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The effects of symmetry and multiplexity on the reproduction of dot patterns by mental retardates.

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THE EFFECTS OF SYMMETRY AND MULTIPLEXITY ON THE REPRODUCTION OF DOT PATTERNS BY MENTAL RETARDATES

by

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ABSTRACT

This study investigated the effects of symmetry and multiplexity on the reproduction from memory of dot patterns by two groups of retardates (cultural-familials and organics) and a group of normals. A marble board procedure was used to present the patterns which were of three types, viz., random and those with vertical and horizontal symmetry. Four-, six-, and eight-marble patterns of each type were used. All subjects were instructed to reproduce the patterns as quickly as possible after a five second presentation period. Both performance level and response time measures were recorded. Error types were also collated.

Analyses of variance showed significant differences in both performance level and response time for the three experimental groups. Analyses of covariance indicated that differences between the normals and retardates were mainly due to differences in IQ level. The experimental task effectively differentiated the two retarded groups.

PREFACE

Although this study was not formally begun until the autumn of 1965, its inception dates back to the summer of 1964 when, serving a psychological interneship, the author was faced with the clinician's problem of making cogent contribution to the diagnosis of brain injury in retarded children.

The author has used the Bender-Gestalt Test, the Grassi Block Substitution Test and the Benton Visual Retention Test as indices of brain injury. These tests are measures of either spatial perception or memory. Since it was felt that brain injury could result in impairment of both perception _and_ memory, an experimental task which tests both of these was chosen. In addition to the value of such a task in assessing brain injury (even on an informal qualitative basis), it presents the brain-injured child with a novel (and apparently enjoyable) testing situation.

I would like to express my sincere gratitude to Dr. A.A. Smith, my mentor, whose suggestions for experimental design and statistical analysis as well as his kindness, enduring guidance, and cogent criticism, made this paper a reality. I wish also to express my appreciation to my readers, Dr. J.A. Malone and Miss Evelyn G. McLean, for their interest, generous contribution of time, and valuable

editorial criticism; to Dr. S.J. Koegler and Dr. J.R. Forde and Mr. Richard Paton of the Ontario Hospital School, Cedar Springs, and to Mr. R.H. Plato of the Wheatley Public School for their interest and co-operation; to Herbert W. Ladd, my friend and office mate, for his encouragement; to Katherine L. Ladd, who typed the final draft of the paper; and finally to Nanci L. Lugsdin, my friend, for her empathy during the writing.

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CHAPTER I

INTRODUCTION

About a century ago, according to Philips (1965), "there was great enthusiasm in the field of mental retardation.... This enthusiasm continued for at least two decades, only to be followed by a period of marked apathy that continued almost to the present time." Benton (1965) states that until fairly recently "mental retardation was an area which was seriously neglected not only by the behavioral disciplines but also by the biological and medical specialties".

The situation has changed radically with mental retardation now a rich field for scientific inquiry. Many new questions are being posed; many old reformulated. Two of the latter which are of concern in this study are: Do retardates differ from normals in special, rather than in general ways? And, within the categories of mental retardation, can a further differentiation be made between retardation due to organic impairments such as brain-injury and retardation of unknown but presumably psychogenic origin?

In the literature, the terms "organically injured", "brain-injured" and "exogenous" are used synonymously and include all types of etiologies. The terms "familial" and "endogenous" are also used interchangeably in referring to mental retardation of unknown but presumably psychogenic origin. In this study the nomenclature, "cultural-familial", from the new medical classification of the American Association on Mental Deficiency (Heber, 1959) will be employed. For "brain-injury" and "brain-injured", the clinician's terminology "organicity" and "organic" will be used.

Cultural-familial retardation is a sub-category within the eighth category of the new medical classification of the American Association on Mental Deficiency (Heber, 1959). In this category are included those conditions which are "due to uncertain cause with functional reaction alone manifest". The cultural-familial sub-category is essentially descriptive in nature; no assumptions are made concerning the role of genetic factors in the etiology of cultural-familial retardation. It is the clinical and social picture which used to be called "simple" or "garden variety" mental deficiency. There is usually no evidence of structural cerebral defect by current standards of neurological judgment. Mental retardation, or at least mental dullness, is found in at least some other members of the family. Cultural background is generally poor, implying some degree of environmental deprivation. The degree of intellectual subnormality is relatively moderate, that is, not more than three standard deviations (SD's) below the mean IQ of the general population.

In comparison with cultural-familial retardation, in which there is no evidence of central nervous system abnormality, organicity implies definite nervous system pathology. Classification of organics is made primarily with reference to clinical manifestations and the etiological factors involved. Strauss and Lehtinen (1947) provide the following definition of the organic:

> A brain-injured child is a child who before, during, or after birth has received an injury or suffered an infection of the brain. As a result of such organic impairment, defects of the neuromotor system may be present or absent; however, such a child may show disturbances in perception, thinking and emotional behavior, either separately or in combination.

Lewis with Strauss and Lehtinen (1951) states:

> It is probable that when damage does occur in the brain, it alters all or many basic functions in varying degrees. In our research, however, we have found four basic deviations in the mental make-up of the brain-injured child.
>
> These are disturbances in perception, in concept formation, in language and in emotional behavior, in sum or in part.

The extent of these disturbances can be gauged by specific tests; no attempt will be herein made, however, to review the vast literature on such tests. Generally it has been found that there is a marked overlap in the effects of different types and degrees of such damage. For example, as pointed out by Hutt and Gibby (1965), "the damage to intellectual functions is not significantly different in chemogenic and histogenic disorders". There are, however, certain basic considerations which these authors summarize from studies on the psychological results of brain damage. "Firstly, the specific impairment in intellectual functions is related to the area of the brain damage, regardless of the cause.... Secondly, the brain damage, even when it produces no deficit in intellectual functioning, may result in extensive changes in emotional reactions, which then produce impaired intellectual functioning.... Thirdly, the child reacts to his organic brain damage as a unitary organism. It is not only intellectual factors, but all aspects of the child that are involved." The reason Hutt and Gibby place great importance on the third consideration can best be understood in the light of their following statement:

> We have seen that the results of organic damage to the same brain area vary in different children so greatly that we cannot adequately predict what psychological defects will result from damage to a specific area --- or, conversely, we cannot predict precisely the area of damage from a knowledge of the symptoms alone. It is thus a mistake to talk about a generalized "brain-damaged child", as many people do. It is a specific child who shows such a condition. His reactions to the organic brain damage, the ways in which he deals with his changed conditions, the behavioral reactions in which he engages, and altered emotional reactions he shows are all functions of his total personality. What must always be considered are the total reactions of the child to the damage.

This important consideration notwithstanding, it is necessary for purposes of statistical analysis in research to deal with organics in groups. It was because of this consideration, however, that specific predictive statements or hypotheses were not made in the present study.

Since Hutt and Gibby (1965) only in a general way refer to the altered intellectual functioning in organics, the reader is referred to Gallagher (1956), Kleganoff, Singer and Wilensky (1954) and Yates (1954), who provide comprehensive reviews of some specific psychological concomitants of brain injury. It should be pointed out, however, that the latter two reviews deal with the literature on implications of organic injury which was not exclusively an adjunct to mental retardation.

Background of Related Studies

Of those studies comparing organically injured mentally retarded children with presumably organically sound mentally retarded children, visual perception is one of the most popular areas of investigation. Studies dealing with the ability to reproduce from memory geometric figures consisting of points, i.e., dot patterns, and those dealing with the ability to copy, i.e., reproduce the figures with the stimuli present, are the studies from the above broad area which have a relative bearing on the present investigation.

Strauss and Werner (1941) attempted to construct tests which would permit them to analyze sensori-motor performance of endogenous and exogenous children. One of their tests dealt with performance on a marble board containing 10 rows with 10 holes in each row. The examiner constructed a mosaic marble pattern (for example, two interlocked squares) out of the subject's sight, and then the child was requested to copy it on a second board. Each move made by the child in reproducing the pattern was recorded on a blank form thereby giving a record of the subject's accuracy as well as the succession and direction of the placement of the marbles. The test required the reproduction of six patterns.

The results, according to Strauss and Werner (1941):

> point to a striking difference in the manner of performance between endogenous and exogenous groups. Although objectively the patterns made by children of both types may be equally correct, the analysis shows that the endogenous child uses a procedure different from that of the exogenous child. Successes and failures of the endogenous are similar to those of a normal child of the same mental age (MA). The endogenous child tends to proceed continuously around the outlines of the pattern. His figures, although not always perfect copies of the original patterns, are whole forms. The exogenous child, on the other hand, constructs his pattern predominantly in an incoherent manner: he jumps from one part of the board to another; he sometimes even starts in the middle of a line. The figures he constructs are frequently disorganized patterns lacking closure, connection of parts, et cetera.

These investigators also point out that these results were not due to visual defect, since no differences in ability to perceive abstract visual forms were found between endogenous and exogenous children on a preliminary task which controlled for this pathological variable.

Werner (1944), who developed the first marble board test, analyzed the quantative and qualtative development of visuo-motor performance of 100 retardates ranging in age from seven to eleven years using this test. He found that correct performance increased significantly with increasing mental age (MA). Also with increasing MA, "continuity-type" of performance (placement of marbles in continous sequences) was gradually replaced by a "constructive" type of performance (enclosing of a mosaic pattern from two opposite sides).

Bensberg (1950) found the marble board test a useful tool in "differentiating feeblemindedness caused by brain injury and that due to hereditary defects as shown by accuracy of reproduction and approach to the problem". He compared a group of 31 "familial mental defectives" and 31 retarded children with brain injury. In addition to determining differences in performance, he investigated the relation of MA and chronological age (CA) to performance. A significant difference in performance ($p = .01$) between the familials and organics was established. Although the correlation of CA with accuracy scores was not statistically significant ($r = .15$), a significant correlation ($r = .80$) between MA and accuracy was found.

Cassel (1949) compared 25 exogenous children with 25 endogenous children, reasonably equated for MA and CA, on their ability to reproduce geometric designs. The endogenous group performed significantly better on the reproductions. He then asked the subjects to identify the same designs presented in another context. No signficant difference in ability to identify the designs was found between the two groups. Thus Cassel concluded that the relatively low reproduction scores of brain-injured children cannot be explained on the basis of poorer memory, but must be due to some other factor.

Before prodeeding to the studies of pattern reproduction involving both short-term memory and symmetry, it should be noted that the above studies are not very recent and also that some of them have not withstood replication. Gallagher (1956), for example, in his comparison of matched groups of 24 brain-injured and 24 cultural-familials, found no group differences in their performances on the marble-board task. The brain-injured group were only slightly poorer on the task, even though a minority of his organic group did display marked perceptual problems.

Symmetry, Multiplexity and Short Term Memory

Ellis (1963) has proposed a theory of stimulus trace deficit in retardates to account for differences between them and normals in behavior dependent upon short-term memory. Ellis' theory is based on the purely hypothetical construct, stimulus trace, which had been postulated by neuropsychological theorists such as Hebb, Hull and Pavlov.

The stimulus trace theory postulates that a stimulus invokes a short-term neural trace process which continues or reverberates for a short time after cessation of the stimulus. These perseverative after-effects are presumed to subserve short-term memory. Persistence of the stimulus trace depends somewhat upon the parameters of the stimulus such as intensity, duration, meaningfulness and complexity.

In addition to stimulus trace, which is defined "antecedently by an environmental stimulus event and consequently by a behavioral event", Ellis proposes another construct, central nervous system integrity which "serves as a limiting function for stimulus trace". CNS integrity is "defined by an intelligence test score or other indices of adaptability... (such as) success in school, institutionalization, and non-institutionalization". Ellis' central hypothesis is that "the duration and amplitude of the stimulus trace are diminished in the subnormal organism", that is, the organism with CNS pathology. From Ellis' viewpoint this term, i.e., the subnormal organism, would be applied to both types of retardate, that is, cultural-familials and organics, studied in the present investigation, since he states that:

> In view of the large literature, it appears that the nervous system is affected in most cases of mental deficiency. Probably in some cases cultural factors have served as causative agents and, no doubt, those agents account for some component of behavioral inadequacy brought about by other conditions.

That Ellis' theory is heuristic, there is little doubt. Among the large number of investigations which have been generated by it is a study by Hermelin and O'Conner (1964) in which young normals and subnormal children (mean CA approximately six years, three months) were compared on a measure of immediate memory (digit recall). A significantly faster decay rate in subnormals than in normals was found. On the other hand Spitz and Blackman (1959), who compared mental retardates and normals on visual figural after-effects and reversible figures, hold that neural changes in the cortex occur less readily in subnormals than in normals, so that "cognitive defect is due to lack of acquisition" rather than to fast decay of an established trace. As pointed out by Hermelin and O'Conner (1964), however, these concepts, that is, lack of acquisition and fast decay, are "not necessarily mutually exclusive, but each may hold for a specific set of circumstances and conditions".

One of the stimulus dimensions which, in part, is postulated to affect the quality of the stimulus trace is complexity. Since random (asymmetrical) patterns are considered to be more complex than symmetrical ones, symmetry can be considered a type of complexity and therefore one of the parameters whose measurement taps short-term memory. The effects of symmetry on reproduction from memory has long been the subject of psychological research. Allport (1930) using

Binet designs (the asymmetrical truncated pyramid and the symmetrical Greek key) found that the subject's reproductions showed a tendency to leave the symmetrical figures unaltered and to changethe asymmetrical ones. In Allport's words: "... There can be no escape from the conclusion that one of the properties of the trace is for it to retain or acquire symmetry".

Perkins (1932) also found that reproduction from memory of visually perceived forms undergoes a change toward symmetry. Hubbell (1940) reported that in memory modification "configurations tend toward symmetry" since she found that, when free to change given material which consisted of 20 symmetrical and 20 asymmetrical geometrical figures (including eight dot patterns), her naive subjects were guided by the principles found to govern "good configuration". Hubbell states that:

> These factors operate as well in the fields of art and aesthetics --- the tendencies toward closure, symmetry, good continuation, simplicity and differentiation. The prevalence of these properties in such natural events as crystal formation, plant structures, etc., attests their fundamental nature.

Four of Hubbell's symmetrical and four of her asymmetrical figures were presented by Soltz and Wertheimer (1959) to 60 undergraduate women at the University of Colorado for 15 seconds. The task was one of recognition (the experimental figures were presented with 72 varied figures) immediately after the exposure and two weeks later.

Their results clearly support the hypothesis that symmetrical figures are easier to recognize than asymmetrical ones. The differences, however, were apparent only after sufficient time (two weeks) had passed to reduce the accuracy of recognition. This finding seems contradictory to that of Irwin and Seidenfeld (1937) who found that changes occurred shortly after exposure, but did not increase with further passage of time. It is possible that Soltz and Wertheimers' recognition task did not provide a ceiling for their subjects' recognition ability immediately after exposure.

Symmetry is, of course, not the only factor which contributes to the degree of complexity of a pattern. A pattern's level of multiplexity, i.e., the number of components which make up the pattern can be another aspect of the complexity dimension of a stimulus. Baumeister, Smith and Rose (1965) compared 28 normal and 50 retarded male adults on their ability to remember ambiguous figures (Chinese characters). They found that complex stimulus presentations were more detrimental to the performance (recognition) of the retardates than of the normals.

French (1954a) also studied the effects of stimulus complexity on memory. Although the subjects used were normal adults, this investigation has a relatively direct bearing on the present research since French was studying identification of <u>dot</u> patterns. Varying the number of randomly chosen dots in a matrix of 112 cells from one to twelve he found that the degree of complexity represented by six to eight dots was optimal for identification of random dot patterns. French also found that "ease of identification was clearly shown to be associated with patterns having dots fortuitously arranged either symmetrically or in linear arrays".

Attneave (1955) investigated the role played by both symmetry and "information", that is, complexity, in memory for patterns. His stimulus-materials consisted of symmetrical and random patterns of dots in 12, 20 and 35 cell rectangular matrices. One hundred and forty-nine airmen (basic trainees) served as subjects. Random patterns were found in all cases to be more difficult the greater their complexity, that is, the more cells they occupied. In none of these experiments, however, were "symmetrical patterns easier to remember than asymmetrical patterns with the same informational content"; for example, an eight dot random pattern was no easier to reproduce than a sixteen cell symmetrical pattern. These two patterns had the same "informational content" since the eight filled cells on the left side of the symmetrical pattern were mirrored in the right. Attneave found in all of the experiments, however, that "symmetrical patterns were remembered more easily than asymmetrical patterns occupying the same number of cells". This superiority was, however, least striking in the case of immediate reproduction. Attneave's results generally support the theory that symmetry is favorable to memory.

Similar research on the effects of symmetry on the reproduction of dot patterns was carried out by Spitz (1964) using 20 mental retardates and 20 equal MA (approximately 8.5 years) normals. His stimulus material consisted of a horizontal sliding board into which were drilled two 3 by 4 hole matrices. The patterns were made by dropping tacks with one-half inch heads into the holes. Spitz found poorer performance of the retardates on the random patterns. On the other hand retardates performed as well as did normals on the symmetrical patterns. These results are interpreted by Spitz as supporting his thesis that symmetry is relatively more of a memory aid to retardates than to equal MA normals, but his results did not show a significant overall difference between the retardates and the normals. This points to one of the questions with which this research is primarily concerned: do retardates differ from normals in special rather than in general ways? On the basis of Spitz' results, it can be stated that such a difference does exist. On the other hand, however, the lack of a significant overall difference between his groups, may have been due to the fact that, since he equated his groups in terms of MA there was a five-year gap in CA in favour of the retardates which may have given them the edge developmentally and experientially. In terms of his theory of stimulus trace and behavioral inadequacy, (Ellis, 1963) states that:

> With respect to the present theory it is speculated that the young child has a stimulus trace deficit, and the establishment of the adult form of the short-term memory function will show a developmental trend. In view of this, it is not surprising that studies matching immature normal humans and mental defectives rarely fail to find behavioral differences.

In addition to the above age consideration, there was a procedural variable which also may have affected Spitz' results. "Incorrectly reproduced patterns were not corrected, but E (the experimenter) gave encouragement throughout." Since one is often tempted to help the underdog it is quite conceivable that E may have unconsciously given more encouragement to the retardates thereby increasing their motivation considerably and indirectly affecting the results.

The following conclusions can be drawn from the results of the related studies. The marble board is a useful diagnostic tool in differentiating organic and cultural-familial retardates. Symmetry is relatively more of a memory aid to retardates than to equal MA normals.

Six to eight appears to be the optimal number of stimulus components for accurate identification of dot patterns. The stimulus trace which subserves short-term memory, is hypothesized by Ellis (1963) to be impoverished with respect to duration and amplitude in retardates. Memory impairment in subnormals may, however, be due to lack of acquisition rather than to fast decay of an established trace Spitz and Blackman (1959). Since lack of acquisition and fast decay are not necessarily mutually exclusive, it is not the purpose of this paper to confirm or refute either theory.

Purpose of the Present Research

The present investigation had as its objective a more precise determination of the effects of symmetry and multiplexity on the ability of retardates and equal CA normals to reproduce dot patterns.

In addition to changing Spitz' (1964) procedure by controlling for extrinsic motivation and separating the retardates into two distinct diagnostic categories, the present research investigated the effects of symmetry on the horizontal as well as the vertical axis, (Spitz' symmetrical patterns were of the former variety only). French (1954b) states that, "many factors of experience... make some patterns easier to perceive than others". It was felt that differences in reproduceability may exist between patterns with vertical symmetry and those with symmetry on the horizontal axis due to the possible fact that the subjects may have had greater experience perceiving the former than the latter.

The present research cannot be considered a replication of Spitz' (1964) investigation because of all of the above changes. In addition, although Spitz varied the multiplexity factor in his study (four, six and eight tack pattern presentations were made), he did not take cognizance of this variable in the statistical treatment of his results. The number of stimulus components was varied in the present study and taken into consideration in the analysis of the results.

CHAPTER II

METHODOLOGY

Subjects

Twenty-eight retardates (14 cultural-familials and 14 organics) from the Ontario Hospital School at Cedar Springs and 14 normals from Wheatley Public School served as subjects. They ranged in age from 10 to 14 years.

The retardates were assigned to the cultural-familial and organic categories on the basis of diagnoses made by the professional (medical and psychological) staff of the hospital school. The cultural-familial sample was drawn from patients diagnosed as such according to the new medical classification of the American Association on Mental Deficiency (Heber, 1959). This classification established the third standard deviation as the lower IQ limit of cultural-familial retardation and 1.01 standard deviations as the upper limit.

Each retardate's IQ had been measured by means of the Wechsler Intelligence Scale for Children (WISC) or the Stanford-Binet (Form L-M) as administered by the psychology department of the Ontario Hospital School, Cedar Springs, or the Children's Psychiatric Research Institute, London. The intelligence testing had been carried out within the last three years; the majority (approximately 70 per cent) of subjects in both retarded groups had been tested on the Stanford-Binet. According to Heber (1959), the IQ at the third standard deviation for the Stanford-Binet is 52, and 55 for the WISC.

The organic group, whose diagnostic characteristics are summarized in Table 1, was comprised of three subjects who had been diagnosed as suffering from "encephalopathy associated with prematurity"; two with "encephalopathy due to postnatal cerebral infection"; one each with "encephalopathy due to postnatal injury", "encephalopathy due to mechanical injury at birth", and "congenital encephalopathy associated with maternal intoxications"; one with congenital cerebral defect" and another, "intracranial neoplasm"; one diagnosed as an arrested "congenital hydrocephalic", two subjects with convulsive disorders (one unspecified and the other having major motor seizures) and one unspecified "organic".

Since emotional disturbances could possibly have compounded the variables under study, children diagnosed as such were not considered part of the total sample. Because of the small number of available organics, however, one was included whose diagnosis included "behavior reaction" as a subsidiary classification.

The 14 organics were the total sample of subjects available within the set age limits and physically capable of participating in the experiment. The cultural-familials and normals were matched as closely as possible with the available organics on the basis of chronological age and sex.

Table 1

Diagnostic Characteristics of Organic Group

Diagnostic Classification	Number of Subjects
Encephalopathy	8
Congenital Cerebral Defect	1
Intracranial Neoplasm	1
Congenital Hydrocephalus	1
Convulsive Disorder	2
Unspecified Organicity	1

The normals were drawn from those 10 to 14 year-old public school pupils with IQ's falling within the 90 to 110 bracket. This interval is considered the area in which average children score on the Dominion Group Test of Learning Capacity (1950 Omnibus Edition) with which these subjects' IQ's had been previously assessed. The majority (over 60 per cent) had been tested within the last three years.

Since it was not possible to obtain equal numbers of male and female organics, the closest possible equating of numbers was effected, that is, there were eight males and six females in each diagnostic category, i.e., experimental group. A Chi-square test (correlated means) was performed on the differences in numbers of male and female subjects in each of the three experimental groups. No significant differences were found. The characteristics of the three experimental groups are shown in Table 2.

Since two different tests had been used in assessing the IQ's of the retardates and a third measure, for testing the normals' IQ's, it was felt that cognizance should be taken of the degree to which performance on these three tests is correlated.* In a study by Rohrs and Haworth (1962), who also used "familials" and "organics" with approximately the same chronological age means as those in the present study, a significant correlation between the new Stanford-Binet (L-M) and the Wechsler Intelligence Scale for Children was found ($r = .69$, $p < .01$).

Apparatus

The main part of the apparatus was constructed in the form of two wooden four by four matrices, which will hereafter be referred to as "marble boards". They were

*The writer is awaiting correspondence from the Guidance Centre of the Ontario College of Education regarding the results of correlation studies on the Dominion Group Test and the WISC and Stanford-Binet (L-M).

Table 2

Characteristics of the Experimental Groups: Age, Sex and IQ

Category	Mean CA (Years)	SD	Range	Sex M	Sex F	Mean IQ	Range	SD
Normal	12.43	1.40	10.50 to 14.50	8	6	102.93	91 to 109	5.38
Cultural-Familial	12.48	1.48	10.58 to 14.58	8	6	61.07	53 to 72	6.81
Organic	12.28	1.68	10.00 to 14.83	8	6	57.28	46 to 70	6.86

made with two squares of $\frac{1}{2}$-inch plywood, $7\frac{1}{2}$ inches square. Into each were drilled 16 holes $\frac{1}{2}$-inch in diameter, $1\frac{1}{2}$ inches from centre to centre horizontally and vertically, with each of the holes in the four outside rows $1\frac{1}{2}$ inches from the edge of the board. The holes were drilled through the boards to facilitate marking. Onto each board was attached a standard four-inch black drawer handle. The marble boards were painted dull black.

A screen 36 inches by 12 inches by $1\frac{3}{4}$ inches served to separate the subject from the experimenter (E) and thereby prohibited any previewing of the stimuli before presentation. It was constructed of off-white wallboard with a natural wood finish $\frac{1}{2}$-inch border. Mounts 2 1/8 inches in height provided a space under the screen for the presentation and removal of the marble boards by E.

The stimulus objects consisted of milk-white marbles $\frac{1}{2}$-inch in diameter. A slightly concave hammered copper dish three inches in diameter with a baked-on enamel finish served as a receptacle for the 10 marbles which were available for each reproduction. A schematic diagram of the physical arrangements of the apparatus as seen by the subjects is presented in Figure 1.

Testing Materials

Random and symmetrical patterns composed of four, six or eight marbles arranged on the marble board made up

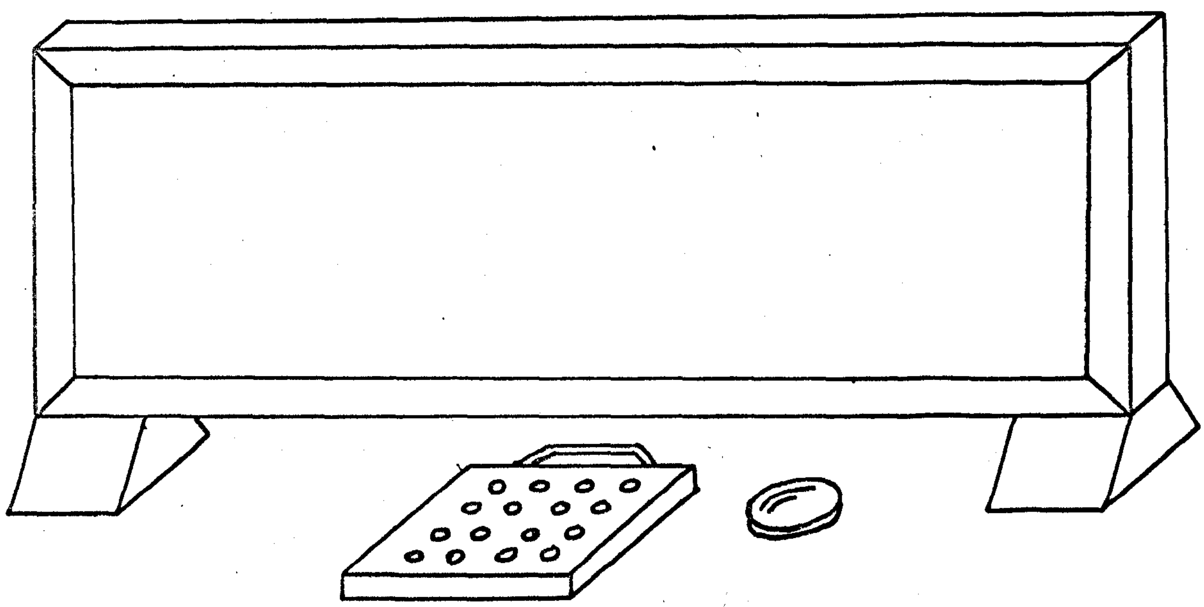


Figure 1. Schematic diagram of the apparatus as seen by the subject.

the testing materials. In generating the random and symmetrical figures, the procedure followed by Attneave (1955) and Spitz (1964) was adapted. A four by four matrix was coded from 1 to 16, starting with 1 in the lower lefthand cell, the cell above it being 2, the cell above that 3, then 4, with 5 in the second lower lefthand cell, and so forth. Next, the first 16 numbers from a table of random numbers were followed so that each odd number designated a filled cell, and each even number a blank cell. Then the next four by four matrix was completed using 16 numbers in the table of random numbers, and so on, until 61 matrices were completed.

Starting from the first pattern generated, the matrices containing 4, 6 or 8 filled cells were selected in the order in which they occurred until there were two matrices with 4 cells filled, two with 6 filled, and two with eight filled. The order they occurred in became the order of their presentation, as in Figure 2.

The eight lefthand cells with 2, 3 or 4 filled cells of the previously generated random patterns, excluding the six which were drawn as random patterns, were mirrored in the right-hand cells so that each matrix contained vertical mirror image symmetry. Then they were matched with the random patterns for number of filled cells in the following manner. Since the first matrix of the random

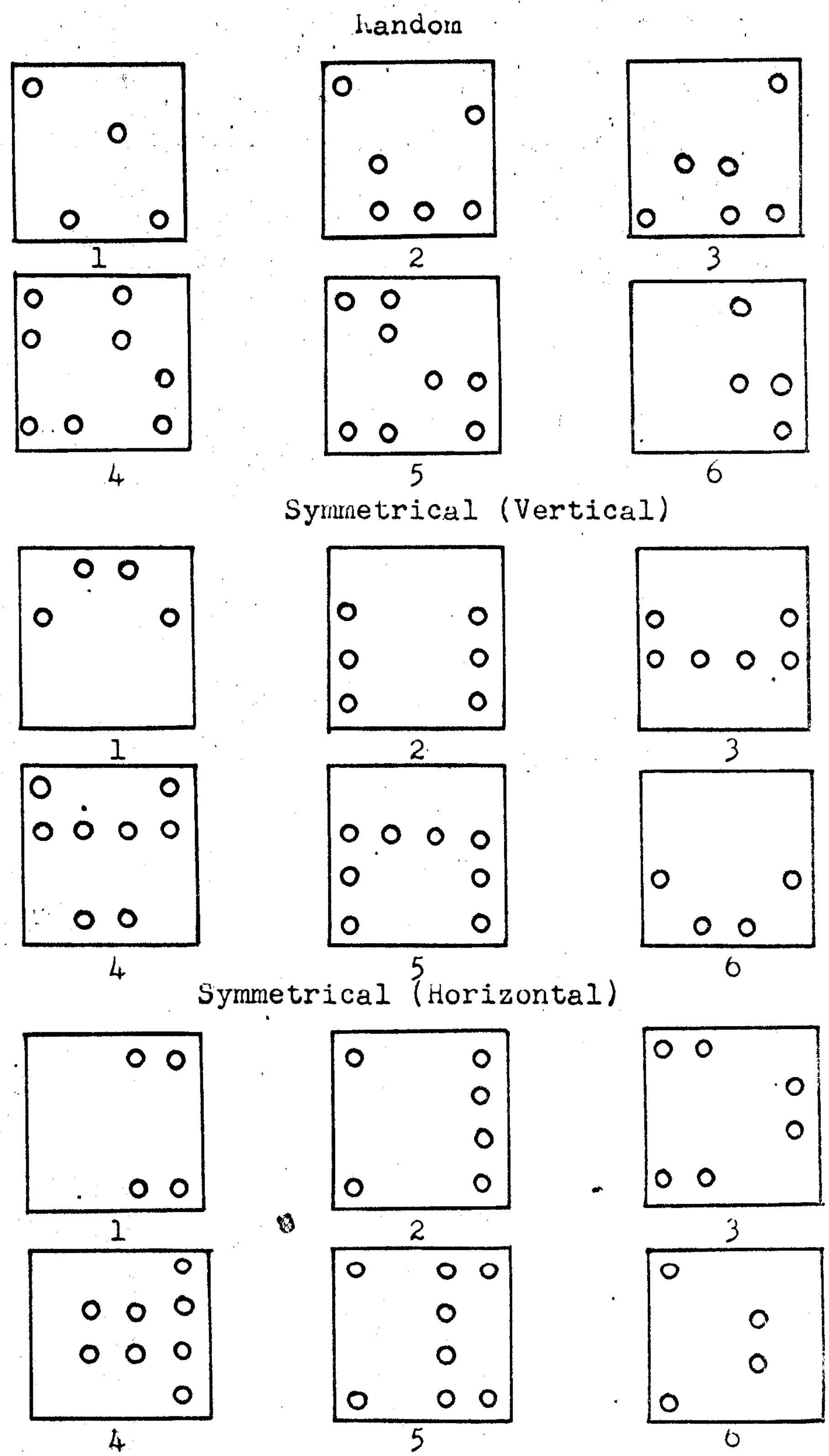


Figure 2. The Patterns in Their Order of Presentation

patterns contained eight filled cells, the first symmetrical pattern containing eight filled cells was chosen as its match. This procedure continued until all six random patterns were matched for number of filled cells by six patterns symmetrical on the vertical axis. The same procedure was followed in arriving at six patterns symmetrical on the horizontal axis, with the exception that the lower eight cells were mirrored in the upper eight so that each of these matrices contained horizontal mirror imagery. For both types of symmetry, patterns which were symmetrical on both axes were excluded.

Procedure

Each subject was greeted cordially on the ward or outside the classroom at which he or she was met by E. He was then ushered down the hall (and on some occasions up or down a flight of stairs) to the experimental room, the walls of which were neutral in background with no pictures. The subject was then seated comfortably at a table whose height was appropriate for his size so that he would be looking down at the marble board presentation. Each subject was then given the following instructions:

> I am going to show you a pattern made with marbles like this for a few moments (the three-marble preliminary pattern was presented). I shall then remove it and give you an empty board like this one (the appropriate action was taken). Now I want you to make the pattern exactly the same as the one I showed you. Work as quickly as you can and tell me when you are finished.

Inability to complete this preliminary task led to the elimination of three "organic" subjects. With all other subjects the experiment proper was begun after dealing briefly with any questions which the subject had.

At this juncture the instructions were re-iterated as follows:

> I shall show you the pattern made with marbles and then remove it. You are to make the same pattern as quickly as you can on the empty board I give you.

Each subject was then given a five-second presentation of each of the random and symmetrical patterns in the order shown in Figure 2. "Look at this carefully" was stated as the pattern presentation was made and, "make one exactly the same" when the empty marble board was presented.

The stop watch was used to measure the five-second presentation period and also to record the response time, i.e., the time (in seconds) required by the subject to complete his reproduction. On its completion the marble board was pulled under the screen, placed on a data sheet (see Appendix A) so that the board coincided with the data sheet representation of the marble board and then those holes which were not filled were marked by inserting a pencil through them. This data-taking procedure was carried out during the presentation of the subsequent pattern. The actual scoring of the data was done later.

The inter-trial interval ranged between three and seven seconds, depending on the number of marbles which had to be placed on the next board. Experimental time for each subject varied between 10 and 25 minutes.

The subjects were not rewarded in any material way for participating in the experiment. They were, however, sincerely thanked individually.

CHAPTER III

RESULTS

The experimental results are presented in two sections; these sections include the level of performance, or the number of patterns correctly reproduced, and response time, the time required to reproduce the patterns.

Level of Performance

The level of performance was determined by all-or-nothing scoring of each subject's pattern reproductions. That is, a reproduction was only scored as correct if all the marbles had been placed correctly. One hundred per cent performance across all tasks was 9 correct responses with a score of 18 for any one subject, or 126 correct responses with a score of 252 for any one diagnostic category. There were, of course, actually 18 patterns presented to each subject - two at each marble-number level over the three pattern types. For purposes of analysis, however, differentiation was not made between the first and second pattern presentation in each experimental task.

The normals had the highest performance level, with a mean performance score of 1.56 on each experimental task. It was also in this group that one subject attained one hundred per cent performance over all tasks with two other subjects at the 94 per cent level. The second highest performance level was achieved by the cultural-familial diagnostic category, whose mean accuracy was 0.86. The lowest mean performance was made by the organics with 0.59 correct reproductions on each task. A breakdown of these performance means in terms of pattern type and number of marbles per pattern is presented in Table 3. Inspection of this table indicates that the normals had the highest performance for all pattern types and for the three levels of the marble number factor. Although the cultural-familials had the second highest over-all mean performance level, this diagnostic category was slightly surpassed in performance on the four- and eight-marble random patterns by the organic group.

When each diagnostic category's performance over pattern type and marble number is portrayed graphically, as in Figure 3, it can be readily seen that the four-marble patterns were presumably the easiest patterns for the normals to reproduce. For the random patterns and patterns with vertical symmetry, the six-marble patterns were easiest for the cultural-familials to reproduce, with the eight-marble patterns symmetrical on the horizontal axis the easiest of that pattern type. For both types of symmetrical patterns, the organics found the six-marble patterns

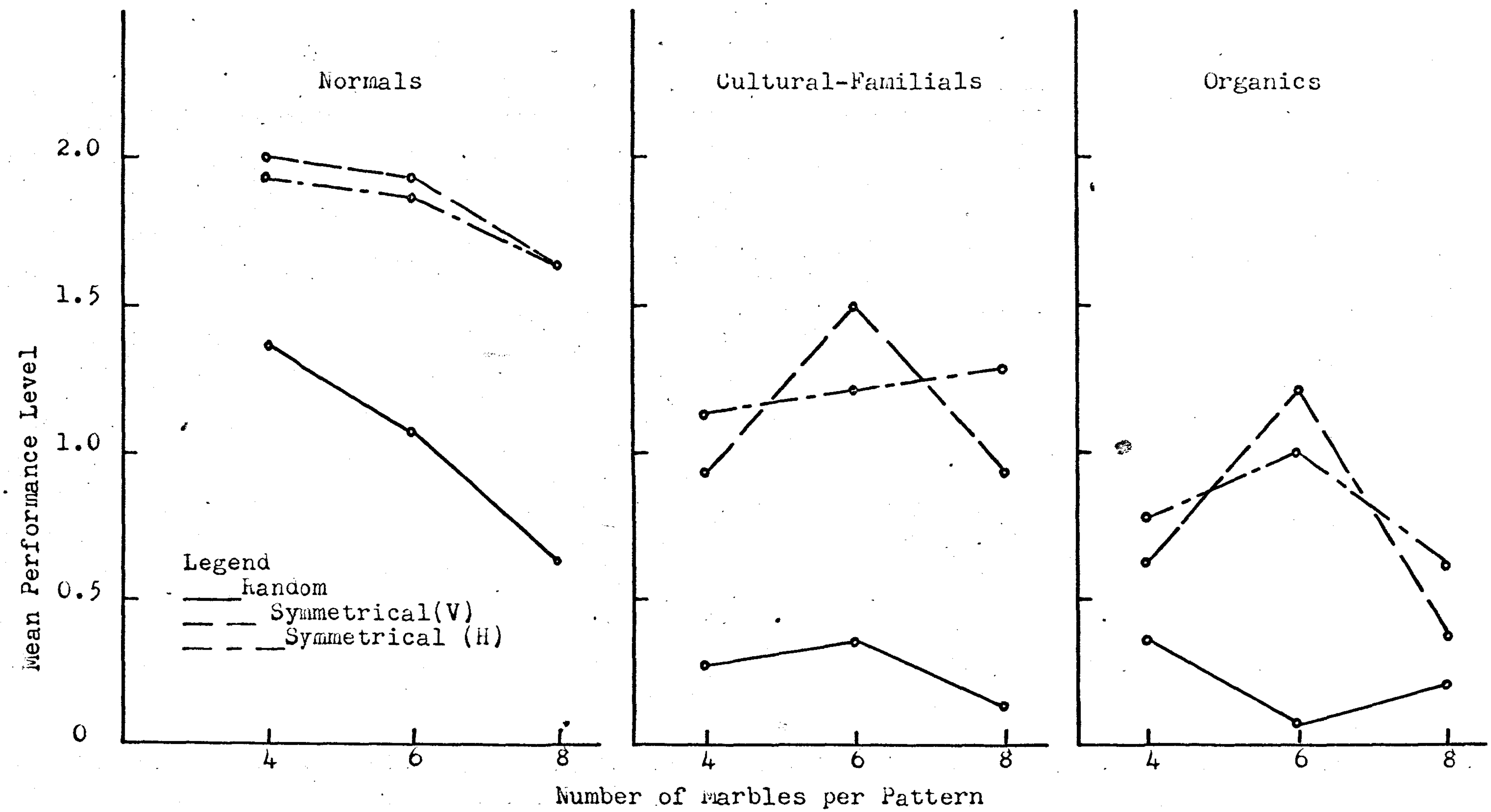


Figure 3. Mean performance level as a function of pattern type and marble number.

Table 3

Mean Number of Four-, Six-, and Eight-Marble Patterns of Each Type Correctly Reproduced by Each Group

Pattern Type Diagnostic Category	Number of Marbles 4	 6	 8
Random			
Normal	1.36	1.07	0.64
Cultural-familial	0.28	0.36	0.14
Organic	0.36	0.07	0.21
Symmetrical (V)			
Normal	2.00	1.93	1.64
Cultural-familial	0.93	1.50	0.93
Organic	0.64	1.21	0.36
Symmetrical (H)			
Normal	1.93	1.86	1.64
Cultural-familial	1.14	1.21	1.28
Organic	0.78	1.00	0.64

easiest to reproduce, with the four-marble random patterns the easiest. Thus it can be seen that the performance of the three diagnostic categories differed not only in degree, but also in kind. The raw scores for the data in Table 3 and Figure 3 are presented in Appendix B.

An analysis of variance was done on this data to determine if the differences among the number of correct reproductions over diagnostic categories, pattern types and number of marbles per pattern were significant. The results of this analysis, as presented in Table 4, indicate that the differences in the number of correct responses between the three diagnostic categories were significant at the 0.01 level, indicating a marked increase in performance level from organics to cultural-familials to normals as shown graphically in Figure 3. The orthogonal partition of group differences, also presented in Table 4, shows that, although the major source of this variation is due to the difference between normals and retardates, there is still a significant residual variance attributable to differences between the two retarded diagnostic categories. In addition, the variation between pattern types and also that between number of marbles per pattern were significant at the 0.01 level. This indicates that for the three diagnostic categories as a whole, ability to reproduce the different types of patterns, as well as patterns with a different number of marbles, differs

Table 4

Analysis of Variance on the Number of Correct Reproductions by Pattern Type and Number of Marbles for the Three Diagnostic Categories

Source of Variation	df	MS	F Ratio
D (Diagnostic Categories)	2	31.88	35.03 '
Normals vs. Retardates	1	58.89	64.71 '
Cultural-familials vs. Organics	1	4.86	5.34 '
Error (d)	39	0.91	
P (Pattern Type)	2	24.18	78.00 '
DP	4	0.51	1.64
Error (p)	78	0.31	
N (Marble Number)	2	3.03	9.77 '
DN	4	0.68	2.19
Error (n)	78	0.31	
PN	4	0.96	4.00 ''
DPN	8	0.37	1.54
Error (pn)	156	0.24	

''$F_{.99}$ (4,120) = 3.48   '$F_{.99}$ (2,30) = 5.39

significantly, as suggested in Figure 3. One of the interaction figures, viz., pattern type and number of marbles per pattern, also reached significance at the 0.01 level. This indicates that ability to reproduce the various types of patterns varied as a function of the number of marbles in the patterns. The other interaction factors, viz., pattern type by diagnostic category, diagnostic category by marble number, and diagnostic category by pattern type and marble number, did not reach significance.

Since the main effects of the diagnostic category, pattern type and marble-number factors were highly significant, further analyses of variance were performed to ascertain at what levels of each of three experimental variables significant differences were present. These main effects were broken down into: 1) simple main effects for the three groups over each of the pattern types and each level of the marble-number factor; 2) for the three pattern types over each of the diagnostic categories and the four-, six- and eight-marble patterns; and 3) for the latter over each of the diagnostic categories and patterns types. These analyses of variance are presented in Table 5, 6 and 7.

The first of these analyses (Table 5) indicated that the total number of correct reproductions between groups varied significantly at the 0.01 level for all three pattern types and for the different levels of the marble-

Table 5

Analysis of Variance on the Number of Correct Reproductions by Pattern Type and Marble Number for Three Diagnostic Categories

Source of Variation	df	MS	F Ratio
Simple Effects of D			
for level p_1 (Random)	2	8.66	16.98 '
p_2 (Symmetrical-V)	2	13.60	26.67 '
p_3 (Symmetrical-H)	2	10.63	20.84 '
Residual	65	0.51	
for level n_1 (Four-marble)	2	16.46	20-84 '
n_2 (Six-marble)	2	8.11	15.90 '
n_3 'Eight-marble)	2	8.66	16.98 '
Residual	65	0.51	

' $F_{.99}$ (2,60) = 4.98

Table 6

Analysis of Variance on the Number of Correct Reproductions by Marble Number and Diagnostic Categories for the Three Pattern Types

Source of Variation	df	MS	F Ratio
Simple Effects of P			
for level d_1 (Normals)	2	9.20	29.68 '
d_2 (Cultural-familials)	2	11.56	37.29 '
d_3 (Organics)	2	4.44	14.32 '
Residual	78	0.31	
for level n_1 (Four-marble)	2	4.67	17.96 '
n_2 (Six-marble)	2	13.08	50.30 '
n_3 (Eight-marble)	2	8.36	32.15 '
Residual	130	0.26	

' $F_{.99}$ (2,60) = 4.98

Table 7

Analysis of Variance on Number of Correct Reproductions by Diagnostic Category and Pattern Type for the Three Levels of Marble Number

Source of Variation	df	MS	F Ratio
Simple Effects of N			
for level d_1 (Normals)	2	2.24	7.22 '
d_2 (Cultural-familials)	2	0.80	2.58 '"
d_3 (Organics)	2	1.34	4.32 ''
Residual	78	0.31	
for level p_1 (Random)	2	1.16	4.46 ''
p_2 (Symmetrical-V)	2	3.50	13.46 '
p_3 (Symmetrical-H)	2	0.30	1.15
Residual	130	0.26	

' $F_{.99}$ (2,60) = 4.98

'' $F_{.95}$ (2.60) = 3.15

'" $F_{.90}$ (2.60) = 2.39

number factor. The analysis of variance for differences in the reproduction of pattern types over the three diagnostic categories and the four-, six-, and eight-marble patterns (Table 6) indicates a highly significant variation at all levels of both the pattern type and marble-number factor. The analysis of variance for differences in the number of marbles per pattern over diagnostic categories and pattern types (Table 7) indicates that they were significant at the 0.01 level for the normal diagnostic category and for patterns symmetrical on the vertical axis. For the performance of the organics on the random patterns, differences in the number of marbles per pattern were significant at the 0.05 level; for the cultural-familials, a significant difference in marble number was only established at the 0.10 level as shown in Table 7. The lack of significance for the marble-number factor and patterns symmetrical on the horizontal axis indicates that ability to reproduce dot patterns with different number of marbles did not vary as a function of horizontal symmetry.

A comparison of individual performance by individual diagnostic categories over pattern type and marble number, as portrayed in Table 8, shows that only one subject from the normal diagnostic category achieved 100 per cent performance on the random patterns, while eight different subjects from that group achieved 100 per cent performance on the two types of symmetrical patterns. No subject in either of the retardate diagnostic categories achieved 100 per cent performance on random patterns; one cultural-familial achieved the 100 per cent level on both types of symmetrical patterns.

Table 8

Number of Subjects in Each Diagnostic Category Reaching 100 Per Cent Performance on the Three Types of Patterns and on the Four-, Six- and Eight-Marble Patterns

Experimental Group	Random	Symmetrical Vertical	Symmetrical Horizontal
Normals	1	8	8
Cultural-Familials	0	1	1
Organics	0	0	0

	Number of Marbles per Pattern: Four	Six	Eight
Normals	6	4	2
Cultural-Familials	0	0	0
Organics	0	0	0

The comparison of individual performance by diagnostic category over the marble-number factor failed to show any difference between the two retarded groups as far as number of subjects reaching 100 per cent percent performance, since no subject in either group achieved it. In the normal group, however, there appears to be a negative linear relationship between the number of subjects reaching 100 per cent performance and the number of marbles per pattern, since six subjects reached the 100 per cent level on four-marble patterns, four on the six-marble patterns, and two on the eight-marble patterns.

That IQ has some bearing on all of the results so far presented, there can be little doubt. Consequently, an analysis of covariance was performed to adjust for the influence of IQ on the performance level. This analysis, as presented in Table 9, indicates that, having extracted the differences between the groups due to IQ, there is no significant difference between the normals and retardates.

Table 9

Analysis of Covariance on the Number of Correct Reproductions by IQ for the Three Diagnostic Categories

Adjusted Variation	df	MS	F Ratio
Diagnostic Categories	2	1.37	1.83
Normals vs. Retardates	1	0.47	
Cultural-familials vs. Organics	1	2.27	3.02 '
Cultural-familials vs. Normals	1	1.82	
Error	38	0.75	

' $F_{.90}(2,30) = 2.49$

A difference between the cultural-familials and the organics, however, was established at the 0.10 level of confidence.

The mean performance levels for the three diagnostic categories, after having been adjusted for IQ, as presented in Table 10, also indicates that differences in performance lay between the cultural-familials and the organics. Inspection of Table 10 also indicates, however, that a trend toward differences between the normals and cultural-familials exists. This trend can be visualized in Figure 4, in which the actual performance means with the adjusted performance are depicted graphically.

Table 10

Actual Mean and Adjusted Mean Performance Levels

Diagnostic Category	Actual Mean	Adjusted Mean
Normals	1.56	0.94
Cultural-familials	0.86	1.11
Organics	0.59	0.92

For interest's sake, all incorrect reproductions were collated according to error type for the normals, cultural-familials and organics. The criterion for each of the different types of errors was arbitrarily chosen on the following basis: "Omissions" include those patterns which were

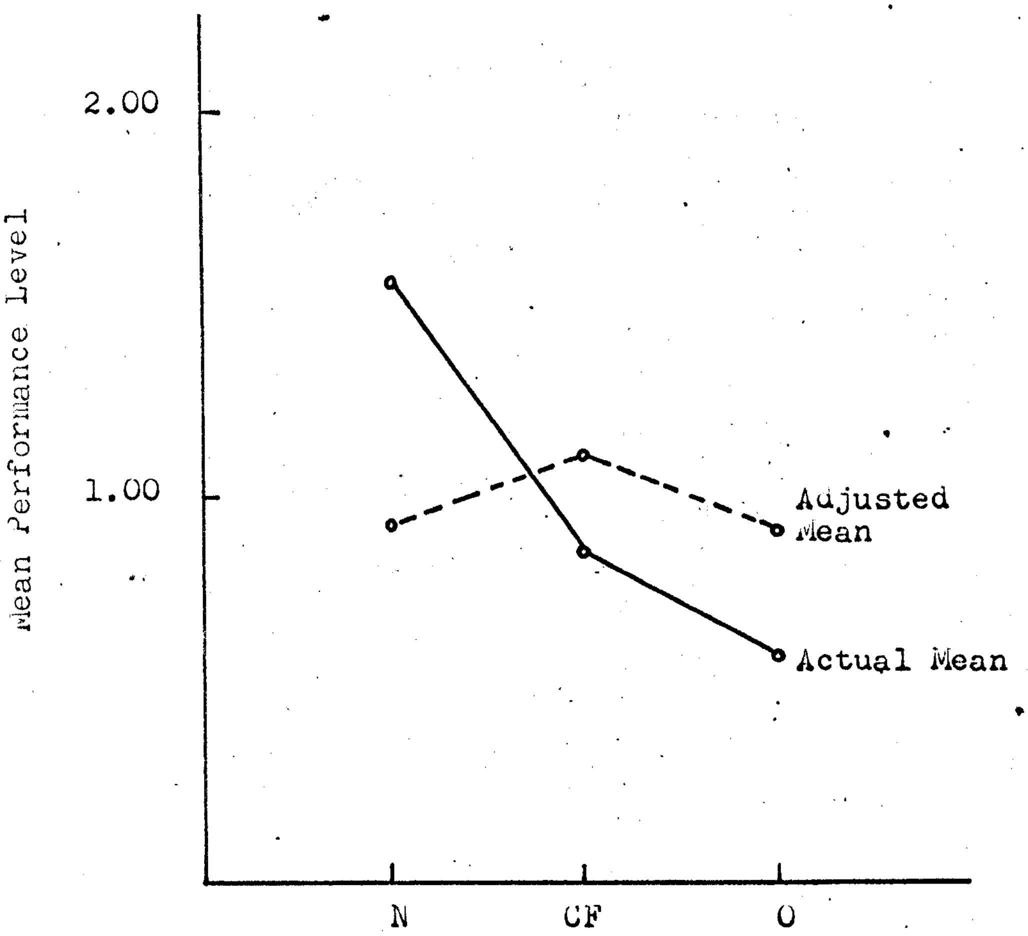


Figure 4. Actual and adjusted mean performance levels for the three diagnostic categories.

essentially correctly reproduced but with one or two marbles missing. "Additions" had one or two marbles added. "Displacements" were those patterns which were correctly reproduced but moved up, down or over one to two rows. "Distortions" were those patterns reproduced with one or two marbles misplaced, but essentially retaining the original configuration. "Inversions" were those patterns which were inverted or reproduced with a 90-degree rotation. Incorrectly reproduced patterns which did not meet any of these criteria exclusively were essentially those reproductions with more than two marbles added, subtracted or misplaced, or else they met two or more of the above criteria. Such errors are included in the "miscellaneous" category.

For purposes of comparison, the errors by type are presented for each group as a percentage of that group's total errors, as shown in Table 11. Inspection of Table 11 suggests that there are important differences in each diagnostic category's manner of approach as evidenced in the different percentage of each type of error made by the three diagnostic categories. This is especially true in the case of "distortion", errors where the normals had the highest percentage, followed by the cultural-familials and the organics. The inverse in the direction of these results held in the case of "miscellaneous" errors with the organics making the highest number of errors followed by the cultural-familials and normals.

Table 11

Percentage of Total Incorrect Reproductions by Error Type for the Three Diagnostic Categories

Error Type	Normals	Cultural-Familials	Organics
		Percentage	
Omission	11	7	6
Addition	2	8	5
Displacement	2	3	0
Distortion	47	24	14
Inversion	2	6	5
Miscellaneous	36	52	70

The collation of the data from which the percentages in Table 11 were derived is presented in Appendix C. The incorrect reproductions were also assigned to the error categories by H.W. Ladd. Disagreement with the writer's categorizing of the errors was less than one per cent.

Although sex of the subjects was not an experimental variable under investigation, for interest's sake, an analysis of variance taking the sex factor into consideration was carried out. The three experimental groups as a whole

(42 subjects) were re-divided into two groups (24 males and 18 females). The least-squares solution for unequal cell frequencies analysis was used. The results of this analysis as presented in Table 12, shows that the variation in performance level between the sexes was not significant. Significant differences at the 0.01 level were found, however, for the pattern type and marble-number factors. A significant interaction ($P < 0.05$) of pattern type with marble number was also found. In addition, a significant interaction at the 0.01 level was discovered between the sex factor and pattern type. This indicates that the ability to reproduce random, symmetrical (vertical), and symmetrical (horizontal) patterns varies as a function of sex.

Because of the presence of the significant interaction effect between the sex and pattern type factors a further analysis was performed. The interaction variance was analyzed in terms of the simple effects for the two groups (male and female) over each of the pattern types and for the three pattern types over each of the groups. The results of this analysis (Table 13) indicate that the differences in the reproduction of random, symmetrical (vertical) and symmetrical (horizontal) patterns were significant for both males and females.

When the sex-pattern type interaction is depicted graphically as shown in Figure 5, it can be readily seen that

Table 12

Analysis of Variance on Total Correct Reproductions by Sex for all Subjects

Source of Variation	df	MS	F Ratio
S (Sex)	1	0.37	
Error (s)	40	2.46	
P (Pattern Type)	2	24.18	86.36 '
SP	2	2.11	7.54 '
Error (p)	80	0.28	
N (Number of Marbles)	2	3.03	9.18 '
SN	2	0.10	
Error (n)	80	0.33	
PN	4	0.96	3.84 ''
SPN	4	0.17	
Error (pn)	160	0.25	

'$F_{.99}$ (2,60) = 4.98

''$F_{.99}$ (4,120) = 3.48

Table 13

Analysis of Variance on the Total Correct Reproductions for the Simple Effects of Sex with Pattern Type

Source of Variation	df	MS	F Ratio
Simple Effects of S (Sex)			
for level p_1 (Random)	2	1.62	1.60
p_2 (Symmetrical-V)	2	0.62	
p_3 (Symmetrical-H)	2	0.07	
Residual	67	1.01	
Simple Effects of P (Pattern Type)			
for level s_1 (Male)	2	8.78	31.36 '
s_2 (Female)	2	17.51	62.54 '
Residual	80	0.28	

' $F_{.99}$ (2,60) = 4.98

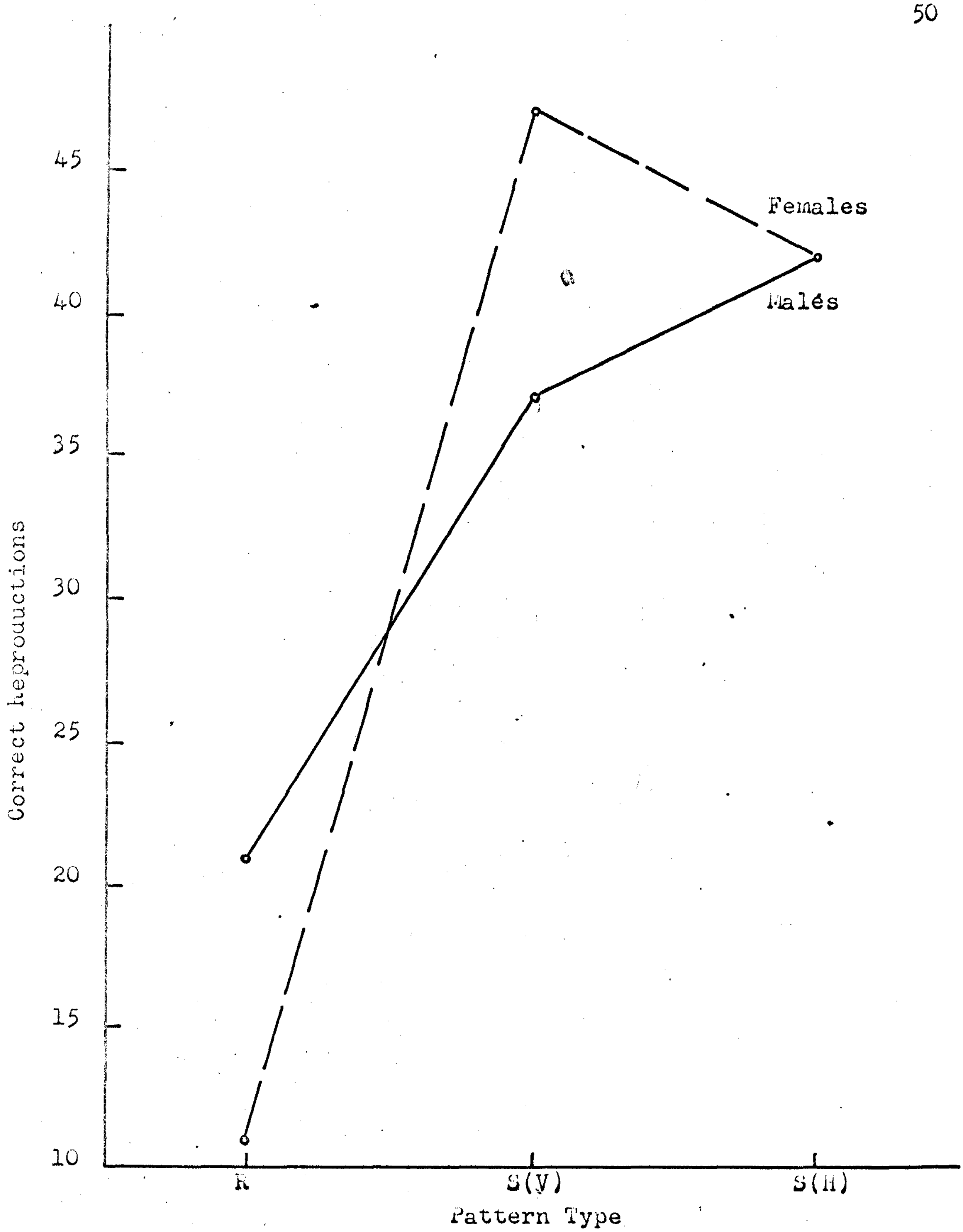


Figure 5. Correct pattern reproductions as a function of sex. The coordinates are drawn from percentages of raw scores since there were unequal numbers of males and females.

the differences in the reproduction of the three types of patterns are differences in performance on the random patterns and patterns with vertical symmetry. The females showed superior performance on the vertically symmetrical patterns and inferior performance on the random patterns. No differences in performance between males and females were evidenced on the patterns symmetrical on the horizontal axis.

Response Time

Response time was determined by stop-watch recording, to the nearest second, from the presentation of the empty marble board to the completion of each pattern as signalled by the subject. The response time results generally parallel those of performance level but in the inverted direction. The organics required the longest time, approximately 37.08 seconds, to complete each experimental task. The cultural-familials took, on the average 28.10 seconds. The normals required the least amount of time, 14.89 seconds, to reproduce each experimental task.

The mean time measure for each group, for each pattern, is presented in Table 14. Inspection of this table indicates that, with the exception of the time required by the cultural-familials to reproduce the four-marble random patterns, it took all groups over all three levels of marble numbers longer to reproduce random patterns than it took for reproductions of either of the two types of symmetrical patterns.

Table 14

Average Time in Seconds per Subject to Reproduce the Four-, Six-, and Eight-Marble Patterns of Each Type

Pattern Type Diagnostic Category	Number of Marbles 4	 6	 8
Random			
Normal	10.14	16.36	22.00
Cultural-familial	22.36	29.26	38.56
Organic	32.72	46.56	46.22
Symmetrical (V)			
Normal	9.28	13.28	18.86
Cultural-familial	25.78	25.50	35.22
Organic	29.78	30.72	44.28
Symmetrical (H)			
Normal	9.64	14.36	20.08
Cultural-familial	18.64	26.28	31.22
Organic	29.64	29.86	43.92

A graphical representation of mean response time as a function of pattern type and marble number is shown in Figure 6. The differences in response time for the three groups over pattern type and marble number are not exclusively differences in magnitude. The normals took longer, on the average, to reproduce all patterns with horizontal symmetry than they did those with vertical symmetry. On the other hand, the cultural-familials took longer on the patterns with vertical symmetry with the exception of the

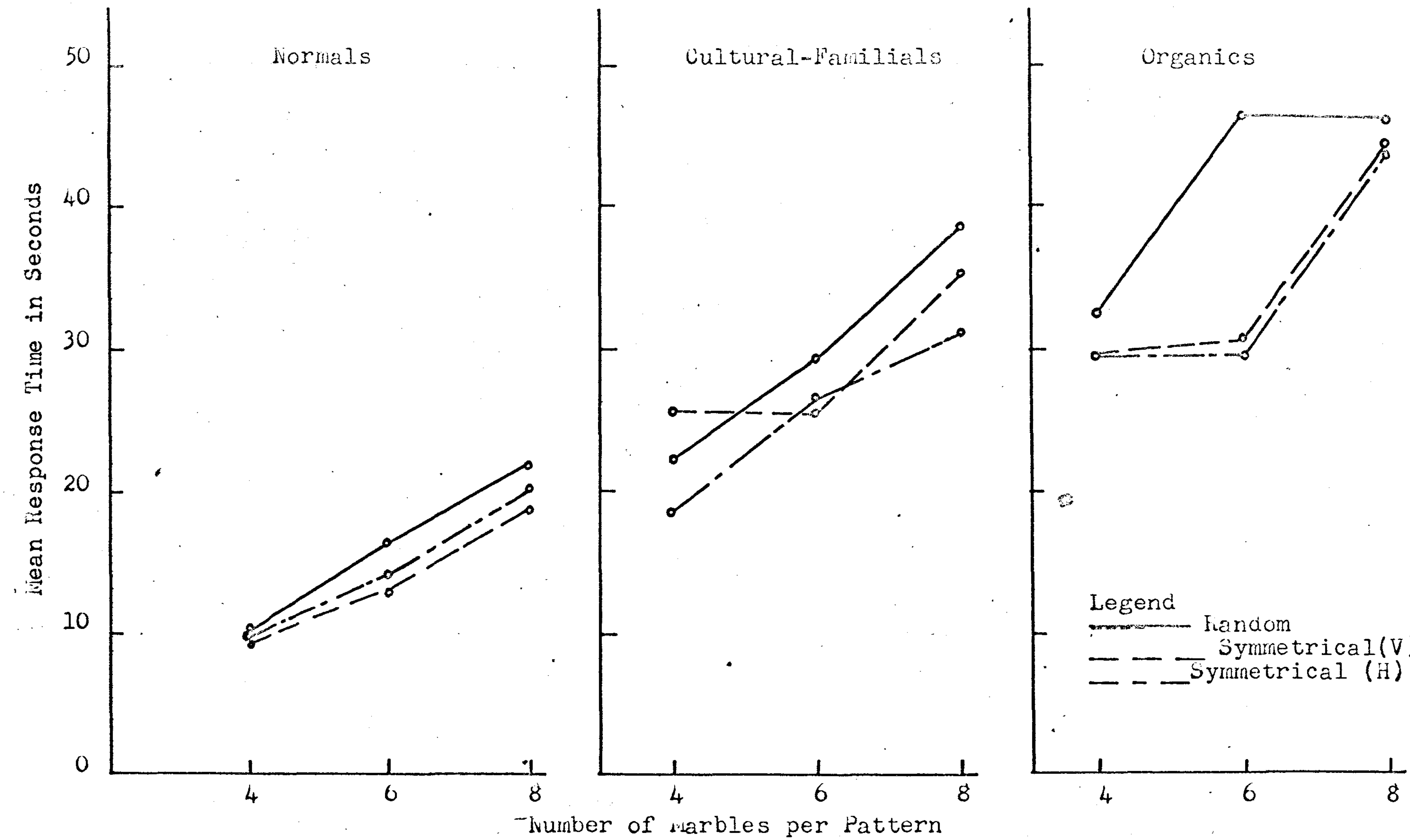


Figure 6. Mean response time as a function of pattern type and marble number.

six-marble symmetrical patterns. The organics, on the average, also required more time to reproduce the patterns with vertical symmetry than they did those with horizontal symmetry. The raw data for the information presented in Table 14 and Figure 6 can be found in Appendix B.

An analysis of variance was done on these data to determine if the differences between the total response time over groups, pattern type and marble number were significant. The results of this analysis, as presented in Table 15, indicate that the differences in the total response time between the three diagnostic categories were significant at the 0.01 level. Orthogonal partitioning of the total variance shows that the normals were differentiated ($P < 0.01$) from the retardates by the time required to complete the experimental tasks and that the two retarded categories were similarily differentiated.

In addition, the variation between pattern types was significant at the 0.05 level and differences between the three levels of marble number were significant at the 0.01 level. These findings indicate, that for the three diagnostic categories as a whole, the time required to reproduce the different types of patterns as well as patterns with a different number of marbles differs significantly. One of the interaction factors, namely pattern type with marble number reached the 0.10 level of significance indicating that time required to reproduce random and symmetrical

Table 15

Analysis of Variance on Response Time by Pattern Type And Marble Number for the Three Diagnostic Categories

Source of Variation	df	MS	F Ratio
D (Diagnostic Category)	2	15699.74	19.38 '
Normals vs Retardates	1	26316.36	32.47 '
Cultural-familials vs Organics	1	5831.12	6.27 '
Error (d)	39	810.38	
P (Pattern Type)	2	708.01	6.96 ''
DP	4	157.89	1.55
Error (p)	78	101.75	
N (Marble Number)	2	4982.72	61.34 '
DN	4	43.23	
Error (n)	78	81.23	
PN	4	155.76	2.23 '"
DPN	8	116.69	1.67
Error (pn)	156	69.79	

'$F_{.99}$ (2,30) = 5.39

''$F_{.99}$ (2,60) = 4.98

'"$F_{.90}$ (4,120) = 1.99

patterns varies as a function of marble number. The results of the analysis as summarized in Table 15 are comparable with those of the performance scores as presented in Table 4, i.e., differences in the diagnostic categories, pattern types and marble-number factor respectively, were found to be significant. The levels of confidence, however, at which significance was established for the pattern type factor and the one significant interaction factor were not as high as for the response time analysis.

Because of the marked similarity in the analysis of the performance level and response time results, a Pearson correlation between the two measures, using overall totals for each subject, was calculated. A correlation coefficient of -.76 was found, which was highly significant ($P < 0.001$). Since it is a negative correlation an inverse relationship between the two measures is indicated. In other words as the response time increased the performance level decreased and vice versa.

Returning to the response time results themselves, further analyses of variance on total response time were performed since the main effects of the diagnostic categories, pattern type and marble-number factors were significant. These main effects were broken down into simple effects for: 1) the three diagnostic categories over each of the pattern types and each level of the marble-number factor; 2) the three pattern types over each of the diagnostic categories and the three levels of marble number; 3) and for the latter over each of the diagnostic categories and pattern types. These analyses of variance are presented in Tables 16, 17, and 18.

The first of these analyses (Table 16) indicates that the total response time between diagnostic categories varied significantly at the 0.01 level for all three pattern types and for the different levels of the marble-number factor. The analysis of variance for differences in response time for the pattern types over the other two factors, as shown in Table 17, indicates that differences in pattern type are significant ($P < 0.01$) for the six-marble patterns only. As far as diagnostic categories were concerned differences in pattern type were highly significant ($P < 0.01$) for the organics and significant at the 0.10 level for the cultural-familials. The analysis of variance on response time for the marble-number factor over the other two factors, as presented in Table 18, indicates that the differences in four-, six-, and eight-marble patterns were significant at the 0.01 level for all three diagnostic categories and for all pattern types.

As pointed out in the presentation of the performance level results, IQ has some bearing on the differences between the normals and the retarded groups. There-

Table 16

Analysis of Variance on the Response Time for the Simple Effects of Pattern Type and Marble Number for the Three Diagnostic Categories

Source of Variation	df	MS	F Ratio
Simple Effects of D			
for level p_1 (Random)	2	6,933.96	20.52 '
p_2 (Symmetrical-V)	2	4,962.16	14.68 '
p_3 (Symmetrical-H)	2	4,119.39	12.10 '
Residual	65	337.96	
for level n_1 (Four-marble)	2	4,700.38	14.40 '
n_2 (Six-marble)	2	4,699.81	14.40 '
n_3 (Eight-marble)	2	6,386.01	19.57 '
Residual	65	326.28	

' $F_{.99}$ (2.60) = 4.98

Table 17

Analysis of Variance on the Response Time for the Simple Effects of Marble Number and Diagnostic Category for the Three Types of Patterns

Source of Variation	df	MS	F Ratio
Simple Effects of P			
for level d_1 (Normals)	2	59.58	
d_2 (Cultural-familials)	2	250.15	2.45 ''
d_3 (Organics)	2	714.06	7.02 '
Residual	78	101.75	
for level n_1 (Four-marble)	2	78.72	
n_2 (Six-marble)	2	773.74	9.61 '
n_3 (Eight-marble)	2	167.08	2.07
Residual	130	80.44	

' $F_{.99}$ (2,60) = 4.98

'' $F_{.90}$ (2,60) = 2.39

Table 18

Analysis of Variance on Response Time for the Simple Effects of Diagnostic Category and Pattern Type for the Three Levels of Marble Number

Source of Variation	df	MS	F Ratio
Simple Effects of N			
for level d_1 (Normals)	2	1,158.58	14.60 '
d_2 (Cultural-familials)	2	1,738.82	21.41 '
d_3 (Organics)	2	2,144.80	26.40 '
Residual	78	81.23	
for level p_1 (Random)	2	2,077.68	28.23 '
p_2 (Symmetrical-V)	2	1,537.31	20.89 '
p_3 (Symmetrical-H)	2	1,679.27	22.82 '
Residual	130	73.60	

' $F_{.99}$ (2,60) = 4.98

fore an analysis of covariance was carried out to discover what influence differences in IQ had on differences in response time. The results of this analysis, as presented in Table 19, show that there are still significant differences in response time between the three diagnostic categories. This indicates that the differences in response time are not exclusively due to differences in IQ.

Table 19

Analysis of Covariance on Total Response Time by IQ for the Three Diagnostic Categories

Adjusted Variation	df	MS	F Ratio
Diagnostic Category	2	2460.15	3.24 '
Normals vs. Retardates	1	1789.05	2.42
Cultural-familials vs. Organics	1	3131.25	4.25 '
Error (d)	38	736.56	

'$F_{.95}$ (2,38) = 3.24

Adjustments for the influence of IQ on response time were made on the groups means as shown in Table 20. When these means are plotted with the actual means, as presented in Figure 7, it is seen that the change in the direction of the results, after adjusting for IQ parallels

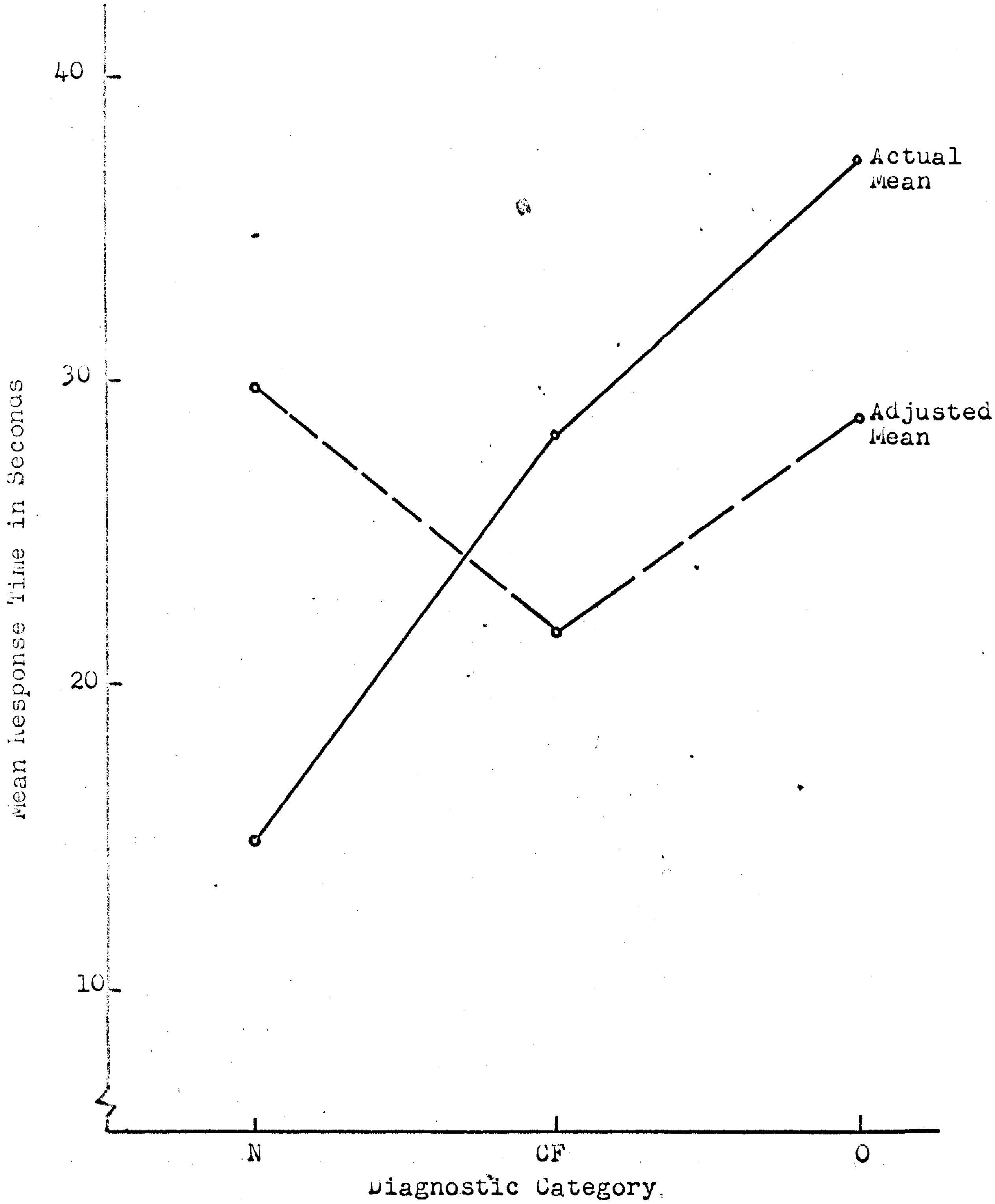


Figure 7. Actual and adjusted mean response time for the three diagnostic categories.

inversely that of the performance level as seen in Figure 4. Response time for the normals increases after adjustment whereas for the retardates it decreases. The opposite was the case for parallel changes in the performance level.

Table 20

Actual Mean and Adjusted Mean Response Time for the Three Diagnostic Categories

Diagnostic Category	Actual Mean	Adjusted Mean
Normals	14.89	29.77
Cultural-familials	28.10	21.63
Organics	27.08	28.68

Again, for interest's sake, an analysis of variance on response time taking the sex factor into consideration was performed. The results of this analysis are presented in Table 21. The variation in response time between males and females was not significant indicating that boys and girls took approximately the same amount of time to complete the reproductions of the patterns. Significant differences found in the initial analysis (Table 15) were corroborated.

Table 21

Analysis of Variance on Response Time by

Pattern Type and Marble Number for Males and Females

Source of Variation	df	MS	F Ratio
S (Sex)	1	51.65	
Error (s)	40	1573.81	
P (Pattern Type)	2	708.01	6.91 '
SP	2	186.25	1.82
Error (p)	80	102.44	
N (Marble Number)	2	4982.72	61.92 '
SN	2	35.76	
Error (n)	80	80.47	
PN	4	155.76	2.34 ''
SPN	4	37.57	
Error (pn)	160	66.67	

'$F_{.99}$ (2,60) = 4.98

''$F_{.90}$ (4,120)= 1.99

CHAPTER IV

DISCUSSION

The performance levels of normals, cultural-familials and organics in reproducing random and symmetrical dot patterns, with varying degrees of multiplexity, were found to be significantly different. This result differs from the previous study by Spitz (1964) who found no over-all significant difference between normals and retardates on a similar task. His subjects were equated in terms of MA, whereas in the present study, CA was used for equating the groups. When this difference in procedure was adjusted for, however, by statistically extracting the differences between the groups due to differences in IQ level, no significant difference in performance was left between the normals and retardates, thereby agreeing with Spitz' findings and also those of Griffith (1959) and Rosenberg (1961). Significant differences remained, however, after adjusting for IQ, between the cultural-familials and organics.

Do retardates differ from normals in special, rather than in general ways? And, within the categories of mental retardation, can a further differentiation be made between retardation due to organic impairments (brain-injury) and retardation of unknown, but presumably psychogenic, origin? These two questions, posed in the present study, must be answered in the affirmative. Additional confidence is given this affirmation when one considers that at all levels of the experimental variables (pattern type and multiplexity level) the three diagnostic categories were significantly differentiated. These results, in part, agree with those of Spitz (1964), since he found that the pattern type conditions (random versus symmetrical) were highly significant ($P < 0.001$). In the present study the same level of significance was achieved for the pattern type factor. Spitz did not analyze his results in terms of the number of components per pattern, but dealt with them in a general way. He did note, however, that "both groups (retardates and normals) had the most difficulty with the six-tack patterns, doubtlessly because there were an equal number of filled and unfilled cells, and the subjects would have as much difficulty remembering which cells were empty as which were filled".

In the present study the six-marble symmetrical patterns were the least effective in differentiating the groups. For the retardates they were generally the least difficult. This is essentially in agreement with French (1954a) who found that the "degree of complexity" represented by six to eight dots was optimal for identification. It is possible that in the present study the lower number (six) was the case for ease of reproduction by the retardates since, presumably, they were recalling the filled cells primarily (there were 16 cells altogether). Since more errors were made by all subjects on the eight- than on the four-marble patterns suggests that the retardates were recalling the filled cells. On both types of symmetrical patterns, however, the reproductions of the cultural-familials were an exception. They correctly reproduced as many eight-marble symmetrical patterns as four.

The fact that filled cells rather than unfilled ones apparently were being remembered by all subjects including the organic group does not support the contention of Robinson and Robinson (1965) who reported that:

> For reasons not yet well understood, many brain-injured children seem to have particular difficulty in separating a significant stimulus from its distracting background. They apparently fail to outgrow the initial chaos of infancy, or what William James termed the "one great blooming, buzzing confusion".

The difference in performance between the two groups of retardates is greatest at the six-marble factor level. This difference suggests that the type of pattern which most differentiates the two retarded groups is the six-marble random pattern

When adjustments for IQ were made on the mean performance levels for the three diagnostic categories, it was found that the adjusted factor had the greatest effect on the mean performance of the cultural-familials. If differences in performance had been exclusively due to differences in intelligence one would have expected the performance of each group to have been similarily affected when equated for IQ. Such was not the case. The differences in the adjusted means, and the fact the cultural-familials had the highest, can be explained in several ways. Since more than half of the normals achieved one hundred per cent performance on the symmetrical patterns, perhaps those patterns were too easy for the normals and, therefore, an artificial ceiling contaminated their scores. In addition, although no material reward was given any of the subjects, it is possible that the retardates level of motivation was higher. The children may have been hopeful that they were being considered for "placement" or "probation" to their homes. Remarks of the retardates at the beginning of the testing session expressed this expectation. However, within the retarded groups, this factor would not account for motivational differences. Significant differences were found between adjusted performance levels. Only the cultural-familial group "over-achieved". This indicated that the experimental task - the reproduction of random and symmetrical dot patterns - does contribute to a differential diagnosis of organicity. There is, however, the reservation that both the WISC and Stanford-Binet were used to assess the retardates' IQs, and the normals' IQs were established on a completely different test.

It may be argued that all subjects IQs should have been established using the same IQ test, but such a test is hard to come by. The WISC, for example, seems ideal save for the fact that "factor analytic" studies suggest that retardates and normals perform qualitatively differently on the WISC (Baumeister, 1964). A more practical suggestion for equating the normals and retardates in terms of IQ assessment would be to use normal subjects whose scores range between 85 and 115 rather than between 90 and 100. This would take into consideration the 15 point difference now considered the appropriate SD interval on IQ measures.

The contention that the ability to reproduce dot patterns is a reliable means of differentiating retardates from normals and, within the retarded population, organics from cultural-familials is supported by comparison of the error types made by each group. Although these data were not subjected to statistical treatment, the gross differences between the groups in their "distortion" and "miscellaneous" type errors has some importance. On an all-or-nothing scoring basis both types of errors are equally wrong. From a qualitative viewpoint, however, the "distortions" by definition (as set down in Chapter III) are "more correct" than the "miscellaneous" type of errors. That the normals made fewer of the latter, followed by the cultural-familials and lastly by the organics is no mere coincidence. It reflects the poorer performance generally of the retardates and specifically the poorest performance by the organics on a task which requires the functioning of perceptual motor ability and short-term memory. Although the marble board test used by Werner and Strauss (1940) was measuring only perceptual motor ability, these investigators found similar qualitative differences in error type between endogenous and exogenous groups.

Ellis' (1963) theory of stimulus trace deficit in the short-term memory of mental retardates appears to have been borne out in the present study if it is assumed that the significantly lower performance levels of the retardates generally, and the organics, specifically, were due to a diminution in the "duration and amplitude of the stimulus trace in the subnormal organism". It is, however, a commonly held belief that organics find it extremely difficult to control attention (Strauss and Lehtenin, 1947; Lewis, 1951; Goodenough, 1956; Hutt and Gibby, 1965). There can be little doubt that attention was a significant variable in the present investigation. Attention may change the intensity of an experience; it may determine the train of associations and thereby add to or detract from the meaningfulness or it may leave certain processes wholly out of the field of consciousness. The experimental task employed in the present study did not allow for the direct investigation of these effects of attention. However, since the screen which separated the subject from the experimenter allowed for the latter's viewing of the subject's head, it was possible to make note of the apparent degree of the subjects' attending to the task at hand, especially during the five second presentation of each pattern. Only one normal was observed to be not attending to the pattern on presentation, while many retardates, especially the organics, often appeared to be distracted by the observer, apparatus and surroundings. Several of the organics went so far as to attempt to push the marble board back to the experimenter after only 2 or 3 seconds of the presentation period. Similar observations were made by Halpin (1954). She noted that some children gave no more than a fleeting glance at the stimulus figure. As stated by Halpin, " it may be inferred that the visual image was not reinforced enough for accurate reproduction". This inference is also applicable to the results of the present study and, therefore, provides an adjunct to Ellis' theory of stimulus trace deficit.

In future research a high screen would partially solve the problem of attention by removing the possible distracting influence of being able to see the observer. It would not, however, keep the subject from possibly attending to other things rather than the stimulus. The use of mirrors to allow for the experimenter's constant observation of everything occurring on the other side of the screen is suggested.

The possibility that ability to reproduce patterns varied with the degree of meaningfulness they had for the individual subjects should not be overlooked. Peterson and Peterson (1961) found that the recall of individual trigrams after six seconds was found to vary with their meaningfulness. Any specific consideration of the contribution made by meaningfulness is, however, precluded in the present study since this factor was not measured. It did seem, however, that symmetrical patterns were more meaningful than the random for all subjects since more of them were reproduced correctly.

Generally, all the preceding remarks may also be applied to the response time results since they parallel inversely those of performance. Increments in performance level were reflected in decrements in response time. These decrements support the contention that reproduction of patterns involves perceptual motor ability <u>and</u> memory. If this is the case, then, from the results of the present study organics can be said to be thus doubly impaired.

That length of institutionalization of the retardates and amount and type of medication being administered previous to, and during the testing period, may have some bearing on the results of this study, cannot be overlooked. Approximately the same number of children in both retarded categories were "on medication" which was essentially of the same type and dosage. The mean period of institutionalization was also similar for both groups.

At this juncture it should be reiterated that quite possibly there is no generalized "brain-injured child", but only specific cases of brain-injured children (Hutt and Gibby, 1965; Wortis, 1956; Gallagher, 1956). With the increasing contributions being made by neurophysiology to the understanding of organicity it is becoming more apparent that it is individual cases of brain-injury with which the clinician and the researcher have to deal. Especially was this the case in the present study wherein the group of organics was composed of 14 patients with ten distinctly different diagnoses of brain injury. Nevertheless, the present study did show that organics can be differentiated from cultural-familial retardates on the basis of their ability to reproduce random and symmetrical dot patterns.

CHAPTER V

SUMMARY

Three groups of children (mean CA 12 years), 14 normals, 14 cultural-familials and 14 organics, were compared on their ability to reproduce from memory random patterns and two types of symmetrical patterns. The number of marbles per pattern was varied. A marble board with four rows of four holes each was employed to present the stimuli.

Both performance level and response time measures were recorded. Adjustments for IQ differences were made. Significant differences between the organics and the cultural-familials in their performance level and response time indicated that the experimental task effectively differentiated the three groups.

The results suggested that the type of pattern which most differentiates the two groups of retardates is the six-marble random pattern. No overall sex differences were found in performance level or response time. Errors were categorized qualitatively. Comparisons across the three groups suggested that important differences in their manner of approach in reproducing the patterns existed.

The results were discussed in terms of motivational levels, Ellis' (1963) theory of stimulus trace deficit in the short-term memory of mental retardates, attention, and meaningfulness. Suggestions for procedural improvements for future research were presented.

APPENDIX A

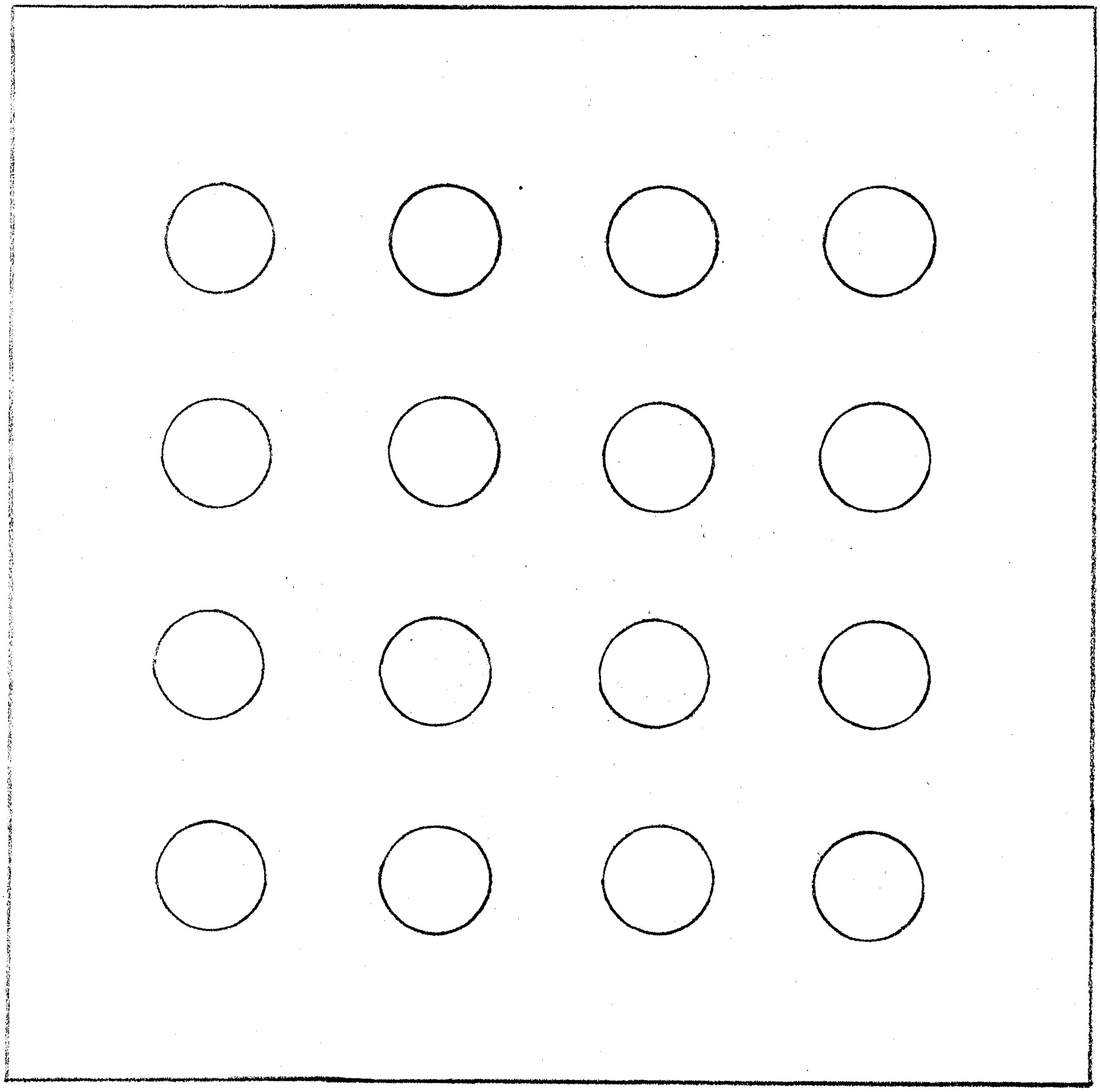
Data Sheet

DATA SHEET

Subject No, _____ Diagnostic Category ______

Pattern No. _____

Time _____



APPENDIX B

Performance Level and Response Time Scores

Performance Level and Response Time Scores for Normal
Subjects by Pattern Type and Number of Components

Subject Sex	IQ	Random Patterns						Symmetrical$_V$ Patterns						Symmetrical$_H$ Patterns					
		Components						Components						Components					
		4		6		8		4		6		8		4		6		8	
		PL	T	PL	T	PL	T	PL	T	PL	T	PL	T	PL	T	PL	T	PL	T
M_1	106	2	12	2	16	0	23	2	10	1	15	2	17	2	13	2	13	1	17
M_2	107	1	10	0	16	1	21	2	15	2	18	1	23	2	9	2	14	1	27
F_1	91	2	9	2	13	1	21	2	11	2	12	2	18	2	10	2	15	2	18
F_2	104	1	14	1	30	0	28	2	9	2	14	1	28	2	8	2	18	2	22
M_3	108	2	12	1	17	1	37	2	9	2	15	1	16	2	13	2	14	2	20
M_4	97	1	9	1	12	0	19	2	10	2	12	1	20	2	9	1	15	1	20
F_3	98	1	13	0	19	0	23	2	9	2	18	2	28	2	13	1	19	2	25
M_5	109	2	7	2	12	0	19	2	7	2	12	1	14	2	10	2	13	2	16
F_4	104	0	9	0	20	1	25	2	8	2	8	2	16	1	7	2	12	1	18
M_6	100	2	10	2	19	2	21	2	13	2	17	2	21	2	11	2	17	2	21
M_7	105	1	13	1	16	1	25	2	8	2	11	2	18	2	9	2	14	1	29
F_5	96	1	7	1	13	0	15	2	7	2	11	2	15	2	7	2	12	2	16
M_8	108	1	9	2	12	2	12	2	8	2	12	2	15	2	10	2	13	2	18
F_6	108	2	8	0	13	0	18	2	6	2	11	2	15	2	6	2	12	2	14

Performance Level and Response Time Scores for Cultural-Familial Retardate Subjects by Pattern Type and Number of Components

Subject Sex	IQ	Random Patterns Components 4		6		8		Symmetrical$_V$ Patterns Components 4		6		8		Symmetrical$_H$ Patterns Components 4		6		8	
		PL	T	PL	T	PL	T	PL	T	PL	T	PL	T	PL	T	PL	T	PL	T
F_7	63	0	27	0	34	0	39	0	66	2	25	1	52	2	22	1	47	1	53
M_9	58	0	32	0	28	0	46	0	43	0	59	1	38	1	30	1	34	0	32
M_{10}	63	0	24	0	48	0	58	1	24	2	49	0	62	2	23	2	23	1	45
F_8	70	0	27	0	39	0	46	1	14	2	14	1	42	1	11	1	29	1	43
M_{11}	72	0	20	0	24	0	29	2	11	2	15	1	33	1	11	2	17	2	27
M_{12}	69	1	13	1	17	1	21	1	17	2	21	1	22	0	20	2	18	2	21
M_{13}	64	1	15	2	26	0	39	1	32	1	20	1	25	2	15	1	26	1	23
F_9	57	1	14	0	43	0	57	2	14	2	21	2	23	2	10	2	17	2	26
M_{14}	53	1	24	0	20	1	27	2	16	0	25	1	29	1	14	0	27	2	24
F_{10}	57	0	13	0	19	0	25	0	36	2	23	1	35	1	24	1	20	1	28
M_{15}	53	0	14	0	29	0	28	0	15	1	25	0	21	1	16	0	23	1	27
M_{16}	58	0	49	2	32	0	62	1	37	2	20	1	52	0	34	1	28	2	26
F_{11}	59	0	25	0	31	0	36	1	20	1	22	1	33	1	16	2	24	1	32
F_{12}	59	0	16	0	21	0	27	1	16	2	18	1	26	1	15	1	35	1	30

Performance Level and Response Time Scores for Organic Retardate Subjects by Pattern Type and Number of Components

Subject Sex	IQ	Random Patterns: Components 4 PL	4 T	6 PL	6 T	8 PL	8 T	Symmetrical_V Patterns: Components 4 PL	4 T	6 PL	6 T	8 PL	8 T	Symmetrical_H Patterns: Components 4 PL	4 T	6 PL	6 T	8 PL	8 T
M_{17}	65	0	28	0	43	0	37	0	13	1	36	0	47	2	18	2	17	1	24
M_{18}	61	0	16	0	57	0	45	0	33	2	21	0	47	1	24	1	23	0	46
M_{19}	52	0	67	0	56	0	31	1	43	0	44	0	65	0	28	1	36	1	47
M_{20}	70	1	24	1	24	1	17	1	13	2	17	1	13	2	11	2	15	1	19
F_{13}	51	0	63	0	65	0	70	1	43	0	58	0	61	0	100	0	58	0	62
M_{21}	53	1	15	0	37	0	43	0	40	1	40	0	44	1	21	1	36	1	34
F_{14}	59	0	55	0	47	0	60	0	44	0	46	0	84	0	44	0	38	1	53
F_{15}	59	2	119	0	55	0	40	2	11	1	21	1	29	1	14	2	26	1	103
M_{22}	66	1	24	0	58	0	51	2	21	2	22	1	38	1	18	1	30	1	28
F_{16}	60	0	21	0	42	1	59	1	31	2	15	2	27	1	25	1	10	1	31
F_{17}	52	0	19	0	30	0	27	0	26	2	25	0	24	0	16	1	26	0	29
F_{18}	60	0	22	0	24	0	29	1	25	2	29	0	26	1	17	1	32	0	32
M_{23}	48	0	70	0	75	0	93	0	47	1	38	0	76	1	50	0	45	1	74
M_{24}	46	0	25	0	39	1	45	0	27	1	28	0	39	0	29	1	26	0	33

APPENDIX C

Total Incorrect Reproductions by Error Type for the Three Diagnostic Categories

Error Type	Normals	Cultural-Familials	Organics
Omission	7	10	11
Addition	1	12	9
Displacement	1	5	0
Distortion	26	34	25
Inversion	1	8	9
Miscellaneous	20	74	124
Total	55	143	178

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