

PROVISIONAL FORMULATION OF NORMATIVE DATA FOR
SEMI AND UNSKILLED BLACK AND COLOURED WORKERS
ON THE TRAIL MAKING TEST

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ABSTRACT

This study provides a provisional normative range of performance for the South African semi and unskilled black and coloured population groups on the Trail Making Test. One hundred and six black and coloured semi and unskilled workers from the Groote Schuur Hospital in Cape Town, satisfying the criteria of 8 years or less of formal education, with no neurological impairment or psychopathology, and some degree of literacy, were randomly selected. Parts A and B of the Trail Making Test were then administered and scored, and the scores reported in tabular form, broken up in terms of race, age and education. A statistical analysis (multiple linear regression) was applied to the data and additional information on the effects of age, education and sex on test performance briefly discussed in terms of previous research findings. The results of this study add weight to Dugmore's (1987) assertion that existing norms currently in use for the Trail making Test are invalid for these population groups. Limitations of the study and suggestions for further research were also briefly discussed.

1.0 CHAPTER I

AIMS AND RATIONALE

1.1 Aims

1.1.1 The aim of this study was to formulate a set of provisional norms for the South African semi and unskilled black and coloured population groups on the Trail Making Test. Norms available to date have been derived from a foreign population group whose socio-cultural, economic and educational background (well documented confounding variables on test performance), render these an invalid normative measure for any population group differing significantly on these variables, (Schepers, 1974). This study, therefore, aims to provide a provisional normative range of performance for the specific South African semi and unskilled black and coloured populations (with a maximum of 8 years formal education or less), who lack any other evidence of brain neuropathology or functional psychopathology.

1.1.2 An additional aim was to briefly consider the influence of four specific variables (age, race, sex and education) on test performance of the semi and unskilled black and coloured populations.

1.2 Rationale

1.2.1 Lack of relevant normative data controlling for variables specific to certain population groups, renders invalid performance assessment of these groups when evaluated against current norms. Establishment of relevant normative data will help to preclude erroneous indications of neuropathology which may arise as a result of confounding variables not controlled for in the normative population sample. The misclassification of false positive performances on the Trail Making Test as a result of confounding variables not controlled for in research design and norm establishment has been well documented in the literature; Reitan and Tarshes (1959), Parsons et al (1964), Goul and Brown (1970), Prigatano and Parsons (1976), Gordon (1978), Norton (1978), Smith and Boyce (1962), Chavez et al (1983), Stanton et al (1984).

1.2.2 Research completed by Dugmore (1987) explored the relationship between performance scores on the Trail Making Test and job skilledness, which was considered as a manifestation of education level achieved. This level was set at a maximum of 8 years for sampling purposes according to justification outlined by Grant (cited in Crawford Nutt, 1977). Grant (ibid) concluded that subjects with less than 8 years of formal education were significantly disadvantaged with pencil and paper assessment formats. Dugmore (1987) in her study of the relationship

between performance scores on the Trail Making Test and job skilledness, based the sampling of her semi and unskilled group on this rationale, hypothesising that both factors are interrelated and influential on test performance, but was unable to determine whether it was education, occupation or an interaction of these factors that affects performance. The Dugmore (1987) study was a primary motivation for this research and provided the rationale for sampling in this way.

1.2.3 The Trail Making Test is a useful clinical screening device for neuropathology because it is cost and time economic, and is also easily administered and scored. These qualities render it readily and easily available as a screening measure in the clinical situation and are particularly significant when employed with large population groups. As the black and coloured semi and unskilled South African populations form a large percentage of the general South African population, valid normative data for this population group would greatly assist in neurological screening procedures for these people. Further rationale for the need of formulating valid normative data for this population group relates to the escalating cost of neuropsychological assessment and treatment. The socio-economic status of these population groups in the South African society makes certain treatment financially difficult to obtain, a factor which renders establishment of a valid screening procedure even more desirable.

2.0 CHAPTER 2

LITERATURE REVIEW

2.1 Historical Review of the Trail Making Test

As best as can be determined according to Brown et al (1958), the Trail Making Test has its origins in a prototype known as the Taylor Number Series, where the subject had to draw lines connecting a randomly scattered series of numbers from 1-50 on a rectangular sheet of paper. In 1958 Partington renamed the test "A Test of Distributed Attention" - a modification of the original which he viewed as a test dealing with speed of motor performance. Further clinical use of the test led Partington to conclude that the subject also needed to be able to integrate previously learned material into a pattern of response that involved shifts in organisation, recall and recognition. Later Partington and Leiter (1949) discovered a high positive correlation with performance on the test and general mental ability, and renamed the test the Partington pathways Test. A follow up study in 1945 on World War II veterans revealed a .68 correlation between the Stanford Binet 1937 revision, and the Partington Pathways Test which was then incorporated as a performance subtest in the Army Individual Test of intellectual functioning. It was also used on clinical populations and found to have some predictive value in differentiating between neurotic and schizophrenic groups (U.S. War Department, 1946).

At the same time Partington and Leiter (1949) investigated the possibility of the test's usefulness in evaluation of brain injury

and Watson (1949) devised a checklist for gauging its possible value in the investigation of organics. Armitage (1946) used the test as part of a battery designed specifically to evaluate brain injury, and using the test was able to show to a highly significant degree, differences between brain damaged subjects and controls composed of normals and neurotics. Scherer and Winne (1956 cited in Brown et al 1958) used the Trail Making Test over a five year period as part of a follow-up study on lobotomised patients, but were not able to discover any relationship between performance on the test and this type of cerebral deficit. Humphries (1957 cited in Brown et al 1958) using a very different administration and scoring procedure was able to distinguish schizophrenic and organic groups from normals as well as from each other. Finally Reitan (1955) obtained results which significantly differentiated patients with brain damage from patients without brain damage.

Since this time the format of the Trail Making Test has remained unchanged apart from modifications of it adapted for specific clinical purposes such as for use with children (Reitan, 1955). Very little work has yet been done on establishing norms for children, although an important start has been made with the work of Levett and Rosin (1988).

In the past 40 years the clinical uses and possible confounding variables affecting performance on the Trail Making Test have been rigorously explored. This will be considered more fully in later sections of the literature review.

2.2 Research pertaining to functions measured by the Trail Making Test

A large proportion of the literature on the Trail Making Test has attempted to identify and isolate functions which it is purported to measure.

Armitage (1946) felt that the test "seemed to measure the following functions: (i) Ability to perceive a double relationship, (ii) Ability to plan, (iii) Ability to "shift", and related to the preceding point, "the presence of any perseverative tendency ...".

Related to the above would be, visual scanning abilities, that is, the ability to move visual attention between stimuli while completing a task, and mental shift ability when the testee must integrate the number and letter series in Part B of the test, shifting back and forth between the two while keeping in mind the ascending sequence of both (Rosin, 1987). Reitan and Tarshes (1959) suggest that certain abilities are required by the content and procedure of the test. The content requires a subject's ability to recognise the symbolic significance of numbers and letters, and the procedure, some ability in spatial organisation.

Greenlief, Margolis and Erker (1985) indicate that Part A of the Trail Making Test is thought to be a task primarily requiring perceptual motor speed, and Part B is a more complex task

requiring both perceptual motor speed and the ability to shift conceptually between numbers and letters, i.e. a capacity for dual conceptual tracking. Alvarez (1962) feels that the task requires the integration of perceptual and motor skills. This view is also held by Lezak (1983). Reitan (1955) also indicates that the need to comprehend and effect visuo-spatial relationships are necessary skills for successful completion of the test.

Lezak (1983) also makes the point that the clinical value of the test goes far beyond what it may contribute to diagnostic decisions, and cites Levinsohn's (1973) findings that performance on Part A was predictive of vocational rehabilitation following brain injury. Lezak (ibid) also suggests that visual scanning and tracking problems that show up on this test give information about how the patient responds to a visual array of any complexity, and how well he/she performs when following a sequence mentally or dealing with more than one stimulus thought at a time (Eson et al, 1978 cited in Lezak, 1983), or how flexible he/she is in shifting the course of an ongoing activity (Pontius and Yudowitz, 1980 cited in Lezak, 1983). Any difficulties observed in performance on this test by a patient can provide insight into the nature of his/her neuropsychological disabilities.

To this list, Rosin (1987) adds that other factors involved may be adequate concentration and attention, the ability to sustain a single task, and knowledge of and a degree of proficiency with, the alphabet and numerical system.

2.3 Format, Administration and Scoring of the Trail Making Test

The Trail Making Test is given in two parts, Part A and Part B (see Appendices I and II), each containing 25 circles randomly distributed on a single sheet of paper. In Part A the patient must draw a line to connect consecutively the circles numbered 1-25, whereas in Part B the patient must draw a line sequentially connecting the circles alternating between numbers and letters, that is, A,1,B,2,C,3 etc. Before attempting either of these worksheets, the patient is presented with a sample page and the examiner explains the task to the patient, pointing out each numbered or lettered circle as it is referred to. The patient follows the instruction for the sample and then is presented with Part A of the test and urged "to do this as fast as you can without lifting the pencil from the paper" (Lezak, 1983). The task for Part B is explained in the same manner using a sample sheet before Part B is presented. The score on each part is the number of seconds taken to complete each part of the test.

Since the test was first used there have been some variations in administration and scoring procedures. Initially whichever part of the test the subject was working on was removed when the subject had made an error and failed to correct it before completing three more numbers (U.S. War Department, 1944). Armitage (1946) allowed the subject to complete both parts of the test regardless of "failures" (according to previous criteria),

basing his scoring on time to complete each part, and accuracy. He accounted for errors "by giving a score of zero to performance in which errors were left uncorrected" (Lezak, 1983). Reitan (undated in Lezak, 1983) also made changes requiring the examiner to point out mistakes immediately allowing the subject to make necessary corrections and based his scoring on time alone. Time scores for completion of Parts A and B were converted to scaled scores and cut-off points calculated to differentiate between brain damaged and non brain damaged subjects. Lezak (1983) suggests that this is the most commonly used procedure today but that a simplified scoring system may have diminished the reliability of the test, as the measurement of time (constituting the final score) includes the examiner's reaction time in noticing mistakes, pointing them out, and the subject's time in comprehending and making corrections. Although this method accommodates errors indirectly, it does not control for variation in response time and correctional styles between different examiners.

This method of scoring has been criticized by numerous subsequent researchers (Brown et al, 1958); (Parsons et al, 1964); (Santz et al, 1964 cited in Rosin, 1987); (Spreeen and Benton, 1965); (Goul and Brown, 1970) as cut-off points produced high percentages of false positives ranging from 16% (Spreeen and Benton, 1965), to 50% without age corrected norms (Goul and Brown, 1970), in differentiating between brain damaged and non brain damaged patients. Further research produced a variety of cut-off points, which took into account the age variable (Davies, 1968);

(Goul and Brown, 1970); (Gordon, 1978); (Bornstein, 1986); and Davies (1968) devised a table which shows a distribution of Trail Making Test scores in seconds for normal control subjects for the six decades beginning with age 20 (reprinted in Lezak, 1983). Lezak (1983) writes that although these Davies (1968) norms are "somewhat coarse grained" they provide standards for evaluating Trail Making Test performance throughout the adult years. Research has considered the inadequacy of available norms in accounting for a number of variables affecting test performance. This will be dealt with in more detail in later sections.

2.4 Variables affecting performance on the Trail Making Test

2.4.1 Age

The correlation of age factors and performance on the Trail Making Test has been a highly considered subject of research. Kennedy (1981) administered the Trail Making Test to 150 non brain damaged subjects classified into 5 age decades to determine the effects of age on performance. He concluded that :

"Between group comparisons as well as correlational data indicated that older subjects performed significantly more poorly than younger subjects".
(pg. 671)

Prigatano and Parsons' (1976) research findings regarding age and test performance correlation, further supported a high correlation to age on neurological test batteries. This was supported by Parsons et al (1964) who further confirmed the

effects of age and other variables on test performance. Stanton et al (1984) further substantiated these findings and point to the potential danger of falsely classifying adults of older ages as possibly being organically impaired.

Lezak (1983) also acknowledges the effect of aging on Trail Making Test performance:

"When interpreting the performance of any test in which response speed contributes significantly to the score, allowances need to be made for the normal slowing of age. The Trail Making Test is no exception, since performance time increases with each succeeding decade."

(pg. 557)

Davies (in Kennedy, 1981) and Goul and Brown (in Kennedy, 1981) formalised age corrected cut-off points which were applied together with Reitan's cut-off points (not age corrected) to research data. Reitan's cutting scores resulted in total percentage of misclassification of 18% on part A, 18% on part B and 24.67% on A plus B. Of the overall misclassification of this research data 12% on Part A, 18% on Part B and 16% on Part A + B occurred in the age intervals of 50-59 years, 60-69 years reflecting the effect of age. With Davies age-corrected cut-off points, misclassification totalled 2.67%, 22.67 and 25.33% for parts A, B, and A + B respectively. The intervals of

50-59 years and 60-69 years again accounted for the larger proportion of misclassification. Conclusions drawn from this study were that adequacy of performance declines with age and this indicates the need for age-corrected norms with the test (Goul and Brown in Kennedy, 1981).

Goul and Brown (1970) also studied the effects of age and intelligence on the Trail Making Test performance using a population sample of 93 brain damaged and 106 control patients ranging from 20-72 years. Results indicated that Trail Making Test performance decreased with age as did Trail Making Test validity. Use of Reitan's 1958 cut-off point misclassified half the control patients, the misclassification increasing markedly with age and, therefore, clearly indicated the need for local age corrected norms reiterating the findings of previous research. They concluded the discussion of this research with the following statement:

"The Trail Making Test is a clinically useful screening device for organicity, but only if age is taken into account specifically in the form of age-corrected cut-off points".

(Goul & Brown, 1970 pg. 325).

Gordon (1978) substantiated these findings in his research comparing performance of brain damage subjects (n=51) and non brain damage subjects (n=72). Analysis of covariance revealed that non brain damage subjects performed at a significantly higher level than brain damaged subjects. He concluded that :

"Negative findings ... indicate the necessity of discovery in which populations (diagnostic and age variations) it is most effective and setting up appropriate cut-off scores."

(Gordon 1978: pg. 191)

King (1967) and Orgel and McDonald (1967), support the conclusions drawn by Gordon (1978) and Goul and Brown (1970).

Boll and Reitan (1973), however, offer contradicting opinions to those stated above, maintaining that performance is independent of age and that cut off scores presented in the manual are applicable across a broad age range.

The primary conclusions drawn from research on age factors and performance on the Trail Making Test seem to support a decline in Test performance with increasing age. Discrepancies in reported opinions may be due to certain methodological and procedural variations evident in specific research, such as small population groups, uncontrolled confounding variables such as education and intelligence and lack of validity in statistical analysis used. It is important that future studies should control for variables such as these which are known or suspected to influence performance on the TMT.

This is supported by Prigatano and Parsons (1976) who stress:

"...the importance of taking age into consideration as well as differences in various 'control' or reference groups when making clinical inferences about the presence of brain dysfunction".

(pg. 527)

2.4.2. Educational and Intelligence Factors

Another factor well documented in literature and research as significantly affecting performance on the Trail Making Test is educational level achieved. This is usually regarded as being closely correlated with intelligence level.

The significance of these variables on test performance has been substantiated by Reitan, (1955); King, (1967); Kennedy (1981); Stanton et al, (1984). Research conclusions drawn by Kennedy (1981) state that:

"Significant small negative correlations of performance with education and intelligence suggested that lower intelligence and education may also adversely affect performance."

(pg. 671)

and:

"Significant negative correlations of the Trail Making Test performance with education and intelligence in the present study were also consistent with previous literature, and despite evidence that these factors are significantly correlated with performance, education and intelligence corrected norms have yet to be developed. Attention to the potential influence of these variables could also increase the clinical sensitivity of the Trail Making Test."

(pg. 674)

Parsons and Prigatano (1978) explored education as a variable affecting performance on neurological tests, as suggested by previous research on the subject:

"The effects of education were demonstrated in a clear-cut fashion in a recent study by Finlayson, Johnson and Reitan (1977). These investigators compared brain damaged and control subjects, stratified in three levels of education on the Halstead Neurological Battery. Both level of education and brain damage had a 'pronounced' effect on scores; the lower education groups scored lower on the Halstead measures, as of course did the brain damaged group."

(pp 609-610)

Stanton et al (1984) studied the reported influence of age and education on a larger population group than considered previously (n=32). Male and female patients between the ages of 40-49 years on whom the Trail Making Test and Wechsler Memory Scales were administered, formed the population sample. Stanton et al (ibid) concluded that age and level of education were strongly associated with performance on the Trail Making Test, but on two subtests of the Wechsler Memory Scale, education alone was associated with test performance. These findings thus point to the potential danger of falsely classifying adults of older ages or with lower education as possibly having an organic brain syndrome. In their discussion of research findings Stanton et al (ibid) emphasised this point:

"In applying cut-off scores of these tests, from 15%-50% of the individuals in this study would have been classified as having organic brain dysfunction. This is a conservative estimate of impairment since we elected not to include those persons who should have been classified as having 'mild' impairment in the above calculation."

(Pg. 13)

Reitan (1955); King (1967); Goul and Brown (1970); and Boll and Reitan (1973) found performance on the Trail Making Test to correlate highly with intelligence, a factor closely related to educational performance.

As outlined above, research strongly substantiates the effect of education on neurological test performance. Factors closely related to education, however, are socio-economic and cultural variables which have also been well documented as adversely affecting performance on the Trail Making test (Prigatano and Parsons, 1976). These factors have been considered in more detail below.

2.4.3 Socio-Economic and Cultural Factors

Parsons and Prigatano (1978) studied the close relationship between the variables of education and other socio-economic and cultural factors and regarded these as significant variables for consideration in neurological evaluation in general:

"This variable is closely related to education and so in most adult studies, education is sufficient. However, as education levels continue to rise and social 'promotions' are the rule rather than the exception, it may be important to again consider the broader variable of socio-economic level. Another aspect is the occupation of the subject. Has there been overlearning of specific skills which in turn could lead to spurious results? For example manual workers and bookkeeper clerks might well differ in patterns of strength in perceptual-motor and verbal-calculation skills."

(Pg. 610)

Stanton et al (1984) also maintained that cross cultural factors have not been controlled for in establishment of available norms on the Trail Making Test. The consequences of this have been outlined in the following quotation by Goul and Brown (1970):

"The high percentage of misclassifications ... suggest that the present cut-off points might also not cross validate to other settings. If so, it would be necessary to develop local norms for each setting in which the Trail Making Test was used."
(Pg. 325)

Occupation and education levels of research subjects have been found to be closely correlated with specific socio-economic and cultural circumstances.

Depending on the type of occupational representation in a given sample of brain damaged patients, many different inferences can be made. The socio-economic variable is quite important in neuro-psychological investigation of children. In a recent study, Amante et al (1977) concluded that levels of neurological integrity vary along a socio-economic gradient. The relevant factors associated with social causation of neurological difficulties include malnutrition, reduced environmental stimulation, and inadequate obstetrical and pediatric care. They recommend adult studies in neuro-psychology consider the occupational variable along with education. Also that with children the general family socio-economic background should be specified.

Ferguson (in Schepers, 1974) supported the views outlined above in speaking about psychological differentiation of cognitive skills and the significance of these facts for cross-cultural psychological testing:

"It is also expected that factors such as age and education will play a role in the differentiation of cognitive structures It is, therefore, imperative that trend analyses be done for various cross-sectional groups as far as usage and education are concerned".

(pg. 399)

Elsewhere Ferguson (in Schepers, 1974) also maintained that:

"Any activity that is practised sufficiently long will result in a new ability crystallizing out".

(pg. 397)

"Abilities" according to Ferguson are "overlearnt acquisitions", and there are thus as many abilities as there are activities to do. These abilities which tend to group together form a number of group factors referred to as "primary abilities", and are moderately correlated with each other. A single second order factor has been found sufficient to account for the primaries, and has traditionally been identified as general intelligence. Following Ferguson's initial premise regarding the role of learning and acquisition of an ability which is related to the external opportunity to practise and crystallize this, - it can be seen that certain socio-economic, education and cultural factors may play a significant role in cognitive development of specific cultural groups.

Difficulties evident in this area have been outlined by Schepers (1974):

"Before biological maturity (15-20 yrs) is reached, difference scores in fluid and crystallized general abilities will mainly reflect differences in cultural opportunity and interest."

(pg. 398)

Schepers (ibid) further substantiates the effect of cultural variables in affecting cognitive development and thus, test performance in the following quotations:

"As far as the growth curves of fluid and crystallized abilities are concerned, fluid ability reaches an early maximum of 14-15 years, while crystallized ability increases to 18-20 years, or beyond depending on the subculture."

(pg. 398)

and:

"The need for distinguishing between fluid general ability and crystallized general ability in cross cultural research should be apparent from the foregoing. Unfortunately, however, the work of Cattell has not yet been replicated with developing groups. Before Cattell's critical experiment can be replicated with developing groups two things are necessary. Firstly it would be necessary to construct a battery of tests according to the the model of Thurstone's Primary Mental Abilities and secondly it would be necessary to construct a battery of tests according to the rationale of Cattell's culture fair intelligence tests."

(pg. 398)

Schepers (ibid) also further considers the recognised deficiency of valid psychological tests and test norms for particular South African population groups.

"Tests have often been produced without any regard to the role of the particular function in the culture of the subjects for whom the test is intended A great deal of test construction has been done without any real insight into the nature of human abilities. Little if any attention has been given to the way in which abilities evolve and are organised. The role of education in the differentiation of abilities has as yet not been fully researched. The long-term effects of early deprivation on the cognitive development of developing groups are largely unknown".

(pg. 396)

Elsewhere in further support of these principles he states that:

"Test technicians have been far too ready to accept the Mental Test Theory of highly developed groups and apply it to developing groups without further consideration. Far too little effort has gone into studying the learning process and resultant learning curves with developing groups."

(ibid pg. 397)

In further consideration of difficulties presented in cross cultural psychological testing, and possible controlling of these, Schepers (ibid) states;

"Because western psychologists are normally unfamiliar with the native languages of these groups, they have customarily avoided verbal tests Non verbal tests of a constructional kind, and certain psycho-motor tests have traditionally been favoured. Little attention has been given to the mode of presentation of learning data. Because the visual mode is the most preferred mode in the Western World, cognitive tests have usually been presented in visual form. Little, if any attention has been given to higher order functions such as considered judgement, risk acceptance, concept attainment and planning abilities. The implicit assumption has thus been made that not only the dominant hemisphere, but the prefrontal lobes as well, are of little consequences as far as the cognitive behaviour of developing groups is concerned".

(pg. 397)

Schepers (ibid) further outlines two approaches that have recognised the deficiency in valid psychological tests and test norms for particular South African population groups, firstly to
....

"...accept basic rationales of existing overseas tests and to modify them in minor ways. ... The second and perhaps more fruitful approach has been to develop novel techniques, utilising concepts and materials familiar to Africans, for measuring their cognitive functions."

(pg. 396)

Specific cultural factors identified as confounding variables to test performance, and which should thus be accounted for in normative population samples include:

- "- The genetic endowment of the subject.
 - The motivation of the subject to practice the particular skill concerned.
 - The utility of the skill in the particular community or subculture of the subject.
 - The educational level of the subject.
 - The age of the subject.
- The earliness of the stage at which learning takes place."

(Ferguson in Schepers 1974 pg. 399)

Other factors contributing to poor validity of tests used across a range of cultural groups in South Africa have been discussed by Schepers (1974), namely issues related to test format where presentation may disadvantage certain cultural groups. Schepers (ibid) illustrated this by saying that :

"Studies conducted in South Africa have revealed an inability on the part of African subjects to deal with pictorial material, particularly if linear perspective, is used without a gradient of texture."

(pg. 401)

Timing as a criterion for evaluation test performance has also presented certain difficulties cross culturally. Schepers (ibid) again outlines this:

"Speed tests might pose particular problems to developing groups, as time is not normally stressed with these groups."

(pg. 401)

Schepers (ibid) also comments on the customary use of mime when administering non-verbal tests to groups speaking several different languages, but acknowledges the lack of conclusive evidence regarding the efficacy of this for subject comprehension of test instructions. Other factors also considered as confounding variables for cross cultural testing include: the lack of familiarity of certain cultural groups with abstract thinking and symbolic thinking; lack of cultural emphasis on scholastic related skills, where lack of familiarity with writing, pencil and paper skills is often evident.

These areas of difficulty outlined by Schepers are highly pertinent to cross cultural performance and evaluation on the Trail Making Test.

2.4.4 Sex

Gender difference has been another factor considered possibly affecting performance on the Trail Making Test. Research in this area, however, suggests that this is not a significant variable affecting test performance. Davies (1968) discovered no significant different performance between males and females tested on the Trail Making Test in particular age groups. This finding was supported by Kennedy, (1981); Chavez et al (1983) and Stanton et al (1984). Chavez et al (1983) explored the effects of anxiety and sex on various neurological tests. Twenty-eight male and 28 female non impaired, high and low test anxious subjects were given the Finging Tapping, Trail Making and Digit

Span and Digit Symbol Tests. Neither variable was reported to significantly affect test performance. Reitan (1971) found performance means on the Trail Making Test to be virtually identical in male and female children. No significant studies offering discrepant findings on this subject appear to exist.

2.4.5 Degree of functional psychiatric disturbance

This is a factor that has been highly researched regarding possible effects on Trail Test performance (Reitan, 1955); (Brown et al, 1958); (Alvarez, 1962); (Smith and Boyce, 1962); (Parsons et al, 1964); (Goldstein and Neuringer, 1966); (King, 1967); (Norton, 1978); (Chavez et al, 1983).

Watson et al (1969) seriously questioned the Trail Making Test's usefulness as a screening device, particularly in the context of discriminating neurologic from psychiatric patients rather than from normal groups. This was substantiated by Norton (1978) in his research findings. Parsons et al (1964) explored Trail Making Test performance of 21 brain damaged and 63 non brain damaged subjects on test and subject variables of: behaviour agitation; anxiety; examiner differences; facility with letters of the alphabet; order of administration and ego involvement. Results indicated that anxiety was the only factor significantly related to performance. In other analyses however, age, education, vocabulary and degree of psychiatric disturbance were significantly related to performance. In a study by Smith and Boyce (1962 in Parsons et al, 1964), it was found that chronic

schizophrenics performed on the Trail Making Test at a level indistinguishable from that of brain damaged subjects. Similar findings were reported by Brown et al (1958) who demonstrated that psychotic subjects scored significantly lower than neurotic subjects on Part A of the Trail Making Test, but brain damaged psychotic subjects could not be distinguished in performance. Smith and Boyce (1962, in Parsons et al, 1964) studied MMPI and Trail Making Test ratings of subject performance and concluded that:

"The greater the psychiatric symptomatology (as measured by the MMPI), the greater the deficit in performance".
(pg. 205)

Beck, Feshback and Legg (1962) investigated the effects of depression, anxiety and severity of illness on performance of the Digit Symbol Subtest of the WAIS. They found no relationship between anxiety or depression and performance. However, "degree of psychiatric disturbance" was discovered to be inversely and significantly related to performance, although the precise variables contributing to "degree of psychiatric disturbance" remain to be investigated.

Parsons and Prigatano (1978) acknowledge the above research findings and implications of these for validity of norms on the Trail Making Test.

Other research however, contradicts the large "false positive" findings of performance of psychiatric patients on the Trail Making Test. Chavez et al (1983) assessed 28 male and 28 female non impaired high and low test anxious patients, who completed the Trail Making Test, Finger Tapping, Digit Symbol tests. Conclusions drawn were that neither variable significantly affected test performance. Gordon (1978) confirmed the opinion regarding the Trail Making Test's relevant discriminatory power when employed with neurologic and pseudoneurologic subjects:

"Analysis of covariance showed that pseudo-neurologic subjects performed at a significantly higher level than brain damaged subjects."

(pg. 191)

Reitan (1955) reported a clear differentiation of neurologic from non neurologic patients in performance on the Trail Making Test. Other researchers have suggested that differences between neurologic and other psychiatric populations in performance on the Trail Making Test is clearly evident, although this has seemingly been a result of qualitative rather than quantitative distinctions in performance. King (1967) in a study of Trail Making performance as related to psychotic state, age, intelligence, education and fine psychomotor ability concluded that:

"... our schizophrenic subjects readily displayed slower performance on the Trail Making Test than the normals further showed significant decreases in all tests of fine psychomotor adequacy by comparison with the normal, and reflected clearly a psychotic intrusion on more than one kind of measure of 'test taking behaviour'."

(pg. 656)

Goldstein and Neuringer (1966) also drew similar conclusions in their research in which the Trail Making Test was administered to 30 schizophrenic and 30 brain damaged patients. Results indicated that:

"While schizophrenic subjects either complete the task without error, abandon the task or produce illogical patterns, the brain-damaged subjects rarely produce these types of performances. Rather they more characteristically exhibit sequence binding, and a tendency to lose track of the alternation pattern and fall into a number or letter sequence. It was suggested that the Trail Making Test shows promise in distinguishing between brain damaged and schizophrenic patients".

(pg. 347)

Alvarez (1962) also studied the effect of psychiatric functional pathology on Trail Making Test Performance, where he compared 32 depressive and 32 brain injured subjects matched for age, sex and education. This comparison was significant because scores on the Trail Making Test are based on time performances and in depression there is usually a reduced interest in work-related activities. As depression is often a secondary feature to other neurological and psychological disorders, it is highly relevant to ascertain to what degree slowed motor performance on the Trail Making Test is related to primary psycho or neuropathology. Results revealed that the kinds of skills demanded on the Trail Making Test are not appreciably diminished by depressive features in the absence of organic impairment.

Conclusions drawn as to the effect of functional psychopathology on Trail Making Test performance, have been strongly contradictory. Although various research methodological difficulties may well have contributed to these discrepant results, for example major differences in the nature of populations sampled, it appears that the Trail Making Test also has limited potential in discriminating between certain functional psychopathology and brain damage. This renders its potential usefulness as a screening device rather disappointing, particularly with the use of presently established cut-off points for indication of neuropathology. Norton (1978) comments on this point in his report on a study where the Trail Making Test was evaluated against both external neurologic criteria and against psychological opinion derived from a more complex evaluation:

"The performance of the measure as a screening device is, however, disappointing. When the conventional cut-off was used, 21% of the patients called normal were classified as definitely abnormal with the complete battery, and 33% had at least one definitely abnormal neurologic study. Raising the cut-off score to 18 for younger and 15 for older patients improved performance vis a vis neurologic studies, but had no effect on the error rate against psychological criteria. Furthermore, the number of patients "screened" by the higher scores is quite small, less than 7% of the total sample. To eliminate only 7% of the pool and still misclassify a quarter of those is not acceptable performance for a screening device."

(pp 919-921)

Although various studies exist that substantiate the Trail Making Test's ability to discriminate between functional psychological disturbances and neuropathology, the stronger consensus on this subject appears to be that the test lacks validity as a differentiator of specific psychiatric groups.

2.4.6 Experimenter and other variables

Parsons et al (1964) explored the effects of experimenter variables and method of test administration, ego involvement of the testee, behavioural agitation and anxiety on Trail Making Test performance, none of which were found to significantly affect performance on this test. Parsons et al (ibid) also explored specific variables affecting Trail Making Test performance. They concluded that performance on the test seemed to be little affected by examiner and order variables, but was considerably influenced by a number of subject variables other than brain damage. These variables have been discussed in more detail in previous sections. Other experimenter variables possibly influencing test performance suggested previously include, the examiner's accuracy with timing and identifying and pointing out errors to the subject, the subject's ability to comprehend instructions and act upon these. Previous studies have not focussed sufficiently upon these variables that may have a significant impact on test performance, and more research is needed in these areas before conclusive statements can be made.

2.5 Further Research Pertaining to the Trail Making Test

2.5.1 Value of the Trail Making Test as a screening measure for neuropathology

This subject has already been indirectly considered through the effect of certain variables on test performance in previous sections. Primary conclusions drawn in this regard have been that specific variables, namely, age, education and

intelligence, socio-economic factors and functional psychopathology, not accounted for in normative evaluation, render the test questionable as a valid screening device for neuropathology. This has been supported by many researchers, (Brown et al, 1958); (Reitan, 1962); (Parsons et al 1964); (Goul and Brown, 1970); (Gordon, 1978); (Norton, 1978); (Horton, 1979). Conclusions drawn by Parsons et al (1964) in this regard have been stated below:

"Although there may be advantages for using the Trail Making Test in research or for specific questions such as lateralisation (Reitan, 1962), we concur with Brown et al (1958), that the Trail Making Test in its present form has little value in general screening for brain damage."

(pg. 202)

Norton (1978) considered literature pertaining to the use of the Trail Making Test as a screening device. He concluded the following :

"The use of the Trail Making Test as a screening device for brain disease has been questioned seriously (Brown et al, 1978) and the measure's high false positive rate has been pointed out, particularly when it is used to discriminate neurologic patients from psychiatric rather than from normal groups (Watson et al, 1969)."

(pg. 916)

Other researchers acknowledge the potential relevance of the Trail Making Test as a screening measure for neuropathology, providing certain acknowledged variables affecting test performance are controlled for in normative evaluation (Sterne, 1973). Parsons et al (1964) supports this point in speaking about the effect of certain subject variables on test performance:

"Until these variables are considered in the scoring system it seems unlikely that the Trail Making Test will be effective as a general screening test for brain damage."

(pg. 199)

Goul and Brown (1970) further support the need for consideration of specific variables in formalised norms for the Trail Making Test:

"The Trail Making Test is a clinically useful screening device for organicity but only if age is taken into account, specifically in the form of age-corrected cut-off points."

(Pg. 325)

Gordon (1978) also supports these opinions in the discussion of his research:

"Negative findings indicate the necessity of discovering in which populations (diagnostic and age variations) it is most effective and setting up appropriate cut-off scores."

(Pg. 191)

Parsons and Prigatano (1978) also substantiate these points.

Norton (1978) assessed 598 subjects on the Trail Making Test and the Bender Background Interference Procedure. The research population group consisted of neurologic and non neurologic patients. In discussing his research findings he stated that:

".... large numbers of false negatives against both neurological and psychological criteria were revealed. It was not possible to establish an optimal cutting score to justify application of these measures as screening devices either alone or in concert...".

(Pg. 916)

Limited literature appears to be available in support of the clinical validity of the Trail Making Test as a screening device, without further attention given to control of certain variables in established norms, or the formulation of specific normative cut-off points for particular population groups.

2.5.2. Relevant research on the Trail Making Test with Children

Research done in this area has primarily documented significant differences in performance of normal, brain damaged and psychiatric subjects (Davids et al, 1957); (Reitan, 1971); (Boll, 1974); (Reitan and Herring, 1985), but all researchers stressed their research findings as preliminary. They also emphasised the need for further research on larger population samples of children with focus on specific cerebral lesions to permit experimental control over such factors as lesion type, location, severity of damage, aetiology and age on onset. Reitan (1971), drew similar research conclusions to those stated above, but cautioned against the use of a single test in determining brain functioning.

In concluding a summary of research done on the Trail Making Test with children Rosin (1987) states that:

"In considering the research looking at the diagnostic effectiveness of the Trail Making Test with children, it should also be noted that analyses of the data were based on quantitative methods of analysis. Here, level of performance - good versus poor - was the sole criterion used in deciding whether the two groups differed or not. While this method has validity, further qualitative analysis, considering factors such as plan of action, the nature of errors made, and strategy used, may provide valuable information regarding performance on the Trail Making Test in different brain damaged groups. In turn, this may well enhance clinical management, and provide valuable insights into neurological and behavioural relationships with children."

(Pg. 16)

It seems pertinent in conclusion of this section to repeat, as was mentioned in Chapter 2 that the only norms for the use of the TMT with children that have been produced to date are those provided Levett and Rosin (1988).

2.6 Synopsis of relevant points in literature pertaining to the Trail Making Test

In this section relevant literature pertaining to the historical background, format, administration and scoring, and psychological functions measured by the Trail Making Test have been considered. Particular variables affecting Test performance, the relevance of these for the usefulness of the Trail Making Test as a screening device, and normative control of these factors in performance evaluation were then also explored. Variables acknowledged as significantly affecting test performance were; age, education and intelligence, socio-economic and cultural factors, and the degree of functional psychiatric disturbance. The variable of sex did not appear to contribute significantly to test performance.

3.0 CHAPTER 3 METHODOLOGY

3.1 Subjects

The subject population consisted of 106 black and coloured semi and unskilled workers (called "General Assistants") at the Groote Schuur Hospital in Cape Town. These subjects were randomly selected on the basis of educational level (8 years or less of formal schooling as discussed in the Rationale Section page 2) and race. Sex was not controlled for as research has shown it not to have a significant effect on test performance. Research has shown the influence of age on test performance and this was included as a variable in the present study.

3.2 Method

Demographic data was collected from each of the subjects using a standard questionnaire administered by the examiner prior to testing (adapted from Dugmore 1987 see Appendix III). The primary purpose of this was to screen out neurological and other psychopathology such as substance abuse (as set out by Norton 1978). Subjects found to be illiterate were also excluded from the study which relies on recognition of letter and number symbols. Time to complete each part of the Trail Making Test was noted and any observations on performance recorded.

3.3 Procedure

Permission to conduct this research was requested and granted by the Ethics and Research Committee of the Faculty of Medicine at Groote Schuur Hospital. Subjects were then randomly selected from the semi and unskilled black and coloured worker population at Groote Schuur Hospital according to number of years of formal schooling (8 years or less). These subjects were then interviewed by the researcher, using a formalised questionnaire to exclude persons suffering from neuropathology, functional psychopathology, or substance abuse. (Appendix III). Part A and Part B of the Trial Making Test were then formally administered and scored according to the method described by Lezak (1983). The performance scores were the times taken by each subject to complete Part A and Part B of the test.

3.4 Presentation of Results

The times taken by the subjects to complete the tasks were reported in tabular form, broken up in terms of race, age and education.

3.5 Statistical Analysis

Although the primary purpose of this study was to present age and education related norms, a statistical analysis (multiple linear regression) was applied to the data, as this provided additional information on the influence of the factors of age, education and sex on test performance.

4.0 CHAPTER 4

RESULTS4.1 Presentation of Research Findings

The performance scores (test performance time) were tabulated according to race, education and age for Parts A, B and A + B of the test, showing means, standard deviations and sample sizes for each cell:

4.1.1 Table 1. Results for Part A of the Trail Making Test

Education		Std 4	Std 5	Std 6	Age Range		20	21-30	31-40	41-50	51-60
BLACK	\bar{x}	87.5	71.923	67.12	BLACK	\bar{x}		59.5	80.0	72.111	88
	SD	31.389	44.009	30.903		SD		30.688	42.303	23.909	32
	N	8	13	25		N	0	16	17	9	4
COLOURED	\bar{x}	82.923	46.111	50.643	COLOURED	\bar{x}	61.667	46.417	58.944	79	67
	SD	54.361	20.025	20.016		SD	27.669	16.668	37.967	64.622	30.54
	N	13	18	28		N	9	24	18	5	3

4.1.2 Table 2. Results for Part B of the Trail Making Test

Education		Std 4	Std 5	Std 6	Age Range		20	21-30	31-40	41-50	51-60
BLACK	\bar{x}	215.875	141	157.68	BLACK	\bar{x}		136.88	171.813	189.556	180
	SD	64.97	54.872	47.187		SD		36.72	70.794	53.951	45.54
	N	8	13	25		N	0	17	16	9	4
COLOURED	\bar{x}	172.385	113.333	104.571	COLOURED	\bar{x}	111.778	109.708	138.778	133	135.67
	SD	65.919	48.599	38.461		SD	44.457	54.459	56.684	62.514	45.24
	N	13	18	28		N	9	24	18	5	3

4.1.3 Table 3. Results for Part A + Part B of the Trail Making Test

Education		Std 4	Std 5	Std 6	Age Range	20	21-30	31-40	41-50	51-60	
BLACK	\bar{x}	303.625	212.923	220.8	BLACK	\bar{x}	195.706	253.813	261.889	268	
	SD	90.601	96.143	68.772		SD	62.43	105.046	68.562	77.75	
	N	8	13	25		N	0	17	16	9	4
COLOURED	\bar{x}	255.308	160.556	155.571	COLOURED	\bar{x}	176.778	156.125	197.722	212	206.667
	SD	110.814	59.7	56.955		SD	68.687	66.868	87.921	126.527	74.844
	N	13	18	28		N	9	24	18	5	3

From the above tables it may be seen that on this population sample, our Parts A and B, there was a tendency for the performance by both Black and Coloured subjects to improve with education level, though Coloured subjects overall tended to perform better on the test (Parts A and B) than Black subjects. There was also a tendency for performance of both Coloured and Black subjects to decline with age on both Parts A and B of the test, both groups performing optimally in the 21-30 age range, and again with Coloured subjects tending to perform better than Black subjects across the entire age range. Because of the extremely high standard deviations it was decided to apply a multiple linear regression to the data to provide more information on the influence of these factors on test performance. This is presented in tabular form in the following section.

4.2 Statistical Analysis

A multiple linear regression was applied to the data for each of Part A, Part B and Part A + Part B scores. (Sex: Male = 1; Female = 0); (Race: Black = 1; Coloured = 0); (Education = Standard obtained); (Age = age in months). Critical tabled T values were 2.46 at the 0.05 level and 5.57 at the 0.01 level, with df 4:91 where 4 was the greater mean square.

4.2.1 Table 4. Regression Analysis, Part A of the Trail Making Test

Variable	Co-efficient	St Error	T	P(2 tail)
Intercept	88.15			
Sex	-4.40	10.33	-.43	.671
Race	15.04	7.64	1.968	.052
Education	-9.55	2.98	-3.204	.002
Age	.05	.03	1.543	.126

From the above it can be seen that the calculated T values for Sex (-.426); Race (1.968); Age (1.543) indicate that those variables did not significantly affect performance on Part A of the Trail Making Test. Education, however, was significantly inversely correlated with performance on Part A of the Test (-3.204 significant at the 0.05 level). Following from this, the prediction equation for Part A of the Trail Making Test is as follows :

$$\text{Predicted Trail A} = 88.15 - 4.4 (\text{Sex}) + 15.04 (\text{Race}) - 9.55 (\text{Education}) + .04 (\text{Age}).$$

4.2.2 Table 5. Regression Analysis Part B of the Trail Making Test

Variable	Coefficient	St Error	T	P(2 tail)
Intercept	169.71			
Sex	-19.85	16.59	-1.196	.235
Race	40.24	12.27	3.278	.002
Education	-16.31	4.79	-3.407	.001
Age	.10	.05	2.118	.037

From the above it can be seen that Sex (-1.196) and Age (2.118) do not significantly affect performances on Part B of the test (at the 0.05 level). However, Race (3.278) and Education (-3.407) both significantly affect performance on Part B of the test (at the 0.05 level). The prediction equation for Part B of the Trail Making Test is as follows :

Predicted Trail B = 169.71 - 19.85 (Sex) + 40.24 (Race) - 16.51 (Education) + 0.098 (Age).

4.2.3 Table 6: Regression Analysis Part A + Part B of the Trail Making Test

Variable	Coefficient	St Error	T	P (2 tail)
Intercept	257.86			
Sex	-24.25	24.24	-1.000	.319
Race	58.28	17.93	3.083	.003
Education	-25.85	6.99	-3.697	.0004
Age	.14	.07	2.108	.038

Again from the above it may be seen that both Sex (-1.0) and Age (2.108) do not significantly affect performance overall on the Trail Making Test (at the 0.05 level) but again that Race (3.083) and Education (-3.697) are both significant at the 0.005 and 0.01 levels respectively. The prediction equation for Part A and Part B is as follows:

Predicted Trail A + Trail B = 257.86 - 24.25 (Sex) + 55.28 (Race) - 25.85 (Education) + .14 (Age).

Overall the variables of Race and Education were found to significantly affect performance and the variables of Sex and Age found not to significantly affect performance.

5.0 CHAPTER 5

DISCUSSION AND CONCLUSIONS

5.1 Discussion

In considering the effects of the independent variables upon performance in this study some agreement and some discrepancies were apparent regarding previous research findings.

The finding that sex does not significantly affect test performance in this study concords with most previous research in this area (Davies, 1968); (Kennedy, 1981); (Chavez et al 1983); (Stanton et al, 1984). This substantiates that there was no need to control for sex in selection of this sample population.

The effects of age on test performance in this study were not statistically significant, a finding discrepant with those of most previous research e.g. Goul and Brown (1970), Gordon (1978), Davies (1968) and Orgel and McDonald (1967), but concordant with the findings of Boll and Reitan (1973). However it must be noted that there was a decline in performance with increasing age and that although not statistically significant (possibly a function of the small sample sizes of the older age groups) the effect of age on test performance cannot be ignored altogether.

The results of this study also support previous documented research which has shown performance on this test to be negatively correlated with educational level achieved, a factor closely

associated with intellectual level. (Reitan, 1955); (King, 1967); (Goul and Brown, 1970); (Boll and Reitan, 1973); (Prigatano and Parsons, 1976); (Kennedy, 1981); (Stanton et al, 1984). However it must be noted that there is a significant discrepancy between educational opportunities afforded different racial groups in South Africa (Pillay, 1984) and that among so called "non white" population groups education level achieved is not necessarily a reflection of intellectual level as it is with white, middle class western groups on whom previous research has been standardised. It is possible that this factor, more than any of the other variables considered accounted for the large within group range of performance in this study. The demographic data collected from the subjects prior to testing suggested that a large proportion of the subjects left school to care for younger siblings or to tend family sheep and cattle, or that their parents simply could not afford to educate them further. The considerations in leaving school were more often a reflection of socio-cultural and practical difficulties rather than a lack of intellectual potential.

It is possible that other socio-cultural factors addressed by Schepers (1974) might have affected test performances. This researcher made the qualitative observation that black subjects tended to disregard the time element of the test although this was made clear in the introductory patter, being more inclined to meticulous and accurate rather than speedy performance. On the other hand coloured subjects seemed more aware of the time factor and tended to be more anxious than the black subjects. Also worthy

of note was the observation that many more black than coloured subjects were "screened out" prior to testing as they were illiterate beyond being able to write their names. This researcher agrees with Dugmore (1987) who writes:

"It cannot be stated to what extent poor performance by the semi and unskilled subjects is the result of unfamiliarity with this format (pencil and paper) created by the type of job they are employed in or to what extent poor performance is attributable to limited education. The researcher would hypothesize that both factors are influential and interrelated but it would require research and statistical analysis of the data to determine whether it is education, occupation or interaction which affects TMT performance."

(pg. 16)

The cross cultural educational and racial discrepancies evident in this study add weight to Dugmore's (1987) assertion that existing norms for this test are invalid for these population groups.

In terms of the existing norms most frequently used in clinical practice in this country (Davies 1968 in Lezak 1983), 65% of black subjects and 38% of coloured subjects in this study would be falsely classified as suffering from brain damage on Part A of the test, 60% of black and 35% of coloured subjects would be classified as brain damaged on Part B of the test in this study.

Perhaps the most noticeable aspect of the norms derived from this population sample (Tables 1-4) is the very high standard deviation among all of the performance scores which renders these norms, strictly speaking, clinically unuseful. Possible methodological reasons for this situation are mentioned below. The normative range

for this research, together with the predicted performance equations will, however, provide some indication of a range of performance where neuropathology cannot be confidently diagnosed for these population groups. Further research is required in this area before valid normative data for these population groups is established.

Methodologically, this study could have been more valid had there been a more rigorous assessment of level of intellectual functioning. In terms of the socio-cultural and educational factors discussed above, an estimate of intellectual level based on number of years of formal education was clearly inadequate, and further research would need to address this issue. Another methodological difficulty encountered in this study was the variation in cell sample size. Further research would provide even more useful results by increasing the overall number of subjects tested and controlling for a better balance of numbers in each cell.

5.2 Conclusions

Statistical analysis revealed that age and sex did not significantly influence performance on the Trail Making Test. The conclusion regarding the influence of sex concurs with previous research findings (Davies, 1968; Chavez et al, 1985; Kennedy, 1981; Stanton et al, 1984), but the conclusion regarding age is discrepant with previous documented research. Possible methodological factors contributing to results in this research have been briefly mentioned.

The variables of education and race, however, were consistently found to be statistically significant in influencing performance on Parts A, B, and A+B, of the Trail Making Test. This finding is consistent with other literature and research (Schepers 1974); (Pillay, 1984); (Dugmore, 1987).

Provisional norms provided for the research population groups were discrepant with established normative data (Davies, 1968; in Lezak, 1983). According to established norms (ibid) performance of 65% and 38% of black and coloured subjects, respectively, on Part A, and 60% and 55% of black and coloured subjects respectively on Part B would be erroneously classified on presenting features of brain neuropathology.

5.3 Suggestions for future reserach arising from this study

The results of this study indicate the need for future research in the area of establishing valid norms for specific South African population groups.

More rigorous research conclusions could be drawn through methodological control of intelligence level in conjunction with educational and occupational factors.

Research towards establishing neurological tests that account for socio-cultural and educational factors affecting test performance of population groups unfamiliar/disadvantaged with certain cognitive skills and tasks is clearly necessary.

REFERENCES

1. Alvarez, R.R. (1962). Comparison of depressive and brain injured subjects on the Trail Making Test. Perceptual and Motor Skills, 14, 91-96.
2. Amante, D., Van Houten, W.W., Grieve, J.H., Bader, C.A. and Margules, P.H. (1977). Neuropsychological deficit, ethnicity and socio-economic status. Journal of Consulting and Clinical Psychology, 45, 524-535.
3. Armitage, S.G. (1946). An analysis of certain psychological tests used for the evaluation of brain injury. Psychological Monographs, 60, 1-48.
4. Beck, A., Feshback, S. and Legg, D. (1962). The clinical utility of the digit symbol test. Journal of Consulting Psychology, 26, 263-268.
5. Boll, T.J. (1974). Behavioural correlates of cerebral damage in children aged 9 through to 14. In R.M. Reitan and L.A. Davison (Eds). Clinical Neuropsychology: Current status and applications (pp.91-120). Washington, D.C.: V.M. Winston and Sons.
6. Boll, T.J. and Reitan, R.M. (1973). Effect of age on performance of the Trail Making Test. Perceptual and Motor Skills, 36, 691-694.

7. Bornstein, R.A. (1986). Classification rates obtained with "standard" cut-off scores on selected neuropsychological measures. Journal of Clinical and Experimental Neuropsychology, 8, 413-420.
8. Brown, E.C., Casey, A., Fisch, R.I. and Neuringer, C. (1958) Trail Making Test as a screening device for the detection of brain damage. Journal of Consulting Psychology, 22, 469-475.
9. Chavez, E.L., Trautt, G.M., Brandon, A. and Steyaert, J. (1983). Effects of test anxiety and sex on neuropsychological test performance: Finger tapping, Trail Making, Digit Span and Digit Symbol tests. Perceptual and Motor Skills, 56, 923-929.
10. Crawford-Nutt, D.H. (1977). The effect of education level on the test scores of people in South Africa. Psychologia Africana, 17, 49-59.
11. Davids, A., Goldenberg, L., and Laufer, M.W., (1957). The relation of the archimedes after effect and the Trail Making Test to brain damage in children. Journal of Consulting Psychology, 21, 429-433.
12. Davies, A.D.M. (1968). The influence of age on Trail Making Test performance. Journal of Clinical Psychology, 24, 96-98.

13. Dugmore, N. (1987). An exploratory study investigating the relationship between education level and performance on the Trail Making Test. Research Project for the Degree B.A. Hons. Psychology. University of Cape Town.
14. Goldstein, G. and Neuringer, C. (1966). Schizophrenic and organic signs on the Trail Making Test. Perceptual and Motor Skills, 22, 347-350.
15. Gordon, N.G. (1978). Diagnostic efficiency of the Trail Making Test as a function of cut-off score, diagnosis and age. Perceptual and Motor Skills, 47, 191-195.
16. Goul, W.R. and Brown, M. (1970) Effects of age and intelligence of Trail Making Test performance and validity. Perceptual and Motor Skills, 30, 319-326.
17. Greenlief, C.L., Margolis, R.B. and Erker, G.J. (1985). Application of the Trail Making Test in differentiating neuropsychological impairment of elderly persons. Perceptual and Motor Skills, 61, 1283-1289.
18. Horton, A.M. (1979). Some suggestions regarding the clinical interpretation of the Trail Making Test. Clinical Neuropsychology, 1, 20-23.
19. Kennedy, K.J. (1981). Age effects on Trail Making Test performance. Perceptual and Motor Skills, 52, 671-675.

20. King, H.W. (1967). Trail Making performance as related to psychotic state, age, intelligence, education and fine psychomotor ability. Perceptual and Motor Skills, 25, 649-658.
21. Lezak, M.D. (1983). Neuropsychological Assessment (2nd ed.). New York: Oxford University Press.
22. Levinsohn P.H. (1973). Psychological assessment of patients with brain injury. Unpublished manuscript. Eugene, Oregon, University of Oregon.
23. Norton, J.C. (1978). The Trail Making Test and Bender Background Interference Procedure as screening devices. Journal of Clinical Psychology, 34, 916-922.
24. Orgel, S.A. and McDonald, R.D. (1967). Notes and comments: An evaluation of the Trail Making Test. Journal of Consulting Psychology, 31, 77-79.
25. Parsons, O.A., Maslow, H.I., Morris, F. and Denny J.P. (1964). Trail Making performance in relation to certain experimental, test and subject variables. Perceptual and Motor Skills, 19, 199-206.
26. Parsons, O.A., Prigatano, G.P. (1978). Methodological considerations in clinical neuropsychological research. Journal of Consulting and Clinical Psychology, 46 (4), 608-619.

27. Partington, J.E. and Leiter, R.G. (1949). Partington Pathways Test. Psychological Services Center Bulletin, 1, 9-20.
28. Pillay, P.N. (1984). The development and underdevelopment of education in South Africa. Carnegie Conference Paper No. 95, Cape Town.
29. Prigatano, G.P. and Parsons, O.A. (1976). Relationship of age and education to Halstead Test performance in different populations. Journal of Consulting and Clinical Psychology, 44, 527-533.
30. Reitan, R.M. (1955). The relation of the Trail Making Test to organic brain damage. Journal of Consulting Psychology, 19, 393-394.
31. Reitan R.M. (1962). Psychological deficit. Annu Rev Psychol. 13, 413-444.
32. Reitan, R.M. (1971). Trail Making Test results for normal and brain damaged children. Perceptual and Motor Skills, 33, 575-581.
33. Reitan, R.M. and Herring, S. (1985). A short screening device for identification of cerebral dysfunction in children. Journal of Clinical Psychology, 41, 643-650.
34. Reitan, R.M. and Tarshes, L.A. (1959). Differential effects of lateralised brain lesions on the Trail Making Test. Journal of Nervous and Mental Diseases, 129, 257-262.

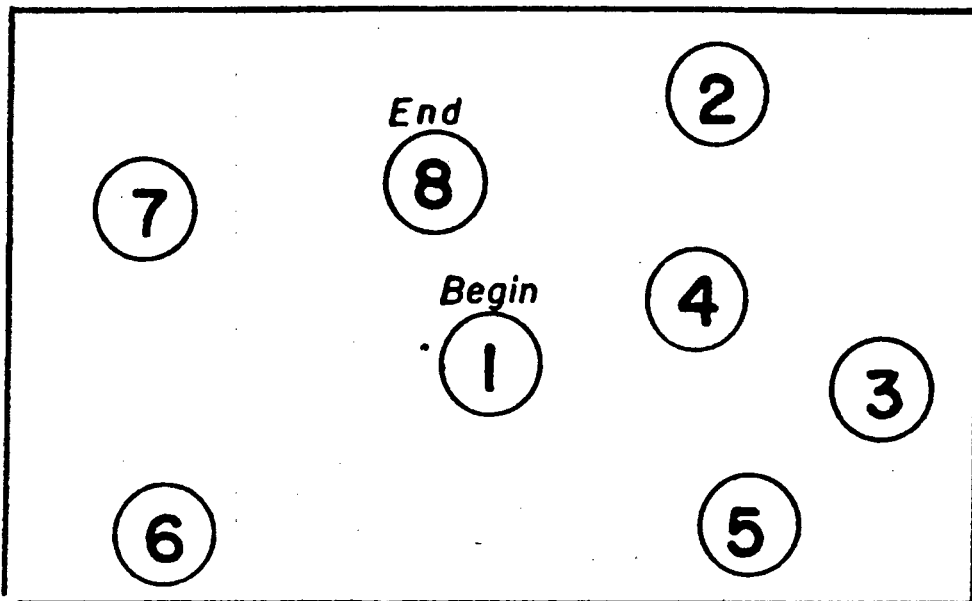
35. Rosin, J.G. (1987). An investigation into the use of the Trail Making Test with children aged 10-15 years. Thesis submitted in partial fulfilment for the degree M.A. Clin. Psych. University of Cape Town.
36. Rosin, J.G. and Levett, A. (1988). The Trail Making Test: performance in a non clinical sample of children aged 10 to 15 years. Submitted to the South African Journal of Psychology.
37. Schepers, J.M. (1974). Critical issues which have to be resolved in the construction of tests for developing groups. Humanitas, 2 (4), 395-406.
38. Smith, T.E. and Boyce, E.M. (1962). The relationship of the Trail Making Test to psychiatric symptomatology. Journal of Clinical Psychology, 18, 450-454.
39. Spreen, O. and Benton, A.L. (1965). Comparative studies of some psychological tests for cerebral damage. Journal of Nervous and Mental Diseases, 140, 323-333.
40. Stanton, B.A., Jenkins, C.D., Savageau, J.A., Zyzanski, S.S. and Aucoin, R. (1984). Age and educational differences on the Trail Making Test and Wechsler Memory Scale. Perceptual and Motor Skills, 58, 311-318.

41. Sterne, D.M. (1973). The Hooper Visual Organisation Test and the Trail Making Tests as discriminants of brain injury. Journal of Clinical Psychology, 29, 212-213.
42. U.S. War Department, Adjutant General's Office, Classification and Replacement Branch, Staff, Personnel Research Section (1944). The new army individual test of general mental ability. Psychological Bulletin, 41, 532-538.
43. U.S. War Department, Adjutant General's Office, (1946). The relationship of Army Individual Test subscores and other mental ability tests to diagnosis of mental disorder. (P.R.S. Report No. 724), Washington.
44. Watson, N. (1949). A qualitative checklist for clinical use of the Partington Pathways Test in evaluating brain injury. Psychological Services Centre Journal, 1, 49-51.
45. Watson, C., Thomas R, Felling, J. and Anderson, D. (1969). Differentiation of organics from schizophrenics with the Trail Making, Dignometer, Critical Flicker Fusion and Light Intensity Matching Test. Journal of Clinical Psychology, 25, 130-135.

TRAIL MAKING

Part A

SAMPLE



5

17

21

20

19

16

18

4

22

5

13

6

Begin

24

7

1

14

2

8

10

3

9

End

25

11

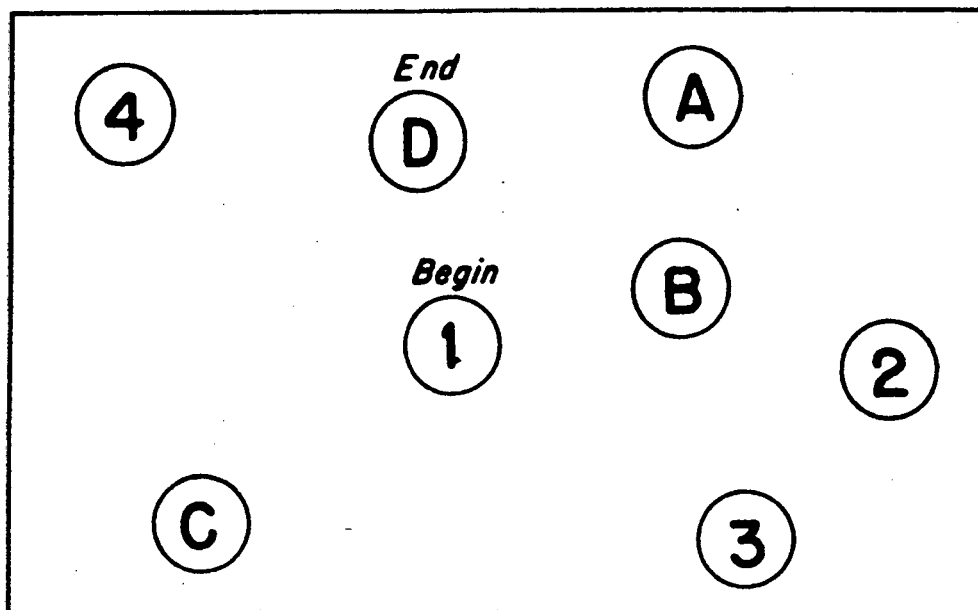
12

23

TRAIL MAKING

Part B

SAMPLE



End
13

10

8

9

I

D

B

4

3

7

Begin

1

5

H

C

12

G

A

J

2

6

L

F

E

K

11

APPENDIX III

INTERVIEW QUESTIONNAIRE

NAME: _____
AGE: _____
SEX: _____
OCCUPATION: _____
NUMBER OF YEARS OF EDUCATION: _____
SCHOLASTIC PERFORMANCE : _____

HISTORY OF BRAIN INJURY (head injury/epilepsy): _____

T.M.T. (Part A): _____ seconds
(Part B): _____ seconds
(Part A + Part B): _____ seconds

COMMENTS: _____

PSYCHIATRIC HISTORY: _____

ALCOHOL/SUBSTANCE ABUSE HISTORY: _____

MEDICAL HISTORY: _____
