A REVISION OF THE INTERMEDIATE VERSION OF THE HALSTEAD CATEGORY TEST

by

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Summary

Research studies have confirmed that the HCT is a valid indicator of brain damage in adults (Reitan, 1955; Wheeler, Burke & Reitan, 1963; Spreen & Benton, 1965; Shaw, 1966). However, in several studies employing the intermediate version of the HCT (a modification of the HCT designed for children between the ages of 9 and 15 years) results have indicated that the test is not a good discriminator of brain damage in children (Reed, Reitan & Kløve, 1965; Reed & Fitzhugh, 1966; Knights & Ogilvie, 1967).

Simmel & Counts (1957) investigated the learning aspects in the HCT and questioned its validity both as a test of learning and as a test of abstraction. Many of their criticisms may be applied to the HCT Intermediate.

In the present study the HCT Intermediate was administered to 389 Ss, 336 normal and 53 brain damaged, between the ages of 9 and 15 years. The data from the 6 age groups was combined into two groups of normal and brain damaged Ss 9 to 11 and 12 to 15 years.

The test was analysed to determine a) the clinical validity of the test in differentiating brain

damaged from normal children, b) the validity of the test as a measure of the ability to form abstract concepts and c) the content validity of the HCT Intermediate as a test of learning.

The reliability of the HCT Intermediate was estimated to be .95 (split half method).

With a view to reorganization and restandardization of the HCT Intermediate a statistical analysis was performed on the data which included item analysis, computation of mean subtest and total test error scores, computation of correlation coefficients between subtest scores and subtest-total test scores.

On the basis of the statistical analysis the HCT Intermediate was shortened from 168 items (6 subtests) to a revised version of 80 items (4 subtests). Items were redistributed in the revised version. The predictions were that 1) the revised version would show no significant loss in reliability and 2) the result of the re-ordering of items would be a consistent upward trend in proportion passing scores throughout the items in the revised version.

The reliability of the revised version was estimated to be .86, indicating that there was no significant loss in reliability with the revised test.

The revised version demonstrated an improved upward trend in learning over the original HCT Intermediate, as demonstrated in proportion passing scores.

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The Halstead Battery is a popular measure employed in many neuropsychological clinics in the assessment of brain damage. Much research has centered around this battery, each test of which is said to tap some aspect of human intelligence, but few investigations have been directed toward evaluation of the individual tests. It would be useful to examine the various tests in the Halstead Battery to determine the consistency of the items and the extent to which they measure what they are purported to measure.

The Halstead Category Test (HCT) (Halstead, 1947), one of the tests in the Halstead Battery, has been widely accepted as a valid measure of brain damage in adults. It is the purpose of this study to perform an item analysis on one version of the HCT in current use, the Intermediate Category Test, with a view to reorganization and restandardization of this test.

Biological Intelligence

There is no doubt that human intelligence, the most fundamental yet the most elusive concept in the study of human behaviour, comprises many more facets than those reflected by intelligence test scores. Detailed discussions of the many definitions of intelligence are abundant in the literature Spearman, 1927; Burt et al, 1934; Freud, 1938; Thurstone, 1938; Angell, 1948; Kohler, 1948; Thorndike, 1948). Tests of intelligence have been constructed to measure various aspects of intelligence (Binet, 1916; Thorndike, 1927; Terman, 1939; Wechsler, 1944); such tests, however, lack the foundation of a basic biological theory that would define the brain-behaviour relationships involved in measures of intelligence.

Reed (1967), in a comprehensive review of the concept of biological intelligence and the research that has evolved from it, states that although the problem of brain-behaviour relationships has been in the fore of laboratory work with animals, (Boring, 1950; Lashley, 1960) where it has been possible either to impose lesions or to stimulate normal brain tissue, clinicians interested in these relationships have been restricted to the observation of brain damaged individuals. Hughlings Jackson and Kurt Goldstein have both tackled the affinity between brain function and behaviour from the clinical rather than the experimental standpoint.

Jackson emphasized the fact that the clinician must deal with the altered function of the part of the brain remaining after damage has been sustained. (Jackson, 1958). Goldstein (1939) stated that alterations of performance observed with brain damage could only be understood in relation to the total human organism, and that brain lesions involve a total reorganization of an individual's problem-solving abilities. But, as Reed observes, the primary contribution of Jackson and Goldstein to the understanding of biological intelligence is their new point of view as compared to psychological theorists; their interest in human intelligence lies not so much in psychometric intelligence, but rather in the alterations in the capacity for behaving adaptively that is observable in brain damaged subjects.

Halstead, in the clinical tradition exemplified by Jackson and Goldstein, was concerned with the adaptive aspect of human behaviour often neglected in the assessment of psychometric intelligence. In concentrating his investigations on the defects of intelligence associated with cerebral lesions in human beings, Halstead endeavoured to isolate the biological variables that might underlie a broader conception of intelligence than that assumed in other measures. His hypothesis was that brain damage, which sometimes shows little effect on psychometric intelligence, should affect biological intelligence severely.

Operationally, Halstead defined biological intelligence as the performance on a battery of tests that included tests of psychometric intelligence, personality functions and sensory capacities (Halstead, 1947). More specifically, he posited four factors that principally define this kind of intelligence: a central integrative factor (C), an ability to abstract factor (A), a power factor (P) and a directional factor (D). These four basic factors emerged from a factorial analysis of a correlational study composed of 27 tests, which had, in previous investigations, shown promise of differentiating between brain damaged and normal individuals. Factors A and C had larger loadings on more of the tests in the battery than the other two factors and may be considered the principal factors in biological intelligence. On the basis of factor loadings, ten tests that best reflected brain injury were selected from the original pool of twenty-seven. These tests form the Halstead Impairment Index, a single score or index which summarizes performance on the selected battery.

Having constructed the Impairment Index for the sole purpose of reflecting brain injury, Halstead demonstrated that the factors of biological intelligence contained in the Battery were apparently disturbed by cerebral lesions (Halstead, 1947). By factor analysis of the data, Halstead confirmed the existence of the basic factors in his original investigations and supported the notion that these factors are stable and universal. To support further his contention of the existence of a biological intelligence, he then attempted to establish that these factors are differentially located in the brain. From data on the performance on the Halstead Impairment Index of frontal lobotomy and lobectomy patients, Halstead concluded that the Impairment Index is a good indicator of frontal lobe damage, and that biological intelligence, while represented throughout the cerebral cortex, has its maximum occurrence in the frontal lobe cortex.

Research studies have confirmed that the Halstead Impairment Index is a valid indicator of brain damage. Reitan (1955) found a striking intergroup difference between brain damaged and normal Ss using the Halstead Battery. Reitan's studies (1956, 1959a, 1966) indicated that the same abilities were being tested in patients with and without cerebral lesions, and that the differences between these two groups were qualitative rather than quantative. These results were compatible with Halstead's interpretation of the factorial structure of biological intelligence. Also, while the intercorrelations between variables in the Halstead Battery and those in the Wechsler-Bellevue were significant, demonstrating that the two concepts of intelligence overlap to some extent, the Halstead Battery was shown to be more sensitive to brain damage than any of the W-B variables. (Reitan, 1959b).

Although the validity of the Halstead measures has been accepted, Halstead's hypothesis concerning the localization of biological intelligence has not received unanimous acceptance (Hebb, 1942; Piercy, 1964; Teuber, 1964).

Reed (1967) suggests that the search for a biological intelligence is only beginning. He finds that the value of the concept lies in the fact that, due to research arising out of this view of intelligence, behavioral scientists are now in the position of being able to draw valid inferences concerning the organic condition of the human brain from psychological test results. Test behaviours can only be applied to specific dimensions of intelligence, but the concept of biological intelligence has expanded the search for more meaningful dimensions of intelligence.

Halstead's Category Test

More than any other test in the Halstead Battery, the Category Test was found to measure Factor A (Halstead, 1947). It also ranks second among discriminators between brain damaged and other subjects (Wheeler, Burke & Reitan, 1963). The subject is required to "abstract" various organizing principles, such as size, shape, number, position, brightness and colour from a series of stimulus figures presented visually by means of a multiple-choice apparatus. The test consists of 208 items, which are photographic slides of geometric figures projected onto a screen. The items are organized into 7 subtests, each with its own organizing principle, which may or may not be the same as the principle employed in the previous subtest. During the course of a subtest, the organizing principle does not change, but the way of applying it frequently does. Subtests I and II are introductory, but from Subtest III to VII the principle underlying the test as a whole is "to find the one that is different". The subject responds by pressing one of four levers, numbered 1, 2, 3 and 4, from left to right, and placed on the apparatus immediately below the screen. A correct response produces a chime, an incorrect response produces a buzzer, sound.

The principles of organization used in subtests III to VII of the Category Test are as follows:

Subtest III: Four figures are presented, one of which differs from the other three in colour, size, shape, outlining or a combination of these. Correct response is depression of the lever whose horizontal position corresponds to that of the unique figure.

Subtest IV: A stimulus figure is presented which can be divided into quadrants, and the correct response is depression of the lever which corresponds to the clockwise position of the deviant quadrant.

Subtests V and VI: A figure is presented which can be divided into four segments. The correct response is depression of the lever whose number corresponds to the proportion of solid segments in the figure (i.e. one fourth, two fourths, three fourths or four fourths of the stimulus figure).

Subtest VII: A review of the items used in the preceding subtests. The subject must recall which of the preceding principles is applicable to the figures presented.

The rationale of the test, as stated by Halstead, is that following an initial period of trial and error groping on the first few items of each series, the organizing principle normally emerges. The principle then holds throughout the remaining items of the particular subtest, regardless of marked variations in their content. For successful performance on the test, the subject must learn the organizing principle in each subtest and apply it, disregarding variations in content. Goldstein (1948) has described two principal difficulties for brain damaged subjects as a) slowness in learning and b) rigidity, i.e. brain damaged subjects experience difficulty in shifting voluntarily from one aspect of a situation to another. Tasks which demand choice or shifting particularly reveal brain damage.

Three forms of the HCT are in current use. The Adult HCT has been described above. The Intermediate HCT is a revision of the Adult HCT by Reitan for children from 9 to 15 years of age; it appears in the Halstead

Neuropsychological Test Battery for Children as modified by Reitan. The Young Children's Category Test, modelled on the Adult HCT but containing many new items, was constructed by Reitan for children between the ages of 5 to 8 years. It is one measure of the Reitan-Indiana Neuropsychological Test Battery for Children.

Validity of the HCT

The HCT has substantial loadings on Factor C (.49) and on Factor A (.63) as shown by Halstead in a factorial analysis of his results. Reitan (1955) states that this finding, as well as subjective interpretation of the content of the test, suggests that the HCT measures, primarily, abstraction ability.

A relationship between abstraction ability, as measured by the HCT, and problem solving ability has been found with retarded Ss. Matthews & Reitan (1963) administered the HCT to mildly retarded subjects and were able to divide them into two groups on the basis of HCT scores. On tests dependent primarily on problem solving ability, the group with good abstraction ability performed better than did the group with poor abstraction ability.

Age has been shown to be a factor affecting performance on the HCT. Fitzhugh, Fitzhugh & Reitan (1964) reported, in a study of the influence of age upon measures of problem solving and experiential background, that a younger group of brain damaged patients exceeded the performance of an older group of brain damaged patients on the HCT.

In differentiating brain damaged from normal Ss a high percentage of correct predictions has been obtained by administration of the HCT. Reitan (1955) found that 94% of control Ss performed better than brain damaged Ss, establishing a predictive rate for the HCT almost as high as that of the entire Halstead Impairment Index. Wheeler, Burke and Reitan (1963) applied discriminant functions to the problem of predicting brain damage using behavioral variables. The HCT demonstrated 83.8% correct predictions over both normal and brain damaged groups. Out of 24 behavioral variables ranked in order of percentage of correct predictions, the HCT attained a ranking of 2. Spreen & Benton (1965), in a comparative study of psychological tests for cerebral damage, found the HCT correctly identified 83% of both brain damaged and normal groups. This combined hit rate compared favourably with that of 70% for the EEG.

Several studies have been carried out to ascertain the degree of differentiation between patients with right and left cerebral dysfunction that might be attained with the HCT (Shure & Halstead, 1958; Chapman & Wolff, 1959; Doehring & Reitan, 1961; Doehring & Reitan, 1962). No significant differences in total error score between patients with right or left cerebral damage was found in these studies, although in the Doehring & Reitan (1962) study both groups made significantly more errors than non-brain damaged control Ss.

These studies contribute to an empirical basis for the clinical application of the HCT.

Reliability of the HCT

Shaw (1966), using the split-half technique, estimated the reliability for the HCT to be .98, the standard error of measurement, 4.47. Simmel & Counts (1957) computed Kuder-Richardson reliabilities for subtests of the Adult HCT as well as for the HCT as a whole. Subtest reliabilities ranged from .75 to .97 and test reliability was an impressive .97, establishing a high degree of item homogeneity for the Category Test.

Item analysis of the HCT

The basic assumption underlying the Category Test is that at first, when Ss do not know the principle needed for a correct response, responses will be random. When the principle has been learned, by reinforcement of correct solutions provided by chime or buzzer, responses will be correct. A necessary condition for the learning of a concept is that it is the only one that may be applied to the situation. When a learning situation is described, responses are assumed to progress from random through to an increase in correct responses over incorrect responses, with the end result of all responses correct.

Simmel & Counts (1957) have presented a detailed analysis of both correct and error responses on the Adult HCT. A basic assumption of the test, that when a principle has been learned responses will be correct, was not supported by their analysis; many correct responses were given by Ss who had clearly not grasped the principle of the test, and many incorrect answers came from Ss who had demonstrated knowledge of the principle by long, errorless runs.

Simmel & Counts found four factors that account for both the success of correct choices and for erroneous choices:

1. Perceptual characteristics of the stimulus configuration. Ss tend to respond to the perceptual organization

and unit formation of the stimulus material. These responses are frequently, though not invariably, wrong in view of the concept to be attained.

2. The application to a new set of items of a specific previously learned principle. Transfer is usually exhibited in the first items of a set but is not limited to these.

3. Einstellungs effects, or unconscious mental sets, induced by several aspects of the total experimental situation.

4. Response tendencies which are part of a more or less permanent make-up of the Ss and which are a function of learning in its widest meaning.

Factors 1 and 4 are considered to be the most influential.

Other major findings in the Simmel & Counts study.

1. Counting

Analysis of the Ss performances revealed systematic stable response tendencies, the most persistent of which was counting. Even Ss who had learned the correct principle for a set of items fell back to counting, the learned response in Subtest II, when in doubt. Simmel & Counts noted that counting, while not sufficient for the attainment of the correct principle in subtests subsequent to Subtest II, was often sufficient for the attainment of the correct answer.

The perceptual organization of the stimulus figures tended to reinforce counting. The popular response of counting all figures dropped off immediately after non-reward, except for isolated items, but then Ss would group figures according to similarity and count the components. Many items elicited incidentally correct responses in this way. Spatial contiguity of some items, i.e., unbroken sequence uninterrupted by the dissimilar figure, produced a strong tendency among Ss to group like figures, and in still other cases, some of the stimulus figures tended to elicit responses that reflected the numerical characteristics of the figure.

2. Randomness of errors

Having recorded each incorrect response rather than recording merely "right" or "wrong" to each item, Simmel & Counts were able to examine closely the distribution of erroneous responses. Their conclusion is that randomness of errors cannot be assumed in the HCT. It cannot be assumed that knowledge of the right answer is the one and only determinant of a Ss response, nor that errors on the test are made only because the S does not know the right answer. The authors state that their data demonstrates that errors may appear to be random in that they are randomly distributed, but they may yet be the result of non-random behaviour by Ss. Item analysis of errors points out that for many stimulus configurations certain types of error are most consistent across Ss.

3. Learning

Decrease in number of errors and increase in correct responses is generally understood to indicate that learning has taken place. In the HCT, according to the Simmel & Counts analysis, there is an increase in the frequency of correct responses throughout the various subtests, but learning in this test cannot be defined on this basis alone. They present evidence that learning of various kinds does take place, even though the incidence of correct responses may not increase. These types of learning are specified as a) inter-set transfer, in which both procedures leading to rewarded responses and those leading to inconsistently rewarded responses may be transferred from one set to another; b) rejection of initially preferred responses, which are counting responses, after non-reward. This condition sometimes has a cumulative effect in that Ss learn to mistrust their preferred response but fail to gain any recognition of the concept involved by so doing; c) establishment of "working rules", defined as a partial attainment of the principle, the application of which may result in success in a number of cases; d) general function of reward of correct responses. Here Simmel & Counts say that although reward of correct responses might be assumed to lead the S to attainment of the principle, in this test many incidentally correct responses are rewarded, leading to a slow-down in the attainment of the concept involved in the test.

The analysis of the HCT presented by Simmel & Counts is provocative, and it raises important questions concerning the content validity of the test. They have emphasized the deleterious effect of counting activities on concept formation throughout the test, but because of the four choice item structure, and the numbered response keys, this effect would seem to be unavoidable. Attempting to find reasons for the strength of counting responses Simmel & Counts discussed the perceptual organization of the stimulus figures at some length, and in this analysis they frequently resorted to inference to prove their point. For example, they spoke of the effect of "numerical resonance", a quality obscurely described as "the intrinsic appeal of the numerical quality of a figure". The example given is item 5 Subtest III, in which a triangular figure is first introduced. The cause of many incorrect "3" responses on this and subsequent items in which triangles appear, is said to be the intrinsic "three-ness" of the figure itself. Since several other reasons could be suggested for erroneous responses, such as transfer from Subtest II of learned counting responses to "like" figures in items, such inferences must be considered as speculations which confuse rather than clarify the problem.

Also related to content validity is the progression in learning of the concepts involved in the HCT. Simmel & Counts give numerous examples in support of their conclusion that there is no consistent upward trend in learning on the HCT. Their analysis emphasizes the need for a statistical evaluation of the contribution of each item to total score, and for the re-distribution of items throughout the subtests. Should such reorganization be carried out there would still be items on which nearly all Ss would be scored "incorrect"; this fact is apparent on the graphs that the authors present in which low points coincide with a change in stimulus configuration. Therefore, while it would be desirable to improve the learning sequence, the resulting graphs would still be irregular.

The assumption in the HCT of randomness in error distribution is refuted by Simmel & Counts. In support of their conclusion they state that there was often great agreement among Ss in selection of incorrect alternatives. However, their assumption of non-random behaviour among Ss is largely dependent on inference. Even if a S were asked why he chose one response rather than another, interpretation of error scores as exhibiting random or non-random behaviour would be a matter of conjecture. In addition, the Simmel & Counts analysis was based on a sample of 61 Ss, 35 brain injured and 28 normal; a larger population of Ss than that employed in this study might tend to increase the randomness of the error distribution.

The general statement of the influence of perceptual organization in slowing down the grasp of a concept could be considered an asset in the clinical application of the HCT if the effect of change in perceptual organization is considered. Research has shown that brain damaged Ss experience difficulty when required to change response set (Halstead, 1947; Ackerley & Benton, 1948; Milner, 1964; Teuber, 1964). When this evidence is considered it might be expected that, while both brain damaged and normal Ss will make more errors when the perceptual organization of stimulus figures changes, normal Ss will adapt to the change with fewer errors than will brain damaged Ss.

Simmel & Counts make a valuable contribution in their suggestions of parameters within which the HCT could be reorganized as a better learning test. They state that in a well-designed test of learning two principal conditions should be met:

1. The coincidence of initially preferred and correct response principles should be avoided; for any given item, the correct response would coincide with one of the weaker response tendencies, though not with the same one on successive items.

2. The number of items within a group with similar basic stimulus figures would be large enough to allow for eventual attainment of correct responses by nearly all

Ss. Such learning should involve three stages:

a) most, if not all, Ss would give the same responses in early items, and these responses would be incorrect in point of view of the correct response principle.

b) second stage of learning begins when the S begins to reject the initially preferred responses. Overall response distributions at this stage should not differ significantly from random.

c) increasing incidence of correct responses should occur to the point where all Ss give correct answers because they have attained the correct principle.

In a brief discussion of the usefulness of the HCT as a test of abstraction, Simmel & Counts outline the need for a higher degree of precision in information conveyed by the test results.

The Simmel & Counts analysis is based on the results from the administration of the HCT to a small number of Ss, 35 patients and 28 student nurses. The brain injured group was composed entirely of patients whose history of cerebral damage was confined to epileptic seizures and irregular EEG patterns. The small number of Ss, together with the restricted composition of the brain injured group, limit the degree to which the Simmel & Counts results may be generalized to larger, more heterogeneous populations. Nevertheless, the painstaking analysis of the HCT items clearly points out the strengths and weaknesses inherent in the test, indicating that a revision and reorganization of the test would be desirable. Similar reviews of other tests in the Halstead Battery would be valuable in indicating ways of increasing the precision of the information obtained in use of these tests.

The Intermediate Halstead Category Test

The purpose of this present study is the consideration of the Intermediate HCT, a modification of the Adult HCT, designed for children between the ages of 9 and 15 years. The original adult version of the HCT was shortened to include only 168 items, divided into 6 subtests. Although the original stimulus items were not used in their entirety, the same organizing principles or concepts were employed (Reed, Reitan & Kløve, 1965).

Before discussion of the Intermediate HCT it will be helpful to review recent research in brain damage with children.

Brain damage in children

While there have been a large number of studies on the effects of brain lesions in adults, little research has been carried out concerning the Intermediate HCT with children. In the few studies employing the Intermediate HCT, results have been conflicting; in some instances (e.g. Reed, Reitan & Kløve, 1965; Reed & Fitzhugh, 1966) the results with the Intermediate test have suggested that brain damage in children has a more diffuse effect than brain damage in adults. Reed, Reitan & Kløve (1965) administered the Halstead Battery and the Wechsler Scale to groups of brain damaged and normal children between the ages of 10 and 14 years. They found that Ss with brain lesions were more frequently impaired on test measures directly dependent on language functions than on tests not so dependent. On the Intermediate HCT, 64% of the control Ss exceeded the performance of the brain damaged Ss, and 32% of the brain damaged Ss exceeded the controls, giving a combined hit rate of only 66% correct group classification. This finding is in marked contrast to Reitan's (1959) study of adult patients in which the Halstead Impairment Index, and notably the HCT, was found to be significantly more sensitive to cerebral dysfunction in adult Ss than was the Wechsler verbal weighted score. Reed, Reitan & Kløve interpreted the results of their study to mean that behaviour deficits associated with cerebral lesions in children may be quite different from the ability losses typically demonstrated by brain damaged adults. Although not discussed in this study, a significant factor in results obtained might have been the precision of the HCT Intermediate as a measure of non-verbal functioning in children 10-14 years.

Reed (1963), in a study with brain damaged, suspected brain damaged and normal children, found that the HCT Intermediate provided significant differences at the .01 level between suspected brain damaged and normal children and between brain damaged and normal children. However, the test did not discriminate significantly between brain damaged and suspected brain damaged groups. The suggestion arising from this study was that psychologists should work with children having clearly identifiable lesions and compare these children with groups of normal Ss on variables associated with intelligence and learning. These results should then be compared with those of groups of minimally brain damaged children. It was also suggested that concurrent existence of response patterns characteristic of different developmental levels and differing in habit strength should be considered in developing tests for use with children.

Reed & Fitzhugh (1966) investigated the influence of severity of cerebral dysfunction on the pattern of psychological deficit in adults and children, both mildly and moderately impaired. None of the adults had a history of brain damage prior to adulthood; all of the children had histories of brain damage occurring during the formative years between infancy through adolescence. The Halstead Battery and W-B tests were ranked, with the test yielding the largest discrimination between brain damaged and normal groups listed as Rank 1. Out of the 20 tests, the Intermediate HCT ranked 16th in discriminating the mildly impaired from the normal Ss and 18th in discriminating the moderately impaired from the normal Ss. The Adult HCT, on the other hand, ranked 5th and 9th respectively. Concerning these results, Reed and Fitzhugh state: "Let it be assumed that brain lesions have a generally impairing effect on the learning potential and adaptive ability of the individual, but that stored memories are relatively spared. The effect of a brain lesion imposed early in life would then be the disruption of the learning process which would later be reflected in a general impoverishment of stored memories". The interpretation of Reed and Fitzhugh's findings would then be that since those Ss with lesions in early childhood will acquire fewer stored memories, their Wechsler scores will reflect impairment to a greater degree than will scores on non-verbal tasks. And since the Category test depends on non-verbal problem solving abilities, it would show less impairment in these Ss.

Support may be found in the literature for the idea that brain lesions in adults have different effects than those incurred in childhood. Hebb (1942) drew attention to the fact that brain injury in children resulted in a more diffuse impairment of intellect than was usual in brain-injured adults. He argued that a greater mass of cerebral tissue was necessary to develop a given intellectual ability than was needed to sustain that ability in later life. Hopkins (1964) tested the efficacy of the WISC in diagnosis of organicity in children of normal intelligence. He found that 22 out of 33 brain injured children rated on the WISC obtained higher scores on performance items than on verbal items. Since this effect is opposite to that claimed in studies with adults, Hopkins concluded that results from adult scales cannot be generalized to predict performance of children.

Reed (1967) made a plea for a more explicit recognition of the problem of measuring the same psychological function in children and adults. He criticized as lacking in sophistication the rationale that "what has worked with adults should work with children", pointing out that this is just one of the many approaches that might have been made to the problem. The Intermediate HCT, as modified by Reitan, is the same in its gross stimulus characteristics as that used with adults. However, further research into the Intermediate HCT is needed to ascertain whether or not the pattern of correct and error responses is similar for adults and children, and whether or not the test is a test of concept learning when used with children.

There is some support for the use of the same stimulus figures in both the adult and the intermediate forms of the HCT. Birch & Lefford (1963) studied the developmental growth of judgmental functions in children from 5 to 11 years of age, and found that it is easier for young children to judge two stimuli as being different than to judge them as being the same, and that these functions clearly improve with age. Also, while the judgment of a difference between geometric forms appears to involve a perceptual discrimination, the judgment of similarity between forms may involve the rudiments of concept formation. This statement would seem to support the use of stimulus figures that are progressively more difficult to discriminate in the Intermediate HCT. Birch and Lefford (1964) found that on perceptual analysis of whole figures brain damaged children do considerably worse than normal children, although both groups show development of this skill with age. The norms established in the Neuropsychology Laboratory of the University of Victoria indicate that the number of errors in the Intermediate HCT also decreases significantly with age, levelling off at age 11 and 12 years. (Spreen & Gaddes, 1969).

Summary and Outline of Present Study

Summary

The stimulus figures appearing in the Adult HCT seem to be suitable items for the Intermediate HCT. Decrease of errors with age would seem to indicate also that within the test there is allowance for developmental growth (Knights & Watson, 1968). Nevertheless, recent evidence points to the fact that, when compared with the discriminatory power of the Adult HCT, this test is not a good discriminator of brain damage in children. It has been demonstrated that differences between the performances of groups of brain damaged and normal children occurred more frequently on the tests of language function, i.e. Wechsler verbal items, Speech Perception test, than on non-verbal tests in the Halstead Battery. This pattern of performance is different from that found in adult brain damaged subjects. The interpretation of this reversal found with the Intermediate HCT is that brain injury in childhood has different effects than brain injury in later years. Before support for this hypothesis can be assumed on the basis of test scores, it would seem necessary to investigate the internal structure of the Intermediate HCT.

Outline of present study

The Intermediate HCT contains 168 items and takes between 40 minutes to 1 hour to administer. A test of such length tires children, especially those with cerebral dysfunction; fatigue and inattention contribute to error variance. For this reason, a shortened version of the HCT Intermediate would seem desirable.

At the same time, shortening may provide a means of discarding items which do not contribute substantially to the validity and reliability of the test.

The proposed study consists of two phases:

A. A revision of the HCT Intermediate based on:

1) An item analysis of the data gathered in the Neuropsychology Laboratory of the University of Victoria that will include computation of proportion passing scores and item-total correlations.

2) Analysis of the contribution of items to the discrimination of brain damaged and normal Ss.

3) An estimate of the optimal length in relation to reliability of a revised version of the HCT Intermediate.

4) Shortening the test with consideration of methods 1 - 3 above, and re-distribution of items.

B. Re-standardization of the shortened version of the HCT Intermediate including computation of actual reliability and item analysis.

This will be a review of the parameters mentioned under Part A (except for item 2) as observed in a new population of normal Ss. It will serve as an indicator of how effective a revision has been accomplished.

Since only a normal population is to be considered, analysis of the contribution of items to the discrimination of brain damaged and normal Ss would require an additional study.

Hypotheses

The shortened version of the HCT Intermediate will show no significant loss of reliability as compared to the original HCT Intermediate.

A monotonic relationship for p values, resulting in a consistent upward trend throughout the items in the HCT Intermediate is predicted as a result of the reordering of items.

Method

a) Subjects

Part A:

A total of 389 Ss was available for the Part A (revision) of the study; 336 of these were normal children between the ages of 9 to 15 years drawn at random from the Greater Victoria school population, and 53, within the same age range, were brain damaged children referred to the Neuropsychology Laboratory, University of Victoria.

Repeaters and children with known brain damage and/or learning problems were excluded from the normal group. The average IQ for the normal Ss was 112, varying between 109 and 118 for the different age levels.

The diagnosis of brain damage was based on neurologists' report of: a) abnormal findings in the neurological examination, b) abnormal findings in the EEG record and/or c) abnormal findings in other medical diagnostic procedures (X-ray, pneumoencephalography, angiography, etc.). Ss were included in the brain damaged group if findings under a), b) or c) were at least moderately severe, or if findings under at least two of the listed criteria were reported.

Part B:

Ss were 80 normal children, 20 at each CA of 12, 13, 14 and 15 years, selected from populations in the Greater Victoria and Ladysmith school districts.*
This age group was selected for the evaluation of the revised version on the basis of findings in the literature suggesting that the ability to form abstract concepts develops between the ages 11 to 15 years (Deutsche, 1943; Inhelder, 1963).

The average IQ was 114, varying between 112 to 118 for the various age levels. A short form of the WISC (Vocabulary/Block Design) was administered to 70 of the Ss. Estimates of correlation between this dyad and Full Scale WISC scores range from .88 to .91 (Silverstein, 1967a; Simpson & Bridges, 1959; Wight & Sandry, 1962). Silverstein's simple regression formula (Silverstein, 1967b) was applied to the scores to reduce the error associated with prorating. Lorge-Thorndike IQ measures were obtained for 10 Ss. The correlation between WISC and Lorge-Thorndike measures for this age group has been estimated to be .71 to .77 (Freeman, 1959).

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* Ss from Victoria were volunteers enrolled in a recreational summer program. Ss from Ladysmith volunteered to participate in the experiment during summer vacation.

b) Procedure

Part A:

The Intermediate HCT was administered to all Ss in accordance with the instructions in the manual accompanying the HCT (Halstead, 1950).

The HCT Intermediate is a non-verbal measure of abstraction and concept formation. From a series of stimulus figures presented visually on a multiple-choice apparatus, the S is required to "abstract" the various organizing principles such as size, shape, number and position.

The test consists of 168 photographic slides of geometric figures, 1 inch to 3 inches in height, presented to the S via rear-screen projection equipment at a distance of approximately 3 feet. The items are divided into 6 subtests.

The S is seated in front of an 8¼ inch by 12 inch ground glass screen, on which is projected the stimulus configuration for each item, one at a time. The S is told that "something about the pattern on the screen will remind you of a number between one and four". The S signifies his response to an item by pressing one of four horizontally-positioned levers numbered, from left to right, 1, 2, 3 and 4. A correct response produces a pleasant-sounding chime, an incorrect response produces an unpleasant buzzer sound.

Each subtest has its own organizing principle, which may or may not be the same as that in the preceding subtest. While the principle is constant within each subtest, the perceptual organization of the stimulus figures changes frequently. The S is warned prior to each subtest that the organizing principle may or may not change.

Responses to test items are scored either "right" or "wrong". The total score on each test is the total number of errors

Part B:

The revised version of the HCT Intermediate was administered and scored by the same method as described in Part A.

Analysis and Results Part A

1. Data from the six age groups 9 to 15 years was combined into two groups, (a) 9 to 11 years, and (b) 12 to 15 years, inclusive, for both brain damaged and normal Ss. The logical basis for this categorization was that if the ability to form abstract concepts develops between the ages of 11 and 14 years, reaching equilibrium at 15 years,

(Inhelder, 1963), the performance of children 9 to 11 years old should differ from that of children 12 to 15 years on a test of concept formation.

2. The following methods of item analysis were applied to the data:

(1) phi coefficients were computed for all items in groups (a) and (b) to provide an index of the contribution of items to the discrimination of brain damaged and normal Ss (Guilford, 1954).

(2) proportion passing scores for all items were computed for groups (a) and (b) in brain damaged and normal Ss to determine item difficulty within each group. Since chance success is an element to be considered in multiple-choice items, a correction formula was applied to the proportion scores, (Guilford, 1936).

(3) item-total correlations and item subtest correlations were computed for groups (a) and (b) in both brain damaged and normal Ss.

In all computations the level of significance accepted was $p = .05$.

<u>phi coefficients</u>

The data in Appendix A reveals that, in the 9-11 year age group, 86 items, or 51% of the total number of items, failed to discriminate significantly between brain damaged and normal Ss as compared with 61 items or 36% of the total number of items in the 12-15 year group.

p scores

The proportion passing scores for each item in the brain damaged and normal groups (a and b) are shown in Appendix A. Figures 1-6 (Appendix C) illustrate the p scores for all items in Subtests III, IV and V.

The figures demonstrate the differences in performance on the test between the younger and older children. The graphs for Subtest III, in which the level of p scores for the 9-11 group was well below that for the 12-15 group, show the greatest difference in performance. In contrast to this observation, the Subtest IV graphs for normal Ss in both age groups are highly similar. The implication is that the concept in Subtest IV is more easily grasped by the younger Ss than are the concepts presented in Subtests III or V.

The assumption in the HCT Intermediate is that as each set of items progresses the percentage of correct responses in a subtest will increase. However, in Subtests III, V and VI little support is found for this assumption.

There is evidence for assuming that some learning has taken place, but Figures 1 to 6 do not show the progressive increase in p scores that might be expected. Only in Subtest IV is there a definite upward trend in the overall learning curve.

item-total correlations and item-subtest correlations

Guilford (1936) states that for well constructed items item-total correlations should range between .30 and .80 and that these correlations should be 90% positive.

In the analysis of the HCT Intermediate it was found that approximately 56% of the item-total correlations ranged between .30 and .80, and that more than 90% of these items had positive item-total correlations.

Approximately 70% of item-subtest correlations were in the .30 to .80 range, and more than 90% of these were positive correlations. If only items in Subtests III, IV and V were considered, 86% of these item-subtest correlations were in the optimal range; this finding supports the assumption of homogeneity of items within subtests.(Appendix A)

3. Subtest and total test mean error scores were computed for groups (a) and (b) for brain damaged and normal Ss.

Mean subtest and total test errors are presented in Table 1.

In the 9-11 year group the mean total test error was 49.00 for normal Ss and 70.57 for brain damaged Ss. Comparative results in the 12-15 year group were 34.28 errors for normal and 61.17 errors for brain damaged Ss.

Further analysis of the HCT Intermediate was based on the performance of the brain damaged and normal Ss in the age group 12-15 years.

4. Correlation coefficients were computed (Pearson r) between subtest scores and between subtest and total test scores for brain damaged and normal Ss.

Subtest intercorrelations and subtest-total test correlations are presented in Table 2. Correlations marked with an asterisk are significant at or beyond the .05 level.

In both normal and brain damaged groups Subtest III had negative correlation with Subtests IV and V, indicating that Subtest III is measuring a factor that varies from that measured in the other two subtests.

5. An estimate of the optimal length in relation to reliability of a shortened version of the HCT Intermediate

Table 1

HCT Intermediate Subtest and Total Test Errors

for Normal and Brain Damaged Ss in Two Age Groups

	9 - 11 Years				12 - 15 Years			
Subtest	Normal N = 128		Brain Damaged N = 30		Normal N = 208		Brain Damaged N = 23	
	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD
1	.09	.28	.50	1.22	.22	.84	.13	.46
2	.55	.67	.83	.95	.51	.61	1.00	1.45
3	17.95	11.68	21.53	10.40	10.11	9.29	19.61	12.19
4	10.19	7.97	17.93	9.89	9.36	7.82	15.52	8.91
5	14.59	5.91	19.66	8.35	10.29	6.64	16.17	7.62
6	4.98	2.98	7.63	4.32	2.42	2.40	6.70	3.31
Total Test	49.00	18.63	70.57	19.72	34.28	15.32	61.17	19.77

Table 2

HCT Intermediate : Subtest Intercorrelations and Subtest - Total Correlations for Normal and Brain Damaged Ss

Group	Subtest	1	2	3	4	5	6	Total Test
	1		.19**	.03	.09	.06	-.07	.14*
12-15 yrs.	2			-.06	-.02	-.04	-.06	.03
Normal	3				-.11	-.10	.36**	.56**
N = 208	4					.36**	.13	.62**
	5						.22**	.58**
	6							.49**
	1		-.15	.24	.00	.07	.21	.19
	2			-.19	.55**	.43*	.19	.38
12-15 yrs.	3				-.23	-.28	.47*	.51*
Brain Damaged	4					.39	.16	.67**
N = 23	5						-.46*	.31
	6							.53**

* Significant at .05 level

** Significant at .01 level

was calculated, based on the K-R 20 formula (Nunnally, 1967).

Reliability of the HCT Intermediate was estimated to be .95 (split half method). Estimate of the reliability of a shortened version of the test half the length of the original 168 items was .91 (K-R 20 formula).

6. The HCT Intermediate was shortened from the original 168 items (6 subtests) to a revised version consisting of 80 items (4 subtests).

Subtests I and VI of the HCT Intermediate were discarded.

Subtest I was deleted as the introductory or "warm-up" subtest since Subtest II seemed to be adequate for this purpose; p scores for Subtest II, shown in Appendix A, indicate that all Ss attained high scores on this subtest. Furthermore, the response to roman numeral figures required in Subtest I bears little connection to responses required in other subtests, and the roman numerals themselves may be unfamiliar to some Ss.

The decision to discard Subtest VI was based primarily on the fact that it is a test of memory rather than of concept formation. All of the items in this subtest are repeats of items presented previously, and retention of the subtest would seem to lengthen the test unnecessarily.

With the deletion of two subtests the correspondence between subtests on the original and revised versions is as follows:

HCT Intermediate	Revised HCT Intermediate
Subtest II	Subtest I
" III	" II
" IV	" III
" V	" IV

Individual items of the subtests retained were deleted primarily on the basis of the statistical data summarized in Appendix A, i.e. significance of phi coefficients, p scores, item subtest and item total-test correlations.

a) phi coefficients

Those items that failed to discriminate significantly between brain damaged and normal Ss were discarded. Examples: items 9,10, 20-24, 28-31, 37, 42, 59, 64, 70, 76, 77, 79, 84, 89, 103, 113-116, 119 and 120.

b) p scores

Those items that accumulated either excessively high or low p values (.99 or above, .32 or lower) which could not be accounted for by the position of the item within a learning sequence* were discarded. Examples: items 10-12, 20-24, 28, 29, 114 and 148. Since there is a tendency for items that have very high or low p scores to be poor discriminators, many of these items appear under a) above.

c) item subtest and item total-test correlations.

Those items showing item total-test and/or item subtest correlations substantially below .30 were discarded. Examples: items 11, 12, 20-24, 28-30, 59, 70, 75, 144 and 145.

7. Items were re-distributed with the objective of maintaining a monotonic relationship between p values.

In Subtest I of the revised version items were retained in the same order of presentation as in the corresponding subtest (Subtest II) of the original test.

In Subtest II (Subtest III in the original test), only the position of items within a learning sequence was, at times, changed; the presentation of learning sets remained in the same order.

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* a "learning sequence" or "learning set" is defined in this study as a group of items having the same correct solution.

In Subtest III, corresponding to Subtest IV of the original test, no changes in order of presentation of learning sequences or items within sequences were made.

Items were re-distributed in Subtest IV (Subtest V of the original test) both in respect to their position within learning sequences and the order in which sequences were presented.

Table 3 presents the items in the revised version of the HCT Intermediate. The numbers in parentheses in the table refer to the number assigned to each item in the original HCT Intermediate.

Discussion Part A

The Intermediate Version of the Halstead Category Test

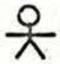
A discussion of the results of this study may be focussed on three aspects of the test under investigation: a) the clinical validity of the test in differentiating brain damaged from normal children, b) the validity of the test as a measure of the ability to form abstract concepts, and c) the content validity of the HCT Intermediate as a learning test.

a) clinical validity

The HCT Intermediate is widely used clinically as one test in a battery designed to distinguish brain

Table 3

Items: Revised HCT Intermediate

Subtest I		Subtest II	
1.(13)	| |	11.(33)	▫ □ ▫ ▫
2.(14)	| | | |	12.(32)	▫ ▫ ▫ □
3.(15)	|	13.(33)	▫ □ ▫ ▫
4.(16)	| |	14.(34)	▫ ▫ ▫ □
5.(17)	○ ○ ○	15.(36)	▵ △ ▵ ▵
6.(18)	○ ○	16.(67)	▵ ▵ ▵ △
7.(19)	○ ○ ○	17.(38)	▵ △ ▵ ▵
8.(25)		18.(44)	□ △ □ □
9.(26)		19.(46)	□ □ □ △
10.(27)		20.(44)	□ △ □ □
		21.(47)	□ ▵ △ ▵
		22.(48)	▵ △ □ ▵
		23.(49)	▵ □ ▵ △
		24.(50)	△ ▫ □ ▫
		25.(51)	□ △ ▫ ▫
		26.(52)	□ ▫ ▫ △

Note.- Item numbers in parentheses refer to item numbers in the original HCT Intermediate.

(continued on following page)

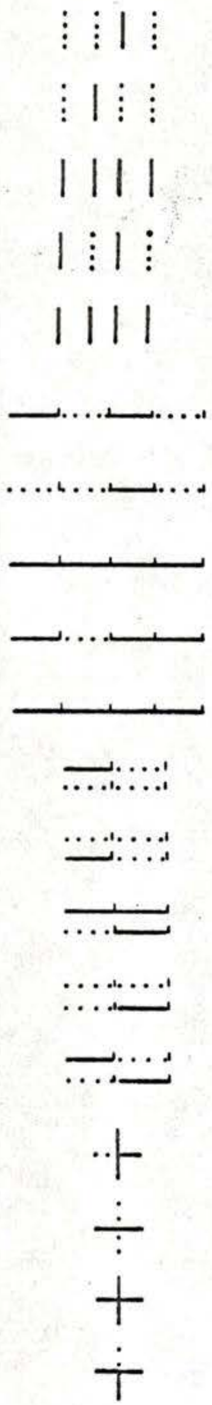
Table 3 (continued)

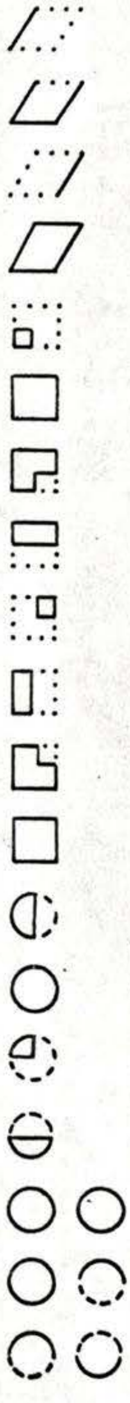
Subtest I	Subtest II	
	27.(55)	**□** **□** **□** □
	28.(56)	**△** **△** △ **△**
	29.(60)	△ **□** **□** □
	30.(61)	**△** △ □ **△**
	31.(62)	□ △ **△** **△**
	32.(68)	▫ □ ▫ ▫
	33.(66)	▫ ▫ □ ▫

(continued on following page)

Table 3 (continued)

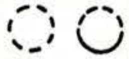
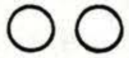
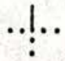
Subtest III	Subtest IV
34.(69)	57.(109)
35.(71)	58.(110)
36.(72)	59.(111)
37.(73)	60.(112)
38.(74)	61.(137)
39.(78)	62.(135)
40.(80)	63.(133)
41.(81)	64.(134)
42.(82)	65.(140)
43.(83)	66.(139)
44.(85)	67.(136)
45.(87)	68.(138)
46.(88)	69.(129)
47.(90)	70.(132)
48.(91)	71.(130)
49.(93)	72.(131)
50.(94)	73.(121)
51.(95)	74.(122)
52.(96)	75.(124)





(continued on following page)

Table 3 (continued)

Subtest III		Subtest IV	
53.(97)		76.(125)	
54.(98)		77.(123)	
55.(99)		78.(128)	
56.(100)		79.(146)	
		80.(147)	W

damaged from normal children. Several studies, mentioned in the review of the literature, have reported low efficiency for the test in this respect, while results of high efficiency are generally reported in use of the HCT with brain damaged and normal adults. These results have been interpreted as an indication that behaviour deficits associated with brain injury in children may be different from ability losses in adults. However, it must be noted that the HCT Intermediate has been used across a wide age range without concern for the developmental levels that occur in children. The varying developmental levels encountered in children from 9 to 15 years may have significant bearing on test results.

In this present study, brain damaged and normal children between the ages of 9 and 15 years were divided into two age groups, 9 to 11 and 12 to 15 years. Mean total test error score for both groups showed the decline in errors with increase in age of Ss that has been noted in other studies (Spreen & Gaddes, 1969; Knights, 1966) The standardized mean error differences between age groups with normal Ss was substantially larger for Subtests III, IV, and VI than for Subtests I, II and IV.

In the age group 9-11 years, 51% of the total number of items failed to discriminate between brain damaged and normal Ss; when Subtest III alone is considered, 82% of the items were non-significant in this respect. In addition, for Subtest III, a t test for independent samples yielded a t value that was not significant beyond the .05 level for brain damaged and normal Ss in the age group 9-11 years (t=1.66), although the t value for total test errors was significant (t=5.45).

As a further indication of the differences in performance between the two age groups, a cutting point of 50 was applied to the data, as suggested by Reitan. In the group 9-11 years 50% of the normal Ss (N=128) and 83% of the brain damaged Ss (N=30) were correctly classified; in the age group 12-15 years, 86% of the normal Ss (N=208) and 70% of the brain damaged Ss (N=23) were correctly classified.

These findings suggest that there is a difference in the quality of the performance in younger Ss that is not revealed by inspection of mean error scores, and that the precision of the HCT Intermediate is lowered when younger Ss are included in the sample.

b) validity of the HCT Intermediate as a measure of the ability to form abstract concepts.

One of the major findings in the Simmel and Counts analysis of the HCT was the high incidence of counting throughout the test, an activity which they define as a perceptual, rather than a conceptual process.

In 133 of the 168 items of the HCT Intermediate counting is a necessary, although not always a sufficient condition for a correct response. The requirement for counting, and the effect that this activity has on the acquisition of concepts throughout the test may be more meaningfully considered within each subtest.

In all but two of the 28 items in subtests I and II counting is both necessary and sufficient for attaining a correct response.

In Subtest IV counting of solid lines in the stimulus configurations will result in correct responses for all items. However, since the instructions given to Ss warn them that the principle in Subtest IV may be the same as or different from that in the preceding subtest, it is not obvious at first that counting is the required activity. Once Ss have learned that solid lines in the figures should be counted, p scores show a steady increase (Appendix C, Figs. 3 & 4). In some items counting of either dotted or solid lines will give the correct response, e.g. items 73, 76, 89, 91, 104 and 108.

Determining the effect of counting on scores in Subtests III and V is a more complex matter. While one counting method or another will produce the correct response on all items in Subtest III, there is no single system of counting that can alone be successfully applied to all items in the subtest. Ordinal counting of position is the necessary counting method, but it must be applied in conjunction with the concept of the "different" figure in the stimulus configuration. The counting method that may be used by any S is dependent on his habitual styles of perceiving and problem solving; both of these factors are dependent on long term day-to-day learning experiences. An incorrect counting method is reinforced and the grasp of the concept hindered in many instances in Subtest III when the answer gained by counting is, coincidentally, the same as the correct response attained by application of the underlying response principle.

The irregular graph for p scores in Subtest V (Appendix C Figures 5 & 6) reflects the contrast between performance on those items in which the concept of proportion must actually be applied to gain a correct response and those items in which counting will suffice. In 17 of the 40 items, (items 109-112, 114, 118, 120, 125, 127, 135, 138, 141-146 and 148) counting of the solid lines results in the correct solution.

Subtest VI is a test of memory, since all of the items have been presented previously in other subtests. Of the 20 items in this subtest, 14 items could be correctly answered by the application of two simple methods of counting: counting the large figures or counting the solid lines.

Counting as a major factor in successful performance on the HCT Intermediate is more evident in Subtests I, II, IV and V than in Subtest III. This finding may account for the positive correlation between Subtests IV and V and for the negative correlation between these two subtests and Subtest III (Table 2). Considerable flexibility is demanded of Ss in the perception of the relevant part of the stimulus configuration that is to be counted, but it may be argued that counting is a perceptual, rather than a conceptual task.

c) the content validity of the HCT Intermediate as a learning test.

In a well designed learning test, response patterns should show gradual transition through three stages: in the first stage most Ss would give incorrect answers, followed by a second stage of "random" responses as Ss search for the correct response principle, and finally, in the third stage, an increasing number of Ss would give correct responses until the majority of Ss had grasped the appropriate response principle. Such a response pattern would be demonstrated in p scores of low, medium and high values, both within learning sets and within subtests,, and, ultimately, across the entire test.

Figures 2, 4 & 6 (Appendix C) show p scores for items in Subtests III, IV & V of the HCT Intermediate (normal Ss, CA 12-15 years). A summary of the proportion passing score patterns in the learning sets within Subtest III, IV and V will assess the validity of the HCT Intermediate as a learning test. Since Subtests I and II are introductory tests, and Subtest VI relies primarily on memory, the patterns within these subtests are not summarized.

For Subtest III (items 29-68) a maximum (.93) was reached on item 66, a repetition of item 30. Of the 13 learning sequences presented, 8 sequences showed some evidence of learning, demonstrated in low initial and higher final p scores (in five instances learning sets consisted of two items only). However, in 6 sets, the p score for the initial item fell below the p score for the initial item in the preceding set.

In Subtest IV (items 69-108) a maximum (.98) was reached on item 107. Although only one learning set in the subtest showed the lowest p score on the initial item and the highest p score on the final item, in all six learning sets presented the initial p value was higher than that of the initial p score in the preceding set, an indication that there was an upward trend in learning throughout this subtest.

In Subtest V (items 109-148) a maximum (.99) was reached on item 145. Of the eight learning sequences presented, only one showed lowest p score on the initial item and highest p score on the final item; however, in four of the learning sets the initial p value was higher than the initial p score in the preceding set.

Figure 7 (Appendix C) shows the learning progression throughout the subtests of the HCT Intermediate. Points on the graph represent final items in sequences of like figures, since theoretically, the final items should show the highest p values and present the best evidence of learning in a sequence. Vertical lines in the graph indicate the terminal item in each subtest. Little progression in learning, as reflected by final p scores in each learning set, is shown throughout the test.

The Revision of the Intermediate Version of the Halstead Category Test.

The HCT Intermediate has high reliability, (.90) but the length of the test presents a problem in administration, especially in reference to brain damaged Ss. The decision concerning which items in the test should be discarded was a difficult one because, in addition to the statistical criteria, several other factors had to be considered:

a) the position of the item in the learning sequence.

In a learning test items occurring in the beginning of a sequence of similar items should have low p scores, while those at the end should have high p scores. Such items, although tending to have lower or non-significant phi coefficients and low item total-test and item subtest correlations, were retained for reasons pertaining to their position in a sequence.

b) the importance of the items in building up a learning "set" in Ss.

Some items that do not meet the statistical criteria for retention in the test are nonetheless valuable in that they permit the Ss to try alternative ways of solving the problem presented in the subtest. Examples: items 69, 71 to 74, 76.

c) the maintenance of sequences of sufficient length to permit the majority of Ss to attain the correct response.

Items of questionable statistical validity were not discarded in some cases where it seemed that they served the purpose of either completing a sequence or of developing the concept in a subtest. On the other hand, particularly in Subtest III, item sets of two items were deleted in the interests of shortening the test.

d) the avoidance of instances in which the correct response principle coincided with the initially preferred response.

In some instances, these clearly ambiguous items were discarded, but because of the four-choice design it was impossible to delete all of them.

In the revision of the HCT Intermediate the two main objectives were 1) to shorten the test without a significant loss in reliability and 2) to improve the learning progression throughout the test.

Results obtained with the revised test are presented and discussed in Part B.

Analysis and Results Part B

1. The following methods of item analysis were applied to the data obtained from administration of the revised version of the HCT Intermediate to a normal population of 80 Ss between the ages of 12 and 15 years.

(1) proportion passing scores for all items were computed to determine item difficulty. A correction formula was applied to the p scores (Guilford, 1936).

(2) correlation coefficients between p values obtained on the HCT Intermediate and p values for identical items on the revised version of the test were computed.

(3) item-total and item-subtest correlations were computed.

A summary of proportion passing scores, item-subtest and item-total test correlations for the revised HCT Intermediate is presented in Appendix B. Items are numbered consecutively from 1 to 80, and, for cross reference, the number assigned to each item in the original HCT Intermediate, together with the original p score for the item, is also listed.

p scores

The proportion passing scores for each item in the revised test are shown in Figures 8 - 11, Appendix C.

The correlation between p scores of items appearing on both the original and revised version of the test was .78. By subtests, the obtained r's were: Subtest I (Subtest II) .84, Subtest II (Subtest III) .66, Subtest III (Subtest IV) .99, and Subtest IV (Subtest V) .77. (The subtest numbers in parentheses refer to subtests in the original version.)

The lowest correlation between p scores in the revised and original tests was obtained with Subtest II (Subtest III). The graph for this subtest indicates that the deletion of items increased the difficulty of the subtest.

item-total test and item-subtest correlations

In the revised test approximately 54% of item-total test correlations were between .30 and .80. (Appendix B) Approximately 79% of item-subtest correlations were within this range and in both cases all correlations were positive.

2. Mean subtest and total test error scores were computed for the entire sample. In addition, mean total test and subtest error scores were computed for ages 12, 13, 14 and 15 years.

Findings presented in Table 4 show little variation in mean errors for Ss at ages 12, 13, 14 and 15 years, supporting the hypothesis that the ability measured on the HCT Intermediate has stabilized by age 12.

Table 5 presents the mean subtest and total test error scores for the combined age group.

Mean error rates on the original and revised HCT Intermediate tests were as follows:

Revised HCT Intermediate		HCT Intermediate	
Subtest I	.049	Subtest II	.026
Subtest II	.398	Subtest III	.253
Subtest III	.220	Subtest IV	.234
Subtest IV	.319	Subtest V	.257

Total mean error score in the revised version was 22.80, which may be compared with total mean error of 34.28 in the original test (normal Ss, 12-15 years).

3. Correlation coefficients were computed (Pearson r) between subtest scores and between subtest and total test scores (Table 6).

Subtest-total test correlations were significant for Subtests II, III and IV (p .01) and for Subtest I ($p < .05$).

The negative relationship, noted previously in

Table 4

Revised HCT Intermediate Total Error

Scores by Age Groups

Age	N	$\overline{X}$	SD
12	20	23.1	8.0
13	20	22.0	9.8
14	20	22.8	8.0
15	20	23.3	11.2

Table 5

Revised HCT Intermediate Subtest and

Total Test Error Scores for Age

Group 12 - 15 Years

Group	Subtest	$\overline{X}$	SD
	1	.49	.60
	2	9.16	6.28
12-15 yrs. N = 80	3	5.05	4.42
	4	7.66	5.06
	Total Test	22.80	9.18

Table 6

Revised HCT Intermediate : Subtest Intercorrelations

and Subtest - Total Correlations for Normal Ss

Group	Subtest	1	2	3	4	Total Test
	1		.13	-.07	.24*	.23*
12-15 yrs.	2			-.41	.26*	.60**
Normal	3				.21	.31**
N = 80	4					.82**

* Significant at .05 level

** Significant at .01 level

Part A, between Subtests III and IV of the original HCT Intermediate was again apparent in the r of -.41 obtained between Subtests II and III of the revised test.

4. Correlation coefficients between IQ of Ss and subtest and total test scores were computed.

Table 7 shows the correlation between IQ measures (WISC short form and Lorge-Thorndike) and errors on the revised test. Within age groups, correlations between I.Q. and error scores failed to reach significance ($p > .05$), but over all 80 Ss the obtained ($r = -.27$) was significant beyond the .05 level.

5. Actual reliability of the shortened version of the HCT Intermediate was computed, based on the K-R 20 formula, and estimated to be .86 for the revised test of 80 items.

Figure 12 (Appendix C) demonstrates the learning progression throughout the subtests of the revised version. Figure 12 may be compared with Figure 11, which shows the final p values for learning sequences in the original test. In some instances sequences in both tests contain the same number of items, while in other instances the revised version utilizes fewer items in a sequence of similar figures than does the original test.

Table 7

Correlation of Revised HCT Intermediate Error

Scores with IQ Measures

Age	N	IQ		HCT		r
		$\overline{X}$	SD	$\overline{X}$	SD	
12	20	115.8	11.1	23.0	7.7	-.10
13	20	112.2	12.9	22.0	9.6	-.37
14	20	111.9	17.0	22.8	7.9	-.26
15	20	117.9	15.7	23.3	10.9	-.36
12-15 Combined	80	114.4	14.6	22.8	9.1	-.27*

* Significant at .05 level

Discussion Part B

The first hypothesis was that the shortened version of the HCT Intermediate would show no significant loss of reliability as compared with the original HCT Intermediate.

The reliability of the revised HCT Intermediate was estimated to be .86, as compared with reliability of .95 for the original test. Some loss in reliability is to be expected in reducing the length of a test from 168 to 80 items, but this loss is offset by the increased efficiency afforded in administering a shorter test. The obtained r is sufficiently high to maintain good reliability for the revised test.

The second hypothesis predicted that the result of reordering of items would be a monotonic relationship for p values, demonstrated in a consistent upward trend of p values throughout items in the revised HCT Intermediate.

It was noted in Part A that many learning sequences in the original version of the HCT Intermediate failed to demonstrate a desirable learning pattern, i.e., low initial p values, followed by medium and finally, high p values. Furthermore the upward trend of p scores evident in the final items of Subtest IV dropped sharply in Subtest V, resulting in a marked trend downward in the latter part of the original test (Figure 11.Appendix C)

By reference to Figures 7 to 10, which illustrate the proportion passing scores in all subtests of the revised version, the value of learning sequences within Subtests II, III and IV may be ascertained. (Appendix C)

In Subtest II (items 11-33) a maximum (.81) was reached on item 20; the p score on the final item in the subtest was .75. The decrease in p scores from item 20 onward may be attributed to the increasing complexity of the items, and the number of item sets presented.

Of the eight learning sequences presented, five sequences demonstrated a learning progression, with low initial and high final p values. In four sequences the initial p score was higher than the initial p value in the preceding set of items.

It is apparent, however, that shortening Subtest III of the original test to the 23 items in the revised subtest resulted in increased difficulty for Ss in Subtest II.

In Subtest III (items 34-56) a maximum (.98) was reached on items 38, 54 and 55. The rapid rise to asymptote on item 38 was probably due to the simplicity of the initial group of stimulus figures.

Of the four learning sequences in this subtest, one showed low initial and high final p values, although in three instances high p scores occurred on final items in sequences, and initial p values were higher than the initial p score in the preceding set of items.

Extensive re-distribution of items resulted in an improved progression in learning in Subtest IV as compared with the learning curve for Subtest V, the comparable subtest in the original HCT Intermediate.

In Subtest IV (items 57-80) a maximum (.95) was reached on items 60 and 80.

Five learning sequences were presented, and four of these showed low initial and high final p scores. In all five sequences high p values were shown on final items, although in only two did initial p scores show improvement over the initial p value in the preceding sequence.

A maximum was reached on the initial group of items presented in the subtest and it should be noted that in this initial sequence Ss were able to use the counting activity that proved so successful throughout the preceding subtest. When, in item 61 and subsequent items, the principle of proportion had to be applied in order to achieve the correct response, p scores declined. Re-distribution of items 121-128 of the original test to a position farther along in the subtest (items 73-78 in the revised version) resulted in minimal improvement in p scores. Apparently the concept of proportion was a difficult one for Ss to grasp both in the original and revised versions, although shortening the subtest did not increase the difficulty.

Figure 12 (Appendix C) shows that re-distribution of items and the deletion of ineffectual items in the HCT Intermediate have resulted in an improved upward trend in learning throughout the revised version of the test.

Other Findings

a) Counting

Because the revised version of the HCT Intermediate retains the basic structure and framework of the original test, counting remains as one of the major problems in the test. The introductory subtest, Subtest I, establishes a set for counting which is, most probably, transferred to Subtest II causing some confusion among Ss in realizing the principle for the subtest. In Subtest III, a simple counting response is rewarded throughout; the graphs for this subtest show that the correct response is not obvious from the beginning, but is gradually learned, and, in fact, the most regular learning curve for the test is shown on this subtest. Many Ss who were unsuccessful in grasping the principle in Subtest II performed well on Subtest III, and, conversely, some Ss who were successful with the problems presented in Subtest II found it difficult to adjust to the simpler demands of Subtest III. The negative correlation ($r=-.41$) found between Subtests II and III demonstrates that these two subtests are apparently measuring different abilities. Although counting is sufficient for a correct response on 10 items in Subtest IV, the correlation coefficient obtained between Subtests III and IV was non-significant ($r=.21$). The largest correlation between subtests is found with Subtests II and IV ($r=.26$), and these two subtests also contribute most to the common variance in the test (Table 6).

In summary, it would seem that the revised HCT Intermediate does measure the ability to form abstract concepts, as demonstrated in Subtests II and IV, but that it also measures, in Subtest III, the ability to learn a counting principle. Although the ability to learn a .

counting principle may be deficient in brain damaged Ss when they are compared with normal Ss, and although the change in "set" demanded for successful performance on both types of subtests may prove to be more difficult for brain damaged Ss, the status of counting as a concept is debatable.

b) Age

Normative data has shown that errors on the HCT Intermediate decrease significantly with age (Ss 9-15 years) levelling off at approximately age 11 or 12 years (Halstead & Rennick, 1966; Reed & Reed, 1967; Spreen & Gaddes, 1969). Data from administration of the revised HCT Intermediate showed no significant differences in total error scores within a group of Ss aged 12-15 years, supporting the view that the ability to form abstract concepts has stabilized in this age group.

In Part A of the present study, analysis of the data from administration of the HCT Intermediate to two groups of brain damaged and normal children, aged 9 to 11 years and 12 to 15 years, suggested that, while discrimination between brain damaged and normal S was satisfactory in the 12-15 year group, the test failed to provide adequate discrimination between brain damaged and normal Ss in the group of Ss with CA 9-11 years. Subtest III was especially deficient in this respect -- 82% of the items in Subtest III failed to discriminate brain damaged from normal S (CA 9-11 years). Mean score for brain damaged Ss was 21.53 errors and for normal Ss, 18.00 errors in this age group. Since Subtest III appears to demand the ability to form abstract concepts, this finding would suggest that, in children of 9-11 years of age, abstraction ability is not well enough developed to permit discrimination on this basis between brain damaged and normal Ss. Support for this hypothesis is found in the literature concerning the development of abstraction ability in young children (Deutsche, 1943; Inhelder, 1963).

A significant relationship between IQ and HCT Intermediate error scores has been reported in several studies with children 9 to 14 years of age. (Reed & Fitzhugh, 1966; Reed & Reed, 1967; Knights & Tymchuk, 1968.)

In this present study, the revised HCT Intermediate was administered to normal Ss within the age range of 12-15 years, who were selected on the basis that they represented a "normal" range of IQ. Correlation between IQ measures and revised HCT Intermediate test scores ($r=-.27$) was significant ($p<.05$) and might be expected to be higher with Ss having a greater dispersion in IQ.

Suggestions for further studies

1. The results from the re-standardization of the revised HCT Intermediate do not allow conclusions about the clinical validity of the test in brain damaged subjects. Clinical validity of the revised test should be appraised in a study with both brain damaged and normal Ss.

It would be helpful if, in further studies, the specific answer given by the S were recorded rather than following the usual practice of recording responses as "right" or "wrong". In this way response patterns could be analysed to determine the effects of stimulus configurations.

2. Further attention should be given to the appropriateness of including a test dependent on learning of a counting principle within a test designed to measure the ability to form abstract concepts. Subtests II and IV (revised version) appear to be the most suitable tests for the measurement of abstraction ability, while Subtest III (revised version) tests the ability to learn and apply a counting principle. The difficulties encountered

by Ss in grasping the underlying concept in Subtest II, and to a lesser extent in Subtest IV, might be lessened by increasing the number of items within each learning sequence. If Subtest III were discarded in full, a new test would not be of undue length. However, such a test would require new items, based on the principles of the items in the HCT Intermediate, but designed in such a way as to avoid the ambiguities which made many of the items ineffectual in the original test.

3. The construction of a test to measure abstraction ability is a complex task, and one in which response tendencies may have a greater effect than has been supposed. Simmel & Counts considered response tendencies which have resulted from the learning experiences throughout an individual's lifetime to be one of the most influential factors accounting for performance on the Halstead Category Test (Simmel & Counts, 1957). When the performance of children is considered, response patterns are complicated by developmental considerations. As suggested by Reed (1967) further research is needed in determining the response patterns characteristic of different developmental levels and in assessing the habit strength of such patterns, before a test can be assumed to measure

concept formation in young children.

Among the habitual response patterns, the response to failure may have a significant effect on performance in the HCT Intermediate. Although the chime and buzzer system employed in the test is effective in giving immediate cognition of success or failure, the loud sound of the buzzer tends to raise anxiety levels; during the administration of the revised test Ss frequently exhibited signs of tension after incorrect responses (e.g. foot shuffling, wringing of hands, squirming) and some Ss verbalized a reluctance to press any of the keys. A study designed to investigate the influence of permanent response tendencies on HCT Intermediate performance would provide some estimate of the magnitude of this effect on performance.

BIBLIOGRAPHY

Ackerley, S. S., & Benton, A. L. Report of a case of frontal lobe defect. Research Publication Association Nervous & Mental Disease, 1948, 27, 479-504.

Angell, J. R. The province of functional psychology. In W. Dennis (Ed.), Readings in the history of psychology. New York: Appleton-Century-Crofts, 1948.

Binet, A., & Simon, T. The development of intelligence in children. Baltimore: Williams & Wilkins, 1916.

Birch, H. G., & Lefford, A. Intersensory development in children. Monographs of the society for research in child development, 1963, 28, 5.

Birch, H. G., & Lefford, A. Two strategies for studying perception in "brain-damaged" children. In H. G. Birch (Ed.) Brain damage in children, the biological and social aspects. Baltimore: Williams & Wilkins, 1964.

Boring, E. G. A history of experimental psychology. (2nd ed.) New York: Appleton-Century-Crofts, 1950.

Burt, J. C., Jones, E., Miller, E., & Moodis, W. How the mind works. New York: Appleton-Century, 1934.

Chapman, L. F., & Wolff, H. G. The cerebral hemispheres and the highest integrative functions of man. Archives of Neurology, 1959, 1, 357-424.

Davis, L. J., Hamlett, Iona C., & Reitan, R. M. Relationship of conceptual ability and academic achievement to problem solving and experiential background of retardates. Perceptual & Motor Skills, 1966, 22, (2), 499-505.

Deutsche, J. M. The development of children's concepts of causal relations. In R. G. Barker, J. S. Kounin, & H. F. Wright (Eds.), Child behaviour and development. New York: McGraw-Hill, 1943.

Doehring, D. G., & Reitan, R. M. Behavioral consequences of homonymous visual field defects in brain-injured adults. Journal of Comparative & Physiological Psychology, 1961, 54, 489-492.

Doehring, D. G., & Reitan, R. M. Concept attainment of human adults with lateralized cerebral lesions. Perceptual & Motor Skills, 1962, 14, 27-33.

Fitzhugh, Kathleen B., Fitzhugh, L. C., & Reitan, R. M. Influence of age upon measures of problem solving and experiential background in subjects with longstanding cerebral dysfunction. Journal of Gerentology, 1964, 19, 2.

Freeman, F. S. Review of the Lorge-Thorndike Intelligence Tests. In O. K. Buros (Ed.) The fifth mental measurements yearbook. Highland Park, N.J. : Gryphon, 1959.

Freud, S. Basic writings of Sigmund Freud. New York: Modern Library, 1948.

Goldstein, K. The organism. New York: American Book, 1939.

Goldstein, K. Language and language disturbances. New York: Grune & Stratton, 1948.

Guilford, J. P. The determination of item difficulty when chance success is a factor. Psychometrika, 1936, 1, 259-264.

Guilford, J. P. Psychometric methods. (2nd ed.) New York: McGraw-Hill, 1954.

Halstead, W. C. Brain and intelligence. Chicago: University of Chicago Press, 1947.

Halstead, W. C., & Rennick, P. M. Perceptual-cognitive disorders in children. In A. H. Kidd & J. L. Rivoire (Eds.), Perceptual development in children. New York: International Universities Press, 1966.

Halstead, W. C., & White, J. B. Manual for the Halstead battery of neurophysiological tests. (Mimeographed manual) Chicago: University of Chicago Press, 1950.

Hebb, D. O. The effect of early and late brain injury upon test scores and the nature of normal adult intelligence. Proceedings American Philosophical Society, 1942, 85, 275-292.

Hopkins, K. D. An empirical analysis of the efficacy of the WISC in the diagnosis of organicity in children of normal intelligence. Journal of Genetic Psychology, 1964, 105, 163-172.

Inhelder, B. Criteria of the stages of mental development. In R. G. Kuhlen & G. G. Thompson (Eds.), Psychological studies of human development. (2nd ed.) New York: Appleton-Century-Crofts, 1963.

Jackson, J. H. The selected writings. New York: Basic Books, 1958.

Kephart, N. C. Perceptual-motor correlates of learning. In H. G. Birch (Ed.), Brain damage in children, the biological and social aspects. Baltimore: Williams & Wilkins, 1964.

Knights, R. M. Normative data on tests for evaluating brain damage in children 5 to 14 years of age. Research Bulletin No. 20, Department of Psychology, University of Western Ontario, London, Ontario, 1966.

Knights, R. M., & Ogilvie, R. M. Comparison of test results from normal and brain damaged children. Research Bulletin No. 53, Department of Psychology, University of Western Ontario, London, Ontario, 1967.

Knights, R. M., & Tymchuk, A. J. An evaluation of the Halstead-Reitan Category Tests for children. Cortex, in press.

Knights, R. M., & Watson, P. The use of computer test profiles in neuropsychological assessment. Research Bulletin No. 71, Department of Psychology, University of Western Ontario, London, Ontario, 1968.

Kohler, W. The mentality of apes. In W. Dennis (Ed.), Readings in the history of psychology. New York: Appleton-Century-Crofts, 1948.

Lashley, K. S. In search of the engram. In F. Beach, D. Hebb, C. Morgan, & H. Nissen (Ed.), The neuropsychology of Lashley. New York: McGraw-Hill, 1960.

Matthews, C. G., & Reitan, R. M. Relationship of differential abstraction ability levels to psychological test performances in mentally retarded subjects. American Journal of Mental Deficiency, 1963, 68, 2, 235-244.

Milner, Brenda. Some effects of frontal lobectomy in man. In J. Warren & K. Akert (Ed.), Frontal granular cortex and behaviour. New York: McGraw-Hill, 1964.

Nunally, J. Psychometrics. New York: McGraw-Hill, 1967.

Piercy, M. The effects of cerebral lesions on intellectual function: a review of current research trends. British Journal of Psychiatry, 1964, 110, 310-352.

Reed, H. B. C. Some relationships between neurological dysfunction and behavioral defects in children. In S. Kirk & W. Becker (Eds.), Conference on children with minimal brain impairment. (Mimeo.) Urbana, Ill.: University of Illinois, 1963.

Reed, H. B. C. Biological intelligence. (Mimeo.) Neuropsychological Laboratory, Indiana University Medical Center, 1967.

Reed, H. B. C., & Fitzhugh, Kathleen B. Patterns of deficits in relation to severity of cerebral dysfunction in children and adults. Journal of Consulting Psychology, 1966, 30, 2, 98-102.

Reed, H. B. C., & Reitan, R. M. Intelligence test performances of brain-damaged subjects with lateralized motor deficits. Journal of Consulting Psychology, 1963, 27, 2, 102-106.

Reed, H. B. C., Reitan, R. M., & Kløve, H. Influence of cerebral lesions in psychological test performances of older children. Journal of Consulting Psychology, 1965, 29, 3, 247-251.

Reed, J. C., & Reed, H. B. C. Concept formation ability and non-verbal abstract thinking among older children with chronic cerebral dysfunction. Journal of Special Education, 1967, 1, 157-161.

Reitan, R. M. Investigation of the validity of Halstead's measures of biological intelligence. A.M.A. Archives of Neurology & Psychiatry, 1955, 73, 28-35.

Reitan, R. M. Investigation of relationships between "psychometric" and "biological" intelligence. Journal of Nervous & Mental Disease, 1956, 123, 6, 536-541.

Reitan, R. M. Impairment of abstraction ability in brain damage: quantitative versus qualitative changes. Journal of Psychology, 1959, 48, 97-102.(a)

Reitan, R. M. The comparative effects of brain damage on the Halstead Impairment Index and the Wechsler-Bellevue Scale. Journal of Clinical Psychology, 1959, 15, 281-285.(b)

Reitan, R. M. Psychological deficit. Annual Review of Psychology, 1962, 13, 415-444.

Reitan, R. M. A research program on the psychological effects of brain lesions in human beings. In N. Ellis (Ed.), International review on research in mental retardation. New York: Academic Press, 1966. Vol. I.

Shaw, D. J. The reliability and validity of the Halstead Category Test. Journal of Clinical Psychology, 1966, 22, 126-180.

Shure, G. H., & Halstead, W. C. Cerebral localization of intellectual processes. Psychological Monographs, 1958, 72, No. 12. (Whole No. 465)

Silverstein, A. B. Validity of WISC short forms at three age levels. Journal of Consulting Psychology, 1967, 31, 6, 635-636.(a)

Silverstein, A. B. Estimating Full Scale IQs from WISC short forms. Psychological Reports, 1967, 20, 3, (Part 2), 1264.(b)

Simmel, Marianne L., & Counts, Sarah. Some stable response determinants of perception, thinking, and learning: a study based on the analysis of a single test. Genetic Psychological Monographs, 1957, 56, 3-157.

Simpson, W. H., & Bridges, C. C. A short form of the Wechsler Intelligence Scale for Children. Journal of Clinical Psychology, 1959, 15, 424.

Spearman, C. The abilities of man. New York: MacMillan, 1927.

Spreen, O., & Benton, A. L. Comparative studies of some psychological tests for cerebral damage. Journal of Nervous & Mental Disease, 1965, 140, 5, 46-60.

Spreen, O., & Gaddes, W. H. Developmental norms for 15 neuropsychological tests age 6 to 15. Cortex, in press.

Terman, L. M. The measurement of intelligence (Rev. ed.). Boston: Houghton-Mifflin, 1939.

Teuber, H. L. The riddle of frontal lobe function in man. In J. Warren & K. Akert (Eds.). Frontal granular cortex and behaviour. New York: McGraw-Hill, 1964.

Thorndike, E., Bregman, E., Cobb, M. et al. The measurement of intelligence. New York: Teachers College, Columbia University, 1927.

Thurstone, L. L. Primary mental abilities. Psychometric Monographs, No. 1, Chicago: University of Chicago Press, 1938.

Wechsler, D. The measurement of adult intelligence. Baltimore: Williams & Wilkins, 1944.

Wheeler, L., Burke, C. J., & Reitan, R. M. An application of discriminant functions to the problem of predicting brain damage using behavioral variables. Perceptual & Motor Skills, 1963, 16, 417-440.

Wight, B. W., & Sandry, M. Short form of the Wechsler Intelligence Scale for Children. Journal of Clinical Psychology, 1962, 18, 1966.

Appendix A

Intermediate HCT: Summary of Item Analysis
of Data for Brain Damaged and Normal Groups

	Item	9 - 11 Years							12 - 15 Years						
		Brain Damaged				Normal			Brain Damaged				Normal		
		phi	rst[1]	rtt[2]	p[3]	rst	rtt	p	phi	rst	rtt	p	rst	rtt	p
1.	I	.03	.08	.16	.97	.50	.04	.98	-.04	.00	.00	.96	.40	.00	.94
2.	III	.16*	.60	.24	.90	.50	-.05	.98	.05	.00	.00	.96	.56	.05	.98
3.	I	.13	.85	-.13	.97	.00	.00	1.00	-.15	.00	.00	1.00	.65	.00	.96
4.	IV	.23**	.63	-.03	.83	.58	.05	.97	.09	.69	.43	.91	.70	.16	.96
5.	II	.13	.85	-.13	.97	.00	.00	1.00	-.11	.00	.00	1.00	.78	.15	.98
6.	IV	.28***	.63	.26	.83	.29	.01	.99	.04	-.05	.40	.96	.77	.16	.97
7.	I	.00	.00	.00	1.00	.00	.00	1.00	-.07	.00	.00	1.00	.74	.11	.99
8.	II	.18*	.78	.01	.93	.00	.00	1.00	.10	-.05	.40	.96	.56	.06	.99
9.	□	.00	.14	-.14	.61	.72	.00	.60	.13	.50	.44	.48	.83	.05	.61
10.	□□□	.06	.33	.03	.93	.25	.09	.96	.09	.90	.21	.96	.23	-.01	.99
11.	□	.03	.63	.17	.97	.26	-.06	.98	.20**	.76	.17	.91	-.06	.04	1.00
12.	□□□□	.15	.62	.23	.93	.46	.01	.99	.12*	.90	.21	.96	.05	-.02	1.00
13.	||	.13	-.16	-.13	.97	.00	.00	1.00	.21**	.66	.45	.91	.00	.00	1.00
14.	||||	.13	.03	.36	.97	.00	.00	1.00	-.07	.00	.00	1.00	.24	-.03	.99
15.	|	.00	.00	.00	1.00	.00	.00	1.00	.15*	.90	.21	.96	.00	.00	1.00
16.	||	.00	.00	.00	1.00	.00	.00	1.00	.15*	.90	.21	.96	.00	.00	1.00
17.	○○○	.13	.16	.16	.97	.00	.00	1.00	-.05	.00	.00	1.00	.17	-.06	1.00
18.	○○	-.06	.00	.00	1.00	.06	.05	.99	-.05	.00	.00	1.00	-.06	.01	1.00
19.	○○○	.00	.00	.00	1.00	.00	.00	1.00	.00	.00	.00	1.00	.00	.00	1.00
20.	○	.00	.00	.00	1.00	.00	.00	1.00	.00	.00	.00	1.00	.00	.00	1.00
21.	AAAA	-.14	.00	.00	1.00	.31	-.09	.96	-.08	.00	.00	1.00	.16	-.03	.99
22.	EEE	.09	.03	.01	.97	.06	.08	.99	-.07	.00	.00	1.00	.08	.00	.99
23.	CABE	-.09	.00	.00	1.00	.08	.01	.98	.00	.00	.00	1.00	.00	.00	1.00
24.	SO	.13	.23	.03	.97	.00	.00	1.00	.00	.00	.00	1.00	.00	.00	1.00

*Significant at .05 level
**Significant at .01 level
***Significant at .001 level

[1] Item subtest total correlation
[2] Item total test correlation
[3] Proportion passing (corrected p)

	Item	9 - 11 Years							12 - 15 Years							
		Brain Damaged				Normal			Brain Damaged				Normal			
		phi	rst	rtt	p	rst	rtt	p	phi	rst	rtt	p	rst	rtt	p	
25.	🯅	.29***	.67	.07	.73	.26	-.10	.95	.12	.09	-.07	.87	.36	.04	.94	
26.	🯅🯅🯅🯅	.09	.63	.17	.97	.19	.07	.99	.00	.00	.00	1.00	.00	.00	1.00	
27.	🯅	.09	.23	.00	.97	-.07	.02	.99	-.08	.00	.00	1.00	.16	.02	.99	
28.	🯅🯅🯅	.13	.63	.17	.97	.00	.00	1.00	.00	.00	.00	1.00	.00	.00	1.00	
29.	□ ▫ ▫ ▫	-.03	.19	-.17	.03	.17	.12	.02	.11	.28	-.21	.04	.08	-.01	.10	
30.	▫ ▫ □ ▫	.04	.32	.39	.57	-.02	.02	.60	.13	-.08	-.12	.48	.10	.12	.61	
31.	□ ▫ ▫ ▫	-.04	.62	.32	.33	.58	.54	.30	.02	.82	.26	.43	.43	.17	.46	
32.	▫ ▫ ▫ □	-.04	.45	.02	.43	.36	.28	.40	.03	.70	.20	.48	.50	.18	.51	
33.	▫ □ ▫ ▫	.00	.51	.33	.47	.54	.43	.47	.18**	.77	.58	.48	.42	.21	.66	
34.	▫ ▫ ▫ □	.11	.60	.38	.43	.51	.41	.55	.11	.57	.35	.61	.54	.24	.71	
35.	△ ▵ ▵ ▵	-.03	.69	.32	.43	.72	.54	.41	.21**	.82	.47	.52	.60	.32	.73	
36.	▵ △ ▵ ▵	.05	.60	.24	.50	.58	.48	.55	.35***	.87	.64	.48	.60	.35	.82	
37.	▵ ▵ △ ▵	.00	.66	.27	.57	.57	.46	.56	.06	.46	.41	.74	.76	.42	.79	
38.	▵ △ ▵ ▵	.12	.63	.48	.50	.58	.44	.63	.23***	.59	.52	.70	.53	.26	.88	
39.	▵ ▵ △ ▵	.07	.57	.16	.60	.53	.37	.66	.17*	.53	.35	.70	.71	.36	.84	
40.	△ ▵ ▵ ▵	.11	.75	.48	.47	.72	.53	.58	.40***	.82	.46	.48	.74	.42	.86	
41.	△ △ △ □	.00	.49	.14	.63	.66	.55	.63	.30***	.73	.34	.52	.76	.34	.81	
42.	△ △ □ △	.09	.63	.14	.57	.67	.51	.66	.07	.49	.47	.78	.74	.40	.84	
43.	△ △ △ □	.05	.39	.40	.63	.71	.55	.68	.25***	.58	.24	.61	.78	.42	.84	
44.	□ △ □ □	.09	.59	.14	.43	.59	.51	.52	.37***	.63	.42	.39	.65	.38	.76	
45.	△ □ □ □	.06	.64	.49	.57	.73	.57	.63	.32***	.67	.49	.61	.70	.37	.88	
46.	□ □ □ △	.00	.53	.16	.60	.78	.56	.60	.31***	.66	.33	.57	.74	.41	.85	
47.	□ ▵ △ ▵	.17*	.70	.30	.30	.51	.27	.47	.24***	.73	.45	.43	.50	.25	.67	
48.	▵ △ □ ▵	.22**	.69	.33	.27	.71	.51	.48	.35***	.55	.21	.43	.68	.43	.77	

Item	9 - 11 Years Brain Damaged phi	rst	rtt	p	Normal rst	rtt	p	12 - 15 Years Brain Damaged phi	rst	rtt	p	Normal rst	rtt	p
49. △ □ △ △	.03	.33	.55	.60	.59	.40	.63	.43***	.95	.56	.39	.66	.41	.81
50. △ □ □ □	.02	.29	.10	.27	.35	.15	.28	.15*	-.18	-.37	.22	.33	.20	.35
51. □ △ □ □	.07	.22	.35	.47	.39	.34	.54	.28***	.64	.41	.43	.42	.27	.72
52. □ □ □ △	.12	.40	.14	.40	.78	.57	.52	.42***	.58	.05	.35	.75	.39	.77
53. □ □ ⌂ □	.11	.38	-.16	.47	.72	.58	.58	.20**	.72	.27	.61	.68	.35	.79
54. ⌂ △ ⌂ ⌂	.02	.25	.01	.50	.42	.33	.52	.41***	.50	.17	.26	.52	.33	.67
55. **□** **□** **□** □	.23**	.79	.21	.33	.84	.60	.56	.31***	.72	.17	.52	.85	.48	.82
56. **△** **△** △ **△**	.18*	.68	.18	.50	.70	.44	.68	.32***	.68	.36	.61	.66	.34	.88
57. **□** □ □ □	.14	.53	.20	.47	.63	.41	.61	.36***	.76	.52	.52	.44	.32	.86
58. △ △ △ **△**	.15	.64	.48	.43	.79	.53	.59	.33***	.73	.28	.57	.72	.46	.86
59. **□** △ □ **□**	.12	.24	.11	.53	.18	.00	.66	.10	-.06	-.07	.61	.17	.12	.71
60. △ **□** **□** □	.00	.63	.08	.47	.64	.46	.48	.32***	.64	.39	.43	.64	.42	.75
61. **△** △ □ **△**	.23**	.40	.10	.30	.53	.37	.53	.40***	.46	.06	.30	.54	.36	.70
62. □ △ **△** **△**	.14	.43	.22	.43	.62	.40	.58	.40***	.54	.18	.43	.52	.26	.82
63. **□** **△** △ **□**	.08	.52	.30	.43	.50	.34	.52	.18**	.45	.33	.39	.32	.20	.57
64. **△** □ **□** **△**	.03	.39	-.22	.53	.63	.46	.56	.10	.36	.30	.65	.52	.34	.75
65. **□** **△** **□** ⌂	.12	.65	.15	.40	.79	.54	.52	.26***	.67	.16	.57	.67	.44	.80
66. □ □ □ □	.20*	.48	.20	.60	.53	.41	.78	.45***	.78	.64	.52	.54	.32	.93
67. △ △ △ △	.14	.71	.28	.50	.76	.59	.64	.35***	.71	.47	.57	.66	.36	.88
68. □ □ □ □	.17*	.80	.27	.50	.74	.58	.67	.38***	.88	.41	.52	.68	.42	.88
69. ⋮ ⋮ ❘ ⋮	.00	.20	.01	.13	.24	-.07	.13	-.15	.01	-.36	.17	.15	-.08	.08
70. ❘ ❘ ⋮ ❘	.10	.26	.18	.57	.07	.11	.66	.05	.30	.42	.57	.00	.06	.61
71. ⋮ ❘ ⋮ ⋮	.22**	.33	.22	.20	.27	-.25	.40	-.12	.24	-.32	.30	.18	-.18	.20
72. ❘ ❘ ❘ ❘	.30***	.48	.37	.70	.12	-.09	.93	.06	.45	-.05	.83	.34	.15	.87
73. ❘ ⋮ ❘ ⋮	.21**	.48	.23	.53	.44	.02	.73	-.05	.38	.09	.74	.44	.18	.69

Item	9 - 11 Years							12 - 15 Years						
	Brain Damaged				Normal			Brain Damaged				Normal		
	phi	rst	rtt	p	rst	rtt	p	phi	rst	rtt	p	rst	rtt	p
74.	.30***	.39	.41	.73	.25	.02	.95	.08	.31	-.07	.87	.38	.17	.92
75.	.12	.14	.33	.60	.24	.08	.72	.21**	.21	.11	.52	.16	.10	.73
76.	.28***	.42	.26	.60	.56	.12	.85	.07	.74	.40	.78	.49	.26	.84
77.	.22**	.54	.41	.47	.53	.08	.68	-.03	.56	.07	.65	.49	.16	.62
78.	.19*	.00	-.05	.40	.40	.18	.59	.26***	.42	.35	.35	.46	.20	.61
79.	.16*	.44	.37	.57	.54	.15	.72	.11	.33	-.06	.57	.55	.28	.67
80.	.17*	.41	.15	.27	.67	.44	.43	.44***	.41	.25	.09	.62	.31	.49
81.	.30***	.02	.01	.23	.50	.40	.52	.23***	.36	.54	.43	.57	.45	.66
82.	.20*	.36	.19	.47	.53	.22	.66	.25***	.35	.44	.39	.56	.35	.64
83.	.26**	.16	.33	.47	.44	.30	.72	.18**	.28	.22	.61	.50	.41	.77
84.	.43***	.49	.39	.30	.59	.40	.73	.11	.39	.51	.65	.61	.40	.75
85.	.24**	.41	.52	.33	.48	.32	.57	.19**	.21	.23	.43	.54	.47	.63
86.	.13	.18	.32	.30	.60	.51	.43	.15*	.44	.30	.43	.51	.35	.59
87.	.29***	.29	.32	.33	.58	.43	.63	.34***	.65	.28	.30	.69	.50	.65
88.	.08	.34	.28	.53	.59	.38	.62	.22**	.39	.45	.57	.53	.44	.77
89.	.26**	.40	.41	.53	.65	.37	.78	.07	.54	.41	.78	.54	.39	.84
90.	.22**	.44	.29	.40	.70	.46	.62	.29***	.70	.28	.39	.71	.50	.68
91.	.14	.33	-.01	.67	.69	.45	.79	.24***	.71	.77	.65	.60	.34	.86
92.	.31***	.36	.49	.37	.65	.46	.68	.19**	.46	.34	.57	.63	.45	.75
93.	.21**	.36	.32	.50	.60	.44	.70	.20**	.68	.38	.57	.74	.50	.75
94.	.24**	.50	.33	.63	.52	.36	.84	.32***	.67	.51	.65	.46	.20	.91
95.	.34***	.52	.42	.57	.57	.33	.88	.36***	.47	.29	.57	.62	.41	.89
96.	.28***	.48	.43	.63	.56	.31	.88	.10	.42	.24	.78	.60	.46	.86
97.	.31***	.57	.62	.50	.66	.33	.80	.20**	.54	.18	.70	.53	.34	.87
98.	.36***	.48	.48	.67	.34	.28	.95	.22***	.50	.30	.78	.53	.38	.94

		9 - 11 Years							12 - 15 Years						
Item		Brain Damaged				Normal			Brain Damaged				Normal		
		phi	rst	rtt	p	rst	rtt	p	phi	rst	rtt	p	rst	rtt	p
99.		.38***	.53	.53	.67	.41	.22	.96	.22***	.74	.40	.78	.53	.33	.94
100.		.29***	.42	.66	.63	.52	.40	.88	.10	.55	.33	.78	.56	.38	.86
101.		.11	.20	.24	.70	.49	.22	.80	.22***	.69	.56	.65	.58	.42	.84
102.		.28***	.53	.66	.63	.50	.39	.88	.19**	.80	.72	.74	.57	.40	.89
103.		.35***	.54	.72	.60	.53	.19	.91	.10	.61	.65	.83	.61	.35	.90
104.		.41***	.73	.70	.57	.49	.28	.92	.17**	.69	.52	.83	.45	.34	.94
105.		.34***	.37	.24	.60	.50	.28	.90	.26***	.52	.62	.74	.43	.25	.93
106.		.30***	.59	.69	.67	.42	.19	.91	.20**	.73	.61	.78	.52	.39	.92
107.		.28***	.34	.26	.73	.50	.31	.94	.31***	.52	.47	.78	.32	.27	.98
108.		.32***	.63	.68	.63	.41	.21	.91	.13*	.54	.45	.87	.43	.33	.95
109.		.12	.25	.29	.53	.19	.07	.66	.00	.00	.17	.48	.14	.08	.46
110.		.29***	.43	.52	.63	.37	.23	.88	.06	.37	.56	.78	.47	.39	.84
111.		.26***	.25	.36	.60	.38	.36	.84	.11	.11	.52	.74	.32	.34	.83
112.		.26***	.43	.53	.73	.41	.26	.93	.24***	.11	.60	.83	.19	.30	.97
113.		.00	-.02	-.15	.17	.08	.02	.17	.08	-.06	-.19	.17	.25	.12	.24
114.		.30***	.34	.36	.73	.35	.16	.95	.10	-.06	.45	.91	.19	.21	.96
115.		.00	.10	.08	.37	.30	.11	.38	.12	.11	.17	.35	.42	.31	.46
116.		.24**	-.26	-.09	.17	.43	.25	.38	.09	.24	.18	.43	.42	.26	.53
117.		.01	.22	.33	.50	.40	.38	.51	.23***	.00	.17	.43	.44	.22	.67
118.		.32***	.28	.24	.27	.33	.28	.59	.28***	.07	.19	.48	.53	.40	.75
119.		.30***	.33	.44	.47	.45	.28	.76	.11	.08	.39	.74	.40	.30	.83
120.		.06	.22	.35	.50	.28	.21	.56	-.01	.42	.37	.70	.33	.28	.68
121.		-.11	.32	.01	.17	.22	.00	.09	.04	.06	.07	.13	.13	.05	.16
122.		.09	.31	.28	.40	.44	.22	.49	.25***	.33	.44	.35	.40	.25	.60
123.		.07	.34	.27	.53	.48	.25	.60	.20**	.28	.46	.61	.42	.26	.79

Item		9 - 11 Years: Brain Damaged phi	rst	rtt	p	Normal rst	rtt	p	12 - 15 Years: Brain Damaged phi	rst	rtt	p	Normal rst	rtt	p
124.		.10	.34	.22	.47	.39	.18	.56	.24***	.14	.21	.52	.24	.21	.75
125.		.18*	.54	.56	.47	.30	.23	.65	.15*	.39	.46	.61	.44	.33	.75
126.		.29***	.33	.30	.50	.40	.21	.78	.24***	.10	.24	.70	.31	.19	.89
127.		.18*	.40	.55	.57	.39	.32	.73	.20**	.12	.36	.70	.40	.39	.87
128.		.20*	.26	.30	.40	.44	.28	.60	.30***	.29	.35	.52	.54	.40	.81
129.		-.02	.10	-.17	.57	.21	-.01	.55	.00	.20	.24	.57	.19	.02	.56
130.		.01	.29	.34	.33	.43	.35	.34	.34***	.63	.48	.30	.57	.38	.65
131.		.12	.20	.19	.57	.25	.17	.68	.35***	.26	.52	.48	.36	.26	.81
132.		.04	.13	.05	.30	.42	.35	.34	.34***	.22	.24	.26	.58	.37	.60
133.		.11	.24	.22	.47	.42	.36	.58	.23***	-.04	-.07	.52	.41	.33	.75
134.		.29***	.22	.21	.23	.47	.37	.52	.29***	.33	.58	.48	.56	.33	.76
135.		.17*	.15	.23	.67	.40	.23	.81	.11	.06	.29	.83	.35	.22	.90
136.		.18*	.14	.30	.53	.26	.20	.71	.32***	.31	.24	.52	.36	.30	.82
137.		.15	.38	.30	.30	.44	.37	.45	.34***	.45	.38	.35	.57	.47	.69
138.		.15	.10	.36	.70	.27	.14	.83	.20**	.17	.44	.78	.35	.25	.92
139.		.28***	.42	.48	.33	.48	.37	.61	.32***	.32	.48	.48	.55	.40	.78
140.		.22**	.55	.49	.33	.45	.46	.55	.33***	.22	.20	.39	.56	.40	.72
141.		.42***	.25	.32	.47	.42	.22	.86	.21**	.23	.14	.61	.46	.36	.80
142.		.34***	.46	.64	.53	.39	.21	.85	.32***	.33	.13	.52	.42	.32	.83
143.		.35***	.26	.23	.57	.40	.23	.88	.16*	.10	.26	.74	.43	.31	.87
144.		.38***	.42	.52	.70	.37	.21	.98	.32***	.12	.53	.74	.17	.25	.97
145.		.31***	.25	.44	.80	.13	.14	.99	.27***	.11	.65	.83	.00	.17	.99
146.	K	.12	.32	.27	.50	.14	.16	.63	.37***	.13	.31	.39	.41	.28	.75
147.	W	.32***	.24	.31	.73	.31	.29	.96	.16*	.17	.47	.87	.13	.16	.96
148.	W W	-.06	-.05	.00	.13	.13	.09	.09	.17*	-.22	-.16	.17	.30	.20	.32

	9 - 11 Years							12 - 15 Years						
Item	Brain Damaged				Normal			Brain Damaged				Normal		
	phi	rst	rtt	p	rst	rtt	p	phi	rst	rtt	p	rst	rtt	p
149. □ □ □ □	.21**	.21	.16	.37	.56	.47	.58	.41***	.46	.47	.48	.32	.16	.87
150. □ □ □	.28***	.14	.45	.80	.17	.20	.98	.06	-.12	.33	.91	.05	.10	.94
151.	.48***	.12	.28	.23	.40	.45	.72	.27***	.20	.32	.52	.35	.42	.78
152. ▱	.32***	.13	.34	.67	.25	.22	.92	.21**	.10	.67	.83	.06	.24	.96
153. □ △ □ □	.10	.21	.30	.27	.56	.36	.36	.25***	.37	.32	.30	.33	.06	.55
154. | | | |	.33***	.21	.61	.77	.15	.17	.98	.02	-.45	.40	.96	.09	.16	.97
155.	.14	.31	.38	.40	.38	.34	.54	.41***	.12	.40	.39	.25	.44	.80
156.	.20*	-.01	.06	.43	.37	.33	.63	.29***	.40	.70	.52	.28	.30	.80
157. △ △ □ △	-.03	.06	.09	.47	.55	.39	.44	.16*	.18	.31	.52	.43	.12	.68
158.	.43***	.38	.61	.63	.17	.20	.98	.22***	-.23	.18	.78	.10	.18	.94
159.	.45***	.24	.57	.53	.21	.21	.93	.26***	.02	.25	.65	.21	.23	.87
160. △ △ △ △	.07	.14	.35	.53	.47	.35	.60	.34***	.45	.48	.52	.41	.26	.84
161. A A A A	.17*	-.17	.34	.87	.23	.27	.96	.22***	-.13	.30	.87	.05	.23	.99
162.	.16*	.30	.43	.33	.47	.33	.49	.23***	.34	.39	.43	.42	.16	.67
163.	.21**	.34	.56	.47	.38	.43	.67	.43***	.29	.48	.39	.26	.42	.81
164.	.25**	.08	.38	.67	.18	.23	.88	.34***	.20	.59	.70	.23	.29	.95
165.	.36***	.18	.54	.73	.11	.06	.98	.34***	.23	.35	.74	.06	.12	.98
166.	.12	.46	.45	.30	.59	.44	.41	.34***	.45	.56	.39	.52	.31	.73
167. ○	.28***	-.17	.17	.80	-.09	-.07	.98	-.06	-.45	.40	.96	.03	.04	.93
168.	.26***	-.05	.22	.57	.28	.33	.81	.41***	-.13	-.02	.57	.20	.38	.92

APPENDIX B

Revised Intermediate HCT: Summary of Item Analysis of Data for Normal SS 12-15 years

Item	rst[1]	rtt[2]	p[3]	Item no. HCT Inter.	p HCT Inter.
1.	.44	.12	.84	13	1.00
2.	.00	.00	1.00	14	.99
3.	.00	.00	1.00	15	1.00
4.	.00	.00	1.00	16	1.00
5.	.00	.00	1.00	17	1.00
6.	.00	.00	1.00	18	1.00
7.	.29	.12	.99	19	1.00
8.	.75	.13	.70	25	.94
9.	.29	.03	.99	26	1.00
10.	.10	.14	.99	27	.99
11.	.25	.25	.04	33	.66
12.	.29	.03	.24	32	.51
13.	.35	.22	.35	33	.66
14.	.51	.27	.46	34	.71
15.	.38	.27	.60	36	.82
16.	.55	.31	.64	67	.88
17.	.58	.35	.75	38	.88
18.	.72	.45	.68	44	.76
19.	.72	.43	.70	46	.85
20.	.60	.43	.81	44	.76
21.	.53	.32	.45	47	.67
22.	.60	.40	.65	48	.77
23.	.60	.44	.72	49	.81
24.	.30	.10	.45	50	.35
25.	.30	.31	.70	51	.72
26.	.76	.43	.55	52	.77
27.	.77	.48	.69	55	.82
28.	.73	.44	.79	56	.88
29.	.60	.46	.55	60	.75

[1]Item subtest total correlation
[2]Item total test correlation
[3]Proportion passing (corrected p)

Item	rst[1]	rtt[2]	p[3]	Item no. HCT	Item no. Inter.	p HCT	p Inter.
30.	.65	.35	.66	61		.70	
31.	.75	.43	.64	62		.82	
32.	.65	.36	.79	68		.88	
33.	.68	.42	.75	66		.93	
34.	.28	.22	.18	69		.08	
35.	.28	.08	.29	71		.20	
36.	.48	.30	.94	72		.87	
37.	.48	.13	.76	73		.69	
38.	.36	.34	.98	74		.92	
39.	.58	.12	.64	78		.61	
40.	.55	.09	.58	80		.49	
41.	.27	.30	.74	81		.66	
42.	.70	.15	.68	82		.64	
43.	.33	.24	.90	83		.77	
44.	.65	.21	.74	85		.63	
45.	.64	.02	.73	87		.65	
46.	.49	.08	.78	88		.77	
47.	.78	.28	.70	90		.68	
48.	.76	.28	.85	91		.86	
49.	.64	.20	.80	93		.75	
50.	.64	.36	.88	94		.91	
51.	.44	.43	.94	95		.89	
52.	.49	.27	.91	96		.86	
53.	.46	.20	.91	97		.87	
54.	.42	.42	.98	98		.94	
55.	.31	.14	.98	99		.94	
56.	.42	.11	.92	100		.86	
57.	.19	.14	.68	109		.46	
58.	.26	.35	.85	110		.84	
59.	.24	.28	.85	111		.83	
60.	.38	.48	.95	112		.97	
61.	.38	.32	.41	137		.69	
62.	.39	.32	.80	135		.90	
63.	.63	.50	.51	133		.75	
64.	.60	.41	.58	134		.76	
65.	.58	.43	.45	140		.72	
66.	.51	.32	.65	139		.78	
67.	.63	.55	.55	136		.82	
68.	.35	.36	.94	138		.92	
69.	.61	.59	.52	129		.56	

Item	rst[1]	rtt[2]	p[3]	Item no. HCT	Item no. Inter.	p HCT	p Inter.
70.	.66	.54	.49	132		.60	
71.	.47	.42	.70	130		.65	
72.	.46	.34	.85	131		.81	
73.	.32	.17	.21	121		.16	
74.	.52	.41	.61	122		.60	
75.	.49	.44	.72	124		.75	
76.	.57	.38	.76	125		.75	
77.	.57	.40	.74	123		.79	
78.	.47	.42	.86	128		.81	
79.	.64	.60	.61	146		.75	
80.	.28	.29	.95	147		.96	

Appendix C

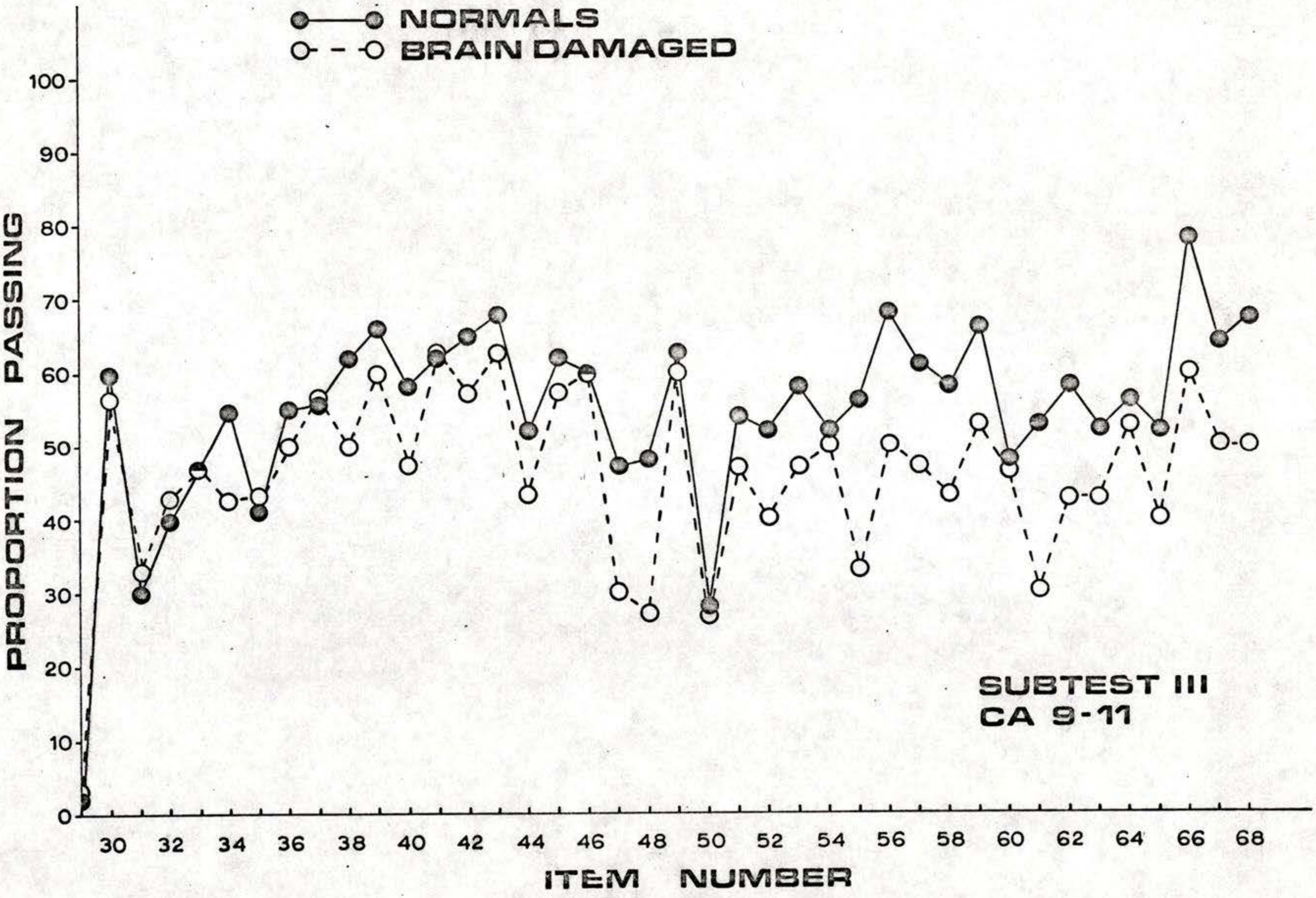


Fig. 1 Intermediate H.C.T. Percentage of Ss answering each item correctly.

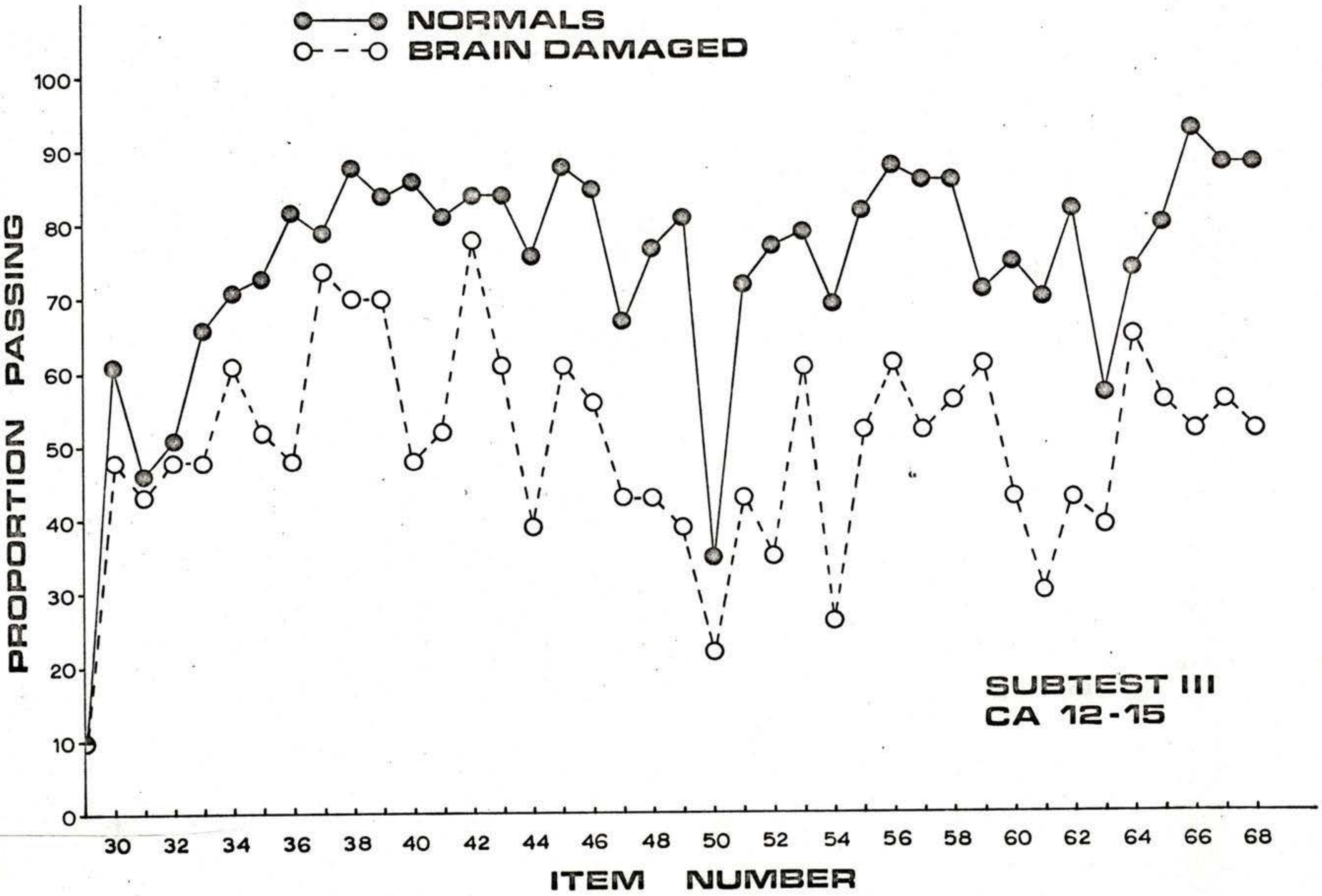


Fig. 2 Intermediate H.C.T. Percentage of Ss answering each item correctly.

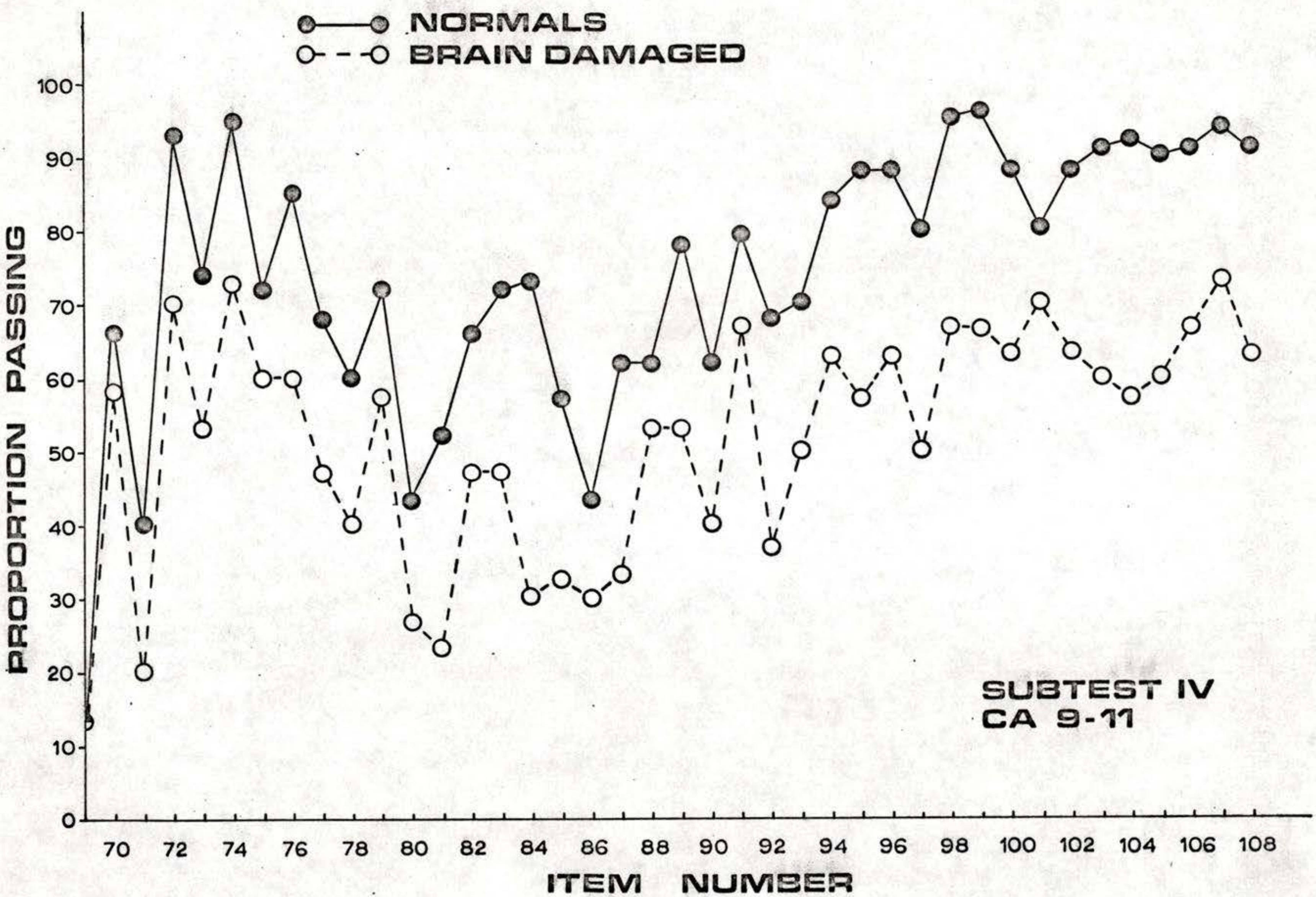


Fig. 3 Intermediate H.C.T. Percentage of Ss answering each item correctly.

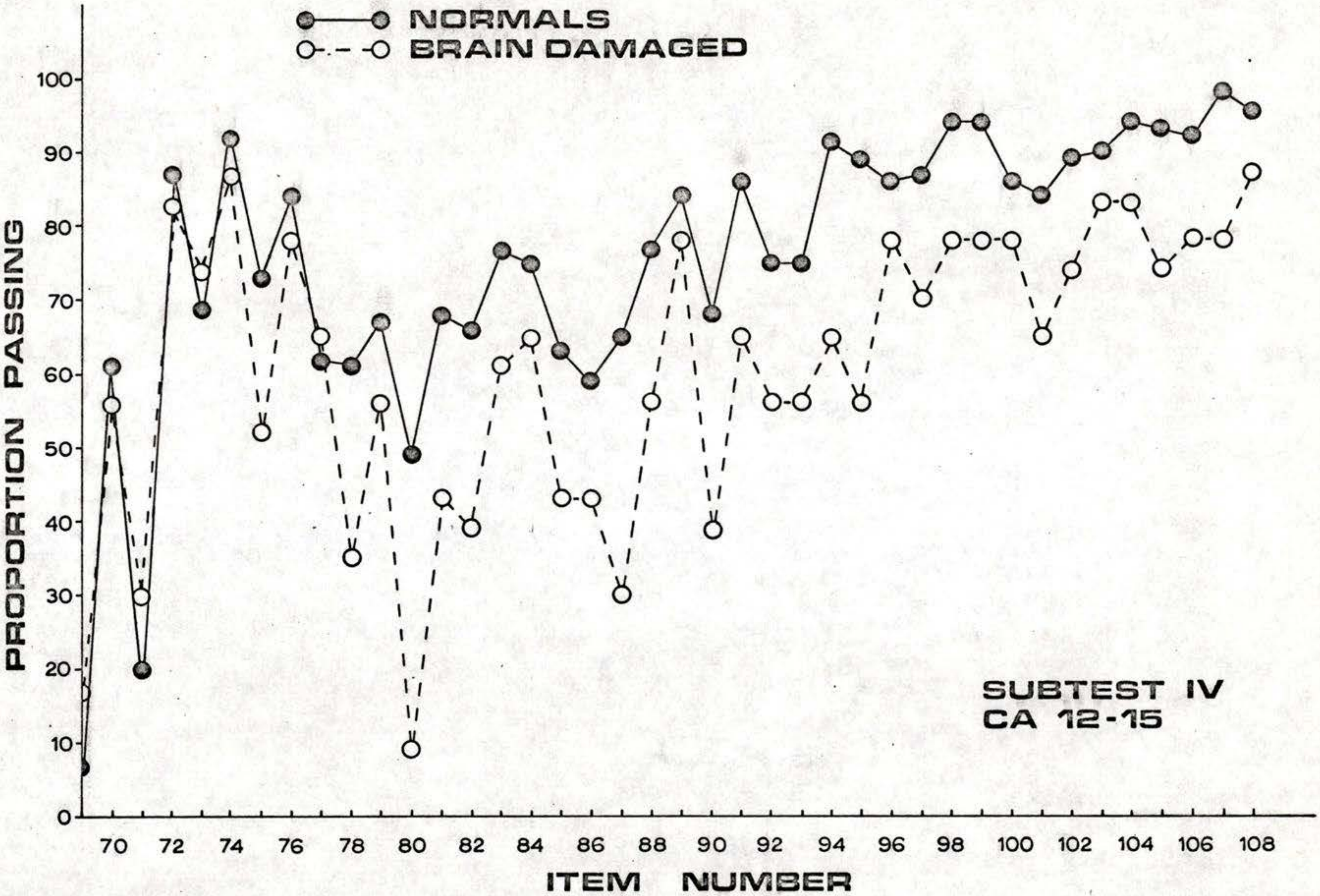


Fig. 4 Intermediate H.C.T. Percentage of Ss answering each item correctly.

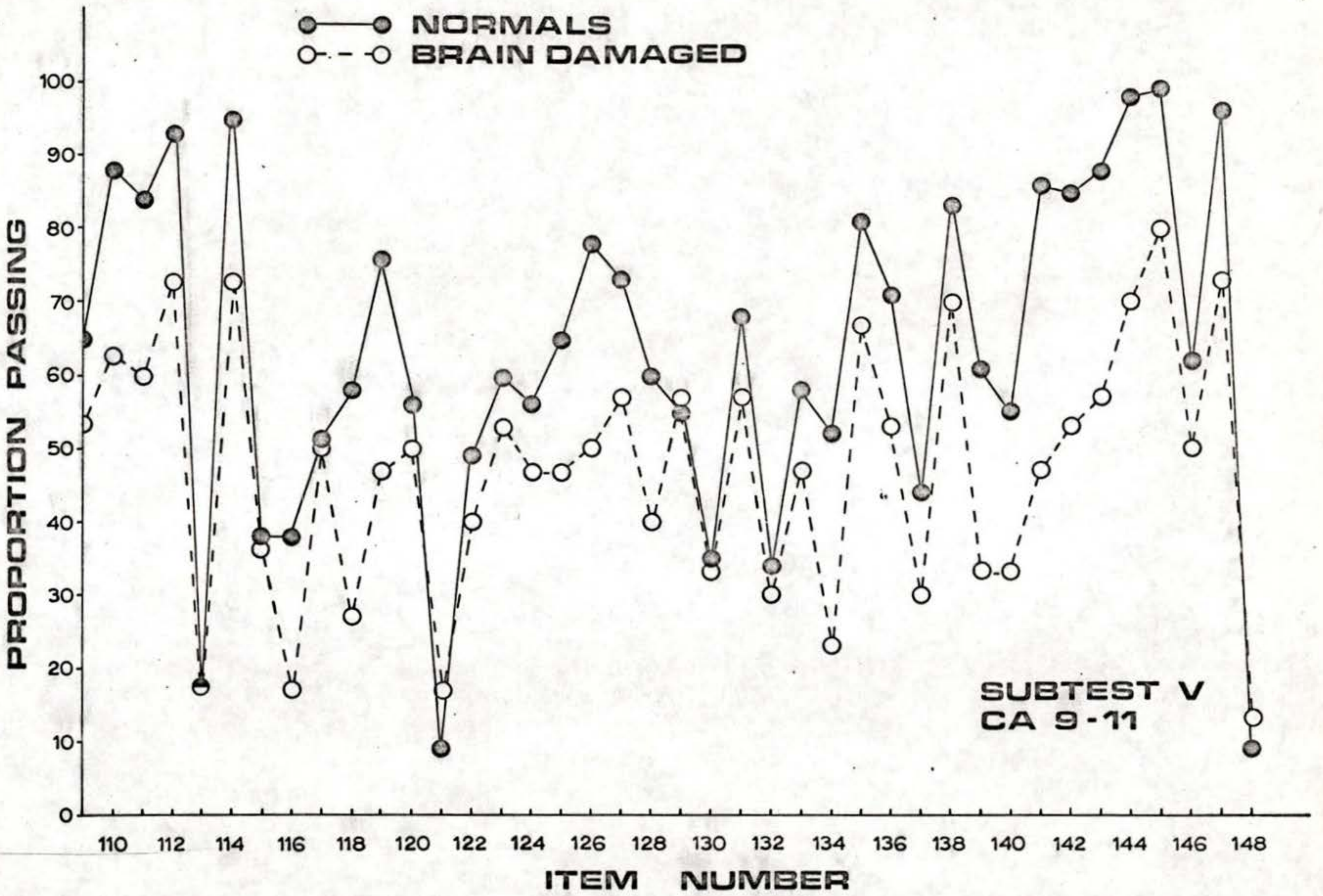


Fig. 5 Intermediate H.C.T. Percentage of Ss answering each item correctly.

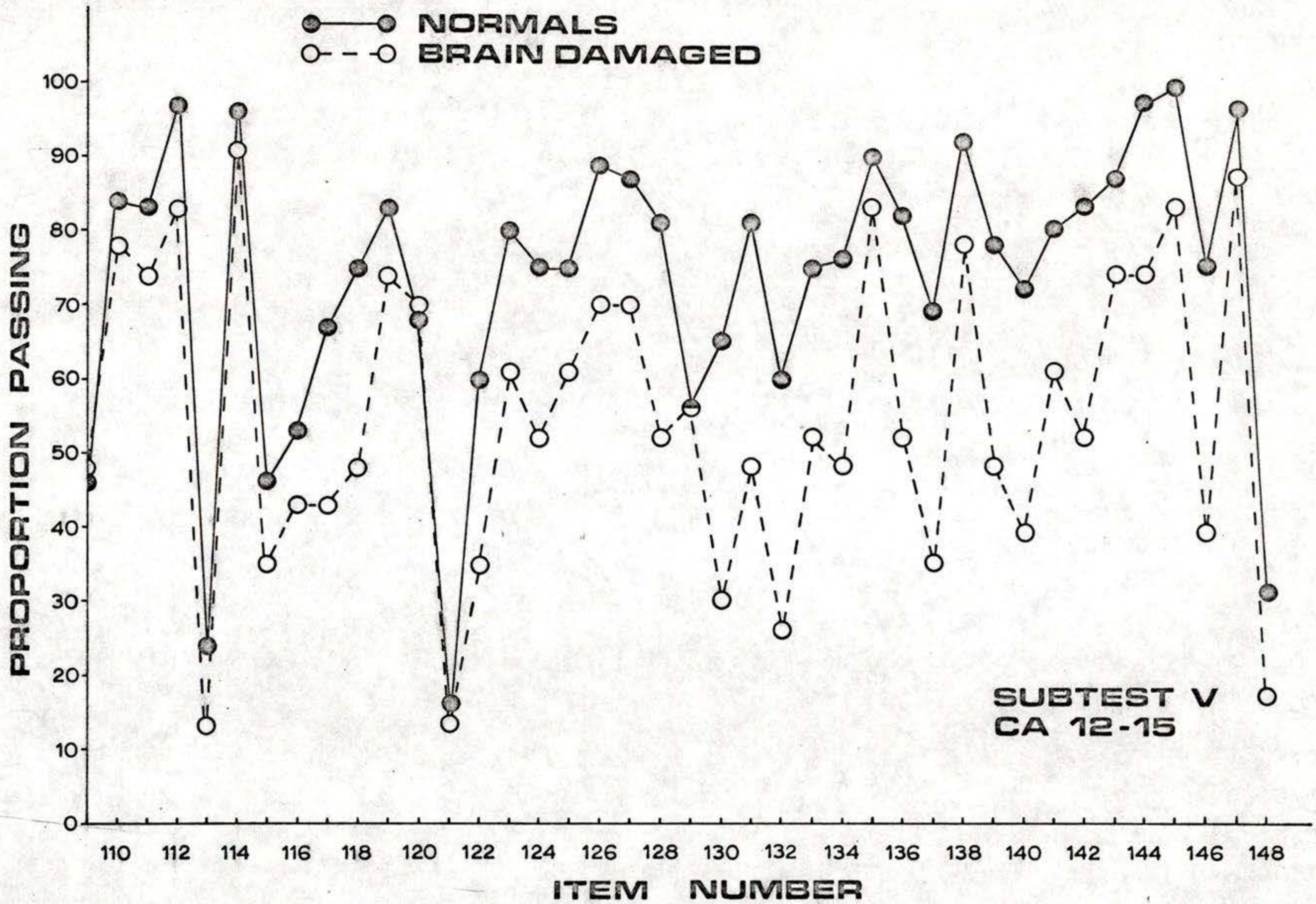


Fig. 6 Intermediate H.C.T. Percentage of Ss answering each item correctly.

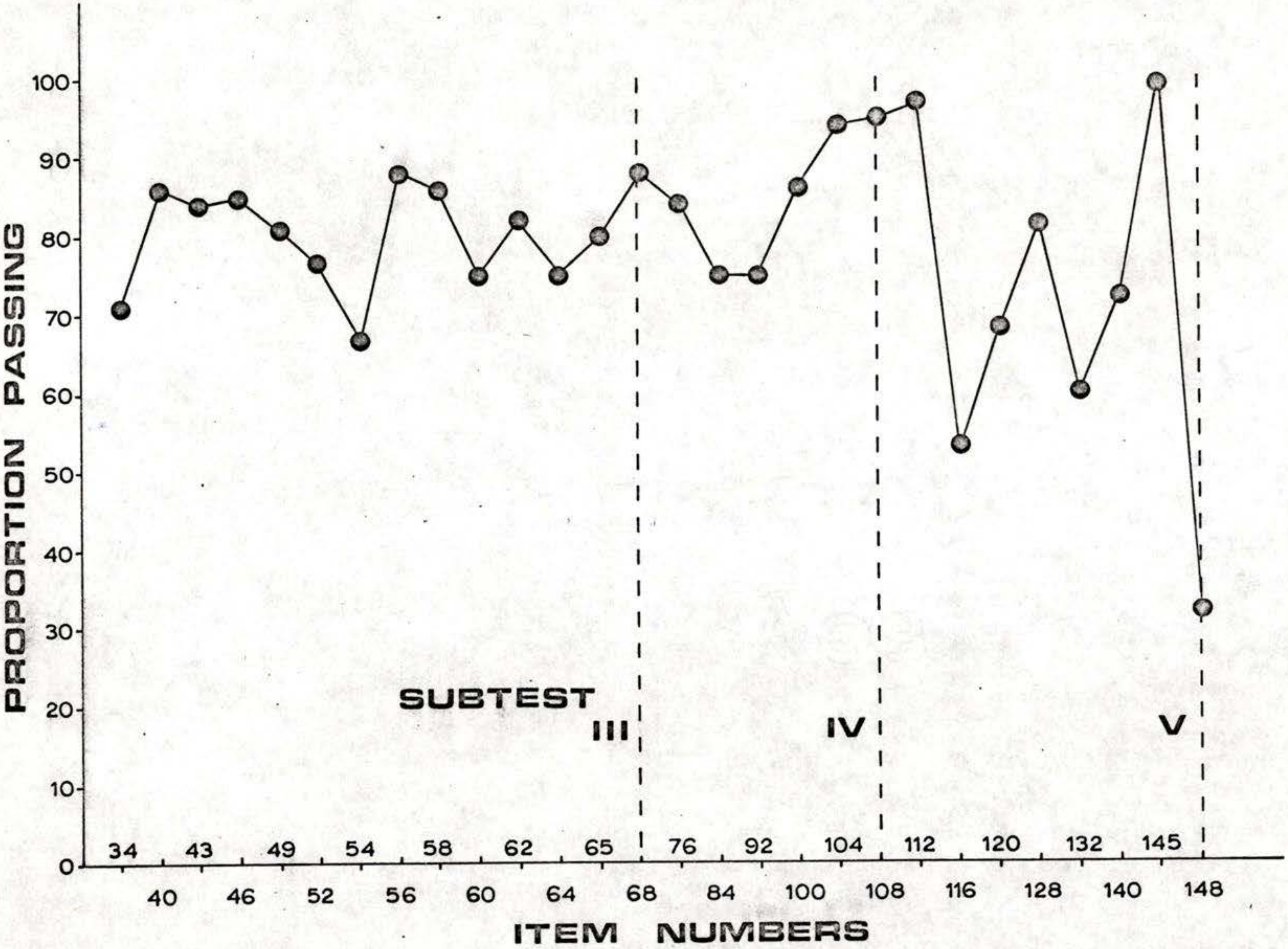


Fig. 7 Intermediate H.C.T.: p scores on final items in learning sequences. (Subtests III, IV & V)

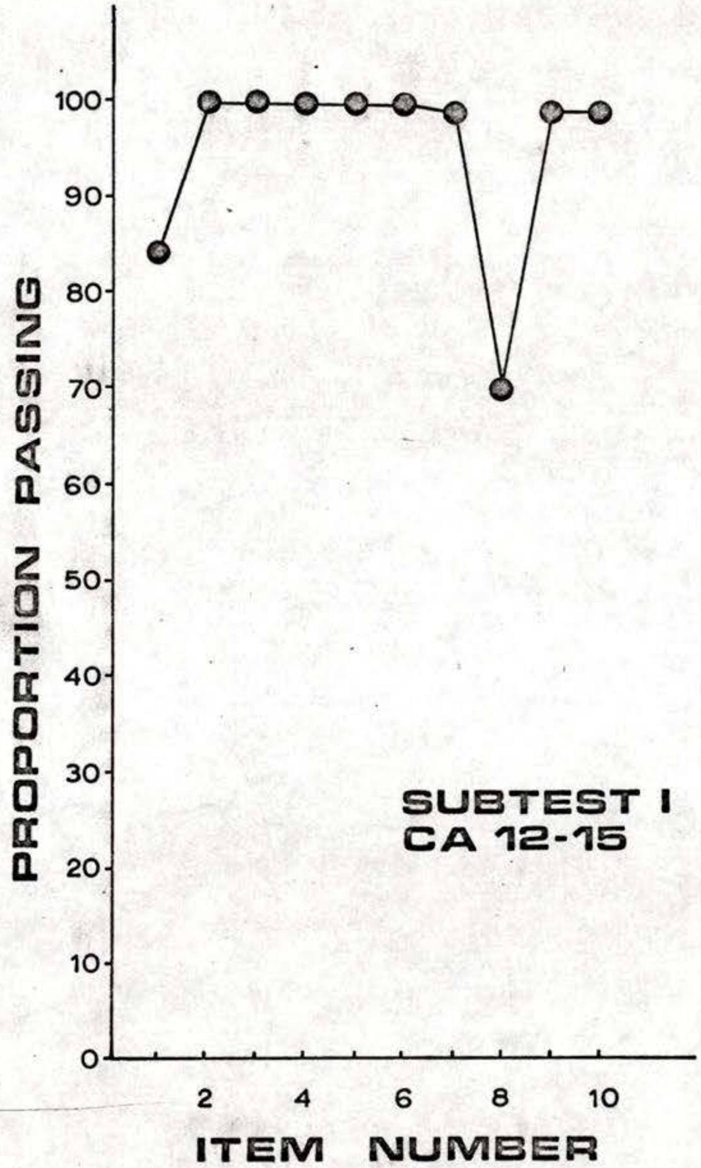


Fig. 8 Revised Intermediate H.C.T. Percentage of Ss answering each item correctly.

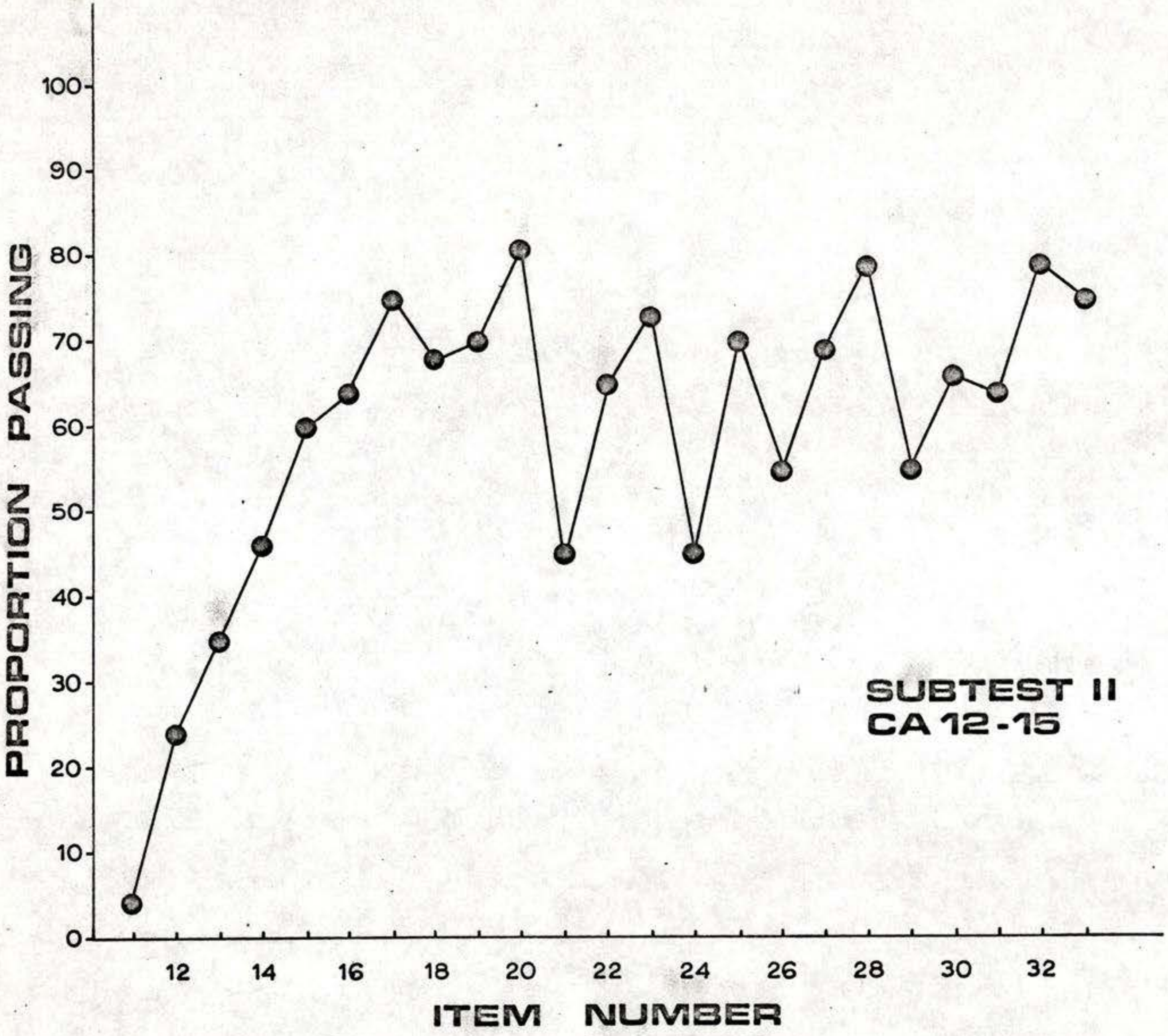


Fig. 9 Revised Intermediate H.C.T. Percentage of Ss answering each item correctly.

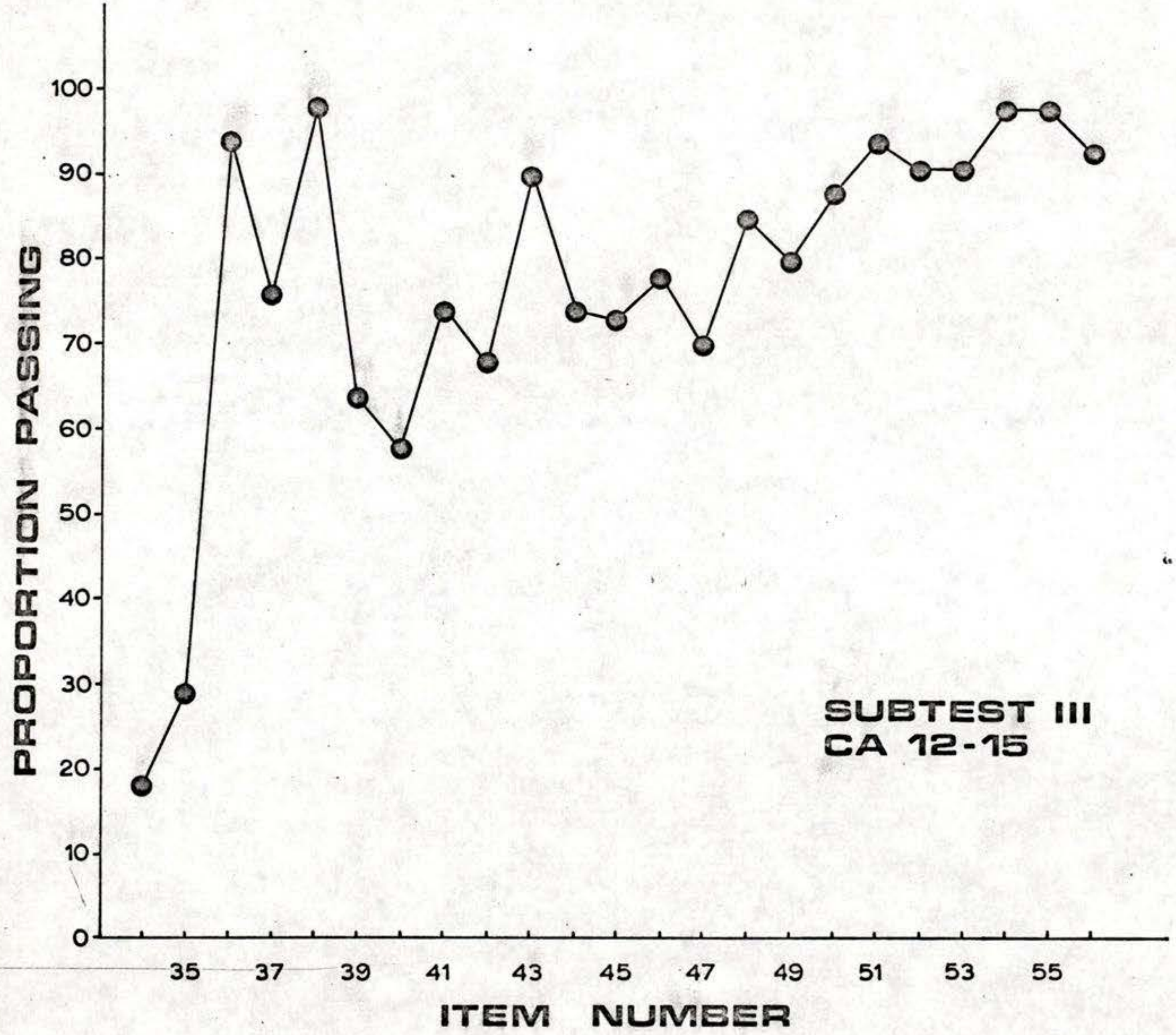


Fig. 10 Revised Intermediate H.C.T. Percentage of Ss answering each item correctly.

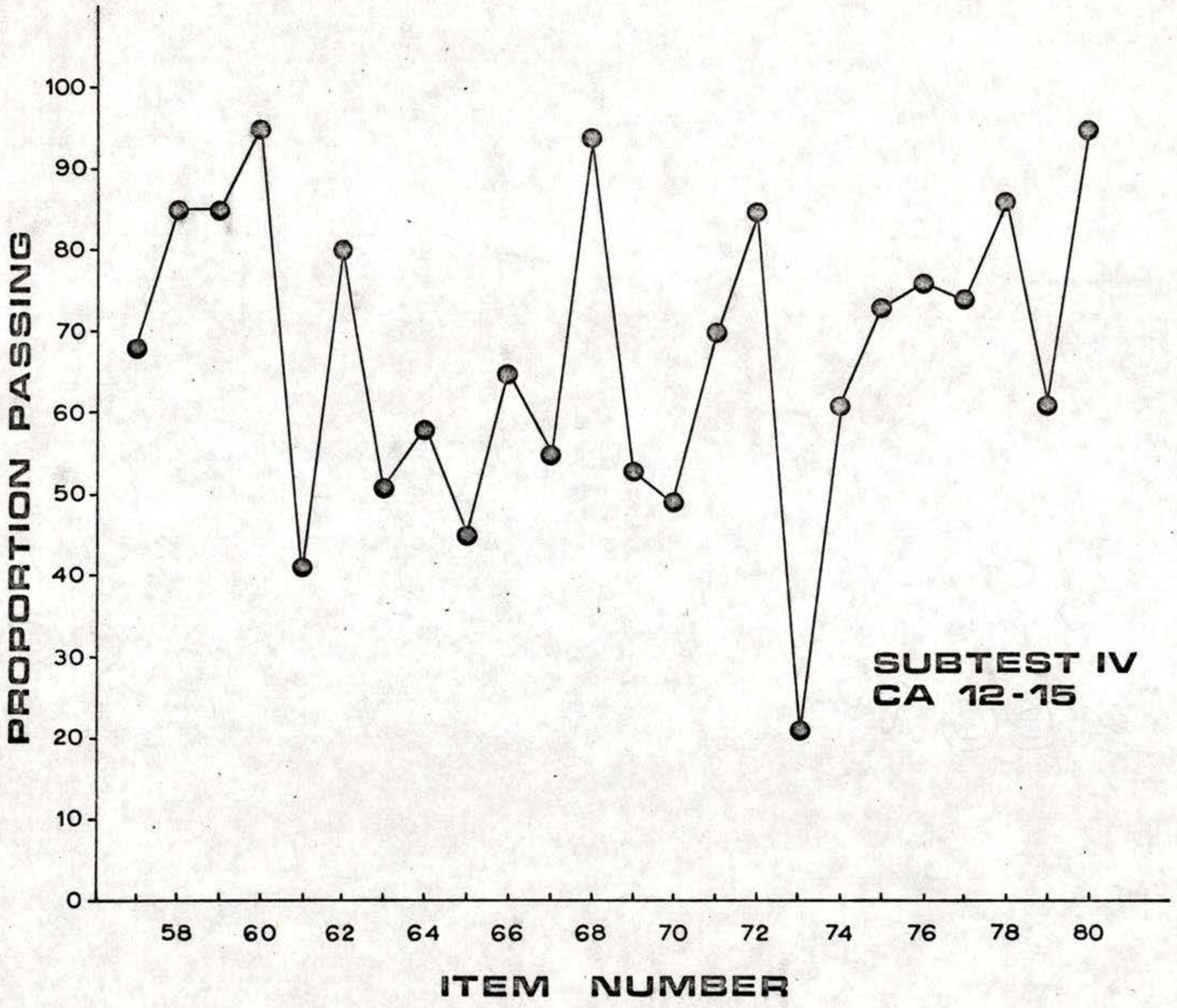


Fig. 11 Revised Intermediate H.C.T. Percentage of Ss answering each item correctly.

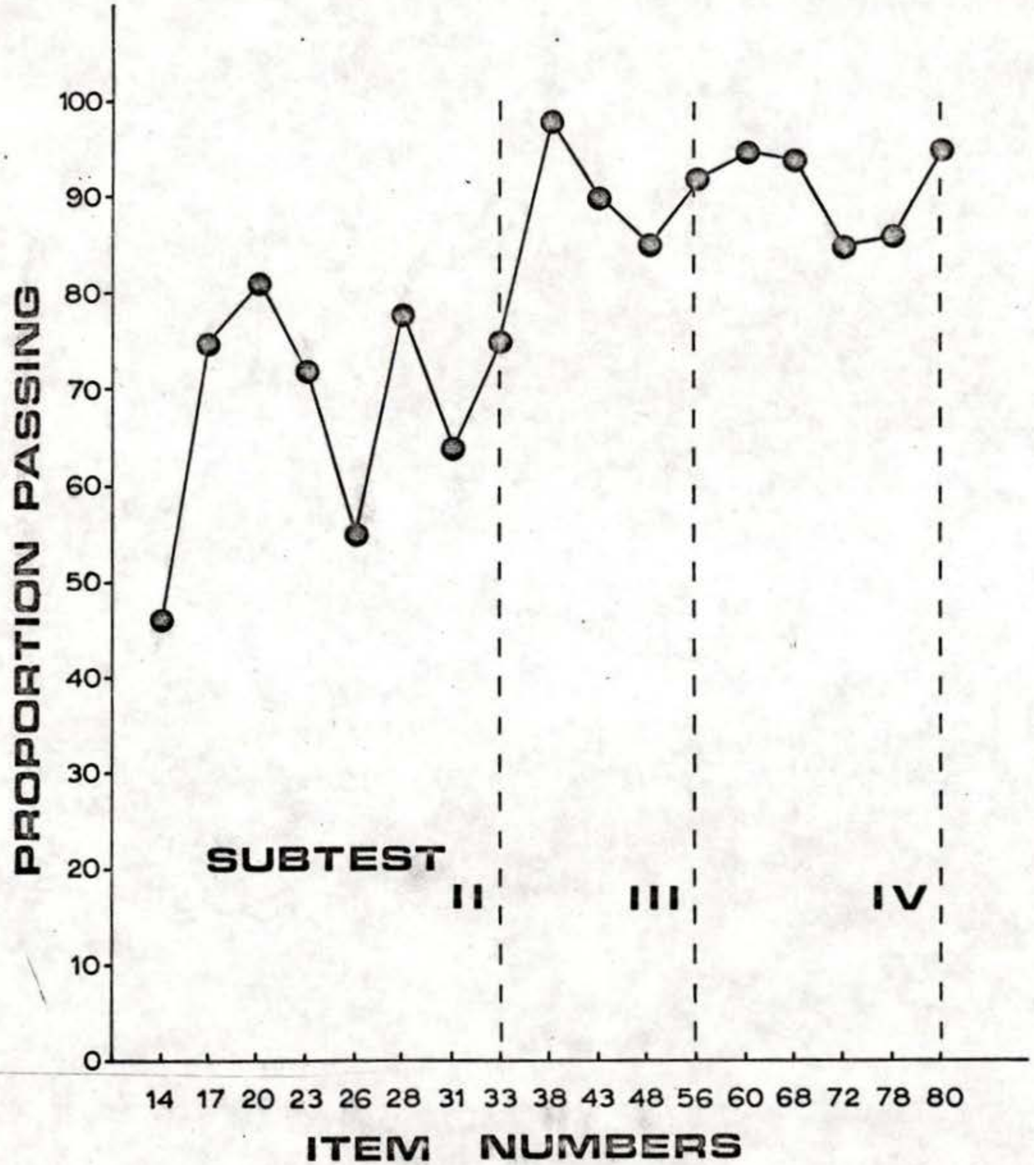


Fig. 12 Revised Intermediate H.C.T.: p scores on final items in learning sequences throughout the test.

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