is important in the exploration of the space within this sphere and in the development of the spatial concepts of subjective space. Through the course of development, spatial constructs although originating in three dimensional forms become transposed to be represented by two dimensional constructs. Responses to this type of space construct make use of visual cues. Dysfunction results in the inability to use cues which are presented in both three and two dimensional form.

The third category of space is **ACTION SPACE** (distance or objective space) i.e. space outside of the immediate environment in which the subject is required to perform mental manipulations of space constructs. Visualisation is a key function of action space. Space visualisation is often represented in two dimensional way e.g. map drawing. The types of dysfunction seen in this group of spatial constructs is firstly that of topographical orientation i.e. the inability to perceive and remember the location of objects and places in space, and secondly, the inability to manipulate spatial concepts in the mind without concomitant physical manipulation of objects. However, evaluation of this space construct often of necessity involves the manipulation of objects.

Tests standardised for adults such as the Standardised Road Map Test of Directional Sense (Money 1976) aspects of the Rivermead Perceptual Assessment Battery (Whiting et al 1985) and drawing tests such as the Bender - Gestalt (Bender 1938), and Reys Complex Figure Test (Lezak 1983) in which spatial function can be measured, are available. However, the tests are divergent in their standardised data and it was found to be difficult to evaluate all the spatial constructs mentioned above. Many tests exist for the measurement of function in children but were felt to be inappropriate for use in adult testing. Thus new tests were constructed for the functions previously named.

STUDY METHODS

ASSESSMENT

The Battery of Tests *consisted of the following:-*

1. In the sphere of **GRASPING SPACE** two tests were constructed, a motor free test and a test requiring a motor response. This was done in an attempt to distinguish between apraxia and a purely spatial perceptual problem.

   The motor free test was labelled the Space Relations Test and is a multiple choice test in which the subject is required to indicate the figure in a sequence of five that has components that hold the same relationship to each other as the example provided (see Figure 1). The test requiring motor ability is a block construction test (Block Construction I) in which the subject is required to build a construction of blocks identical to a three dimensional model constructed by the examiner.

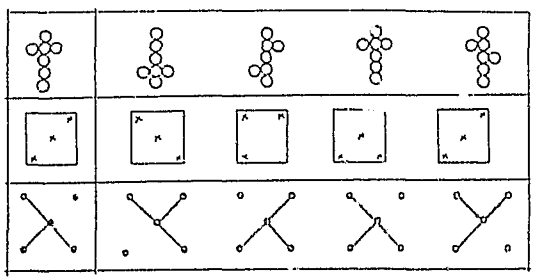


Figure 1 – Space Relations Test

2. In the sphere of **ACTION SPACE** two tests were also constructed, a motor based block construction and a motor free test for the same reason as that described above. Both tests required the skills of mental rotation, revisualisation and spatial orientation. The motor free test was called The Position In Space Test and is a multiple choice test, in which the subject is required to rotate the designs in his mind to find the design matching the example (see Figure 2). The Block Construction II Test required the subject to transpose a two dimensional drawing into a three dimensional construct. Topographical orientation as not included due to the difficulty in providing standardised measures of individual experience.

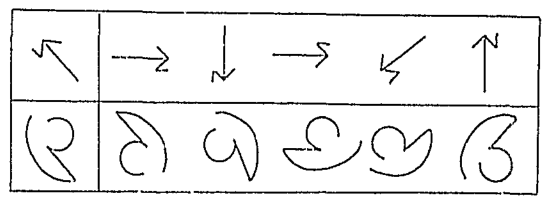


Figure 2 – Position In Space Test

THE SUBJECTS consisted of two groups of individuals i.e.

1. A normal group of 118 subjects aged between twenty and seventy nine years (see Table I). Of the 118 subjects 39 were male and 79 female. The test, were administered to this group in order to verify if age related changes were evident in the performance on the test and to provide data against which patient performance could be compared.

   Criteria for inclusion were that the subjects:-
   - were between the ages of twenty and seventy nine years.
   - had no history of neurological disease or disorder or of a psychiatric disorder.
   - had had seven years of primary school and had been promoted to high school.
   - understood English.
   - gave consent and were willing to co-operate with testing procedures.
   - were caucasian.
   - had no visual problems that could not be compensated for with spectacles.
   - were completely independent in activities of daily living and in the management of their lives.

   The population was drawn from two retirement villages (one in a low socio-economic section of the population and one in a more affluent one) and the relatives accompanying patients to the out-patient facility of the Johannesburg General Hospital which serves a cross section of the city's population.

2. A patient group consisting of right hemisphere stroke patients in the same age range. The numbers of patients varied on each test, the total number tested being 27. Seven patients were unable to do the Position in Space test and three the block construction tests. Unfortunately zero scores were not included for those patients (See Table I).

Table I: Number of subjects per age group

AGE	SR		AGE	PIS	
	Normal	Patient		Normal	Patient
20-69	98	24	20-59	79	13
70-79	20	3	60-79	39	7
	n = 118	n = 27		n [illegible]	n = 20

AGE	BCI		AGE	BCII	
	Normal	Patient		Normal	Patient
20-69	79	22	20-79	118	24
70-79	39	2			
	n = 118	n = 24		n = 118	n = 24

Patient criteria for inclusion in the study were that they:

- had suffered a right hemisphere stroke and had received no prior occupational therapy testing or treatment for visual perceptual function
- were orientated for time, person and place and had completed the bed rest phase of treatment and were able to sit up in a chair without tiring for at least two hours.
- had suffered a stroke no more than six months prior to testing.
- were caucasian and gave consent.
- used spectacles (if prescribed) during testing.

The patient group was drawn from the in and out patient attendance of CVA patients at the Johannesburg General Hospital. The patient data was used to determine whether the tests were useful in the diagnosis of spatial problems.

The subjects were introduced in to the study in the order in which they became available for testing.

PROCEDURE

The normal group of individuals was evaluated by three testers after inter-rater reliability had been established. The patients were evaluated by the author. The results were analysed by the Medical Research Council, S.A.

The test results of the normal group were used to:-

1. determine whether there were age differentials in the scores obtained.
2. compile percentile ranks in the age categories between which no statistical difference was found. Percentiles were used to provide a measure against which the performance of the patients could be judged.
3. determine the validity and reliability of the test to help in the compilation of the final test form.

STATISTICAL ANALYSIS

The results of testing were analysed in the following ways:-

1. The mean accuracy scores obtained by the normal men and women within each group were compared using the U test of Mann Whitney for unequal sample size. As no statistical difference occurred in the scores, they were combined for all future analyses.
2. The mean and SD of the accuracy scores was calculated for each normal age group. (See Table II).

Table II: Mean and SD for accuracy scores on space tests – Normal group

AGE	SR		PIS		BCI		BCII	
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
20-29	38,25	2,05	72,25	28,30	11,90	0,31	10,90	1,52
30-39	38,10	2,86	71,38	24,61	11,38	1,07	10,38	1,86
40-49	38,21	2,20	65,21	18,54	11,90	0,32	9,84	2,12
50-59	38,47	2,37	64,17	22,08	11,53	0,70	9,90	2,28
60-69	38,47	1,95	40,94	23,63	11,37	1,30	9,86	2,87
70-79	35,50	4,76	25,95	25,22	10,95	1,23	8,30	3,03

3. The data obtained above was skewed as determined by the co-efficient of skewness. Therefore, non parametric statistics were used to determine if there was any difference in the performance of the elderly group from that of the younger group. Thus value counts were performed and 2x2 tables constructed in which the figure equal to and less than the 50% level of accuracy of each test was calculated. When the minimum expected value was equal to or greater than 5, then the chi-square test was used after applying Yates Continuity Correction (Afifi and Azen 1959). If the minimum expected value was less than 5 then Fischers Exact probabilities were calculated. If the null hypothesis of no significant difference among the age groups was rejected, further analysis was conducted to determine if each group differed from the other, or if two of them were similar both differing from the third. According to the differences found, the data was regrouped.

In the case of the space relations test and the Block Construction Test I, a drop off in function occurred at approximately 69 years of age (see Table III). The drop off in function occurred within the 50 year old group in the position in space test. Contrary to expectations there was no change in the performance of the elderly on the Block Construction II test.

Table III: Differences in scores obtained by normal subjects per age group

TEST	AGE GROUP	P VALUE
SR	20-69 years & 70-79 years	0,0026**
PIS	20-59 years & 60-79 years	0,0000***
BCI	20-69 years & 70-79 years	0,0124*
BC II	20-79 years	6,916

* $P<0{,}05$ ** $P<0{,}01$ *** $P<0{,}001$

Percentile ranks were calculated from the normal scores to make it possible to compare individual patient performance with that of the normal group and thereby to establish the patient's level of function.

4. To determine whether the accuracy scores obtained by the normal group and the patient group differed statistically from each other, one way analysis of variance was employed. The Levine Test for equal variance was first used to establish whether the variance differed between the two groups. If the Levine Test showed no signi-

CCLXXVIII.

ficant difference the F Test was used to determine whether there was a statistical difference between the mean scores obtained by each group. If the Levine Test was significant, the Welch Test for unequal variance was used. The normal subjects and the patients were grouped for the purposes of this analysis according to the ages within which no difference was found in the scores obtained by the normal population. A significant difference between the scores obtained by the patients and the normal group within the younger i.e. 20-69 years in the case of the Spatial Relations test and 20-59 years in the case of the Position in Space test was found. The differences between the patients and the normals in the older group i.e. 70-79 years was not calculated due to an insufficient number of patients (see Table IV).

Table IV: Differences between patients and normal subjects on the space tests of the V-P-M Battery

TEST	AGE GROUP	P VALUE
SR	20 - 69 years	0,0000 ***
PIS	20 - 59 years 60 - 79 years	0,0000 *** 0,3286
BC I	20 - 69 years	0,0068 **
BC II	20 - 79 years	0,0116 *

* P<0,05 ** P<0,01 *** P<0,001

Table V: Reliability Studies

	SR	PIS	BC I	BC II
Split Half	0,61 ***	-	0,43 **	0,73 ***
Kuder-Richardson	0,92 ***	-	0,73 ***	0,86 ***

*** P<0,001 ** P<0,01

Table VI: Content Validity

	SR	PIS	BC I	BC II
Grasping space/spatial relations	3,3 *	2,9	3,66 *	3,73 *
Action space/position in space	1,6	3,70 *	1,1	1,1

* An adequate measure of the defined function.

5. The reliability of the tests were studied through the Kuder Richardson Formula 20 and the Split Half reliability, using the data from the normal individuals. Test re-test reliability was not determined as various conditions affect the technique and limit its effectiveness (Downie and Heath 1974). The results of the reliability studies can be seen in Table V. The reliability of the tests varied from r = 0,43 to r = 0,92. All reliability co-efficients were however significant at the P<0,01 level. The reliability studies mentioned could not be carried out on the position in space test as this is a timed test and therefore not all the items are completed in every case.

   Inter-rater reliability was established by comparing the results of three examiners testing the same six individuals. Friedman's two way analysis of variance showed that there was no statistical difference in the accuracy scores obtained by these examiners. The test could therefore be said to have inter-rater reliability. Friedman's two way analysis of variance was chosen as it provided a more accurate method of determining consistency between testers than the more conventional Pearson Correlation Co-Efficient (Allan 1982).

   In addition an item analysis was conducted to give additional information on the internal consistency of the test. Due to a lack of space these results will not be reported here.

6. To determine content validity a method proposed by Huysamen (1980) was used i.e. the content of the test was evaluated by fifteen experts in the field. These expert occupational therapists rated the appropriateness of the test for the perceptual functions as defined. A scale of 0-5 was used where a score of 5 meant that the test was an excellent measure of the described function (see Table VI). A mean score of 3,75 and above would fall in the upper quartile of the range 0-5 and would indicate that the test was a better than average assessment of the perceptual ability mentioned.

   The results showed that the therapists rating of three of the tests indicated that the content as a valid measure of the skill that it was constructed to measure. However, the block construction II test, although constructed to measure action space, was rated as a measure of grasping space.

7. Discriminative validity was determined through assessing the diagnostic value of the tests i.e. the clinical features of patient test results were examined.

THE RESULTS

It can be seen from the foregoing that:-

All but the Block Construction II test were able to differentiate the performance of the elderly individual from that of the younger normal individuals. This would confirm the findings of other workers (Horn and Cattell 1966, Hayslip and Sterns 1979 and Botwinick 1981). Studies have shown that older adults tend to score less well in tests of perception than younger adults. Several investigators have noted a similiarity in the performance deficits of normal older pepole when compared to those of patients with right hemisphere damage (Klisz 1978, Farver and Farver 1982 and Concha 1984).

Schaie and Schaie (1977) remind us that although tests of old people may look like those of right hemisphere patients, they do not necessarily reflect right hemisphere dysfunction. It seems that the normal ageing process depresses skills that are integrative and sensory perceptual in nature and involve speed of response. It is therefore important to note that perceptual changes do not always result in functional deficits, hence the apparent disagreement among researchers investigating the links between perception and activities of daily living. Some studies have indicated a correlation between visual perceptual defects and self care status (Lorenze and Cancro 1962, Anderson et al 1974, Feingonson et al 1977 and Titus et al 1991) whereas some have indicated that there is no relationship (Rosenthal et al 1965 and Taylor et al 1971). The functional relationship between perceptual dysfunction and activities of daily living in the adult undoubtedly needs to be pursued using tests that are sensitive to the normal ageing process.

Scores on tests are indicative of dysfunction when normative data are used for comparative purposes. In this study percentiles were used for this comparison. However, the occupational therapist also needs to analyse and compare the results of test performance on the different tests to determine the type of failure occurring (discriminative validity).

Barton (1979), Benton (1969), Critchley (1953) and Luria (1980) have enumerated the features of spatial problems in drawing and construction tests which are a help in diagnosis. Examples of these features in relation to the tests discussed are:-

Grasping Space

- Constructions and drawings are crowded into a corner.
- Horizontal constructions become oblique.
- There is a poor and inaccurate placement of a component in a construction with relation *to another component (see Figure 3)*
- There is an inability to correctly orientate the blocks as represented in the 2 dimensional drawing as well as rotation of components or the entire design (Figure 5).

As the space relations and the position in space tests are multiple choice tests, problems can only be diagnosed through the scores obtained. However, comparison between the motor free and motor tasks can help in the diagnosis of a *constructional apraxia.*

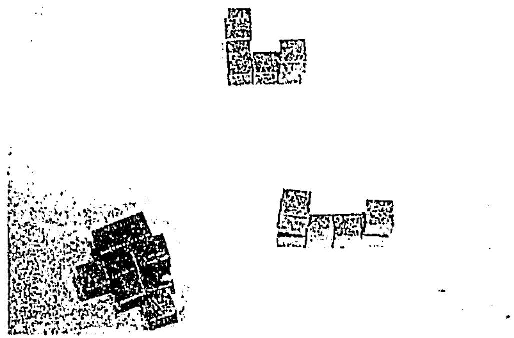


Figure 3 – Grasping Space: Inaccurate Placement of Components

- There is inaccurate intersection of co-ordinants in construction tasks.
- Blocks are added or omitted from the construction.
- The task is tackled in a piecemeal manner and not visualised as a whole.
- Construction is completed through trial and error i.e. the design is not viewed as a whole.

Action Space

- There is a confusion of planes.
- There is abnormal representation of perspective and depth (Figure 4 a and b) and abnormalities of relative size and articulation.

The question that needs to be answered is whether the spatial skills of grasping space and action space are hierarchical in nature i.e. does skill in grasping space form the basis upon which skills in action space are built? Will problems in grasping space automatically cause problems in an action space? According to De Ajuriaguerra and Tissot (1969), grasping space or subjective space develops in the child before that of action or objective space.

In analysing the difference in the performance between the motor free and motor tests, it was observed that twelve patients performed below the 15th percentile and therefore could be said to perform outside the normal range of function of both types of task. Seven of these patients

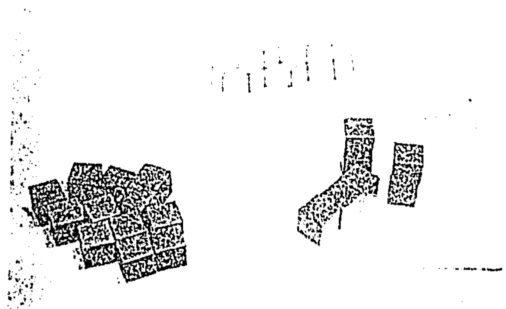


Figure 4 a – Action Space: Abnormal Representation of Perspective and Depth

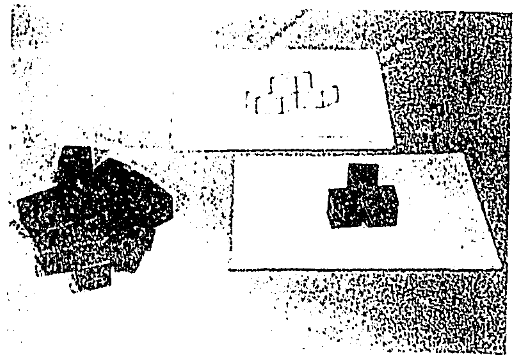


Figure 4 b – Action Space: Abnormal Representation of Perspective and Depth

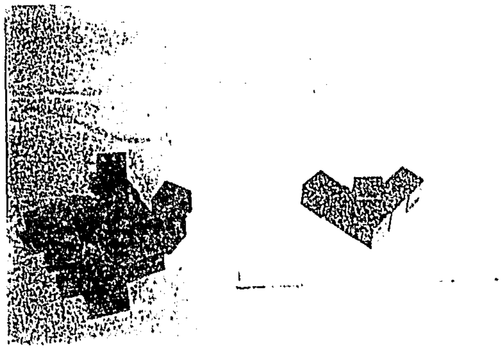


Figure 5 – Action Space : Rotation of the Design

were thought to be apraxic due to the types of mistakes they made. These mistakes have been previously described (Concha 1987)

Three patients performed below the 15th percentile on motor free spatial tasks but within normal limits on the construction tasks. These patients could therefore be said to have a problem of space visualisation which improved with object utilisation i.e. in the field of action space but not grasping space

Only one patient performed below the 15th percentile on the construction tasks but within normal limits on the motor free tasks. Although unusual to find a constructional apraxia without concomitant space problems, it was felt that this patient's problems were more in the field of a constructional apraxia as many of the symptoms of apraxia were present.

Five of the patients performed well above the 15th percentile on all the spatial tests, they were therefore felt to have no spatial problems.

The fact that all the patients who failed the space relation test also failed the position in space test seems to indicate that the hierarchical nature of the skills was in operation in the motor free space tasks. This pattern was not apparent in the block construction tests as 52% of the patients passed both tests, 22% failed both and an equal number failed one or the other. This may be due to the poor content validity found on the Block Construction II test.

CONCLUSIONS

It is important for the therapist to realise that there is a normal decrease in perceptual function with age and thus to be able to determine the difference between normal and abnormal function before therapy can take place.

In addition it is also helpful in the selection of activities for treatment if the therapist is able to make the distinction between problems of grasping space and action space as well as between those problems that include motor output and those that do not

However, as previously concluded analysis of test taking behaviour as well as the comparison of scores with normative data needs to take place before the type of spatial dysfunction can be diagnosed. For the V-P-M battery to provide a satisfactory method of doing this the construction tests need to be revised

The importance of isolating space visualisation tasks which involve more "thinking" than "doing" skills cannot be overemphasised. Our movements without our environment are dependent upon space visualisation and very little information is available on this skill in the literature. In addition it is often neglected in therapy.

This preliminary study has indicated the shortcomings of the test constructed for the purpose of evaluating spatial skills. Alterations need to be made and extensive normative data collected for the test to become a useful tool for the diagnosis of different types of spatial function.

REFERENCES

Afifi, A.A. and Azen, S.P. **Statistical Analysis: A Computer Orientated Approach** New York. Academic Press, 1959.

Allan, J.C. **Learning about Statistics** Johannesburg: MacMillan, 1982.

Anderson, E., Bourestom, M., Greenberg, F.R., and Hilyard, V.G. Predictive Factors in Stroke Rehabilitation **Arch Phys Med Rehabil** 1974; 55(12) . 545-553.

Barton, A. Visuoperceptive, Visuospatial and Visuoconstructive Disorders. In K.M. Heilman and E. Valentin **Clinical Neuropsychology** New York: Oxford University Press, 1979.

Bender, L.A. A Visual Motor Gestalt Test – Its Clinical Use **American Orthopsychiatric Association Research Monograph** 1938, No. 3.

Benton, A.L. Disorders of Spatial Orientation. In P.J. Vinkun and G.W. Bruyn (Ed) **Handbook of Clinical Neurology** New York: John Wiley, 1963.

Botwinick, J. Neuropsychology of Ageing. In S.B. Filster and J. Bool (Ed) **Handbook of Clinical Neuropsychology** New York: John Wiley, 1981.

Concha, M.E. Adult Performance on the Developmental Test of Visual Motor Integration **South African Journal of Occupation Therapy** 1984; 16(1) 11-19.

Concha, M.E. A Review of Apraxia **British Journal of Occupational Therapy** 1987, 50(7) : 222-226

Critchley, M. **The Parietal Lobes** New York. Hafner, 1953

Downie, N.M. and Heath, R.W. **Basic Statistical Methods** New York. Harper and Row, 1974

De Ajuriaguerra, J. and Tissot, R. The Apraxias. In P.J. Vinkun, G.W. Bruyn (Ed) **Handbook of Clinical Neurology** Amsterdam. North Holland Publishing Co. 1969

Farver, P.F., and Farver, T. Performance of Normal Older Adults on Tests Designed to Measure Parietal Lobe Function **American Journal of Occupational Therapy** 1982; 36(7) : 444-449.

Feingenson, J.S., McDowell, F.H., Meese, P., McCarthy, M.L., Greenberg, S.D. Factors influencing outcome and length of stay in a Stroke Rehabilitation Unit, Part I **Stroke** 1977; 8(6) : 651-656.

Hayslip, B and Sterns, H.L. Age Differences in Relationships between Crystallised and Fluid Intelligence and Problem Solving **Journal of Gerlantology** 1979, 34(3) : 404-416.

Horn, J.L., and Cattell, R.M. Age Differences in Primary Mental Abilities Factors **Journal of Gerlantology** 1966; 22(2) : 210-220.

Huysamen, G.K. **Psychological Test Theory** Cape Town: National Book Printers, 1980.

Klisz, D.K. Neuropsychological Evaluation of Older Persons in M Storandt, I.C Siegler, and M.F. Elais (Ed) **Clinical Psychology of Ageing** New York: Plenum Press, 1978.

Kolb, B. & Whishaw, I.G. **Fundamentals of Human Neuropsychology** New York: W.H. Freeman & Co. 1985

Lezak, M.D. **Neuropsychological Assessment** New York: Oxford University Press, 1983.

Lorenze, S.J., and Cancro, R. Dysfunction in Visual Perception with Hemiplegia : Its Relation to Activities of Daily Living **Arch Phys Med and Rehabil** 1962 43(10) : 514-517.

Luria, A.R. **Higher Cortical Functions** New York. Basic Books, 1980.

Money, J.A. A Standardised road Map Test of Directional Sense Academic Therapy Publications, 1976.

Shaie, K.W. and Schaie, J.P. *Clinical Assessment of Ageing* in J E. Birren and K W. Schaie (Eds) Handbook of the Psychology of Ageing New York: Van Mostrand, 1977.

Rosenthal, A.M., Pearson, L., Modinila, B., Manaster, A., Smith, C.S. Correlation of Perceptual Factors with Rehabilitation of Hemiplegic Patients Arch Phys Med Rehabil 1965; 46 : 461-466.

Taylor, M M., Schaeller, J N., Blomenthal, F.S., Grisell, J.L. Perceptual Training in Patients with Left Hemiplegic Arch Phys Med Rehabil 1971; 52(4) : 163-169.

Titus, M N.D., Gall, N G., Yerxa, E.J., Robertson, T A., and Mook, W Correlation of Preceptual *Performance and Activities of Daily Living* in Stroke Patients American Journal of Occupational Therapy 1991; 45(5) : 410-418.

Whiting, S., Lincoln, N., Bhavanani, G., Cockburn, J. Rivermead Perceptual Assessment Battery Windsor. NFER-Nelson, 1985

APPENDIX 6

LETTER I

TO THE NORMAL SUBJECTS

I ________________________ consent to carry out the tests of Visual-Perceptual-Motor function. I understand that:

my results will used to provide data on the scores obtained by normal people so that it can be determined whether patients who have suffered a stroke have problems with V-P-M function.

that my name will not be used in any way and

that I may withdaw from being tested at any time.

Signed:______________________________

Date:_______________________

LETTER II

TO THE PATIENTS

I ________________________ consent to do the V-P-M tests, which as explained to me by Marjorie Concha, is a new battery of tests and is an extension of the evaluation that I would normally undergo preparatory to receiving Occupational Therapy. I understand that I may withdraw from being tested at any time without jeopardising my right to therapy and that my name will not appear in the results.

Signed: ___________________________

Date:___________