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CONCEPT IDENTIFICATION:

POST FEEDBACK VARIATION IN THE BRAIN DAMAGED

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CHAPTER I

INTRODUCTION AND HISTORICAL DEVELOPMENT

The many problems of studying thinking and thought processes are as formidable as any one can choose to tackle. In fact, as Hebb states,

> The failure of psychology to handle thought adequately has been the essential weakness of modern psychological theory (1949, p. 16).

Bruner, Goodnow, and Austin (1956) have also recognized this point in their discussion of the revival of interest in the study of cognitive processes. They attribute this revival to a recognition of the complex processes that mediate between the classical "stimulus" and "response" out of which S-R learning had hoped to fashion a psychology that would by-pass anything sounding "mental." The strict "S-R bond" concept was to become modified into a concept that has been called an "S-O-R" concept; the O standing for all the subtle events that may occur between the input of a physical stimulus and the emission of an observable response. Other sources of the revival are the development of information theory after the communication model and a decline in interest in the unyielding determinism inherent in the Freudian view of human behavior.

A further factor that has called attention of psychologists to these central processes of thinking is the realization by experimentalists working with animals that perception and learning are not wholly peripheral and self-sufficient processes, but that even at the minimal level they are complicated by generalization and transfer. It is now generally realized that no sharp dividing line can be drawn between generalization and transfer at the sensori-motor level and conceptual thinking. As Piaget points out, "Intelligence is not a completely new power superimposed all of a sudden on completely prepared previous mechanisms, but is only the expression of these same mechanisms when they go beyond present and immediate contact with the world"(1957, p. 85). Fields (1932) in demonstrating that, after training, rats could eventually discriminate any kind of triangle in any position from other figures, went on to suggest that they had attained the concept of triangularity. Pavlov's (1927) stimulus generalization, Lashley's (1934) equivalent stimuli, Harlow's (1949) learning sets lead away from the assumption of a sensory dominance of behavior and toward the acceptance of autonomous central processes. An important aspect of these central processes is that they are concerned with sorting, classifying, ordering, abstracting--with the operations, therefore, that are characteristic of conceptual thinking. As Hunt has recently stated, "Understanding how humans learn abstractions is essential to the understanding of human thought" (1962, p. 1).

Although concepts are the principal tools of thinking and were among the first psychological problems to be investigated by the ancient Greeks, especially the platonic Socrates, they have been the subjects of fewer investigations than have some other cognitive processes such as sensation, perception, imagery, serial learning, and retention. Among the classic works on concept formation are those of Külpe (see Wilcocks, 1925), English (1922), Fisher (1916), Hull (1920), and Smoke (1932, 1933, 1935). Smoke gives us a summative statement concerning this earlier work on concepts,

> Prior to 1920 all of the experimental work on concepts was carried on by means of an introspective technique. This work, though careful and painstaking, is so lacking in objectivity (in the sense of which the natural sciences are objective) that it seems to us to be of little value today (1935, p. 274).

The first important non-introspective attempt to study concept learning was that of Hull (1920). Hull was also to summarize the earlier work as being "introspective in method, analytic in purpose, and qualitative in result"

(1920, p. 1). This work investigated the comparative economy of the simple-to-complex method versus the complex-to-simple method, moderate familiarity with a certain number of concepts versus thorough familiarity with half as many, drawing special attention to the common elements versus equal distribution of attention to all parts, and the influence of psychotic conditions. Hull considered his Ss to have "evolved" a concept when they discovered the "common element" hidden in each member of a group of Chinese characters. Each character in a given group had this common element in a sense that it contained certain strokes in common with the other characters of the group, and the process of discovering these common elements was taken to be "the evolution of concepts." As Hull states:

> All of the individual experiences which require a given reaction, must contain certain characteristics which are to all members of the group requiring this reaction and which are not found in any number of the groups requiring different reactions (1920, p. 13).

Smoke (1932) took issue with Hull and his view of a concept on the grounds of it being over-simplified and elementaristic. He criticized Hull and those who continued his work (Gengerelli, 1927; Kuo, 1923) for leaving out the "relationship" involved in the stimulus complex. The criticism is essentially concerned with the Gestaltist-Behavioristic split. If one divorces himself from this controversy, the two dissertations of Hull and Smoke can be seen as similar. Both used nonsense words as well as the discrimination of certain common aspects of a stimulus pattern in their experimental definition of the concept. Smoke's classic definition of concept formation is often quoted:

> By "concept formation," "generalization," or "concept learning," we refer to the process whereby an organism develops a symbolic response (usually, but not necessarily linguistic) which is made to the members of a class of stimulus patterns but not to other stimuli (1932, p. 8).

Smoke's work used geometric design patterns of differing shape, color, position, width of lines, and number. His investigation was concerned mainly with the investigation of positive as compared to negative instances as well as the relationship between intelligence and the ability to identify concepts.

Hull and Smoke can provide a point of departure in several respects:

(1) They both attempted an objective, more quantitative investigation of the process in question.

(2) Hull suggested that the study of concept thinking in psychopathology may be fruitful.

(3) Smoke suggested that basic dimensions such as shape, color, number, and position as useful conceptual dimensions.

In 1934 the Russian psychologist Vigotsky, on the basis of clinical observations and experiments, put forward the theory that the characteristic feature of schizophrenia was the loss of the ability to think in abstract concepts and a regression to a more primitive level which he called "thinking in complexes." His test, which was a modification of one developed by Asch, used blocks of varying shapes, colors, and sizes that were to be placed in categories in relation to the concept in question. Vigotsky's work was followed up by Hanfmann and Kasanin (1942) in the United States. This work was based on the assumption that one's ability to form and test miniature theories or concepts is the highest form of thinking. And the placing of blocks into groups according to a classification principle is the specific indicator of this form of thinking.

Probably the most celebrated and influencial worker using a concept formation test consisting of blocks of different form, shape, and color is Kurt Goldstein. In fact, Hanfmann and Kasanin (1937) credit Goldstein with having termed what they call the very core of conceptual thinking, the "categorical attitude." A second aspect they mention, "insight into the multiple possibilities of the choice," also sounds very much like Goldstein's discussion of shift in thinking. In short, it can be seen that on theoretical grounds, at least, there is a great similarity between the Hanfmann-Kasanin and the Goldstein tests. In their classic monograph Goldstein and Scheerer (1941) described a number of sorting tests using a variety of objects including blocks, skeins of wool, and everyday objects (pipe, nail, pencil, etc.) that can be sorted into groups that reflect conceptual dimensions of color, shape, size, and category names like "tools." These tests became the standards by which conceptual deficit was observed in brain damaged. Indeed, even though the form of various tests have changed, still the basic dimensions of size, color, shape, and number remain standards in research on conceptual thinking.

Memory Function in Psychopathology.--In any review of the literature concerning cognitive deficit in psychopathology the importance of the assessment of the memory function soon becomes apparent. In fact, the degree to which the memory function is contributing in any kind of psychological test assessment is not really known. At an even more general level there is hardly a task, be it intellectual or otherwise, that does not, to some extent, draw on the human capacity to store and retrieve information and experience. As Kraeplin stated long ago:

> All higher mental activity depends largely on memory. The formation of concepts is the necessary condition for the fullest development of ideation (in Halstead, 1947, p. 15).

A wealth of clinical observation and research have for many years suggested that loss of memory is one of the most salient symptoms of brain injury (Benton, 1946; Stone, Gridner, & Albrecht, 1946; Wechsler, 1945). Goldstein also listed as a component of the concrete attitude the inability to hold in mind simultaneous aspects of a particular task. This inability can be thought of as reflecting a recent memory deficit.

One of the most popular traditional measures of recent memory deficit is the digit span test where the subject repeats increasing series of digits presented one second apart. The subject is asked to repeat them forward and backward. This test, as one indicator of recent memory, has been found, with varying degrees of success, to be indicative of cerebral pathology (Allan, 1947, 1948; Anderson, 1951; Collins, 1951; Diers & Brown, 1950; McFie & Piercy, 1952). Heilbrun (1956) using a variety of memory tasks found very different performance in the brain damaged group. Subtest breakdown on the digit span revealed a significantly greater deficit in the patients with left sided lesions as opposed to right sided lesions. This was part of the larger finding of a greater deficit in verbal abilities with left sided lesions. Whether this memory deficit is a result of a disturbance of the neural trace or storage mechanism is not clear. There are many studies that have established a relationship between anxiety or stress and digit span performance (Blankenship, 1938; Calvin, 1955; Keyes, 1953; Moldawsky, et al., 1952). This work suggests that the recent memory function tapped by the digit span test is sensitive to or can be lowered by induced stress or anxiety. Of course there is no reason to suggest an either-or situation. Both variables could conceivably contribute to a reduction of storage capacity in any particular instance. In fact, Goldstein states that the "catastrophic" anxiety that is so debilitating is primarily a reaction of the patient to his inadequate performance. Part of this inadequate performance could certainly be a memory loss.

Memory Deficit in the Mentally Retarded.--The interpretation of inadequate functioning of the mentally retarded in terms of memory functions has been proposed by Ellis (1963). It is called the "stimulus trace theory" and is invoked as an explanatory mechanism to account for immediate memory. The theory is fashioned after Hebb (1949) and postulates "reverberatory circuits" as the basis of short term memory. These circuits, which do not initially entail a change in neural structure, are felt to be the most sensitive to CNS disturbance. Ellis cites a considerable number of studies that lend support for this theory and concludes,

> Evidence from neurophysiology supports the notion

> of a reverberatory circuit and the role of perseverative aftereffects in short-term memory. These considerations along with empirical findings from the research with animals lend appeal to the stimulus trace concept and to its promise as an explanatory construct for behavioral differences resulting from CNS insult in the human (1963, p. 138).

This research is viewed in support of the consideration of memory functions in the evaluation of the performance of Ss with CNS damage.

Memory, Brain Function, Concept Formation.--As Mark suggested, one of the most distinguishing behaviors to be found in the higher organisms is that of more efficient problem solving or, quite synonymously, concept formation. This behavior

> permits the system not only to classify within-brain activity patterns of the basis of operational equivalence but also to classify external stimulus pattern similarities and differences by the same operational criteria. This allows for the possibility of substituting one external pattern for another, and therefore, for conditioned intra- and inter-modality discrimination (1962, p. 77).

Both of these classification activities depend on the ability to code and retain both spatial and temporal patterns.

One of the most extensive investigations of both brain function and memory deficit has been done by Talland (1965). Over the years his investigations of Korsakoff's Disease have been designed to test specific hypotheses about disturbances characteristic of the amnesic syndrome and, indirectly, the processes involved in normal memory function. The results of his studies using tasks such as those used by Goldstein, Hanfmann, and Kasanin, Halstead, etc., plus many other categorical, perceptual, and sequential tasks reveal a singular deficit in the brain injured or Korsakoff patient. Talland summarizes this work by stating that,

> Impaired memory function certainly hampered their concept attainment, particularly when the examples drawn from a class were presented serially, but reluctance to adopt alternative criteria also contributed to their ineffective performance (1965, p. 199).

Talland also states that his work fits Goldstein's theory of brain damage where the patient is performing at a level of reduced complexity, in a concrete rather than an abstract or symbolic fashion. The Korsakoff patients revealed strong tendencies to adopt the concrete attitude which was part of their general orientational inflexibility.

CHAPTER II

MATHEMATICAL THEORY AND CONCEPT IDENTIFICATION

The application of mathematics in the biological and social sciences is neither so widespread nor so successful up to the present time as it has been in the physical sciences. However, one area that has been shown to be well adapted to mathematical treatment is that of learning. Relationships expressed in the form of learning curves or retention curves can be easily expressed by equations. Ebbinghaus as early as 1885 developed a retention curve roughly logarithmic in form. Ebbinghaus used the procedure that has since come to be known as empirical curve-fitting. When one follows this procedure, he first plots the empirical data and then looks for a mathematical function to fit it. The main point in empirical curve-fitting is that we select the curve family solely on the basis of fit and not on the basis of theory. If the curve is selected on the basis of theory it is called rational curve-fitting. In the development of mathematical theory, it soon became apparent that the development of rational curve-fitting would be necessary if mathematics was to best serve psychological theory. An advance in the application of mathematical thinking to learning was made by Thurstone (1930a, 1930b) when he based his equations on a theory as to how learning takes place. What happens, according to Thurstone, is that the learner performs a number of acts per unit of time. His attainment can be stated as the probability that one of these acts will be successful.

The next major development in rational curve-fitting in learning came with the work of Hull, _et al._, (1940) with his vigorous mathematical theorizing and symbolic logic. As we saw earlier, Hull was already active in the field of concept formation and thinking processes and his work has become synonymous with the most rigorous quantitative methods.

Another attempt to handle thinking processes in a quantitative fashion, based on the systematic analysis of human communication, has acquired the name of "information-theory" (Shannon & Weaver, 1949). This communication model suggests that psychological events can be understood through analogy with the events that occur when a message is transmitted through an electronic transmission system.

The usefulness of information theory has been its attempt to provide a _unit_ by which information can be measured. This unit of information is defined in terms of how much uncertainty is reduced by a selection of an alternative. The more alternatives there are, the more information is conveyed by each choice. The relation of information to number of alternatives is given more formal expression; the amount of information yielded by specifying one of a number of alternatives increases as the logarithm of number of alternatives. The formula is simply:

$$\text{Number of Guesses Required} = \text{Log}_2 \text{ Number of Alternatives}$$

This is the model used for information theory. The unit of information is called the "bit," which is a condensation of "binary digit," and refers to two choice situations. The "bit" of information is the unit of information gained whenever the number of alternatives is reduced by one-half. If a message reduces the number of alternatives R to some fraction R/X, then the amount of information in the message is $\log_2 X$ bits.

One of the first applications of information theory to concept learning was by Hovland (1952) where he re-analyzed the studies of Smoke (1932, 1933) with regard to the preference of positive as opposed to negative instances in concept identification (the preference for cues relevant to what the concept _is_ rather than to what it is not). His findings (to be discussed later) and conclusions based on the information analysis approach did much to stimulate research in thinking processes in general and concept identification in particular.

A combination of mathematical theorizing (Restle, 1955, 1957, 1958) and information theory techniques has been developed by Bourne and Restle (1959) and deals explicitly with concept learning problems. It has been called a cue conditioning and a stimulus sampling theory. The basic notion concerns the number of relevant cues in any given universe of stimuli (defined by a problem); the greater the number of relevant cues in the universe, then the greater is the probability of selecting one or more of these in any sample. This greater probability leads to faster solutions to the problem. As Hunt states:

> Stimuli are specified by binary dimensions, each dimension indicating the presence or absence of a particular set of cues. In a two-choice problem, each dimension is either relevant (in the sense that one of its values is always associated with the appropriate name) or irrelevant. Thus, the discovery of any one of the relevant dimensions transmits sufficient information for the subject to make the appropriate discrimination (1962, p. 58).

In this formulation the theoretical parameters are derived mathematically and are based on probability statements. For instance, the probability of a correct response on the Nth trial is P(n), assuming no response biases and no adapted cues, is given by the following formula

$$(1) \qquad P(n) = 1 - \frac{1/2\ (1-\theta)^{n-1}}{r+(1-r)(1-\theta)^{n-1}}$$

where r equals the number of relevant cues in the universe (the problem) and θ equals the product of the probability of a particular response being reinforced and the probability that a relevant cue will be present. One can see by the number of r components in the denominator that as r increases the probability of a correct response increases. Another way of stating this--that when the proportion of relevant cues increases, so does the probability of making a correct response on any single trial.

As Hunt states, the only variable in the equation for P(n) which is not under the control of the experimenter is r, the proportion of relevant cues in the universe of stimulus elements. This value must be estimated from the total number of errors; that is, must be derived empirically from initial data. In this sense, the scheme involves both rational and empirical methods of describing the learning function. In formula form (1962, p. 60):

$$(2) \qquad r = \frac{kR}{(R+I+C)}$$

where the k equals the number of relevant cues, R equals the number of relevant dimensions in the problem, I the number of irrelevant dimensions, and C the total of all uncorrelated cues arising from background stimuli; then we see that only k and C must be determined empirically. Once these values are determined, the model can be used to predict difficulty of concept learning with various combinations of relevant and irrelevant information.

Complexity.--In concert with the investigation of variables relevant to solution processes, we arrive at a consideration of the complexity of the stimulus situation and its effect on cue utilization. In the mathematical theory of concept identification (Bourne & Restle, 1959) solutions of concept tasks are presumed to be related to the number of relevant cues in the stimulus situation. The cues, in turn, are represented in part by the number of relevant and irrelevant dimensions which together define the conceptual task. It is assumed that the measure of relevant cues is proportional to the number of relevant dimensions, and the measure of irrelevant cues from dimensions alone is proportional to the number of dimensions made irrelevant.

The complexity of the task can now be defined in terms of the ratio of irrelevant to relevant dimensions: the greater the ratio, the greater the complexity. The mathematical presentation of this concept was given earlier and it can be seen to be one of the most basic and verified variables in the theory. The advancement is the ability to define quantitatively difficulty levels independent of the subject's response, a perennial problem in the area of learning and problem solving.

This dimension of complexity as described here was being utilized before Bourne and Restle's (1959) theoretical presentation. For instance, Hovland and Weiss (1953) although studying particularly the relative informational content of positive as opposed to negative instances did also include a variation in the ratio of relevant to irrelevant dimensions. Investigation of their data with this in mind reveals a decrement in performance as the ratio of relevant to irrelevant became smaller.

Archer, Bourne, and Brown (1955) modified the Hovland and Weiss techniques and performed two experiments in which complexity was the central consideration. In the first experiment, using 2 bits of relevant information and 1, 2, and 3 bits irrelevant, means scores of 70.5, 101.0, and 173.8 were obtained for complexity levels of 1, 2, and 3 respectively. These were significantly different on the linear component only. In the second experiment five levels (1, 2, 3, 4, and 5 irrelevant dimensions) were used and both the linear and the quadratic components were significant. One of their conclusions in this regard is that:

> Performance in concept identification degraded as a positive exponential function of amount of irrelevant information measured in bits (Archer, Bourne, & Brown, 1955, p. 164).

With the establishment of the complexity dimension the future work was inevitably to be concerned with the verification as well as the investigation of it in relation to other variables in concept identification. Bourne (1957), for instance, investigated the delay of information feedback (the period from the time a decision response is made until the indication of correctness or incorrectness is made) and complexity in a 6 x 3 factorial design. Both main effects were found to be significant sources of variance but the predicted interaction (a greater divergence at each level of complexity as the delay interval increased) was not observed. The explanation offered was the restricted range of delay intervals (.0 to 8.0 secs.).

Pishkin (1961) investigated three levels (1, 3, 5 bits) of complexity and its relationship to response tendencies. The response tendency groups were defined by their own tendency to choose one of two keys in response to a stimulus presentation where "neither a right nor a wrong choice" was possible. Each _S_ had 3 trials to determine his tendency group placement. Again the main effects (complexity and response tendency) were significant. But again we fail to find a differential effect of a response tendency as the problem becomes more complex.

It should be noted at this time that in all of these experiments (Archer, _et al_., 1955; Bourne, 1957; Pishkin, 1961) a problems variable involved the systematic presentation of various dimensions as relevant or irrelevant. For instance, one problem may have shape relevant and color irrelevant while in a second problem the reverse may be true. In all these experiments the problems variable was an insignificant source of variance. This suggests that the basic dimensions such as shape, color, size, and number do have somewhat equal probabilities of being selected as a relevant dimension. This does not support the claims for hierarchical response tendencies as being associated with various stimulus dimensions (Grant & Curran, 1953; Grant, Jones, & Tallantis, 1949; Heidbreder, 1946; Wohlwill, 1957).

In a study dealing exclusively with the complexity dimension Battig and Bourne (1961) tried to compare the interdimensional variability (complexity variation in terms of the ratio of relevant to irrelevant dimensions) and intradimensional variability (variation within the dimension). For example, in the latter case a color dimension might have different shades of the color representing the dimension. The results very clearly demonstrate that both manipulations as main effects are highly significant both in terms of total errors to criterion and by using trial number on which the last error was made. This study demonstrates the similar effect of the complexity variation with two dependent measures.

Another study by Walker and Bourne (1961) used these same two response measures and all possible combinations of three levels of relevant and irrelevant dimensions. Results of this experiment revealed that the most difficult problem is one involving three levels of relevant and three levels of irrelevant dimensions. A comparison of the two variables revealed that the amount of relevant information had the greatest effect on performance. It should be noted here that the manipulation of relevant dimensions is somewhat different from that in previous experiments. Others using more than one relevant dimension used the second as a redundant dimension (either can be used to solve the problem). This state of affairs leads to facilitation of performance. In this study the increase in relevant dimensions increased the difficulty because all were needed for solution of the problem.

Another series of investigations has grown out of a continuing attempt to relate interactively the complexity variable to other variables within the concept identification framework. It can be noted that previous work reflects an inability to find a variable to relate interactively with complexity. In the following series, however, a meaningful relationship has been found. The variable is called "misinformation feedback" (Bourne & Haygood, 1960; Bourne & Pendleton, 1958; Johannsen, 1962; Morin, 1955; Pishkin, 1960, 1961; Wolfgang, Pishkin, & Lundy, 1962). Morin gives us a definition of the variable:

> Misinformation feedback is said to occur when an optimum response, one which provides the greatest expected return over a series of trials, is followed by a consequence or signal which informs the responder he has made an incorrect response, or when a non-optimum response results in a signal that the response was correct (1955, p. 343).

Bourne and Pendleton (1958) were among the first to compare complexity and misinformation feedback (MF) in a factorial design. Although "completeness of information feedback" (one being allowed to respond until correct which is complete feedback or to respond only once after a choice was made which was incomplete) was also investigated, the second experiment used four levels of MF (100%, 90%, 80%, and 70%) at three levels of complexity. In the misinformation experiment both main effects were significant sources of variance. In the first study the incomplete feedback condition had a significant inhibitory effect on concept identification. Performance level was seen as an inverse function of both the complexity and percentage of misinformation. Among these and other findings, Bourne and Pendleton conclude:

> Although the analysis of variance indicated no significant probability x complexity interaction, the data do suggest this is a possibility (1958, p. 419).

This suggestion of interaction between complexity and MF was demonstrated by Pishkin (1960). In a study using five degrees of MF (0%, 10%, 20%, 30%, and 40%) and three levels of complexity (1, 3, and 5 irrelevant dimensions) main effect significances were observed. In addition to this a differential effect of misinformation was observed as the complexity was increased. Misinformation was seen to be the most retarding on the more complex problems.

An extension of Pishkin's (1960) work was performed by Johannsen (1962) in which he assessed the effect of MF on concept identification under misinformation and 100% correct feedback, *i.e.*, no misinformation, conditions. The only essential difference in this study is that after 200 trials no more misinformation was given. The first part of the experiment confirmed Pishkin's (1960) results with both complexity and misinformation main effects and the interaction term significant at the 1% level. An analysis of the subsequent 100% correct feedback condition revealed significant differences as a function of complexity; *i.e.*, the greater the complexity the more errors to criterion.

Two studies that further demonstrate the interactive relationship between complexity and misinformation are Pishkin (1961) and Wolfgang, Pishkin, and Lundy (1962). In the first of these the main purpose was to demonstrate the facilitative effect of more regular misinformation as opposed to random assignment of the same percentage of misinformation. The analysis included two levels of complexity (1 and 3 irrelevant dimensions) as well as two levels of misinformation feedback (10% and 30%). All main effects except problems as well as the interaction of misinformation and complexity were significant sources of variance. It appears that the distribution of misinformation is an important consideration in concept identification tasks; the more regular the distribution the better the performance. It was also shown that misinformation has the most inhibiting effect as the complexity is increased.

In the latter study the design was expanded to include three degrees of misinformation (0, 15, and 30%) as well as three levels of complexity (1, 3, and 5 irrelevant dimensions). All main effects except anxiety (forced choice Anxiety Scale, Christie & Budnitzky, 1957) as well as the interaction of misinformation and complexity were significant. In both these studies the effect of misinformation feedback is most inhibiting as the problem becomes more complex.

It can be noted in summary that this review of the complexity variable within the concept identification framework is not exhaustive. Many others have included complexity in their analysis but in every case the effect is unambiguous. Indeed, it would appear that Underwood's (1949) suggestions on his review of the literature in concept learning, *i.e.*, (1) that more research concentrate on the theoretical aspects of conceptual behavior, and (2) that tasks of various levels of complexity be developed and standardized to facilitate inter-laboratory communication, has, in some degree been realized. Complexity has been defined independent of *S*'s responses as well as described in strict mathematical theoretical terms and has been found to demonstrate stable and repeatable effects on the rate of concept identification.

Memory and Concept Identification.--Hunt (1962), after an introduction to behavior theory, concept formation, and classical learning (Chapter I, II, and III) goes on (Chapter IV) to describe methods and experiments that reflect attempts to define the stimulus complex in an objective and quantitative manner. The first attempt to consider concept learning in terms of a human ability is in Chapter V, "Memory and Concept Learning." In spite of the so-called "no memory models" (Restle, 1961; Trabasso & Bower, 1964) and strategies which suggest minimal use of memory (Bruner, *et al.*; 1956) the more general consensus is that memory in terms of information storage is an important ingredient in problem solving behavior. As Hunt states:

> The studies by Bruner and his associates, although among the important in the field, cannot be taken as proof that humans normally use strategies which eliminate memory requirements in concept learning. It is certainly true that strategies exist which can eliminate most memory requirements (1962, p. 143).

Dominowski (1965), in his review of the role of memory requirements in concept learning, also concludes that there are many demonstrations bearing on the importance of memory in concept learning. He does, however, point out the many problems presented by the extreme heterogeneity of problems and techniques used. He further suggests that these various procedures might well create different memory requirements. And, as Hunt suggests, these same differing requirements can only be interpreted in the light of individual differences in strategy selection. He concludes:

> There can be little doubt that concept learning is affected by memory. How and how much will be determined by the strategy of inductive reasoning used by the learner (1962, p. 156).

The limitations of the "human computer" in terms of information storage is evidenced by the finding of a facilitative effect of positive as opposed to negative instances (hypotheses as to what the concept is rather than to what it is not) in concept attainment (Bourne, Goldstein, & Link, 1964; Braley, 1963; Donaldson, 1959; Hovland & Weiss, 1953; Olson, 1963; Pishkin & Wolfgang, 1965; Smoke, 1932, 1933).

The relevance of the investigation into the preferences for positive and negative instances concerns the limitations of the "human computer" in terms of information storage. The use of positive instances puts a lighter load on memory storage. The extreme in this direction is the "no memory" models (Restle, 1961) where sampling is with replacement. In this instance only positive instances are used in the identification of the concept:

> The use of exclusion (negative instances) solutions then is a distinctly secondary or "higher level" problem solving strategy, and because of the load it puts on memory processes it is likely to have a low probability of evocation (Braley, 1963, p. 159).

This investigation of positive and negative instances in concept formation can be traced back to Smoke (1932, 1933) where he first demonstrated the preference of positive instances in the identification of concepts. Hovland (1952) reconsidered Smoke's data and suggested that the question could not be so conclusively decided on the basis of his technique. The criticism concerned the instructional definition of the positive and negative conditions. As the problem was constructed it could be defined by either positive or negative or both types of instances. In an attempt to provide a more conclusive answer to this question, Hovland and Weiss (1953) replicated Smoke's study, using visual stimuli which were equated for information content and, in one part, for number of instances. The results in general supported Smoke's conclusions with the qualification that concepts _can_ be learned by negative instances, _i.e._, there is information to be used even if most find it easier to use the positive instances. As Hovland and Weiss state:

> The all-negative instances are thus shown to be consistently inferior to all-positive. At the same time, the results disprove the generalization that concepts cannot be learned from negative instances (1953, p. 182).

More direct information concerning the role of memory and concept formation is given by Cahill and Hovland (1960). Using the same "closed" system procedure (*S*s are aware of the universe of dimensions in the situation) as Hovland and Weiss, they attempted to simulate an "unlimited memory" condition. The unlimited memory condition consisted of making available to the *S* all previous instances of the concept as he proceeded toward solution. The "limited memory" condition was the very opposite, *i.e.*, all previous instances were removed from the *S*'s view. The results show conclusively on problems of two levels of difficulty that the "unlimited memory" condition facilitated concept identification. An analysis of hypotheses that were incompatible with previous instances also revealed that errors of "incompatibility" rose as the number of instances increased. This did not occur in the condition where all previous instances remained in view. Hunt (1961) replicated this work using both positive and negative instances.

Bourne, Goldstein, and Link (1964) followed up the effect of availability of previously presented information (Cahill & Hovland, 1960), also using both positive and negative instances, and found support for this previous work, *i.e.*, the more available previous instances of the concept the fewer the errors of identification.

It was also shown that the facilitative effect of availability was greatest in the more complex task. This also confirmed the results of Cahill and Hovland. An analysis of positive and negative instances indicated that significantly more presentations of the negative instances were necessary for solution as compared with positive instances for each level of availability.

Pishkin and Wolfgang (1965) extended this problem in an attempt to find out what kinds of available information are most useful. Hovland and Weiss (1953) and Cahill and Hovland (1960) used only negative instances while Hunt (1961) and Bourne, Goldstein, and Link (1964) used both positive and negative instances. Pishkin and Wolfgang (1965) therefore investigated each of these three instances as conditions (positive, negative, and combined) as well as a degree of availability (number of available instances 0, 1, 2, 3, 4). The results confirm the generalization that the availability of instances does facilitate concept identification and that the availability of positive instances is a most important variable. The presence of the positive instances was found to be more important than the number of previous instances made available.

A final study by Bourne, Guy, Dodd and Justesen (1965) dealing with variation of intertrial intervals

(1, 15, 29 secs.) and the availability of either or both the stimulus pattern and reinforcement signal also showed a facilitative effect due to the availability of the stimulus instance. This difference also was most marked at the longer (29 secs.) intertrial interval.

In summary of this work it seems very clear that memory plays an important part of the identification of concepts. There seems little support for the "no memory" model (Restle, 1961). As Pishkin and Wolfgang point out:

> Facilitative effects of availability of "memory" formation from past trials lend no support for the "no memory" assumption in concept learning (1965, p. 8).

Two facts, then, seem to emerge here. First, the longer the intertrial interval the greater the load on the memory capacity (Archer, 1953). The second generalization concerns the complexity of the concept task; the greater the complexity the greater the memory load. These generalizations are drawn from the findings of greater facilitation due to available instances in these conditions, *i.e.*, longer intertrial intervals and on the more complex problems.

The preference for the use of positive instances in the identification of concepts also suggests that the *S* stores best the dimension upon which he received reinforcement. This is consistent with the operant, S-R paradigm which stresses the facilitative effect of immediate reinforcement on learning (Holland, 1960; Skinner, 1958).

If this statement has any validity then it would seem important to investigate the effect of immediate as opposed to a delay of reinforcement in the identification of concepts. If immediate reinforcement is associated with the better storage of stimulus dimensions then a delay of this same reinforcement should result in a diminution in storing which should, in turn, be reflected in poorer performance in the identification of concepts. This notion has been interpreted by Dominowski (1965) as a form of response contiguity, a term postulated by Underwood (1952) to be an essential ingredient in concept learning. In concept identification terms it is called "delay of information feedback." The facilitative effect in the Bourne and Restle model rests on the "stimulus trace argument" of Estes (1955) which assumes that the number of elements in the sample of stimulus elements chosen decays exponentially with the time since the stimulus has been presented. Within this framework Bourne (1957) proposed that an increase in the temporal separation between presentation of the stimulus and indication of the correct response to that stimulus should interfere with concept identification because the stimulus and the correct response occur less contiguously and, as Bourne states:

> The greater the delay interval the more S must rely on memory to maintain the stimulus across the time gap (1957, p. 201).

Bourne's study was a 6 x 3 factorial design using three levels of complexity (1, 3, and 5 irrelevant dimensions) and six levels of feedback delay (.0 to 8.0 secs.). As predicted by main effect variables were significant; but the hypothesized interaction of these variables was not.

Another interval that has been observed to be important in terms of concept learning is the post-feedback interval or intertrial interval. This interval involves the amount of time between the reinforcement of any response and the appearance of the next stimulus instance. In fact, Bourne and Bunderson (1963) looked at Bourne's (1957) study more closely and found that these two intervals were confounded in his study. When Bourne increased in delay of reinforcement interval he did not adjust the post feedback interval accordingly. This resulted in a situation where a long delay of reinforcement resulted in a short post feedback interval. In view of this situation Bourne and Bunderson (1963) replicated the study taking into account the previous limitation. They expanded the design so that both the delay of reinforcement interval and the post feedback interval were varied. Two degrees of task complexity were also included. The results of this study revealed that the post feedback interval to be the most important. Delay of reinforcement was quite insignificant. The main effect of complexity was significant as well as the interaction between the post feedback interval and complexity. The observed effect of variation in post feedback interval was greater in problems with five than in problems with one irrelevant dimension.

In summary, it would appear that the delayed feedback interval is not a significant variable when the delay is unfilled. Other studies have also reported the ineffectiveness of this interval (Bilodeau & Bilodeau, 1958; Bilodeau & Ryan, 1960; Denny, Allard, Hall, & Rokeach, 1960; Noble & Alcock, 1958). However, the post feedback was found to account for a significant proportion of the variation. The implication, of course, is that the intertrial interval is probably the more appropriate interval to use in the study of memory effects in concept formation.

CHAPTER III

STATEMENT OF PROBLEM

In a recent essay on the psychological study of conceptual thinking, Hearnshaw pointed to the many problems in this area that need attention:

> What is the place of the capacity to conceptualize in the structure of human abilities? Is it the same thing as, or an aspect of, the general factor of intelligence? Is it linked in any way to the verbal factor and linguistic ability? Or to the spatial factor and the ability to appreciate patterns? . . . Is it related somehow to some memory factor? (1954, p.5.)

The basic problem underlying the present investigation concerns the lack of understanding of the processes by which one identifies concepts. To paraphrase Hearnshaw, what is the place of the capacity to identify concepts in the structure of human abilities? The attempt to answer this question has led to the investigation of three general areas. First, the investigation of higher thought processes (conceptual behavior) has always been important in the study of psychopathologic groups. Goldstein's (1939, 1944, 1959, 1963) work could be mentioned to illustrate this point. And, not only did Goldstein point out this deficit, he also made an attempt to conceptualize his observations. Concepts like "abstract-concrete" and "catastrophic anxiety" are part of this attempt to explain the processes involved in the formation of abstract concepts.

A second area of investigation concerns another clinical observation reported by those working with psychopathologic groups: that of a memory deficit. This observation has a long history and is an established clinical symptom. Wechsler (1945) emphasized this area of cognitive activity in the diagnosis in psychopathology. The development of the Wechsler Memory Scale (Wechsler, 1945) illustrated this emphasis and is used to this day.

It should be noted here that memory deficits do not occur equally to all events stored. As Russell and Nathan point out:

> Memory for events is not a static process. If it were, then distant memories would surely fade gradually and would be the more vulnerable to the effects of injury. On the contrary, when the brain is injured, these distant memories are the least vulnerable. . . . The normal activity of the brain must steadily strengthen distant memories so that with the passage of time these become less vulnerable to the effects of head injury.
>
> General brain trauma therefore has an effect on recent memory which is much greater than its effect on remote memory. . . . (1946, pp. 298-299.)

The question can pose in the light of these two areas of investigation is: are the deficits observed in concept identification somehow connected to the observed memory deficits? In other words, what is the role of the human capacity to process and store information in the identification of abstract concepts? The attempt to answer this question brings one to the third general area of investigation: the investigation of the contribution of memory and concept identification in normal subjects using standardized and quantifiable techniques. The traditional techniques have been characterized as too global and qualitative to help in delineating the role of this memory function in the identification of concepts.

This area of investigation can be described as a combination of information theory principles and mathematical model techniques. The specific model which antecedes this experiment is that of Bourne and Restle (1959). And among the great number of experiments stimulated by this model there are many that have dealt with this problem of memory and concept identification (Bourne, Goldstein, & Link, 1964; Bourne, Guy, Dodd, & Justesen, 1965; Cahill & Hovland, 1960; Hunt, 1961; Pishkin & Wolfgang, 1965; Pishkin, Wolfgang, & Rasmussen, 1967).

The main variable and one of the most reliable features of the concept identification (CI) work is the systematic manipulation of the difficulty level. This is a problem that has always plagued the concept formation and problem solving area. The CI model has accomplished a systematic variation of problem complexity that can be defined independent of the subject's behavior. This complexity variable is also felt to be related to memory requirements. In other words, the more complex the task, the greater the memory requirements.

A second variable that has been traditionally used in memory work is the manipulation of time between events that depend on each other for the solution of the problem. The greater this time interval the greater the memory requirements.

In a recent study (Baumeister, Smith, & Rose, 1965), using retarded and normal adults, the variables of intelligence, stimulus complexity, and intertrial intervals were investigated. The task appeared to be modelled after that of Hull (1920) because Chinese characters were used in a "common element" paradign of concept identification. A 2 x 4 x 3 analysis of variance design indicating the group, complexity, and interval variables was used. The intertrial intervals were 2, 12, and 20 seconds.

The results indicated that all main effect and first order interactions were significant sources of variance. The normals were first seen to give a significantly greater number of correct identifications across all levels of complexity and intertrial intervals. A significant decrement in correct identifications was also seen as a function of an increase in complexity, i.e., both groups made more errors as the complexity of the problem increased, and the significant interaction of these two variables revealed that differences in performance between normals and retardates became greater as the complexity increased, the retardates, of course, showing a steeper drop in correct responses as the complexity increased. The analysis of the intertrial interval also revealed significant differences between intervals as well as a significant interaction with groups; the longer the delay interval the greater the inhibiting effect on the retardates. These results were interpreted within the "stimulus trace hypothesis" (Ellis, 1963) where differences in performance were predicted on the basis of a short term memory loss in the mentally retarded. It is also obvious from this study that the more complex the task, the greater the load on memory.

The significance and effect of the intertrial interval on concept identification within the Bourne and Restle model has already been discussed (Bourne & Bunderson, 1963; Bourne, Guy, Dodd, & Justesen, 1965). In the latter study the main effect variables of complexity and intertrial interval were significant. Furthermore, the interaction of these variables was also significant. Greater errors occurred in the more complex problems as the intertrial increased beyond 17 seconds.

The present experiment used these variables (complexity and intertrial interval) plus a groups variable involving the use of brain injured patients. The following main hypotheses were tested:

(1) A significantly greater number of errors will be observed in the brain injured than in the control group.

(2) The more complex tasks are expected to result in a greater number of errors in both groups.

(3) A differential effect of complexity on the groups was also expected. The more complex tasks will lead to a relatively greater number of errors in the brain damaged group.

(4) The introduction of intertrial intervals will result in significant differences in the identification of concepts. The greater intervals will lead to poorer performance.

(5) This variable was also expected to exert a differential effect on _S_s groups. The brain damage _S_s will be expected to perform significantly poorer

as the intertrial interval increases as compared to controls.

(6) Due to the hypothesized added memory load in more complex tasks, an interaction between complexity and intertrial intervals is also expected; performance being poorest at the higher complexity and longest intertrial interval.

CHAPTER IV

METHOD

Subjects

The subjects for the present investigation were patients from the Veterans Administration Hospital, Oklahoma City, Oklahoma. The experimental group of 45 brain damaged was selected against a strict neurological criterion (Appendix I) and later rated by a staff neurologist as to the degree and locus of CNS involvement. The control group of 45 hospitalized patients was also selected against a strict medical criterion intended to exclude evidence of CNS involvement (Appendix II). These patients were also rated to confirm the initial selection. The control group consisted almost entirely of patients from the orthopedic ward of the hospital. Only five patients were included from other medical wards and were included because of obvious peripheral difficulties such as skin rash or hernia. Descriptive data on control patients appears in Appendix IV.

The subscale used for final group selection appeared on a five point scale (Appendix II). Table I illustrates this scale and gives the total subject pool from which the experimental and control groups were determined.

TABLE I

NUMBER OF Ss BY RATINGS

Brain Damage	Control	Brain Damage Scale
45	0	1. Definitely
4	0	2. Strongly suspected
3	2	3. Suspected
1	9	4. Not likely
0	45	5. Definitely not

In the final brain damaged group the major neurological diagnostic classifications were as follows:

TABLE 2

DESCRIPTIVE DATA ON THE BRAIN DAMAGED GROUP

Number of Ss	Diagnostic Category
9	1. Tumor
15	2. Cerebral Vascular Accident (CVA)
13	3. Trauma
2	4. Inflammatory or Infectious Disease
3	5. Degenerative or Demyelinating
3	6. Atypical

Additional descriptive data on the brain damage group appears in Appendix III.

The mean age for the brain damage group was

45.91 years and for the control group, 45.55 years. A *t*-test computed on these data indicated this was not a significant difference. The mean educational level of the brain damage was 10.22 years, the controls, 9.80 years. Again the difference was tested by a *t*-test, which revealed these as not significantly different. It can also be stated that the individual cell means on these variables were also found to be insignificantly different (Appendix IV).

Design

The experimental design consisted of a 2 x 3 x 3 factorial: two groups, brain damaged and control; three levels of complexity, 1, 3, and 5 irrelevant dimensions; and three intertrial interval periods, 1, 15, and 29 seconds. Each *S* performed individually and the dependent variables relevant to the factorial design were errors and decision time. The design was replicated five times.

Apparatus and Task

The stimulus instances of the concept were back-projected onto an 8 x 10 inch opaque screen by a Dunning Animatic 16 mm. strip-film projector. The screen was mounted on a 4 x 4 x 8 foot panel which was painted flat black. This screen was situated at eye-level on the panel. Just below this screen panel was a response panel upon which were situated two response keys and, above each of these, two small amber lights. The S's task was to solve a two-choice discrimination problem by successively selecting one or the other of two keys in response to invariant pattern dimensions, *e.g.*, depression of the left key for the image of a triangle, of the right key for a square, etc. The keys were not marked in any way. The apparatus was the same as used by Pishkin (1960).

Procedure

The S was instructed as to the nature of the task, the meaning of the feedback lamps (which indicates whether the response was right or wrong), and manipulation of the controls:

> On the screen in front of you, you will see a series of geometric patterns. Each pattern is a part of a problem which can be discovered by pressing one of two buttons you find on the panel below the screen. When you have chosen the correct button the light just above the button will light up. When you have chosen the wrong button the light above the other button will light up. Your task is to discover the rule which will light the light above the button each time. If you are not sure, guess; your guesses or hunches may turn out to be right, and it is important that you be right as often as possible. The patterns will change in various ways but the rule will remain the same throughout all the patterns. Any questions before we begin?

In most cases these instructions were sufficient to inform the S of the task at hand. When there was a question the E emphasized by an example how the S could tell if he got a right or wrong response. No information concerning the stimulus characteristics was given.

The task was begun by the S viewing a geometric pattern projected on a screen directly in front of him and at eye level. After a self-determined interval (the S could view the pattern as long as he wished before responding), S responded by pressing one of the two keys. The depressed key initiated a signal which recorded S's choice on a chart of an Esterline-Angus operations recorder and triggered a cascaded multiple-phase electronic timer. Phase 1 of the timer advanced the film strip to a blank frame. Phase 2 activated a Western Union tape transmitter which was punched to match the filmstrip programming. This enabled the response (either correct or incorrect) to be registered on the Esterline-Angus operations recorder. In addition, the same information coded on the tape led to the illumination of one of the two panel lights situated just above each of the S's response keys. The lamp remained illuminated for 1 second. Phase 3 advanced the filmstrip to the next stimulus to begin another trial after either a 1 second, a 15 second, or a 29 second interval from the S's last response.

Three strip-filmed series of patterns were used;

each having one relevant dimension and either 1, 3, or 5 irrelevant dimensions. A dimension was found to be relevant when its use by the S led to successive positive identifications indicated by the illumination of the lamp just above the key chosen. A negative identification is indicated by the illumination of the lamp above the other key. All irrelevant dimensions had a zero correlation with correct responses. When a particular dimension was neither relevant nor irrelevant, it appeared without variation at only one of its two levels within a given series.

Following this initial experimental procedure each S was given a series of psychometric tests.

Psychological Measures

Wechsler Memory Scale (Form I) (Wechsler, 1945).--The assumption underlying the analysis of concept identification in terms of memory requirements was that all brain damaged patients to some greater or lesser degree will demonstrate an impaired memory. In order to provide an independent check on this assumption it was decided to include a traditional clinical measurement of memory functions.

Vocabulary and Block Design Subtests of the

Wechsler Adult Intelligence Scale (Wechsler, 1958).--Concept tasks have frequently been found to bear a correlative relationship to intelligence. This finding has not, however, always been found in relation to the concept identification task (Lydecker, Pishkin, & Martin, 1961; Wolfgang, Pishkin, & Lundy, 1962). In both of these studies a different population as well as a different measure of intelligence was used.

Gorham Proverbs Test (Best Answer Form) (Gorham, 1956).--Several studies in the concept identification area have used an abstraction score as a measure of intellectual functioning (Lydecker, Pishkin, & Martin, 1961; Pishkin & Blanchard, 1963; Wolfgang, *et al*., (in press); Wolfgang, Pishkin, & Lundy, 1962). Again it was felt that the inclusion of a traditional measure of abstract thinking would be appropriate. This instrument has been used in the study of brain damaged populations and has been shown to reflect different conceptual levels. A theoretical base for this test is within Goldstein's (1939) characterization of the consequences of brain damage.

Motivational Rating Scale (Hoepfner, Guilford, & Merrifield, 1964).--This scale included questions designed to reflect gross motivational level. The first item was a request to rate how much you like the tests you have taken. The scaled items were: (1) very much, (2) pretty much, (3) a little, (4) not very much, and (5) not at all. The second item was rate how hard you have worked on the tests you have taken. These items were: (1) as hard as I could, (2) very hard, (3) fairly hard, (4) not very hard, and (5) not hard at all.

CHAPTER V

RESULTS

The purpose of this experiment was to investigate the role of memory in the identification of concepts. The technique used was to (1) select a group that is known to exhibit symptoms of memory loss and (2) use an experimental task that could be ordered in terms of memory requirements.

The analysis of variance of error scores is given in Table 2.

Figure 1 illustrates this linear component as well as the groups main effect. This figure also illustrates the failure of the hypothesized G X C interaction. The only other factor that approached significance in this analysis was the G X I interaction term (Table 2). It can be seen here that the effect of intertrial interval is evident in the control group but without effect in the brain damaged. The effect in the control group was such that a Duncan's Test was used to test the decline in errors at the longer intertrial interval conditions. This revealed a significant drop in errors (df = 42, $p < .05$) between the 1 and 15 second interval periods (Figure 2).

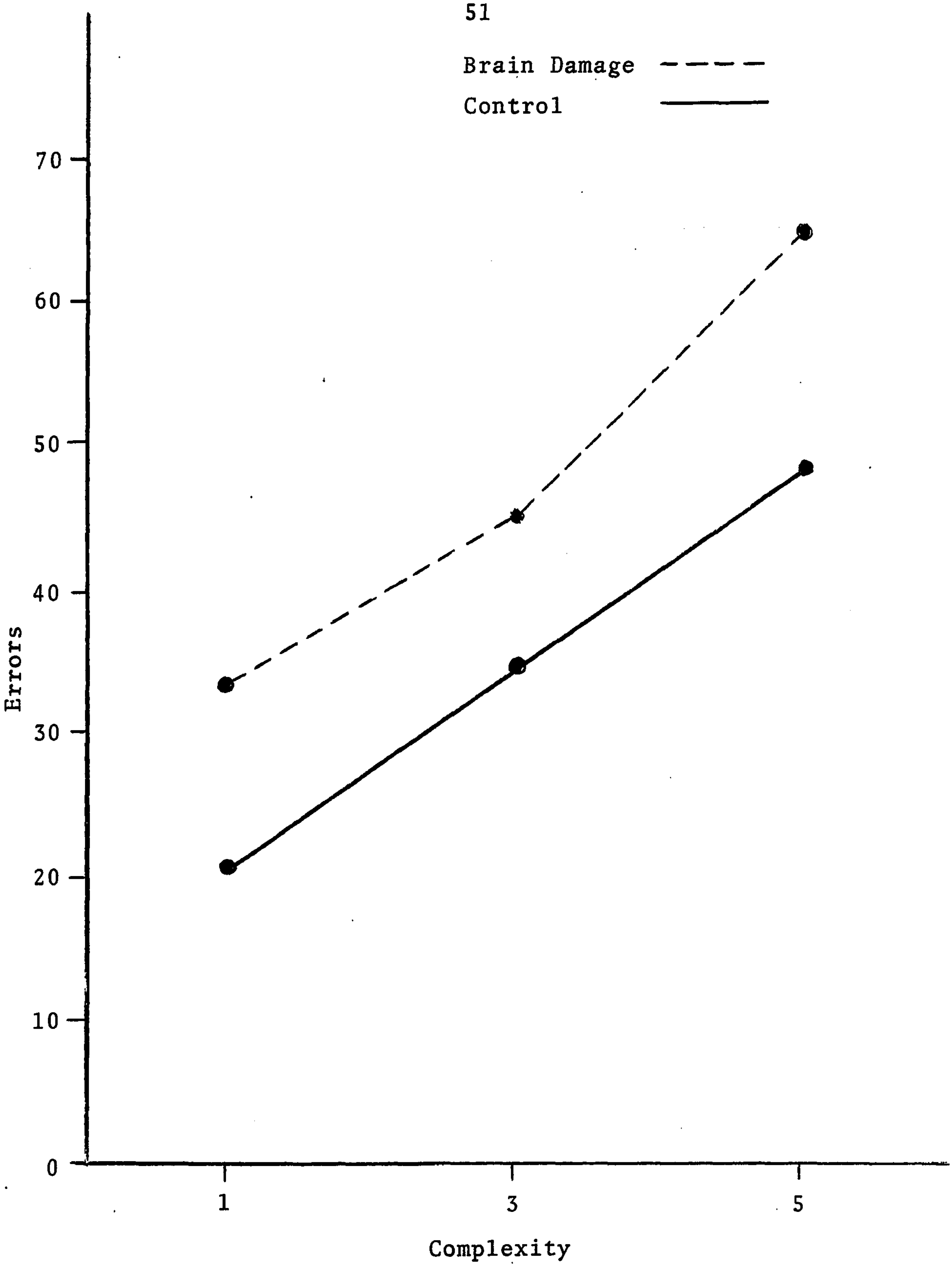

Fig. 1.--Mean error scores for brain damaged and control groups at different levels of complexity.

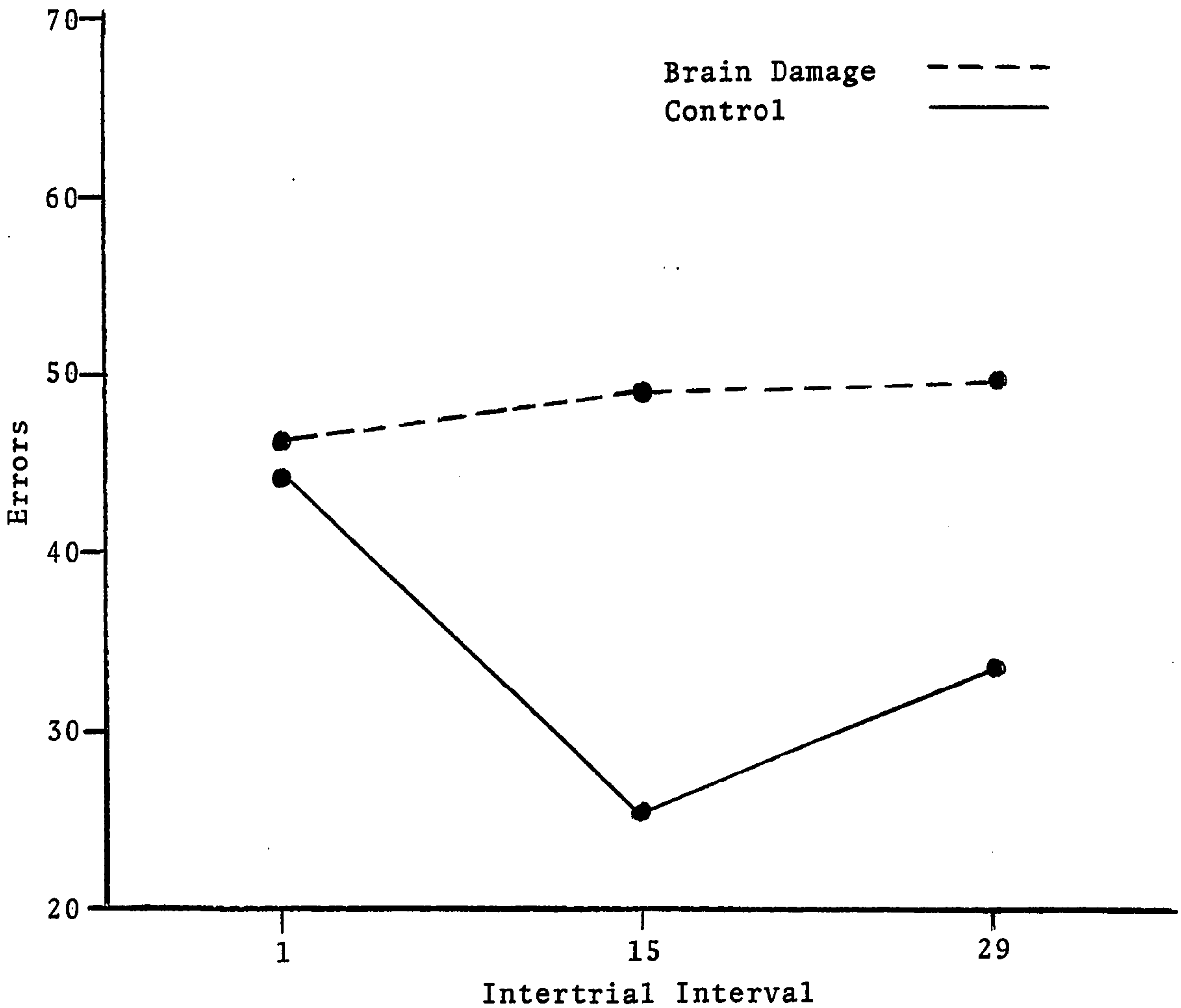

Fig. 2.--Mean error scores for brain damaged and control groups at different intertrial intervals.

The analysis of variance of decision time scores is presented in Table 3. This dependent measure was a result of the self-paced aspect of the experimental procedure and represents the mean amount of time taken to decide which of the two buttons to push.

TABLE 3

ANALYSIS OF VARIANCE: ERRORS

Variance Source	df	ss	ms	f	p
Groups (G)	1	4466.18	4466.18	7.05	.01
Complexity (C)	2	13259.46	6629.73	10.48	.001
Linear	1	13201.66	13201.66	20.86	.001
Quadratic	1	57.80	57.80		
Intertrial Interval (I)	2	1069.26	534.63		
G X C	2	113.97	56.98		
G X I	2	1745.37	872.68	1.38	
C X I	4	715.70	178.70		
G X C X I	4	1036.18	258.04		
Error	72	45564.80	632.80		
Total	89	67970.92			

As can be seen in Table 3 the groups and intertrial main effects were the only factors significant in the analysis. The significant groups effect illustrates the tendency for the brain damaged S to take longer to decide which button to push. This groups effect is illustrated in Figure 3. It can also be noted here that in the brain damaged group there is a tendency for the decision time scores to become greater as the difficulty

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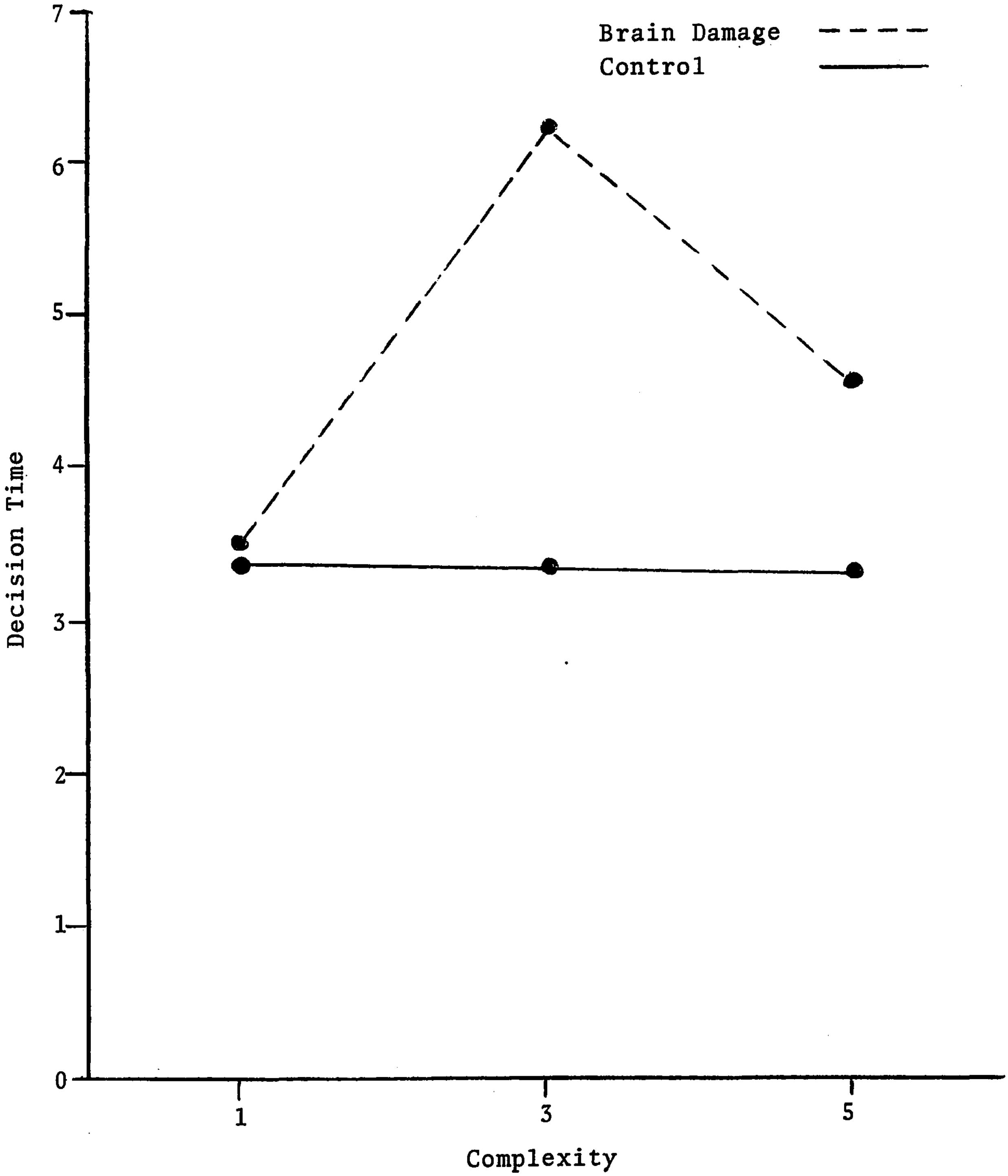

Fig. 3.--Mean decision time for brain damage and control groups at different levels of complexity.

of the problem increases. A Duncan's was used to test this tendency and there is a significant rise in reaction time on the 3 as opposed to the 1 complexity level (42 *df*, $p < .05$).

The significant intertrial interval main effect represents the tendency for *Ss* to take longer to decide as the intertrial interval increases. An orthogonal polynomial analysis was also employed on the intertrial factor and revealed a significant linear effect (Table 3). It can be seen from Figure 4 that the greater group contribution to this effect comes from the brain damaged.

The next results to be presented concern the analysis of the various psychometric measures that were

TABLE 4

ANALYSIS OF VARIANCE: DECISION TIME

Variance Score	*df*	*ss*	*ms*	*f*	*p*
Group (G)	1	628451.70	628451.70	7.42	.01
Complexity (C)	2	282571.00	141235.50	1.67	
Intertrial Interval (I)	2	672308.63	336104.31	3.97	.05
Linear	1	510788.27	510788.27	6.03	.05
Quadratic	1	161520.36	161520.36	1.91	
G X C	2	190039.95	95019.97	1.12	
G X I	2	173393.12	86696.56	1.02	
C X I	4	490831.67	122707.91	1.45	
G X C X I	4	194296.03	48574.00		
Error	72	6095814.40	84664.10		
Total	89	8727706.50			

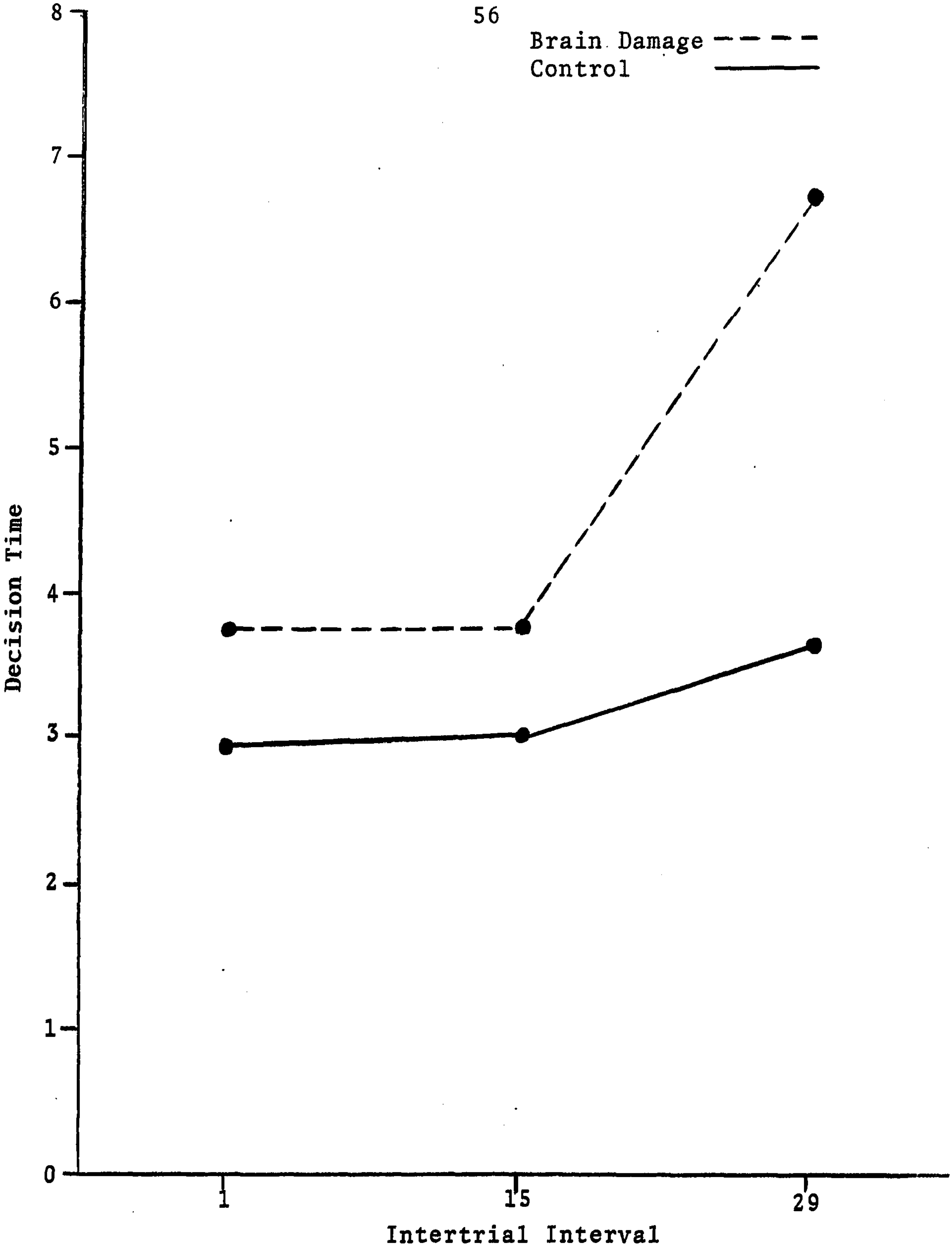

Fig. 4.--Mean decision time for brain damage and control groups at different intertrial intervals.

administered each patient. The group differences between these measures are presented in Table 5.

In addition to these group differences several correlations were computed to relate the psychometric tests with the concept identification task. These results appear in Table 6.

TABLE 5

GROUP DIFFERENCES ON PSYCHOMETRIC TESTS

Psychometric Test	Brain Damage	Control	*t*	*p*
1. Wechsler Memory Scale	79.14	94.18	4.40	.001
2. Vocabulary Scale	7.66	8.87	1.80	.10
3. Block Design Subtest	7.34	10.24	4.68	.001
4. Full Scale Estimate	15.00	19.10	3.94	.001
5. Abstract Score	16.20	20.30	2.32	.03
6. Motivation	3.09	3.40	1.03	N.S.

TABLE 6

CORRELATIONS OF PSYCHOMETRIC MEASURES WITH CONCEPT IDENTIFICATION

Measure	Brain Damage		Control		Overall	
	r	*p*	*r*	*p*	*r*	*p*
Age	.04	ns	-.09	ns	-.05	ns
Education	.00	ns	-.21	ns	-.09	ns
Memory Scale	-.38	<.005	-.20	ns	-.38	<.0005
Vocabulary Subtest	-.23	ns	-.22	ns	-.26	<.01
Block Design Subtest	-.31	.025	-.10	ns	-.30	<.005
Full Scale Estimate	-.33	.025	-.20	ns	-.33	<.005
Abstract Score	-.20	ns	-.25	<.05	-.28	<.005
Decision Time	.06	ns	-.10	ns	.12	ns

CHAPTER VI

DISCUSSION

Since the analysis of variance of errors was the first consideration it will be handled first. The original hypotheses will be stated and discussed in order.

> 1. A significantly greater number of errors will be observed in the brain damaged as opposed to the control group.

This hypothesis was supported and as such confirms a wealth of clinical and experimental evidence that indicates that patients with lesions of the brain do not perform as well on tasks requiring conceptualization as patients who do not. The importance of this finding lies in the fact that the deficit is demonstrated on a task that is characterized by very standardized procedures and rigorous stimulus definition. This allows a certain amount of control over conditions which will be necessary if the uncovering of the complex processes involved in conceptual thought is to be accomplished.

The importance of these differences should also be viewed in the light of the experimental control variables such as age, education, motivation, and, as it turned out, vocabulary level. Many investigators have stressed not only the importance of controlling for age, sex, education, socio-economic class, and intelligence (Hebb, 1945; Meyer, 1961; Reitan, 1962; Smith, 1962) but also have emphasized the distortion that can occur from lack of or misuse of control data. The care that was taken to insure control on these variables makes the effect observed even more unequivocal. Indeed, there would seem to be little room for doubt that the presence of a cerebral lesion in humans does have quantifiable effects and that these effects are shown to be related to higher conceptual activity. It is also important to note that these groups also differed in terms of measures that were obtained clinically. They demonstrated large differences on the Wechsler Memory Scale as well as the Block Design subtest of the Wechsler Adult Intelligence Scale (WAIS). Both of these are standard instruments used to evaluate conceptual and intellectual functions. With this in mind, it is interesting to look at the lack of group differences on the Vocabulary measure, a finding somewhat unusual with studies using brain damage. This, of course, is because aphasics are often used as well as a lack of adequate control of age and education. All the brain damaged in this study, while not in every case entirely free of aphasic symptoms, could communicate with the examiner in free conversation. It is interesting to note the large differences in Block Design scores and concept identification scores in the face of an insignificant difference in vocabulary level. If we look at these two tasks we see they both entail the "spatial" dimensions of color, shape, number, etc. Now in the traditional brain-behavior framework this lack of proficiency with "spatial" tasks is characteristically associated with right hemisphere damage. It would be significant, in terms of the present investigation, if the deficit shown on the concept identification task could be shown to be coming mainly from those patients with right hemisphere lesions.

To find the answer to this question of laterality of lesion and CI performance the rating data were employed. Using these data the brain damaged Ss were divided into left and right sided groups (Appendix III). Of the 45 brain damaged patients, only 36 (20 left sided and 16 right sided) could be used for this purpose. The remaining Ss had injury that was bilateral in nature. An investigation of concept identification performance showed no difference between the left and right sided groups ($\overline{X}_1$ = 46.95; $\overline{X}_r$ = -7.87; t = <1). It should be noted that whenever a within group breakdown is related to error scores the relative number of 1, 3, and 5 complexity levels is seen to be equal or at least not significantly different. In this instance there was an equal number of solutions in the right sided and the left sided groups.

The finding of a visual conceptual task being equally sensitive to both right and left hemisphere impairment is not unique. Doehring and Reitan, using the Categories Test, found no differential performance between similar left and right sided lesion groups. In explanation of this finding, they conclude that

> Concept attainment on the Category Test may involve a fundamental kind of reasoning ability that is impaired to a certain extent by any cortical lesion; or concept attainment on the Category Test may require the combined application of a number of primary abilities, both verbal and non-verbal (1962, p. 32).

They also mention similar results by Shure and Halstead (1958) and Chapman and Wolff (1959).

The extent to which a similar interpretation can be given the present results may indicate the extent to which the two tasks used are similar. Some of the more obvious similarities are: (1) an automatic feedback system involving the mechanical manipulation of a button or key, (2) basic conceptual dimensions such as color, shape, number, etc., and (3) they are both self-paced tasks.

In summary, it would appear that performance on the concept identification task is not hemisphere-specific, i.e., the abilities tapped cannot be characterized in the usual verbal-performance type dichotomy. This has important implications for the study of conceptual processes as a unitary non-specific ability. It points up the necessity of choosing measuring instruments for conceptual activity very carefully. As Heibrun has stated: "The theoretical psychologist is faced with the problem of divorcing his brain-behavior hypotheses from the characteristics of his measurement techniques (1962, p. 514). This problem would not seem to be as acute using the concept identification task.

> 2. The more complex tasks are expected to result in a greater number of errors by both groups.

This hypothesis is tested by the complexity effect and is one of the most striking differences observed in this investigation. Figure 1 illustrates this finding with its linear component. This finding is most significant in that it confirms the quite extensive number of investigations that have consistently established the linear character of the complexity variable. This investigation also confirms this relationship on a population that is different from those used in some of the other studies using the complexity variable. The present study, of course, used a patient population which was characterized by a somewhat low socio-economic status, middle age, (45 years), and relatively low education (10 years schooling). In addition, one half of these patients demonstrated positive signs of central nervous system damage. Other studies finding significant main effects of complexity have used college students (Archer, Bourne, & Brown, 1955; Bourne, 1957; Pishkin, 1960), male and female psychiatric aides (Wolfgang, Pishkin, & Lundy, 1962), male psychiatric nursing assistants (Pishkin, 1961), and schizophrenics (Lydecker, Pishkin, & Martin, 1961; Pishkin, 1963; Pishkin & Wolfgang, 1964; Pishkin, Wolfgang, & Bradshaw, 1963). It can be seen here that with the addition of the present population the generalizability of this variable is even greater. There would seem to be little doubt that the concept identification model does provide well defined complexity levels that lead to differential responses.

> 3. A differential effect of complexity on the groups was also expected. The more complex tasks will lead to a relatively greater number of errors in the brain damaged group.

This hypothesis was tested by the group x complexity interaction and was found to be insignificant. The assumption underlying the hypothesis is an interpretation of the complexity variable in terms of memory requirements. In the face its failure, this assumption would not appear valid. How, then, is one to interpret the poorer yet parallel performance of the brain damaged group?

One attempt to discover an answer to this question was to break up the brain damaged group into the previously mentioned lateralized groups. It was felt that this breakdown would indicate either some support for the original assumption or suggest an alternative. It did not. The performance of these two lateralized groups did not differ significantly.

If, indeed, the more complex tasks place an added load on memory functions, it is not apparent here. At first one might question whether or not the brain damaged do differ in terms of memory abilities. This, however, must be rejected to the extent to which one can agree that the Wechsler Memory Scale measures memory capacity. How, then, can these parallel effects become meaningful?

One possibility of interpretation was suggested by a combination of events. These are: (1) significant differences on the block design, a traditional perceptual task, (2) the concept identification performance being non-specific to the lateralization of the lesion, (3) the previous finding of similar parallel performance of brain damage and controls on a perceptual task (Parsons, Majumder, & Chandler, 1966).

These points, and especially the thinking involved in the third, suggests that a hypothesized <u>non-specific perceptual deficit</u> may account for the fact of different but parallel performance. The basic thinking involved in the use of this interpretation centers around the idea that there may be a flaw in the initial processing of information rather than a deficit in recalling information. And the same disturbed neural processes that would explain the memory disturbance can also be postulated to underlie the perceptual deficit. Hebb (1949), in his classic treatment of learning and perceptual processes, established a strong argument for perceptual generalization in terms of neural processes. Disturbed perceptual processes for Hebb involve a disturbance in the "phase sequences" that underlie the recording of the perceptual information. Other authors have used similar types of concepts such as a "filter" between cortical levels (Gaddum, 1966) or "gating" central mechanisms (Cheatham & White, 1952). At the psychological level the effects of this mal-adaptive filtering process could be termed "instability of attention" (Hebb, 1949) or "reduced psychological vigilance" (Shure & Halstead, 1958).

In summary, it has been suggested here that the parallel effects manifested by the brain damaged group are better explained as a defect in the "information processing" or "filter" mechanisms that are involved in visual learning tasks rather than in terms of a memory deficit. The argument has been developed that this perceptual deficit is equally evident in the three complexity levels even though at the lower levels of complexity the deficit does not, in some instances, impair solution of the problem.

4. The introduction of intertrial intervals will result in significant differences in the identification of concepts. The greater intervals will lead to poorer performance.

5. This variable was also expected to exert a differential effect on Ss groups. The brain damage subjects will be expected to perform poorer as the intertrial interval increases.

6. Due to the hypothesized added memory load in more complex tasks, the interaction between complexity and intertrial interval is also expected; performance being poorest at the higher complexity and longest intertrial interval.

These hypotheses were tested and the groups by intertrial interval interaction as well as by the complexity by intertrial interval interaction terms. They were not significant and they will be discussed together.

These hypotheses were predicted on an assumption of "trace decay" with time (Ellis, 1963). Here, as with the complexity variable, the longer intervals were expected to place the greater load on the memory functions. The failure of these hypotheses would seem to bring this assumption into question. As can be seen in Figure 2, the brain damaged were entirely unaffected by the intertrial interval condition. The controls, on the other hand, demonstrated a general tendency for improvement as the intertrial interval increased. This was especially apparent on the 15 second interval condition. In fact, the facilitative effect of this interval was so striking a Duncan's test was used to test the differences between these means. It was demonstrated that there was a significant decrement in errors from the 1 second to the 15 second condition (42 *df*, $p < .05$). A *t*-test was also applied to the group differences at the 15 second interval and this difference was also significant ($t = 2.34$, $df = 28$, $p < .05$). It is obvious, in spite of the lack of statistical significance, there are differential group effects on this variable.

The most obvious interpretation of the overall effects would appear to lie within the boundaries of hypothesized differences in memory storage. The direction of effects is certainly interactive and suggests that the control group was better able to retain the information presented on a particular trial and apply it to subsequent trials. The brain damage group, on the other hand, as a possible result of defective storage capacity, was not able to maintain the information over the time.

The performance of the control group on the three intertrial interval conditions has confirmed, in a striking manner, some results recently reported by Bourne, Guy, Dodd, and Justesen (1965). In an intertrial interval condition of the same magnitudes, i.e., 1, 15, and 29, means were obtained that were almost identical with the means obtained in this investigation. This finding is demonstrated in Figure 5. The striking similarity of these means suggested a closer look at the conditions of each experiment. It was noticed, for instance, that in the Bourne experiment only one level of complexity was used: the five level. In the present experiment a combination of all three levels led to a very similar curve. Consequently it was decided to separate the three levels of complexity. This led to another striking pattern. It can be seen in Figure 5 that in the present experiment the 3 level complexity, as well as the combined curve, approximated the Bourne, et al., (1965) results. Interpretation of these results can stress two points, i.e., (1) the similarity of the absolute number of errors and (2) the similarity of pattern. Even if one does not choose to grant the significance of the absolute number of errors, the similarity of pattern cannot be overlooked. It is quite tempting to reflect on the fact that an older and less educated group performed on a 3 level complexity

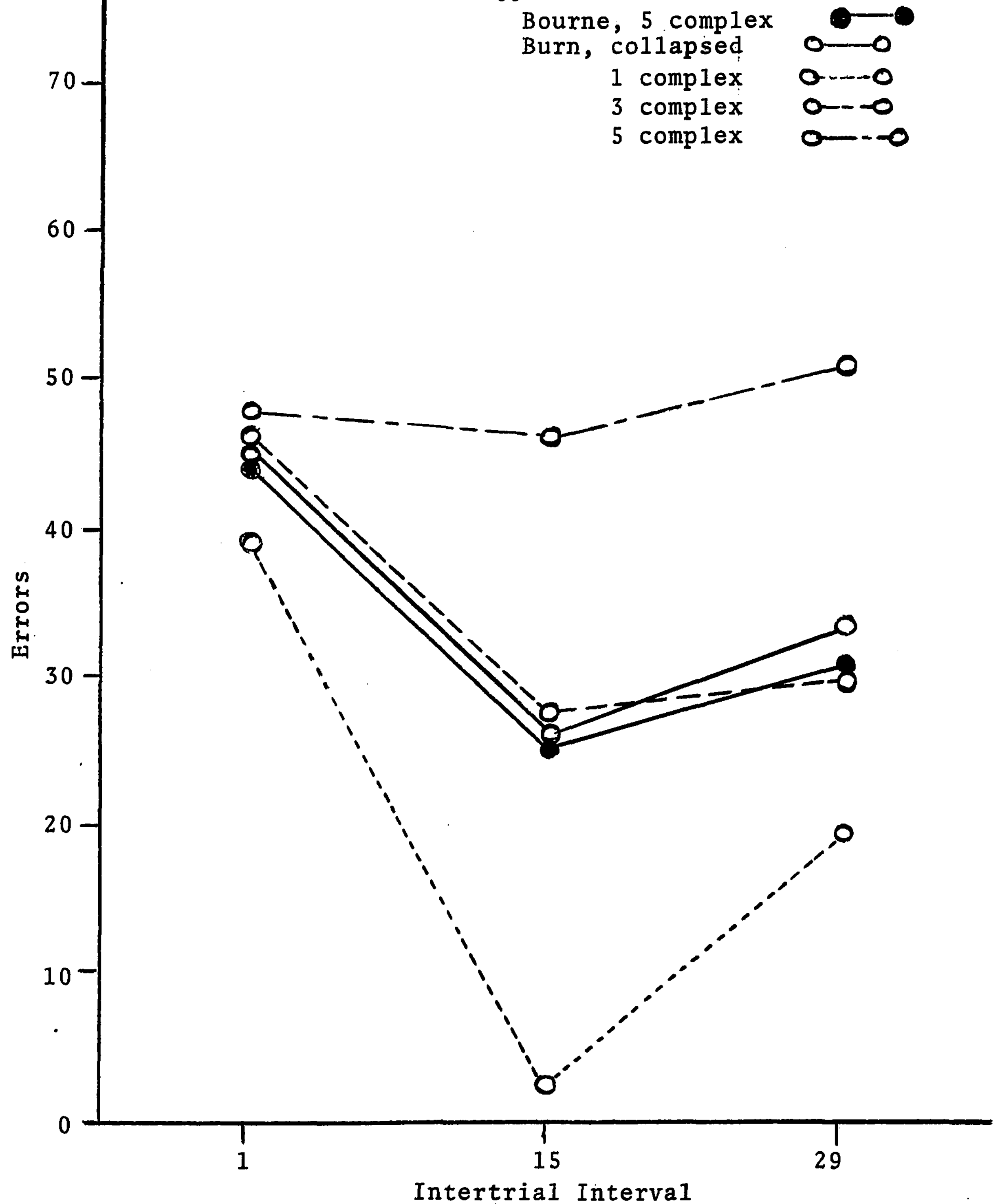

Fig. 5.--Mean errors for control group separated on complexity with comparative data from Bourne, et al., 1965.

task practically the same as the younger college group did on the 5 level complexity. This finding, at the very least, points up the importance of considering variables such as age and education when evaluating conceptual behavior.

The interpretation of the similar pattern suggests a stability of the effects of the complexity variable on groups free of CNS pathology.

It remains to interpret this stable pattern in terms of psychological processes. Bourne, et al., explain these findings in the following way:

> There are several plausible interpretations of facilitation due to lengthened intertrial intervals; for example, the interval may provide opportunity: to associate characteristics of the stimulus with the signaled response category; to rehearse retained information; and/or to formulate new hypotheses about solution. These possibilities, however, are incomplete, since they predict only an asymptote and not the deleterious effect observed when intertrial intervals exceed 9-17 secs. A second controlling process apparently determines the optimizing of performance, but available evidence fails to specify its source(s) (1965, p. 626).

Within the same publication (Bourne, et al., 1965) there is a suggestion that errors at the longer intertrial intervals are a result of loss of memory. The present data in no way contradict this interpretation.

A post-script on this section might be stated here in lieu of the previously mentioned perceptual deficit hypotheses. It will be recalled that this was directed at the performance of the brain damaged group and involved the proposition that the difficulty was in the initial perceptive phase of learning rather than in the associative phase. If one accepts the argument that the brain damaged are not processing the stimulus material as well and that consequently memory functions are not as prominent an issue, then it does not appear strange that they are unaffected by various intertrial intervals. If information is not being recorded in the first place, then any length of interstimulus time is completely irrelevant. If, on the other hand, one accepts the proposition that the control group are processing the incoming information, then an interpretation in terms of memory requirement is appropriate.

Decision Time Data.--One of the original considerations of this experiment was the use of the self paced aspect of the experimental design. It was finally agreed that a fixed interval arrangement would lead to more distortion in terms of the primary questions being asked. It was, however, of interest that a record of the effect of self pacing was obtained. This was allowed by the experimental apparatus and led to another analysis of variance with decision time being the dependent variable. It can be noted, however, that this measure has a somewhat different interpretative value from error scores as it relates to the dimensions involved. With this in mind only the significant and more meaningful relationships will be discussed.

The most obvious differences on this comparison relate to the significant groups and intertrial interval main effects (Figures 3 and 4). No other main effect or interaction terms were significant. The significant groups effect demonstrates the fact that the brain damaged group had significantly longer decision time scores. This finding was expected and, as such, emphasizes the group effects in terms of error scores. The brain damaged Ss took longer to decide on their response but still performed more poorly on the conceptual task. In other words, it is shown that even though the brain damaged group had the advantage of more time in viewing the stimulus material, they still did more poorly. In this regard it might be reasoned that if the design had used a fixed interval procedure the differences in error score would have been still greater. And, in terms of the hypothesized non-specific perceptual deficit, the failure to process the information is even more striking.

The main effect of the intertrial interval demonstrates the tendency for the decision time to lengthen as the intertrial interval increased. This result confirmed the observation in the testing situation of the response reaction to the pace of the equipment. This tendency is demonstrated in Figure 4, and has some interesting implications. First, it can be seen that the brain damaged group are contributing most to this relationship. With this in mind one might say that the brain damaged as a group are responding in a manner that more closely represents the mechanical timing of the test apparatus. Now if one can view this behavior as more concrete, i.e., they respond more to external physical characteristics than to the conceptual task, then the behavior has some theoretical import. That brain damaged groups do behave on a variety of tasks in a manner that can be described as "concrete" was the theoretical contribution of Kurt Goldstein (1939).

Another instance where a brain damaged group is seen to respond to the physical aspects of the stimulus complexity was in the study by Majumder (1966). In this investigation a brain damaged group was unable to respond to instructions to ignore an extreme weight that was introduced into a series of weights. This was in a paired comparison judgment situation. In both these instances examples of reacting to the physical claims of the environment can be seen.

Concept Identification and Psychometric Variables.--Jensen (1966) in a recent discussion of individual differences in concept learning has made an argument against the use of psychometric or, as he called them, "extrinsic" variables in the explanation of the variance observed in concept learning. While the present author realizes full well that the correlation coefficient is not the end in terms of understanding the phenomena in question, it does appear somewhat premature to dispense with the fruitful leads and aids to theoretical development that correlations provide. Indeed, these correlations many times help establish the concurrent validity of the task in question. And, as has been pointed out earlier, certain basic data such as age, education, some measure of intellectual functioning, etc., are so necessary when studying psychopathologic group that their exclusion provides an important basis for rejection of results.

Without further justification, the psychometric variables used in this experiment will be discussed as they relate to the concept identification performance.

The first question that bears consideration is the relationship between the measures of intelligence and the CI performance. Psychologists have usually worked under the assumption that there is a definite relationship between general intelligence and the ability to solve various conceptual problems (Vinacke, 1951). This assumption, however, has not always been substantiated in the concept identification area. In at least three studies (Lydecker, Pishkin, & Martin, 1961; Pishkin & Blanchard, 1963; Wolfgang, Pishkin, & Lundy, 1962) there was no relationship between the measure of intellectual functioning and concept identification performance. There were, however, some important differences in these studies in terms of subject population and measures of intelligence. All three studies used a verbal measure of intelligence as well as employing an age restriction. It is suggested that these procedures may have limited the possible relationship between intelligence and concept identification (McNemar, 1962, p. 144).

In the present study the relationship between the IQ measure and CI is not unequivocal but there is enough to comment on. If the overall correlation is computed there is a significant relationship on the Vocabulary and Block Design Subtest ($\underline{r} = -.26$, $\underline{p} < .01$, $\underline{r} = -.30$, $\underline{p} < .005$, respectively). If, however, the groups are looked at separately, only the Block Design subtest in the brain damaged group remained significant ($\underline{r} = -.31$, $\underline{p} < .025$). This finding is interesting in in light of the previous discussion between group differences in CI error scores and Block Design scores. It appears that at least with the groups used here the perceptual task used to measure intelligence is the best predictor of CI performance.

Another measure used in this investigation can also be discussed in this connection: the abstract score of the Gorham Proverbs Test. It also was significantly correlated when the entire group was considered ($r = -.28$, $p < .005$), but when the groups were separated only the control group continued to demonstrate a significant relationship ($r = .25$, $p < .05$). It seems noteworthy to mention that in a recent study by Wolfgang *et al.*, (in press) a correlation between the abstract thinking (Shipley) score and CI performance in schizophrenics was $r = -.28$, $p < .05$. This is a very similar finding.

In summary, it would appear unwarranted to conclude that the intellectual level is not at least one predictor of performance in the identification of concepts. It has also been suggested that the best predictor of a particular group's performance may not be the same measure of intelligence. In the present study the Block Design subtest score was the best predictor for the brain damaged while an abstract proverb score was the best for the control group. One must also be aware of methodological considerations such as restriction of range or matching procedures when evaluating correlational data.

Another test used in this experiment to provide a clinical measure of memory functioning was the Wechsler Memory Scale (WMS). Group differences were quite significant and supports a limited amount of research with this scale (Drachman & Arbit, 1966; Howard, 1950). When the entire group is considered the correlation between the WMS and CI is -.38 (p < .0005). But, as with the Block Design score, when the groups are separated only the relationship in the brain damaged group remains significant. This finding is difficult to interpret in connection with the "perceptual deficit" explanation of the brain damage performance. This is not, however, to say that the deficit observed in the brain damaged group need be of only one dimension. Indeed, with different levels of complexity the results may well have been interpretable in terms of a memory variable.

Suggestion for Further Research.--One of the goals of this project in terms of further work was to investigate and evaluate the main experimental variables against the characteristics of the groups used. More specifically, the question of what level or levels of the variables used might lend themselves to use as a tool to investigate further very specific questions of memory and its role in the identification of concepts. A consideration of the complexity variable does not allow a definite conclusion. The failure of the groups by complexity interaction term revealed that the brain damaged did equally poorly on all levels of complexity, so that within the limitations of this experiment it would seem the use of any of the 3 levels of complexity might equally reveal differences between the groups used. Each level appears equally difficult for the brain damaged when compared to the control performance. One possible factor in this finding is inadequacy of the assumption of a demonstrable memory impairment in some of these patients. It was, for instance, realized that many patients would not demonstrate a memory deficit by any measure. It was hoped that these patients would be few and not affect greatly the overall results. And the very practical consideration of lack of availability of brain damaged subjects accents the possibility of a few of these patients affecting the results. The heterogeneity inherent in any measure using psychopathologic groups is well documented and requires particular methodological considerations. It is for this reason that the next step should entail the use of patients highly selected in terms of locus of lesion. In this way the within group variance can be cut down, which may well lead to a more unequivocal demonstration of the relationship of memory capacity and the complexity dimension.

And in context with this more specialized design it would seem advisable to use the 15 second intertrial interval condition. The reasoning is that this appears to be best in reflecting group differences. Of course, this assumes that one is no longer interested in manipulating this variable further. If one is, however, there are some suggestions that can be made.

It would have been interesting, for instance, to have started with the 15 second interval point and extended to a minute. This would appear to be a better test of the decay phenomena for now one would be starting at the point of maximum "rehearsal" (for this group as well as a college group) and going toward the point of maximum "interference." This would eliminate the perhaps confusing effect of the rapid 1 second intertrial interval condition. That this condition is complicated by reactions to the equipment is very apparent.

In summary, it has been demonstrated that the variables used in this experiment do confirm to an impressing degree the previous work. That every prediction in the present design was not confirmed should not dissuade the attempt to further investigate conceptual activity with this task. In fact, in addition to these variables the whole gamut of concept identification variables should be applied to these groups. That this will lead to a better understanding of pathological as well as normal thinking processes is a reasonable conclusion.

CHAPTER VII

SUMMARY AND CONCLUSIONS

The value of standardized procedures as well as the quantifiability of various dimensions has long been recognized as desirable ends for scientific investigation of conceptual processes. With these fundamental assumptions in mind the present investigation has attempted to:

1. Extend the generalizability of the concept identification model by investigating the complexity and intertrial interval variables on a brain damaged and matched control population.

2. Show that variations among these two variables are consistent with assumed differences in memory storage capacity of the two groups.

3. Demonstrate that concept identification is to some extent concerned with the same processes that are involved in general intellectual functioning.

The rationale of this experiment was that one of the many affects of brain lesions is an impairment of memory functions. This assumption is well documented in the clinical literature on a number of types of lesions if not the whole range of cerebral injury. It is recognized that many variables such as type and location of lesion, severity and chronicity of injury, as well as the intellectual level of the patient all must be considered as a source of variance that can influence the outcome. Indeed, it was recognized that some of the brain damaged patients would demonstrate no memory loss from any measure employed. It was, however, necessary to make the assumption in the interest of the design in relation to the availability of brain damaged subjects.

This was a factorial design replicated on brain damage and control groups, levels of complexity, and intertrial intervals. The procedure consisted of the concept identification test followed by the administration of the following psychometric tests: the Wechsler Memory Scale; the Vocabulary and Block Design subtests of the WAIS; the Gorham Proverbs Test (best answer form) and a short self report measure of motivation (Hoepfner, *et al.*, 1964). The order of administration in each patient was the same.

The subjects for this investigation were ninety patients from the Veterans Administration Hospital, Oklahoma City, Oklahoma. The brain damaged patients were selected initially on the basis of the presence of positive neurological signs by the *E* and later rated by a staff neurologist as to the presence and locus of CNS damage. The control patients were selected from the same hospital and were also rated by the neurologist as being without CNS damage. Each patient was individually seen by the present investigator and the average testing time was between one and one-half and two hours.

The results generally supported the previously mentioned aims. The substantiation of previous work reflected itself in three aspects of the analysis: the groups main effect, the complexity main effect, and the groups by complexity interaction term. In the first instance there is a demonstration that the brain damaged do significantly poorer on the identification of concepts. This was an expected finding and it demonstrates that deficits in brain damaged groups can be shown. Only with adequate experimental procedures can separation of the complexities of conceptual processes be accomplished. The second aspect that was most reflective of the mathematical model was the complexity main effect. In this instance the linear nature of its effect was significant. This result adds another study to the already large body of work that has consistently demonstrated the linear nature of this variable. It is indeed remarkable to find an experimental variable that can be applied with such consistent effects across so many different groups.

The final result relates to performance across the intertrial intervals. Even though the main effect was insignificant, the groups by intervals did demonstrate some differential effect. In the control group there was observed a general facilitation in performance as the intertrial interval increased. This effect was not without precedent, for in a study by Bourne, *et al.*, (1965) using the same intervals, the curves are virtually the same. It was pointed out, however, that in the Bourne study only the 5 level complexity was used. A consequent separation of the complexity levels in the present study revealed the 3 level complexity again approximating the Bourne curve. The discussion of this finding centered around the similarity of interval effects as well as an explanation of this effect in terms of a "rehearsal" phenomenon that becomes compromised as the intertrial interval approaches 29 seconds. The interference was concluded to be one of memory loss. And, it was also pointed out that the brain damaged, possibly being without the memory capacity that would allow "rehearsal" would not show the facilitative effect of increasing intertrial intervals. This was indeed the case as the brain damaged showed absolutely no facilitative effect.

The analysis of variance on decision time led to a consideration of the groups and intertrial interval main effect. In the groups effect the brain damaged were found to take significantly longer to decide on a response. This was interpreted as an emphasis of original error score difference, i.e., the brain damaged were exposed to the stimulus material longer but still were deficient in the identification of concepts.

The significant intertrial effect on this dependent measure indicated that the longer intertrial intervals elicited longer decision times. This effect was pointed out to the most obvious in the brain damaged group and the interpretation was presented in Goldsteinian terms. This approach points out the tendency of brain injured to react more to the external physical stimulus situation than controls. This tendency was conceived as "concrete" and as such reflects a lack of capacity to deal on a conceptual level (in this case, the solution of the conceptual problem) with aspects other than those making immediate perceptual decisions.

The third question concerning the relationship between measured intelligence and CI performance was handled by psychometric variables. In the brain damaged the correlative relationship between Vocabulary and Block Design measures, while positive in both was only significant in the Block Design score. This indicates that this Block Design score is the best predictor of conceptual identification performance in the brain damaged. In the control group, however, the abstract score of the Gorham Proverbs Test was the only significant predictor. The major conclusion here was that it would be difficult to say there was no relationship between measured psychometric intelligence and concept identification performance. It was pointed out, however, that the relationship was contingent upon the tests and the groups. This finding would seem to indicate that some caution is necessary in making generalizations about broader concepts based on a particular measure of intelligence. It seems possible in some groups a verbally loaded measure of intelligence might be the best predictor of concept identification performance while in others, it may be a spatially loaded measure. It was also the purpose of this investigation to help in the ongoing process of investigating conceptual behavior from the standpoint of group characteristics as well as with different measuring instruments.

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APPENDIX I

CRITERIA FOR GROUPS

Criteria for Brain Damaged Group

All patients tested were selected as belonging in one of the following eight categories:

1. Tumor or operation.
2. Cerebral aneurysm.
3. CVA, with possible neurological findings.
4. Head injury, with positive neurological findings.
5. Suspected cerebral lesion, with positive neurological findings.
6. Cerebral abscess.
7. Korsakoff's syndrome.
8. Cortical atrophy (Alzheimer and Pick's disease).

NOTE: A history of seizures even with positive EEG was not considered sufficient evidence for inclusion in this group.

Criteria for Control Group

The control group was selected on the basis of being free from the following conditions:

1. Severe head injury.
2. Prolonged unconsciousness.
3. Seizures.
4. CVA
5. Blood dyscrasias
6. Pernicious anemia
7. Long-standing and uncontrolled diabetes.
8. Long-standing and uncontrolled hypertension.
9. Chronic, severe, cortical difficulties.
10. Chronic, severe, lung difficulties.
11. Chronic, severe, renal difficulties.
12. Severe endocrine disturbances.

NOTE: Patients with the following diagnoses were excluded from both groups:

1. Multiplesclerosis.
2. CNS syphilis.
3. Parkinsonism.

APPENDIX II

NEUROLOGICAL RATING SCALE

Form For Rating Cerebral Damage

Name ____

____ Group	Severity.... ____
____ Subject Number	1. Very mild
____ Date of Rating	2. Mild
____ Age	3. Moderate
____ Education	4. Severe
____ Sex	5. Very severe
____ Race	
____ Rater	Focal vs. Diffuse.... ____
	1. Diffuse
	2. Focal
Location	3. Focal and diffuse
R. Frontal ____	4. Bilaterally focal
R. Temporal ____	
R. Parietal ____	Progression (Clinical) ____
R. Occipital ____	1. Static
L. Frontal ____	2. Slow progressive
L. Temporal ____	3. Moderately progressive
L. Parietal ____	4. Rapidly progressive
L. Occipital ____	5. Slow recovery
Cerebellar ____	6. Moderate recovery
Subcortical ____	7. Rapid recovery

Cerebral Vascular Disease: ____

Hemorrhage ____ vs. Insufficiency ____

Arteriosclerotic ____	A.V. Malformation ____
A.V. Malformation ____	Hypertensive ____
Aneuryam ____	Encephalopathy ____
No source found ____	Arteriosclerosis ____

Tumor

Intrinsic ____ vs. Extrinsic ____ vs. Metastatic ____

Fast growing ____	Lung ____
Slow growing ____	Not lung ____
Meningioma ____	Pituitary adenoma ____
Craniopharyngioma ____	Acoustic neurinoma ____

Trauma: __________

Birth trauma ____________________
Penetrating head injury ________________
Closed head injury ____________________

Inflammatory or Infectious Disease: __________

Encephalitis ____________
Meningitis ____________
Abscess ____________
Syphilis ____________
Gumma ____________
Tuberculoma ____________

Degenerative or Demyelinating Disease: __________

Multiple sclerosis ______
Alzheimer's disease ______
Pick's disease __________
Anemia ________________
Metabolic disease ______
Cerebral atrophy ______

Brain Damage Scale: __________

1. Definitely
2. Strongly suspected
3. Suspected
4. Not likely
5. Definitely not

APPENDIX III

DEMOGRAPHIC DATA ON BRAIN DAMAGED GROUP

Descriptive Data for Brain Damaged Subjects

S No.	Diagnosis[a]	Location[b]	Age	Education	Time Since Injury (Months)
4	T	LF	29	12	3
5	CVA	LFT	58	5	204
6	CVA	LFP	54	9	7
8	Tr	LFT	22	11	8
12	Tr	FRP	53	12	3
15	Tr	BILAT	34	9	212
17	T	LPO	50	14	214
18	CVA	RLO	55	8	54
20	Tr	BILAT	33	7	8
22	CVA	RFP	46	3	4
27	T	RP	40	7	3
28	CVA	RFT	46	16	17
29	T	RP	40	12	2
30	Tr	LFP	42	12	4
31	DEGEN	SUBCOR	47	9	32
32	INFECT	LP	31	12	78
36	CVA	FRP	56	6	2
39	CVA	LP	47	9	2
46	Tr	LFP	37	12	24
47	CVA	LFTP	56	15	2
49	ATYP	BILAT	54	12	31
52	CVA	LFT	70	10	16
53	CVA	LF	70	6	1
54	T	RF	54	12	1
57	Tr	SUBCOR	48	12	108
58	Tr	RTP	35	12	91
59	T	LF	38	12	114
62	T	LFP	55	7	30
63	T	RFP	62	7	1

Descriptive Data for Brain Damaged Subjects--Continued

S No.	Diagnosis[a]	Location[b]	Age	Education	Time Since Injury (Months)
70	Tr	LFP	44	8	261
71	CVA	LFT	34	11	43
72	CVA	RF	63	8	3
73	Tr	LFTP	56	10	49
74	T	RT	52	4	4
78	Tr	RFP	46	15	2
79	ATYP	RP	43	10	86
81	CVA	RF	29	9	105
83	Tr	LFT	36	8	10
88	Tr	RT	31	12	97
95	Tr	BILAT	29	13	77
100	INFLAM	SUBCOR	45	10	2
101	T	SUBCOR	43	8	73
102	DEGEN	LFT	50	16	7
103	CVA	RFTP	56	13	4
107	CVA	LFT	46	14	53

[a]CVA = cerebral vascular disease (hemmorrhage, aneurysm, etc.); T = Tumor; Tr = Trauma; INFLAM = Inflammatory disease; DEGEN = Degenerative Disease.

[b]L = Left; R = Right; BILAT = Bilateral; D = Diffuse; F = Frontal; T = Temporal; P = Parietal; O = Occipital; SUBCOR = Sobcortical.

APPENDIX IV

PRESENTATION ORDER, DEMOGRAPHIC, PSYCHOMETRIC, ERROR, DECISION TIME, AND LATERALITY DATA

Order of Testing

Complexity	1			3			5		
Intertrial Interval	1	15	29	1	15	29	1	15	29
Brain Damage									
Replications	12	20	5	18	6	4	8	15	95
	17	103	30	29	27	32	28	52	22
	46	47	54	31	49	39	36	58	107
	101	62	102	100	57	53	63	88	59
	74	81	71	83	79	70	78	73	72
Control									
Replications	108	9	93	11	90	2	13	10	1
	16	33	25	35	106	97	37	24	21
	50	41	42	51	44	43	55	105	38
	80	64	92	67	77	109	76	66	65
	91	75	104	87	85	86	89	99	82

Age

Complexity	1			3			5		
Intertrial Interval	1	15	29	1	15	29	1	15	29
				Brain Damage					
	53	33	38	55	54	29	22	34	29
	50	56	42	40	40	31	46	70	46
Replications	37	57	54	47	54	47	56	35	46
	43	55	50	45	48	70	62	31	38
	52	29	34	36	43	44	46	56	63
				Control					
	49	46	61	32	29	39	39	34	25
	59	44	44	45	57	52	51	47	53
Replications	42	42	37	60	59	53	55	57	48
	33	59	40	52	40	39	47	42	44
	54	38	50	36	54	39	39	41	44

Education

Complexity	1			3			5		
Intertrial Interval	1	15	29	1	15	29	1	15	29
Brain Damage									
Replications	12	8	5	8	9	12	11	9	13
	14	13	12	12	7	12	16	10	3
	12	15	12	9	12	9	6	12	14
	8	7	16	10	12	6	7	12	12
	4	9	11	8	10	8	15	10	8
Control									
Replications	4	12	7	11	9	4	10	14	17
	8	16	14	12	12	14	4	6	7
	10	8	8	5	6	8	12	7	8
	11	7	9	8	10	6	7	12	12
	14	7	14	13	12	14	16	12	4

Wechsler Memory Scale

Complexity	1			3			5		
Intertrial Interval	1	15	29	1	15	29	1	15	29
Brain Damage									
Replications	80	73	57	64	80	90	55	57	79
	70	100	58	94	59	69	58	99	72
	90	64	99	63	118	101	77	132	64
	..	99	49	92	70	92	92	84	59
	77	92	81	73	61	89	99	55	96
Control									
Replications	66	96	100	84	106	94	86	103	97
	96	101	87	99	83	108	77	74	103
	92	93	64	80	87	108	96	106	94
	80	90	110	89	100	93	93	83	90
	110	77	114	126	110	100	116	101	76

Vocabulary Score: Age Scaled

Complexity	1			3			5		
Intertrial Interval	1	15	29	1	15	29	1	15	29
Brain Damage									
Replications	7	8	6	6	7	9	7	1	11
	9	13	2	12	5	8	2	12	8
	10	5	13	8	11	10	7	13	2
	..	7	9	9	4	10	9	10	0
	3	8	9	5	7	7	13	2	13
Control									
Replications	3	10	7	7	8	6	12	16	10
	9	12	12	6	11	11	7	7	6
	6	9	5	7	8	13	11	8	8
	7	7	6	7	11	8	12	9	12
	7	6	13	12	11	8	12	10	6

Block Design Score: Age Scaled

Complexity		1			3			5	
Intertrial Interval	1	15	29	1	15	29	1	15	29
				Brain Damage					
	6	0	0	7	8	11	10	6	9
	12	6	7	9	0	8	7	12	6
Repli-cations	11	10	9	7	10	10	7	9	10
	..	10	9	9	9	8	8	7	8
	9	5	10	6	0	9	5	0	4
				Control					
	10	12	8	11	9	8	11	15	14
	11	12	8	9	6	10	6	14	12
Repli-cations	9	9	7	8	7	16	9	11	9
	9	8	10	9	14	11	9	11	11
	14	10	11	13	13	7	15	9	6

Full Scale Estimate: Age Scaled

Complexity	1			3			5		
Intertrial Interval	1	15	29	1	15	29	1	15	29
Brain Damage									
Replications	13	8	6	13	15	20	17	7	20
	21	19	9	21	5	16	9	24	14
	21	15	22	15	21	20	14	22	12
	..	17	18	18	13	18	17	17	8
	12	13	19	11	7	16	18	2	17
Control									
Replications	13	22	15	18	17	14	23	31	24
	20	24	20	15	17	21	13	21	18
	15	18	12	15	15	29	20	19	17
	16	15	16	16	25	19	21	20	23
	21	16	24	25	24	15	27	19	12

Gorham Proverbs Test: Abstract Score

Complexity	1			3			5		
Intertrial Interval	1	15	29	1	15	29	1	15	29
Brain Damage									
Replications	12	13	6	4	24	7	11	8	25
	16	26	7	29	15	20	7	23	17
	24	13	24	6	19	30	5	32	13
	..	8	..	26	13	9	23	33	6
	7	24	20	8	12	18	29	10	15
Control									
Replications	15	22	14	14	14	13	27	33	34
	12	31	24	14	19	24	8	19	9
	16	16	25	16	18	24	26	13	19
	10	9	16	8	26	23	35	18	36
	24	13	33	27	29	18	29	28	9

Motivation Scale

Complexity	1			3			5		
Intertrial Interval	1	15	29	1	15	29	1	15	29
Brain Damage									
Repli-cations	2	4	2	2	2	2	4	3	3
	6	3	2	4	6	5	2	3	4
	2	2	2	2	5	4	6	5	2
	[illegible]	2	10	4	2	2	2	2	3
	3	2	2	2	5	2	4	4	3
Control									
Repli-cations	6	4	4	2	2	5	5	2	5
	2	3	3	6	5	3	3	2	2
	2	2	4	2	4	3	3	3	2
	5	2	8	4	2	2	6	5	3
	4	2	6	2	2	4	3	2	2

Errors (CI)

Complexity	1			3			5		
Intertrial Interval	1	15	29	1	15	29	1	15	29
Brain Damage									
Replications	71	74	69	60	4	8	71	64	72
	63	7	28	3	67	67	66	63	71
	28	48	2	69	26	65	55	71	59
	6	6	60	21	73	63	64	71	69
	5	33	8	60	67	38	60	62	63
Control									
Replications	59	3	8	41	54	71	12	70	67
	13	1	18	54	59	3	61	13	60
	82	2	5	65	2	15	63	69	60
	30	1	66	70	17	57	50	71	13
	11	6	1	0	1	8	52	7	55

Decision Time (CI)

Complexity	1			3			5		
Intertrial Interval	1	15	29	1	15	29	1	15	29
				Brain Damage					
Replications	2.28	3.92	10.20	6.68	5.36	21.84	3.20	3.96	3.16
	2.52	2.16	4.00	3.64	5.84	2.16	4.48	4.92	4.36
	4.56	2.56	2.80	5.96	1.32	18.52	3.12	4.88	4.36
	1.36	1.76	2.48	3.52	3.76	4.24	3.32	2.92	12.80
	1.96	5.32	4.68	4.96	2.32	3.04	4.88	5.56	2.76
				Control					
Replications	2.28	5.48	4.88	3.12	2.72	5.92	2.64	2.52	4.76
	3.28	2.20	3.48	2.88	1.84	2.96	4.00	2.84	.88
	2.32	7.72	3.28	4.28	3.76	1.80	3.24	2.04	4.96
	3.60	2.08	2.20	2.04	1.56	10.28	4.28	2.92	2.60
	2.28	3.68	1.68	2.28	1.88	2.32	2.20	2.08	3.12

Right/Left Hemisphere

Complexity	1			3			5		
Intertrial Interval	1	15	29	1	15	29	1	15	29
				Brain Damage					
Replications	R	..	L	..	L	L	L	..	..
	L	R	L	R	R	R	R	L	R
	L	L	R	..	..	L	R	R	L
	..	L	L	..	..	L	R	R	L
	R	R	L	L	R	L	R	L	R