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CHAPTER I

INTRODUCTION AND HISTORICAL DEVELOPMENT

The study of thinking or cognitive processes, of which concepts are one of the principal tools of thinking and were among the first psychological problems to be investigated, has a long and formidable past. At one time, prior to the first World War, the investigation of the higher mental processes was considered a core topic within psychology. However, since that time and up to 1950 many individuals (e.g. Hebb, 1949) have criticized psychology for not adequately dealing with thought or cognitive processes.

Recently, as Bruner, Goodnow, and Austin (1956) have pointed out, there has been a stimulated increase in the interest and investigation of cognitive processes. This renewed interest in the area of cognitive functioning seems to have stemmed from several sources. One of these sources has been the recognition of mediating processes which intervene between the classical "stimulus" and "response"; in this respect, _S_-_R_ learning had hoped psychology would eliminate anything dealing with "mental processes." This _S_-_R_ bond concept was transformed into an S-O-R concept whereby the O stood for the subtle events that could occur between the input of a physical stimulus and the outcome of an observable response. Other sources stem from information theory (Shannon and Weaver, 1949), personality theory (e.g. Allport, 1959), and experimenters working with animals (Fields, 1932; Lashley, 1934; Harlow, 1949). All of these sources contributed to ideas that lead away from the assumption of a sensory dominance of behavior and more toward the acceptance of autonomous central processes of which concept formation is an integral part.

Although the investigation of concepts was studied by the ancient Greeks, other cognitive processes, such as sensation, perception, retention, serial learning, and imagery have been investigated more frequently. At the beginning of the twentieth century, it was felt that cognitive processes could be identified by discerning their qualitative characteristics as conscious experiences. In fact, the early scientific approach attempted to analyze concept formation by studying the conscious experience attendant upon it. However, early investigators who were members of the "Wurzberg School" demonstrated by careful introspective observations that the above hypothetical process did not hold up. That is, if cognitive processes were responsible for certain judgments, those cognitive processes were not in themselves conscious, even though they yielded a conscious end product.

The same general finding resulted from experiments which sought to investigate more complex processes. Watt (1905), working in the Wurzberg laboratory, asked his subjects to report on their conscious processes when they were given tasks such as naming a superordinate for a subordinate, or a part for a whole. He found that if an observer was adequately prepared, there was little or no observable conscious content. Likewise, Boring reports that, with Ach,

> . . . it became clear that the problems of thought and action are essentially the same. In both cases one has some specific end to achieve, and the psychophysical process, released by a stimulus, runs its course to that end. To name a rhyme for a stimulus-word is psychologically no different from pressing a given finger when a given letter appears [1929, p. 404-405].

Thus, Ach and many of his contemporaries (Grunbaum, 1908; Moore, 1910; Fisher, 1916; English, 1922) continued to experiment within the framework of introspective analysis.

It was not until 1920, when Hull (1920) made the first non-introspective attempt to study concept learning, that an objective approach was established which was independent of introspection. His procedure was devised to collect data on possible quantitative relationships between stimulus and response variables. In order to establish these relationships, Hull performed an experiment in which 144 chinese characters were drawn on cards. The cards were divided into 12 packs, each containing 12 cards, and each pack consisted of one instance of each of the different concepts. Each card was exposed by means of a memory drum, and, with each presentation, a nonsense syllable was given which was to be associated with that character. The subject was told merely to learn the label. After the presentation of the first pack, the subject was requested to state what the label of each character was. If he could not do so, prompting was given. This procedure continued through all 12 packs. The first six packs were considered the learning series, and the last six packs the test series. Three measures of concept acquisition were used: (1) the ability to state the label of the concept when the learning series was repeated, (2) the number of promptings, and (3) a drawing of each concept or identical elements of each character. The general results showed that human subjects can gradually learn to associate a particular nonsense syllable with a particular, stable element of a changing stimulus pattern. Then once this association has been established, it can be transferred to a new stimulus pattern containing the element. Finally, the subject can accomplish this without necessarily being able to define the guiding concept. In this respect Hull had made two significant and related contibutions to behaviorism. He provided an experimental procedure for the study of cognitive functioning without recourse to introspection and he offered an analysis of concept formation in terms of S-R relationships without recourse to processes occurring between observables. Although Hull did not confine his later theorizing to this level, there are several contemporary analyses of concept formation restricting themselves to S-R relationships without maintaining any mediating events. For example, Skinner (1953; 1957) describes a process whereby any property of a stimulus that is present when a response is reinforced acquires some degree of control over that response. The amount of control grows with the repeated occurrences of response and reinforcement in the presence of the stimulus, and this control continues to be exerted when the property appears in other combinations. According to Skinner, when behavior is brought under control by a single relevant property or by a few relevant stimulus features of a variety of otherwise dissimilar patterns, that behavior is known as an abstraction and is called conceptual. In this sense, only the existence (or nonexistence) of the conditioned stimulus characteristics is critical, for these determine how the subject will respond.

Smoke (1932) criticized Hull's experiment by pointing out that concepts are rarely characterized by distinguishing identical elements or class marks. Rather, according to Smoke, concepts are defined by the common perceptual relationships which are used. That is, according to Smoke, it is the Gestalt or configurational pattern which defines the concept. In Smoke's experiment, he employed three criteria for mastery of a concept: (1) verbal definition, (2) drawing, (3) choosing examples of the correct instance from a series of figures containing "correct" and "incorrect" designs. Smoke reported that the subjects could generally meet the last two criteria without necessarily meeting the first. Thus, a subject can form and use a concept without verbalization. This finding seems to be similar to the recent studies on "learning without awareness" and verbal conditioning (see Krasner, 1958). Here, much is often made of the subject's lack of awareness, either of what he is learning or of the response-reinforcement contingency. However, evidence is accumulating that such learning actually does not occur (Levin, 1959). It seems that awareness of the condition of reinforcement is necessary for learning to occur.

Smoke's experiment also demonstrated that concepts based on the common features of material more complex than that used by Hull (geometric design patterns of differing color, shape, position, width of lines, and number) can be formed even when no identical elements exist. Finally, the main differences between Hull and Smoke seem to be essentially concerned with a Gestalt-behavioristic split even though both were trying to establish an experimental definition of a concept centered around the discrimination of certain common aspects of a stimulus pattern.

Heidbreder (1946a, 1946b, 1947, 1948) used a method which was similar to Hull's and materials which were similar to Smoke's, in that the concepts were defined by some common relationships. The stimulus materials were presented via a memory drum and the materials could be classified into three categories such as concrete objects, spatial forms, and abstract numbers. The subjects were required to learn non-sense syllable names for the various categories through the use of the anticipation method. From the results Heidbreder concluded that the concepts of concrete objects are attained most readily, with spatial objects next and abstract numbers last. Similarily, Heidbreder (1948, 1949), attempting to increase the role of perception by using a card sorting format where subjects could manually sort the drawings into their respective piles, found that sorting for number was more difficult than sorting for concrete objects which was easier. Furthermore, Grant and his associates (Grant and Curran, 1953; Grant, Jones, and Tallantis, 1949) using the Wisconsin Card Sort Task found somewhat different results from that of Heidbreder and her associates. Overall, the discrepancies seem to be related to the different experimental procedures used by these investigators, to measure concept formation.
For example, one major difference lies in the fact that Heidbreder's subjects were required to learn more than one concept concurrently whereas

Grant's subjects were required to learn only one concept at a time. In addition, in Heidbreder's procedure only one instance of a concept was presented at a time whereas in Grant's procedure each stimulus presentation was a different instance of the concept being learned at the time. Recently, Wohlwill (1957) showed experimentally that the "dominance heirarchy of concepts" will vary with different procedures. He differentiated between abstraction, which he defines as a selective response to a given aspect of the stimulus, and conceptualization, which he considers a process of mediated generalization. Different experimental operations were set up to correspond with abstraction and conceptualization. Finally, the results indicated that color and number are more easily abstracted than form, but that form and number are more easily conceptualized than color. Overall, though different experimental definitions of a concept have been attempted, the basic dimensions of size, form, color, and number still remain as standard in research on concept formation.

In any review of conceptual behavior or concept formation, one becomes immediately aware of the large volume of work reported on the performances and comparisons of various normal subject groups to different psychopathological groups. Indeed, it was Hull (1920) who suggested that the study of concept thinking in psychopathology may be fruitful. In addition, for many years a wealth of clinical observations have suggested that the conceptual processes are impaired in the schizophrenic and brain-damage individuals. Thus, the investigation of conceptual behavior has been a prime objective in attempting to understand a conceptual deficit in schizophrenia. The following review will address itself to this area of investigation which is the focus of the present study.

Conceptual Deficit and Schizophrenia

The nature of conceptual deficit in schizophrenia has been well documented in a number of reviews (Cameron, 1944; Haufmann and Kasanin, 1942; Hunt and Cofer, 1944; Rabin and King, 1958; Payne, 1961; Lothrop, 1961; Buss and Lang, 1965; Lang and Buss, 1965; Yates, 1966a). In fact, a deficit in concept formation has long been considered as one of the most salient symptoms of schizophrenia.

Hull (1920) suggested that the study of concept thinking in psychopathology may be fruitful. In fact, he found that constitutional inferiors, dementia praecox subjects and peretics had greater difficulty in evolving functional concepts as compared to normals. However, it was not until 1934 that a Russian psychiatrist, Vigotsky, described a theory whereby the schizophrenic was characterized by a loss of ability to think in abstract concepts and a regression to a more primitive level. Vigotsky believed that the conceptual disturbance in schizophrenia was a function of an underlying central nervous system disorder. In order to test his hypothesis, he developed a classification test made up of blocks (modification of one developed by Ach) of varying shapes, colors, and sizes that were to be placed in categories according to the concept in question. Kasanin and Haufmann (1938), continuing the work of Vigotsky's in America, not only confirmed Vigotsky's findings on a greater number of patients, but tried to place the test on a quantitative basis. In particular, Kasanin and Haufmann reported that although not all schizophrenics showed conceptual disturbances when compared with normals, those who did show such a disturbance manifested a general deterioration of conceptual thinking and an inability to generalize.

Other investigators, working with brain-damage individuals, have found similar results as those reported by Vigotsky, Haufmann, and Kasanin (e.g. Bychowski, 1935). Probably the most noted series of studies which is very similar, theoretically, to that of the Haufmann-Kasanin studies are the works of Goldstein (1939a; 1939b) and his associates (Bolles and Goldstein, 1938; Goldstein and Sheerer, 1941). The Goldstein and Sheerer sorting test included such objects as blocks, skeins of wool, and everyday objects which could be sorted into conceptual groups reflecting dimensions of color, shape, size as well as category labels. The results of such tests have been interpreted by Goldstein and his associates as showing an impairment in the ability to maintain the "abstract attitude," resulting in concreteness, and resembling the impairment found in certain types of brain pathology.

Overall, Goldstein, Vigotsky, and Haufmann-Kasanin typify one interpretation of a conceptual deficit in schizophrenia. This is that an abstract attitude may be achieved only by normal adults; individuals outside of this class (schizophrenics and brain-damaged) are characterized by a marked loss of the ability to conceptualize on an abstract level, and by an increased tendency toward the use of concrete forms of conceptualization. However, these findings are not clear, since poor scores on these tests could be purely a function of mental slowness or a tendency to produce unusual generalizations. That is, it was very difficult to differentiate between the performances of schizophrenics and brain-damaged individuals on these tests. In addition, in the many investigations cited in support of this approach, adequate control groups were absent and inadequate statistical procedures were used. Recently, better controlled studies, using "sorting" tests of concept formation have produced more consistent results. Schizophrenics are not regarded as concrete in the sense of being unable to generalize at all. Rather, they tend to produce unusual generalizations. For example, Rapaport, Gill, and Schafer (1945), using an object sorting test similar to Goldstein, found that a group of schizophrenics were no more "concrete" than normals. The concepts which the schizophrenics evolved tended to be eccentric and unusual. Similar results have been reported by Fisher (1950), who found no difference between schizophrenics and hysterics; by Rashkis, Cushman, and Landis (1946), who found that schizophrenics could form concepts but they were eccentric and unlike those used by normals; by Fey (1951) who found that schizophrenics had a higher frequency of perseverative responses even though they could form concepts. Finally, recent studies have shown that schizophrenics can form the same kind of concepts as normals (Hall, 1962; Kew, 1963) or whatever kind of conceptual deficit is present, it is not due to an impairment in abstracting ability (Ross, 1963; Nathan, 1964; True, 1966; Salzman, Goldstein, Atkins, and Babigian, 1966).

Partly because of a reluctance to accept an organic interpretation as to the nature of a conceptual deficit in schizophrenia, other investigators have centered on a functional interpretation. Cameron (1938a, 1938b, 1939a, 1939b, 1944) felt that a conceptual deficit in schizophrenia was due to a disturbance in social communication and/or in substaining attention (overinclusion) rather than an actual loss of abstract ability. Cameron argues, in one sense, that concepts formed by schizophrenics are "overinclusive," they are unable to maintain the normal conceptual boundaries, and incorporate into their concept elements (some of them personal) which are merely associated with the concept, but are not an essential part of it. It is interesting to note that Cameron relegated disturbances in conceptual functioning as secondary in nature to the schizophrenics' interpersonal difficulties or "social disarticulation." Since Cameron's initial formulation, there have been many studies investigating "overinclusion" in schizophrenics. At first, many studies (e.g. Zaslow, 1950; Lovibond, 1954; McGaughran and Moran, 1956; Payne, Matussek, and George, 1959) have shown positive results, that is, overinclusive behavior is part of schizophrenia. However, recently, even though Payne (1962) and his associates (Payne, Caird, and Laverty, 1964) have been fairly consistent in finding schizophrenics to be overinclusive in their thinking, other studies have tended to criticize the concept of overinclusion (e.g. Eliseo, 1963; Goldstein and Salzman, 1965; Strum, 1965). Overall, it is apparent that whether overinclusion is a characteristic of schizophrenia or not, may very well depend upon the measure or test used to establish overinclusive thinking. Different tests find different results and even those tests that do find positive results are often not reliable (Goldstein and Salzman, 1965). Furthermore, overinclusiveness may be confounded with a more general idea of concreteness (Strum, 1965), or may be a function of heterogenity differences within the schizophrenic diagnosis (Buss, 1966).

Traditionally, as has been pointed out, the work of Goldstein (1939a, 1944, 1963) with the loss of the abstract attitude on the one hand, and that of Cameron (1947) with interpersonal dysfunction and over-inclusion on the other hand, has been used to illustrate the nature of the conceptual deficit in schizophrenia. However, in recent years, many investigators of cognitive deficit in schizophrenia (e.g. Chapman and McGhie, 1962, 1963, 1964; Yates, 1966a, 1966b; Buss and Lang, 1965; Buss, 1966) have placed emphasis on an impaired selective attention, inability to maintain a set, and an inability to process incoming information efficiently. From such studies, it is clear that a theoretical orientation regarding psychological deficit in schizophrenia has been emerging. The orientation centers around conceptualizing the human operator as an information-processing unit. Essentially the model can be outlined as follows: any set of sequential stimuli have to pass through various levels of the nervous system before a response is made. For example, stimuli must first be received by the organism and translated into peripheral physiological data (receptor level); next, the data is subjected to initial organization for orderly presentation to higher nervous structures (data processing level); finally, the data is dealt with by the highest parts of the nervous system (cortical or mediation level). In terms of this model, it seems possible that any thought disorder in schizophrenia could be due to a cortical or mediation level, or due to a failure at a lower level which will adversely effect higher levels of thinking, even though the higher levels are not impaired. Empirical evidence which supports the model has shown that in comparison to normal subjects, schizophrenics have a marked inability to attend selectively to stimuli in such a way that only relevant information is processed (McGhie, Champman, and Lawson, 1965a); a deficit in channel capacity which increases with chronicity (Pishkin, 1966); an inability to maintain a set over time and in shifting a set when necessary (Shakow, 1963). Thus, it appears that although schizophrenics have a conceptual deficit, it is not due to a loss of abstractness (Lothrop, 1961; Tolor, 1964). Rather, it appears due to an inability to screen out irrelevant information and noise in order to process relevant incoming data. In fact, McGhie and Chapman, using Broadbent's (1958) filter theory, have postulated that:

> . . . schizophrenic patients have a marked inability to attend selectively to stimuli in such a way that only relevant information is processed. This inability on the part of the schizophrenic to filter out irrelevant data tends to lead to an overloading of the limited information processing and storing mechanism available to him [1965b, p. 397].

Overall, it appears that the interference and distraction in the input and organization of relevant information as well as an abnormally slow rate of processing relevant information (Yates, 1966a, 1966b) tends to disrupt the schizophrenic's performance on a variety of perceptual-cognitive tasks.

Hypothesis, Strategies, and Conceptual Behavior

As Van De Geer and Jaspers suggested, cognitive processes can be differentiated from simple learning processes in their emphasis on strategies when,

> . . . the individual is selectively collecting inputs in order to arrive at a final or semifinal decision, he brings with him a view of his own in dealing with the environment. This seems to imply that cognitive behavior cannot be explained by learning

> principles alone. Rather, we must look for principles which govern the selection of experience and its further processing [1966, p. 147].

In order to develop a more complete description and understanding of human conceptual behavior, it would seem important to consider an individual's approach to a conceptual task.

In the beginning, hypothesis behavior theories were first developed and evaluated in the context of experimental tasks, like discrimination learning, which are simpler than conceptual problems. In fact, Krechevsky (1932) produced some important and convincing evidence on hypothesis-like behavior in rats while they were learning a simple two-choice discrimination task. More recently, Levine (1959, 1963, 1966, 1967) has adapted certain features of Krechevsky's analyses and coupled them with Harlow's (1959) error factor notions so as to produce a more explicit model of hypothesis behavior in humans and in somewhat more complicated circumstances. Perhaps the most noted pioneering work done on hypothesis or strategies for conceptual problems was by Bruner _et al_. (1956). Bruner and his colleagues inspected the subject's stimulus selections and verbalized hypotheses in order to detect systematic, sequential behavior of the subjects. By using such stimulus material as thematic cards, geometric designs (color, size, border), facial types, and aircraft designs, Bruner _et al_. obtained four kinds of strategies: "conservative focusing," "focus gambling," "successive" and "simultaneous scanning." These strategies are referred to as selection strategies. That is, the subject selects his own instances of what he thinks the concept is.

Several investigators, rather than rely on the selection paradigm, have used the reception paradigm whereby the subject has no opportunity to select stimuli and must rely on an experimentally regulated flow of information. Bruner et al. in using this approach, reported two ideal strategies: the "wholist" strategy, and the "partist" strategy. In fact, Bruner et al. stated that:

> In the main, the focussing strategy appropriate to an initial whole hypothesis is less demanding both on inference and memory than the scanning strategy required to make good an initial part hypothesis . . . It appears that far more people prefer to start with a whole hypothesis than with any other form of hypothesis. Moreover, people are consistent from problem to problem in their initial approach [1956, p. 150].

Bourne (1963) reported results which were in accord with Bruner et al. However, in contrast, Bourne reported that the "wholist" strategy was used in only nine per cent of the problems. Furthermore, Bourne (1965) using the reception paradigm involving constant clusters and investigating the relationship between category responses and hypothesis, reported that the efficient learner starts with a more encompassing initial hypothesis (wholists), changes it only after he makes a category error, and changes the hypothesis in only one respect at a time. Also, the more efficient learners' hypotheses tend to be more consistent with previously given information.

Overall, most of the studies and positions espoused by many of the investigators tend to remain largely as post-hoc descriptions of experimental data. Furthermore, since most concept formation tasks are based upon a reception paradigm, it would appear that Bourne's (1965) analysis of hypothesis behavior in relation to category responses could be applied to the identification of concepts. Finally, although most of the results have tended to support Bruner's _et al_. original findings, most comparisons have been between successful or efficient learners and less efficient learners rather than different psychopathological groups.

CHAPTER II

CONCEPT IDENTIFICATION

Kendler (1964) pointed out the distinction between "concept acquisition" and "concept identification" tasks, concept identification (*CI*) tasks are those in which the subject has available, at the beginning of the task, the response common to the dissimilar stimuli. That is, when a person is said to be using previously learned discriminations and habits, rather than the learning of new ones, to solve conceptual problems, he is engaged in the task of *CI*. Concept acquisition tasks involve the learning of the common response. The primary concern of this investigation is a *CI* task.

In order to qualify as *CI* a task must fulfill two requirements (Garner, 1962). First, as Kendler (1961) suggested, the same response must be assigned to more than one stimulus. Unless the same response is elicited by two or more dissimilar stimuli the subject cannot be said to have identified a concept. It is this requirement that differentiates *CI* tasks from paired-associate tasks where each stimulus has a unique response. The second requirement of *CI* tasks is that the stimuli involved be multivariate in nature. Since the stimuli must be multivariate in nature, it is possible for the experimenter to decide *a priori* which of the stimulus dimensions will be used in classifying the events and which, if any, will not be used in the classification of events. The former dimensions are called relevant dimensions and the latter irrelevant dimensions. Once the experimenter has made the decision concerning the relevant and irrelevant dimensions the subject's task becomes one of ascertaining which variables are relevant and which are irrelevant and identifying the state or states of the relevant variables which defines the concept.

Finally, many different types of concepts have been used in _CI_ tasks. Bruner _et al_. (1956) used three basic types of concepts: conjunctive, disjunctive, and rational. Neisser and Weene (1962) constructed ten types of concepts, all of which involved only the presence or absence of just two variables. Recently, Haygood and Bourne (1965) summarized the various concept types and suggested that the structure of concepts reveals two major features: relevant attributes, and the conceptual rule by which the attributes are combined to form the concept. Haygood and Bourne pointed out further that most _CI_ studies have employed simple and familiar unidimensional concepts. For example, in a problem using three dimensions, e.g., color, form, and size, the correct solution might be form whereby the subject would have to respond "square" to _A_ and "triangle" to _B_ regardless of changes in color or size. It is this type of familiar unidimensional concept that will be utilized in the present investigation.

CI and Mathematical Model

Learning is probably the one area in psychology which has adapted well to various mathematical treatments applied to it. As early as 1885, Ebbinghaus utilized a procedure referred to as empirical curve-fitting in order to represent his retention curves. In extending the idea of empirical curve-fitting to rational curve-fitting, mathematics was rapidly taking its place in serving psychological theory. For example, Thurstone (1930a, 1930b) stated that when a person performs a number of responses per unit of time, his learning ability is based upon the probability that one of his responses will be successful. Other developments have stemmed from Hull's et al. (1940) vigorous mathematical theorizing and symbolic logic, but, perhaps more important was the development of a systematic analysis of human communication (Shannon and Weaver, 1949). "Information Theory" has provided a unit by which information can be measured. This unit of information is generally defined in terms of how much uncertainty is reduced by a selection of an alternative. That is, the more alternatives there are, the more information is conveyed by each choice. This relationship of information to the number of alternatives can be given a more formal expression. The expression is:

$$H = \log_2 A \qquad (1)$$

where H is the amount of information in bits, and A represents the number of alternatives. Thus, the amount of information yielded by specifying one of a number of alternatives increases as the log (see equation 1) of the number of alternatives. In this respect the log is to the base two refering to the binary system or two choice situations. Also, the information "unit" is referred to as "bit" (binary digit) and refers to two choice situations. Thus, since the operation of binary choice involves the choice between two alternatives, one can measure the bits by determining to what power 2 has to be raised in order to arrive at the number of alternatives. Finally, it was not long after the development of information theory until the first applications to concept learning (Hovland, 1952). These initial applications of information analysis to concept formation studies did much to stimulate research in cognitive processes in general and in particular to CI tasks.

A model utilizing a combination of rational and empirical methods of describing a learning function as well as utilization of information theory techniques has been developed by Bourne and Restle (1959). This model, dealing explicitly with CI problems, has been called a cue conditioning and/or a stimulus sampling theory whereby it is assumed that relevant (rewarded) cues are conditioned and irrelevant (unrewarded) cues are adapted. That is, by the use of reinforcement (information feedback) relevant cues, which are consistently associated with a given (conceptual) response, gradually become conditioned to the response; irrelevant cues, which are not consistently associated with any available response come to lose their effectiveness and are adapted. It is assumed that the rate of learning (conditioning and adaptation) is determined by the proportion of relevant cues as well as the probability that a cue is present at the time of reinforcement. Of course, the greater the proportion of relevant cues in any given universe of stimuli, then the greater is the probability of selecting one or more of these cues while sampling. Overall, the theoretical parameters are generally derived mathematically, and they are based on probability statements. For instance, Bourne and Restle (1959) suggested that the CI learning rate parameter (θ) is determined by the proportion of relevant cues (r) times the proportion of trials on which a relevant cue is reinforced (α). Furthermore, if relevant cues are reinforced 100% of the time, as in the present investigation, Bourne and Restle developed the following equation to account for the theoretical (θ) of an individual learner. That is,

$$\theta = \frac{kR}{R+I+B} \qquad (2)$$

where _k_ is the proportion of relevant cues utilized, _R_ and _I_ are the number of relevant and irrelevant cues in the problem, respectively, and _B_ is the total amount of background irrelevant (uncorrelated) stimulation from the experimental setting. As one can see the _k_ and _B_ parameters must be determined empirically; however, once these values are established, the formula can be used to predict the difficulty of concept identification with different combinations of relevant and irrelevant information.

Recently, Pishkin and Blanchard (1963), working within the Bourne and Restle framework, extended the model in order to account for social cues in a _CI_ task. When both social and stimulus cues are available as well as relevant, along with irrelevant stimulus cues, Pishkin and Blanchard showed that:

$$\theta_{st.} + soc. = \frac{kR+1S}{R+I+B+S} \qquad (3)$$

where _1_ is the proportion of social cues utilized and _S_ refers to the overall value of the social cue (other person). The other parameters (_k_,_R_,_I_,_B_) are the same as in equation two (2). The basic assumption here is the additivity of cues; however, Pishkin and Bourne (In Press) have shown that the additivity of cues assumption holds for normal subjects, but not for schizophrenics.

Complexity

Of the many experimental variables that CI studies have been concerned with, perhaps task complexity has been given the most attention. Many of the early investigators of concept learning (Chapter I) had no direct, systematic, or independent means of measuring task complexity from that of the subject's response. Generally, qualitative differences in performance were used to determine complexity of a concept. The most common rule for establishing complexity among early investigators was the ease with which a concept was acquired. In the mathematical theory of CI (Bourne and Restle, 1959), the cues are represented, in part, by the number of relevant and irrelevant dimensions which define the concept. Furthermore, the assumption is made that the measure of relevant cues is proportional to the number of relevant dimensions whereas the measure of irrelevant cues is proportional to the number of dimensions made irrelevant. Thus, a definition of complexity in a CI task can be in terms of the number of irrelevant dimensions to relevant dimensions: the greater the irrelevant to relevant dimensions, the greater the complexity. The main advantage in this approach is the ability to define quantitatively difficulty levels independent of the subject's response. This has been a longstanding problem in the area of learning and concept formation.

It wasn't until 1952 that the perennial problem of task difficulty level came under a more systematic experimental definition. During this period, Hovland (1952), as well as Underwood (1952), suggested how information theory, through probability measures, might be used to quantify the variable of task complexity. Thus, Archer, Bourne, and Brown (1955) investigated a method, in which complexity was the main variable, designed to assess the complexity of stimuli, independently of the subject's responses. The above authors varied task complexity quantitatively by systematically increasing the amount of irrelevant information along different binary stimulus dimensions. It was assumed that complexity was defined by the number of irrelevant dimensions to relevant dimensions. For example, in one experiment, Archer et al. used two bits of relevant information and one, two, and three bits of irrelevant information. In the two experiments performed, the authors reported that systematic increases in the amount of irrelevant information made the task increasingly difficult and resulted in a significant linear relationship (in terms of errors) up to around four bits of irrelevant information. However, the relationship seemed to become positively accelerated as a fifth bit was included. Later research involving the complexity variable (e.g. Bourne, 1957; Bourne and Pendleton, 1958; Pishkin, 1960) finds the relationship to contain more of a linear component rather than quadratic or accelerated, even with the fifth bit of irrelevant information included. Indeed, the complexity variable appears to be the most clear, stable, and repeatable effect found in studies involving concept identification.

Although the finding that the number of errors is linearly related to the number of dimensions has often appeared regularly, this finding has been incidental to that of other experimental variables being investigated. For example, some of the experimental variables which show significant main effects, along with the significant complexity main effect, include the following: delay of information feedback (Bourne, 1957); response tendencies (Pishkin, 1961b); redundant relevant information (Bourne and Haygood, 1959); intertrial interval (Bourne, Gury, Todd, and Justesen, 1965); electromyographical gradients (Pishkin and Wolfgang, 1964); sex and problems in auditory concept identification (Pishkin and Shurley, 1965); dimension availability and misinformation feedback (Pishkin, 1965); finally, social versus mechanical feedback (Lydecker, Pishkin, and Martin, 1961; Pishkin, 1963). Furthermore, in the above studies complexity was defined in terms of the increase in the number of irrelevant dimensions; however, two studies have investigated the effect of complexity defined somewhat differently. Walker and Bourne (1961), using all possible combinations of three independent levels of relevant and irrelevant dimensions in a factorial design, found that the most difficult problem was the one involving the three levels of relevant and three levels of irrelevant dimensions. Individual comparisons of the two variables showed that the amount of relevant information had the greatest effect on performance. Thus, as the number of independent relevant dimensions increase, so does problem difficulty. Here, "independent" refers to the fact that the relevant dimensions were not contingent upon or correlated with one another in any way. Finally, Battig and Bourne (1960) compared interdimensional variability (complexity in terms of irrelevant dimensions) and intradimensional variability (complexity in terms of number of values within a dimension) in a factorial design. The results revealed that both main effects of interdimensional and intradimensional were highly significant. Thus, it was demonstrated that complexity increased directly with the number of values per dimension. Furthermore, this effect did not interact with or change the basic relationship between performance and inter-dimensional variability.

Another source of interest in the complexity variable has centered around possible interactions with other experimental variables within the concept identification framework. Perhaps the most noted variable found to interact with complexity is that of "misinformation feedback." This interaction has been demonstrated by Bourne and Pendleton (1958); Morin (1955); Pishkin (1960, 1961a, 1965); Pishkin, Shurley, and Wolfgang (1967); Wolfgang, Pishkin, and Lundy (1962). Misinformation feedback has generally been defined as feedback which indicates to the subject that he had responded correctly (or incorrectly) when in fact the reverse was actually true. Pishkin (1960) demonstrated the nature of the interaction between complexity and misinformation (MF) which had been suggested in the Bourne and Pendleton study. Five percentages of MF (up to 40%) were combined in a factorial arrangement with three levels of complexity. The results showed that both main effects were significant; however, as irrelevant information increases misinformation feedback becomes increasingly disadvantageous to performance. Finally, Pishkin (1961a) attempted to demonstrate what effect the distribution of misinformation would have in concept identification. A factorial arrangement involving two levels of MF (which was distributed randomly or regularly over a specific number of trials), two levels of complexity, and three different problems were employed. All main effects, except problems, as well as the interaction of misinformation and complexity, were significant sources of variance. In addition to substantiating previous findings regarding MF and complexity (Pishkin, 1960), the results revealed that when the distribution of MF is more evenly distributed there is a less inhibiting effect upon performance.

In summary, it can be stated that the effect of the complexity variable within the CI framework is in every case unambiguous. Indeed, as Underwood (1949) suggested "(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," complexity has been defined independent of the subject's responses as well as described in strict mathematical theoretical terms. Perhaps, more than any other variable, complexity has been found to demonstrate stable and repeatable effects on the rate of CI.

Stimulus Redundancy

Shannon and Weaver (1949) in outlining their theory of communication defined redundancy as follows:

> One minus the relative entropy is called redundancy. This is the fraction of the structure of the message which is determined not by the free choice of the sender, but rather by the accepted statistical rules governing the use of the symbols in question. It is sensibly called redundancy. . . that is to say, this fraction of the message is unnecessary (and hence repetitive or redundant) in the sense that if it were missing the message would still be essentially complete, or at least could be completed [1949, p. 104].

Furthermore, Garner (1962) has pointed out that information theory techniques, in particular redundancy, have been applied to such areas of psychological investigation as perceptual discrimination, pattern perception, language, and concept formation.

Generally, the concept of redundancy has been experimentally defined in terms of the "amount" of redundancy and the "form" of redundancy. Amount of redundancy is defined as the number of stimulus patterns actually used relative to the total set of patterns generated by a given number of dimensions. Form of redundancy is defined as the particular patterns included, in order to make up a stimulus set, out of the total possible stimulus patterns that can be generated. Thus, for example, in a CI task, an experimenter may select five dimensions along which the stimuli may vary with each dimension having two levels. In this case the total possible number of different stimuli that may be constructed is 2^5 or 32 stimuli. Next, if the experimenter selects only four stimuli out of the 32 possible stimuli, then only two bivariate dimensions are necessary to generate the four independent stimulus events. In such a case, three of the five stimulus dimensions are present in the other two dimensions or in combinations of these two. Therefore, the amount of redundancy present is a function of the number of superfluous bivariate dimensions. In the sub-set of four, there are three bits of redundancy. The form of the redundancy may either be a direct contingency relationship, two redundant dimensions correlating perfectly with a third dimension, or an interaction contingency, a redundant variable correlating perfectly only through a combination of two other independent dimensions.

Most of the early experimental studies investigating the role of redundancy upon performance developed out of pattern identification or perceptual discrimination studies (e.g. Bricker, 1955; Deese, 1956; Rappaport, 1957). Most of these studies have reported that redundancy facilitated rapid discrimination or identification of visual patterns, particularly in the presence of background noise (irrelevant information). It wasn't until Bourne and Haygood (1959, 1961) as well as Haygood and Bourne (1964), working within the mathematical model of CI, that a series of studies using the concept of stimulus redundancy was reported. Initially, Bourne and Haygood (1959) conducted two experiments concerning the effects of stimulus redundancy in the relevant and irrelevant dimensions of a CI task. In the first investigation, the authors hypothesized that increasing the number of redundant relevant cues should increase the proportion of relevant cues available for subjects' use and thereby facilitate performance. Redundancy was introduced by adding one or more dimensions in a completely correlated fashion (direct contingency) to another relevant binary stimulus dimension used as a minimum. For example, if color (red, blue) is the one minimum relevant dimension, redundancy is introduced by correlating perfectly another dimension (e.g. form) to color, such that squares are always blue and triangles are always red. Here, one does not need to know the form of a pattern if he knows its color, for in a certain sense form is completely determined by color. The design of the experiment called for six levels of redundant, relevant information and three levels of non-redundant, irrelevant information arranged factorally. Although the design was incomplete (not all levels of relevant redundant dimensions were represented at levels of irrelevant dimensions), the results demonstrated that redundant relevant information improved concept learning performance and the amount of improvement increased with increasing noise or irrelevant information.

In the second experiment, redundancy was introduced into a set of irrelevant dimensions. Five levels of irrelevant, redundant information were combined with two levels of relevant information. A two choice and a four choice (two relevant bivariate dimensions) were employed in the investigation. The two choice problem was significantly easier than the four choice problem. Furthermore, as the number of irrelevant redundant dimensions increased, performance deteriorated; however, the inhibiting effect of irrelevant redundant dimensions was less than the effect obtained in comparable conditions of nonredundant irrelevant information.

In a follow-up study, Bourne and Haygood (1961) attempted to extend their findings by testing the effects of relevant redundant information in a noise free situation (no irrelevant information). Seven levels of relevant redundant dimensions with no irrelevant dimensions were employed. The results indicated that relevant redundancy facilitates rather than inhibits performance.

Overall, the above studies by Bourne and Haygood are, in general, only concerned with the amount of redundancy. That is, fewer patterns than the total number possible were used in the above studies which is consistent with Garner's (1962) definition of the amount of redundancy. Furthermore, the above studies were not concerned with the form of redundancy, although the particular form of redundancy used was the direct contingency type. However, as Garner points out, there are many other forms of redundancy which may produce differential effects on performance, irrespective of any concomitant variation in the amount of redundancy.

As Garner (1962) suggests redundancy can be established by interactions or combinations of dimensions. That is, redundancy could be established through a combination of one or more relevant or irrelevant dimensions. With this in mind, Haygood and Bourne (1964) explored the effects of two forms of relevant stimulus redundancy within a conjunctive concept identification problem (four response categories). Conventionally, such four-response problems have a unique solution in two binary dimensions, produced by the four conjunctive combinations of levels within the designated relevant dimensions. Within this framework, Haygood and Bourne introduced the two different forms of redundancy as follows: (1) Form A redundancy was established by correlating perfectly a third dimension with one of the initially relevant conjunctive dimensions. This is similar to the relevant redundancy situation established in previous studies (Bourne and Haygood, 1959, 1961). (2) Form B redundancy was established by correlating the levels of a third dimension with a combination (interaction) of both the initially relevant conjunctive dimensions. Furthermore, two control conditions were set up whereby the total number of patterns in the population was the same as in the redundancy conditions. Finally, these four types of relevant information (Form A, B; Control I, II) were varied independently along with increasing irrelevant information. The results not only confirmed Bourne and Haygood's (1959) previous study, but confirms Garner's (1962) expectation about the reliable difference between two forms of redundancy, independent of amount of redundancy. The results indicated that form A redundancy facilitated performance more than form B. Also, both types of redundancy improved performance over the two control conditions with control condition I being better than control condition II in performance.

Finally, it will be recalled that an interaction existed between the amount of redundancy and irrelevant information in the Bourne and Haygood study whereas in the 1964 study (Haygood and Bourne) no such interaction between form of redundancy and irrelevant information was found.

A few studies have concentrated more on response variables in a CI task involving stimulus redundancy situations. Peterson (1962) as well as Trabasso, Bower, Gelman, and Schaeffer (1966) report that with increasing degrees of relevant stimulus redundancy (direct contingency), subjects did not reliably report more than one relevant dimension for solving the problems. However, as redundancy increased, most subjects reported at least one correct dimension more frequently. Thus, it appears as though the subjects were focusing more on only one dimension.

In summary, it can be noted that this review of stimulus redundancy within the concept learning framework is not exhaustive; yet, in every case the effect is unambiguous. Indeed, relevant stimulus redundancy facilitates performance, particularly in the presence of noise (irrelevant information). Finally, Evans (1967) suggests, theoretically, that concept learning can be viewed as follows: the experimenter can be represented as the source and encoder of information, the patterns presented to the subject are represented as signals in the communication channel, and the subject is represented as the decoder. The advantage being that the uncertainty of the channel, measured in bits per signal or per pattern, may be much greater than the uncertainty of the subject's responses. Thus, the subject may reduce and refine the information it receives. If the channel contains redundancy or a combination of redundancy and noise, these may partly or wholly be removed by the subject, so that his output has fewer states than does the channel.

Schizophrenics, Redundancy, and CI

Relatively few studies have directly compared the performance of schizophrenics and normals on a CI task. Most of the studies have been concerned with the effect and/or manipulation of social cues in the experimental setting (e.g. Pishkin and Blanchard, 1963). However, recent CI studies (Pishkin and Bourne, in press; Lydecker, 1966) have suggested (a) that normals utilize more of the relevant stimulus information and learn at a faster rate than do schizophrenics, and (b) that schizophrenics tend to make more errors than normals as complexity increases. Furthermore, an extensive review of the literature has failed to reveal the utilization of the concept of stimulus redundancy in a concept learning task involving schizophrenics. Yet, evidence is available which suggests that redundancy has a differential effect upon information processing by schizophrenics depending upon the type of task employed.

Lawson, McGhie, and Chapman (1964) as well as Nidorf (1964) reported evidence that schizophrenics are able to repeat sentences of low redundancy (no contextual constraint) equally as well as normals, but schizophrenics do not improve to the same extent as normals when redundancy is increased. Lawson *et al*. concluded that it was the inability of the schizophrenics to screen out or filter the redundant words, which occur in most verbal communications, and, therefore, resulted in an overloading of the short-term memory system. Although the finding of this study was interpreted by the authors within the framework of a faulty attention mechanism, it does make contact with the findings on overinclusion in schizophrenics. Overinclusion is the tendency of schizophrenics to include irrelevancies in their concepts. In this respect, the schizophrenics in the Lawson _et al_. study may have been too overinclusive to ignore the distracting effects of the redundant words which consequently lead to a breakdown in information processing. Finally, recent studies (Payne _et al_., 1959; McGhie, 1966) have concluded that faulty attention, not overinclusion, is the fundamental cognitive defect in schizophrenia.

Other evidence points to the fact that redundancy of information facilitates rather than inhibits performance of schizophrenics on a variety of different tasks. Johannsen and Testin (1966) found that the basic perceptual functions of detection and stimulus identification are unimpaired by chronicity of schizophrenics under conditions of high stimulus redundancy. Furthermore, Pishkin, Smith, and Leibowitz (1962) as well as Pishkin (1966) found that schizophrenics with unlimited information performed on the same level as normals in a perceptual size judgment task. In each study, the schizophrenics tended to illuminate the perceptual field more often than did normals and thus required more redundant visual cues. Pishkin concludes by stating that:

> Schizophrenic _S_s required more information, as reflected by their need to illuminate the field significantly more frequently than normal _S_s before making a judgment. This particular finding supports original expectancies based on the notion schizophrenics' channel capacity is deficient and that schizophrenic _S_s may be more distractable and unable to utilize cues as effectively as normals [1966, p. 6].

In summararizing this work, several facts seem to emerge. First, although schizophrenics are capable of forming and identifying concepts, their performance tends to be poorer than normals, particularly as irrelevant information increases. Secondly, schizophrenics utilize less relevant stimulus information than do normals. Finally, redundancy of information seems to facilitate encoding of information, particularly in the presence of noise or irrelevant information. However, there does not appear to be unequivocal evidence for this last generalization. In some cases where noise or irrelevant information is absent, redundancy may inhibit the encoding of information (Rappaport, 1957; Lawson et al., 1964).

If these statements have any validity, then it would seem important to investigate the effect of stimulus redundancy in the identification of concepts by schizophrenics. That is, if a conceptual deficit in schizophrenia is due to an inability to screen out irrelevant information such that the primary processing channel is overloaded, then it would seem that redundancy of information may provide an effective means for overcoming perturbation in a stimulus brought on by noise or irrelevant information in a communication channel. In this sense relevant redundant information should provide additional cues for the schizophrenic to utilize in order to improve his efficiency in processing information. That is, in those situations where additional cues help the schizophrenic individual to overcome the distracting influences of irrelevant information or noise present in the stimulus, his performance on processing information would be more efficient. This has been demonstrated with normals (Bourne and Haygood, 1959, 1961). However, even though the schizophrenic's performance should improve, there is reason to doubt that his performance would reach the same level as the normal subject due to the possible distracting effects of the redundant cues or surplus information (Lawson *et al.*, 1964).

CHAPTER III

STATEMENT OF PROBLEM

The basic problem of the present investigation is the lack of understanding of the process by which schizophrenics identify concepts. More specifically, "Does the nature of the information to be processed influence the schizophrenic's capacity to identify concepts?" "How does the schizophrenic's approach to identifying concepts differ from the normal, if it does differ?" The attempt to answer the above questions has led to the investigation of four general areas. These areas are: (1) investigation of a conceptual deficit in schizophrenia, (2) the role of redundant information in information processing, (3) hypothesis behavior, and (4) concept identification.

First, the investigation of higher thought processes (conceptual behavior) has always been a prime objective in the study of schizophrenia. Such recent investigators as McGhie and Chapman (1962, 1963, 1964), Yates (1966b), and Buss and Lang (1965) can be mentioned to illustrate this area. These authors place emphasis upon impaired selective attention, on inability to process incoming information efficiently, and on abnormally slow rate of processing information as to the nature of this conceptual deficit.

A second area of investigation in the present study concerns the nature of the incoming information to be processed. The role of irrelevant information as well as redundant information has been clearly demonstrated in the information processing by normals (Bourne, 1957; Bourne and Haygood, 1959, 1961). However, in terms of the schizophrenic's processing, the relationships are more equivocal. Indeed, the role of redundancy has been demonstrated to have both a facilitating and/or an inhibiting effect upon information processing in schizophrenics. Such discrepant results point out differences in theoretical interpretation. Does redundant information act as a source of distraction or does redundant information facilitate transmission by reducing the potential amount of information to be transmitted?

There seem to be several questions regarding the present study which can be posed in the light of these two areas of investigation. What is the role of irrelevant information in the schizophrenic's capacity to process information and identify abstract concepts? Furthermore, what is the effect of stimulus redundancy in the schizophrenic's capacity to process information in the identification of abstract concepts? That is, does redundancy improve the schizophrenic's processing of information, especially in the presence of noise or irrelevant information or does redundancy act as an additional source of distraction which may impair performance, particularly in the presence of no irrelevant information?

The third area of investigation concerns the more efficient use of relevant information by normals in the identification of concepts as compared to schizophrenics (Pishkin and Bourne, in press). That is, does the normal person utilize an approach which differs from the schizophrenic in the processing of information and identifying of abstract concepts? Thus, Bourne (1965) in trying to develop a more complete description and understanding of human conceptual behavior by the subject's hypothesis behavior in relation to his category responses, reported that there were significant differences between more efficient and less efficient learners.

Finally, the attempt to answer these questions brings one to the fourth general area of investigation: the investigation of the role of stimulus redundancy, hypothesis behavior, and concept identification in normal subjects using standardized and quantifiable procedures. This area of investigation involves a combination of information theory principles and mathematical model approaches. That is, the specific model which antecedes the present experiment is that of Bourne and Restle (1959). Among the many experiments stimulated by this model, only a few have investigated redundancy and hypothesis behavior in concept identification (Bourne and Haygood, 1959, 1961; Haygood and Bourne, 1964; Bourne, 1965).

Present Study

The purposes of the present study are to investigate the performance of schizophrenics and normals in the identification of abstract concepts involving relevant stimulus redundancy and increasing irrelevant information (complexity), and to investigate the hypothesis behavior of these subject groups in relation to category responses and overall performance.

Of the main variables taken into consideration, one of the most reliable features of the concept identification work is the systematic manipulation of the difficulty level by increasing irrelevant information. In the CI model, a systematic manipulation of problem complexity can be defined independent of the subject's behavior. Furthermore, the complexity variable has been shown to influence the nature of information processing. In other words, the more the irrelevant information, the greater the inhibiting effect upon solution.

The second variable employed in the present study which has been shown to influence information processing and solution on CI problems is that of relevant stimulus redundancy. In CI work, relevant stimulus redundancy can be defined independent of the subject's behavior. In the present study, the form of the redundancy was defined as the perfect correlation (direct contingency) of the levels of two or more dimensions. Finally, relevant stimulus redundancy has been shown to influence the nature of information processing on a CI task. That is, redundancy facilitates information processing, particularly as irrelevant information increases. However, this has been demonstrated for normal subjects only. There have been no studies reported that have attempted to investigate the effect of relevant stimulus redundancy on CI problems involving a schizophrenic population. Thus, in addition to complexity and redundancy variables, the present study employed a group variable involving the use of schizophrenic patients.

The following main hypotheses were tested:

Considering the findings and assumptions of Chapman and McGhie (1963, 1964) as well as McGhie and Chapman (1965) that schizophrenics have an impaired selective attention, an inability to process incoming information efficiently, and a marked inability to attend selectively to stimuli in such a way that only relevant information is processed it was hypothesized that:

1. _A significantly greater number of CI errors will be observed in the schizophrenic group than in the normal control group._

Due to the consistent findings that complexity in a _CI_ task results in a greater increase in errors (Bourne, 1957; Pishkin, 1960) it is expected that:

2. _With increasing irrelevant dimensions (complexity), a greater number of CI errors will be expected in both groups._

According to McGhie and Chapman's formulation, schizophrenics tend to make a greater number of errors due to the distraction and overloading of increasing irrelevant information than do their normal counterparts. Furthermore, Pishkin and Bourne (in press) on a _CI_ task found that performance became progressively poorer when irrelevant information increased, especially the performance of schizophrenic subjects. Assuming the above to be the case, it was hypothesized that:

3. _With increasing irrelevant dimensions a relatively greater number of CI errors will result in the schizophrenic group as compared to the normal group._

In the Bourne and Haygood (1959, 1961) studies, where relevant redundancy was defined as the perfect correlation between two relevant dimensions, performance in the identification of abstract concepts improved when relevant redundancy was introduced into the _CI_ problems. Considering this finding, it was hypothesized that:

4. Increasing relevant redundancy will lead to improved CI performance (less CI errors) in both groups.

In addition, the Bourne and Haygood studies found that with redundancy the amount of improvement increased as the amount of irrelevant information increased, although this finding is not unequivocal (Haygood and Bourne, 1964). Here, it was hypothesized that:

5. Due to the hypothesized improved performance with the introduction of redundancy, an interaction between complexity and relevant redundancy is also expected; with relevant redundancy performance improving more as there is an increase in complexity.

According to Lawson et al. (1964), redundant elements of a stimulus may act as distractors for schizophrenics whereby their performance may be impaired, particularly with increasing redundant cues. In this sense, the stimulus patterns increase in complexity even though the same amount of information is transmitted. However, there is evidence that redundancy of information facilitates the schizophrenic's performance, particularly in the presence of irrelevant information (Johannsen and Testin, 1966; Pishkin, 1966). Furthermore, in the CI model relevant redundant cues increase the number of relevant cues and leads to improved performance (Bourne and Haygood, 1959). On the basis of such evidence, it is expected that:

6. The schizophrenic group will be expected to make more CI errors than the normal group as redundancy increases, even though their performance should improve with redundancy, particularly in the presence of irrelevant information.

Due to the findings of Bourne (1965) that there are significant differences between more efficient learners and less efficient learners in terms of their hypothesis behavior in relation to category responses it was hypothesized that:

7. _Normal subjects will start with a more encompassing initial hypothesis, keep the same hypothesis after a correct response more frequently, and be more consistent with previously presented information than will schizophrenic subjects._

CHAPTER IV

METHOD

Subjects

The subjects in the present investigation were patients from the Veterans Administration Hospital, Oklahoma City, Oklahoma. Fifty male schizophrenic patients and 50 male normals were selected against a strict criterion (Appendix I). Schizophrenic patients were drawn from both the inpatient wards and the day hospital units. Table 1 contains the diagnostic categories of the schizophrenic patients and the number of subjects in each category that participated in the present study. The control group was drawn from the orthopedic, general medical, and surgical wards of the hospital. Table 2 contains the distribution of hospital wards for normal patients and the number of subjects from each ward that participated in the study.

Table 1

Diagnostic Categories

Number of Subjects	Diagnosis
1	acute undifferentiated
1	catatonic
15	paranoid
33	chronic undifferentiated

Table 2

Distribution of Normal Patients

Number of Subjects	Ward
17	Orthopedic
21	General Medical
12	Surgical

The mean age for the schizophrenic group was 38.84 years, and for the normal group 38.46 years. A *t*-test indicated that this was not a significant difference. The mean educational level of the schizophrenic group was 11.0 years and for the normal group, 10.7 years. Again, a *t*-test indicated no significant difference.

Design

The experimental design was an incomplete 4 x 4 x 2 factorial: four levels of irrelevant (nonredundant) information, 0, 2, 4, and 6 irrelevant dimensions; four levels of relevant and redundant information, 1, 3, 5, and 7 dimensions; and two groups, schizophrenics and normals. The design is incomplete since not all levels of relevant information are represented at all levels of irrelevant information. The design was incomplete due to the fact that in practice only seven dimensions are equally salient for the subject. The stimulus dimensions used as relevant and irrelevant appear in Appendix II. Each subject performed individually and the dependent variables relevant to the factorial design were errors, trials to solution, talk time, and hypothesis behavior in relation to category responses.

Apparatus and Task

The apparatus is similar to that used by Wolfgang (1965). It consisted of an 8 x 12 inch opaque screen mounted on a 4 x 4 x 8 foot panel painted black. The panel screen was enclosed by a soundproof cubicle with a top and two sides. It was 63 inches high, 36 inches from front to back, and 48 inches in width. The stimulus instances of the concept were back-projected onto the screen by a Dunning Animatic 16 mm strip-film projector. The screen was situated at eye level on the panel, and just below this panel the subject's response panel is located. The Ss response panel contained seven hypothesis buttons and a correction button. The seven hypothesis buttons were labeled according to each of the stimulus dimensions (Appendix II) and the order of their appearance was randomized after every twenty subjects. The correction button was unlabeled and was of a different color from the seven dimension buttons. Immediately above the dimension buttons and correction button were two larger response category keys, identified by the letters A and B. Finally, positioned directly above each category response key was a small amber feedback light.

Behind and to one side of the subject's cubicle containing the screen and response panel was the E's control panel. This control panel was electronically connected to the Ss panel and contained seven dimension lights, two category lights, and two feedback keys. In addition, an Esterline-Angus 20-pen operations recorder was electronically connected to both the experimenter's and subject's panel board to record the subject's responses and the experimenter's feedback. In addition, the Esterline-Angus was connected to a throat microphone in conjunction with a noise operated relay (Hunter model 320s) which, when activated, automatically recorded each subject's frequency and duration of vocal and subvocal activity.

The subject's task was basically to solve a two-choice CI problem by categorizing a series of geometric patterns in accordance with a relevant dimension. In addition, the subject was to give his hypothesis on each trial by selecting one or more of the stimulus buttons he felt were correct for solution to the problem. The task was self-paced in that the subject progressed at his own rate.

Procedure

Upon their arrival at the experiment Ss were administered the vocabulary and abstract portions (scores are in Appendix IV) of the Shipley Institute of Living Scale (Shipley, 1940). This test was administered by E in a small anteroom across from the main experimental room. All Ss were then ushered into the soundproof CI room and seated inside the cubicle (used to reduce apparatus noise). The cubicle was so arranged that the subject could clearly view only the screen and response panel. The throat microphone was placed around the subject's neck and the instructions were read to him (Appendix III). After instructing the subject as to the nature of the task, the meaning of the feedback lights, and the manipulation of the response controls, E returned to his control panel and began the examples and the experiment proper.

The experimental task was begun by having the subject view a geometric pattern projected on the screen directly in front of him and at eye level. After a self-determined time, the subject responded by pressing one or more stimulus dimension buttons (Hypothesis) and by pressing one of the two category response keys. The depressed stimulus dimension button or buttons initiated a signal or signals that triggered corresponding lights on the experimentor's panel and which recorded the S's choice or choices on the chart of the Esterline-Angus recorder. The depressed stimulus dimension buttons stayed in a down position (continuous signal) until the subject pressed one of the two category response keys. When the subject pressed one of the two category keys, a light (A or B) on the experimenter's panel indicated the subject's choice; then the experimenter, using a planned program of information feedback coordinated with the filmstrip programming, depressed a key which lit up one of the amber feedback lights (A or B) on the subject's panel for approximately one second, indicating to the subject the correctness of his response. Both the subject's category response and feedback were recorded on the Esterline-Angus recorder. In addition, as the subject depressed one of the category keys, the stimulus dimension button or buttons returned to their original ready position. Finally, as E depressed the appropriate feedback key, for approximately 1 second, an electronic timer was triggered which automatically advanced the filmstrip to a blank frame for 4 seconds, and then to the next geometric pattern allowing the subject to start another trial after his last response. Criterion to solution for all subjects was 16 consecutive correct responses or a maximum of 192 trials.

Ten strip-filmed series of patterns were used; four each had one relevant dimension and either 0, 2, 4, or 6 irrelevant dimensions; three had 0 irrelevant dimensions and either 3, 5, or 7 relevant redundant dimensions; and the last three had a combination of 3 or 5 relevant redundant dimensions and 2 or 4 irrelevant dimensions (Appendix II). The relevant dimension is that property of the pattern, which, when identified by the subject, enables him to press the appropriate category key as well as state the appropriate hypothesis for a correct solution. An irrelevant dimension had a zero correlation with the correct response. When a particular dimension was neither relevant nor irrelevant, it appeared without variation at only one of its two levels within a given series. Redundancy was introduced by adding one or more dimensions in a completely correlated fashion (direct contingency) to another relevant binary stimulus dimension used as a minimum. For instance, if color and form are relevant and redundant, then squares are always red and triangles are always blue. Finally, it should be noted that the stimulus dimensions were always available to the subject. In this way, Pishkin (1965) has shown that not only does performance on a CI task improve, but apparently the availability of the dimensions serves to limit the number of possible hypotheses the subjects must consider.

Following the above experimental procedure, each S was given the following psychometric test:

Test of Behavioral Rigidity (Schaie, 1955)

Since it has been demonstrated that schizophrenics in comparison to normals manifest certain response sets such as position bias or perserveration tendencies as well as being more rigid on a conceptual task (Fey, 1954), it was felt that the inclusion of a measure of behavioral rigidity, in order to correlate such measures with CI performance and hypothesis behavior, would be appropriate. This instrument yields three measures: (a) motor-cognitive rigidity, (b) personality-perceptual rigidity, and (c) psychomotor speed.

CHAPTER V

RESULTS

Since the instructions stressed accuracy, the number of errors was the main dependent variable. However, upon inspection of the data, it was noted that variance differences for the error scores in the normal and schizophrenic groups were quite large. Cochran's test of homogenity (Winer, 1962) revealed that for normal's ($\underline{C}$ = .916, $\underline{df}$ =4, $\underline{p}$ <.01) and schizophrenic's ($\underline{C}$ = 1.081, $\underline{df}$ = 4, $\underline{p}$ <.01) error scores, there was significant heterogeneity. Due to the marked heterogeneity (the difference between the largest and smallest variance was well over 100), a log transformation upon all error scores was performed which resulted in homogeneity of variance.

Analysis of Error Scores

The structure of the design necessitated several statistical analyses in order to determine the significance of the relevant redundant information source, the population source, and the complexity source. In accordance, analyses of variance were computed at each level of irrelevant information, at the one relevant dimension level, on six groups with 1 or 3 relevant dimensions and 0, 2, or 4 irrelevant dimensions, and on six groups with 1, 3, or 5 relevant dimensions and 0, or 2 irrelevant dimensions. The results of these analyses are shown in Table 3.

As expected, the main effects of relevant redundant dimensions (_R_) was significant. This indicated that with complexity (_C_) and populations (_P_) pooled, fewer log mean errors were made with the introduction of redundant dimensions. At the 0 and 2 irrelevant dimension level, the number of _R_ dimensions were significant (section _A_ and _B_ of Table 3) beyond the .05 level, but with 4 irrelevant dimensions the number of _R_ dimensions was significant (section _C_) beyond the .001 level. Furthermore, an analysis performed on the six groups with 1 or 3 relevant dimensions and 0, 2, or 4 irrelevant dimensions (section _F_) revealed a significant _R_ x _C_ interaction ($F = 5.009$, 2 and 48 _df_, $p < .05$). This indicated, as does Figure 1, that with the introduction of redundant dimensions fewer log mean errors occurred and the amount of decrease in errors was greater as the number of irrelevant dimensions increased. Subsequent analysis with Duncan's (1955) multiple range test revealed that at each level of irrelevant information the greatest log mean errors were produced on the one relevant dimension condition as compared to the relevant redundant dimension conditions (_df_ = 32, $p < .05$; _df_ = 24, $p < .05$; _df_ = 16, $p < .001$ respectively). At the 0 and 2 levels of complexity, no significant differences were manifested between relevant redundant conditions (_df_ = 32, $p > .05$; _df_ = 24, $p > .05$ respectively). It is interesting to note that the _R_ x _C_ interaction was found only in the analysis performed on the six groups involving 1 and 3 relevant dimensions and 0, 2, or 4 irrelevant dimensions (section _F_). The _R_ x _C_ interaction in the analysis on the six groups involving 1, 3, or 5 relevant dimensions and 0 and 2 irrelevant dimensions was not signifi-

Table 3

Analysis of Variance of Log Errors
(Relevant Redundancy [R], Complexity [C], Population [P])

Source	df	MS	F	p
(SECTION A) - 0 irrelevant information level				
R	3	.32904	3.823	.05
(Linear)	1	.31371	3.650	.07
(Quadratic)	1	.58389	6.784	.05
P	1	.16137	1.875	NS
RP	3	.11410	1.325	NS
Error	32	.08607		
(SECTION B) - 2 irrelevant dimension level				
R	2	1.581	4.489	.05
(Linear)	1	2.599	7.379	.05
(Quadratic)	1	.56302	1.598	NS
P	1	1.186	3.367	.09
RP	2	.004		
Error	24	.352		
(SECTION C) - 4 irrelevant dimension level				
R	1	7.8494	96.882	.001
P	1	.7609	9.392	.01
RP	1	.1120	1.382	NS
Error	16	.08102		
(SECTION D) - 6 irrelevant dimension level				
P	1	.97363	7.646	.05
Error	8			

(Table 3 continued on next page)

Table 3 -- continued

Source	df	MS	F	p
(SECTION E) - 1 relevant dimension level				
C	3	3.71739	20.360	.001
(Linear)	1	9.525	52.167	.001
(Quadratic)	1	1.02947	5.638	.05
P	1	1.23633	6.771	.05
CP	3	.1309	---	
Error	32	.18258		
(SECTION F) - 0, 2, or 4 irrelevant dimension levels and 1, or 3 relevant dimension levels				
C	2	3.870	20.395	.001
(Linear)	1	7.73326	40.751	.001
(Quadratic)	1	.00764		
R	1	8.8898	46.845	.001
P	1	1.10498	5.823	.05
CR	2	.95065	5.009	.05
CP	1	.236	1.244	NS
RP	1	.0017		
CRP	2	.0749		
Error	48	.18977		
(SECTION G) - 0, or 2 irrelevant dimension levels and 1, 3, or 5 relevant dimension levels				
C	1	1.68964	8.294	.01
R	2	1.90043	9.328	.001
(Linear)	1	2.90919	14.280	.001
(Quadratic)	1	.89165	4.377	.05
P	1	.67138	3.295	.09
CR	2	.17175		
CP	1	.51937	2.549	NS
RP	2	.01736		
CRP	2	.00283		
Error	48	.20373		

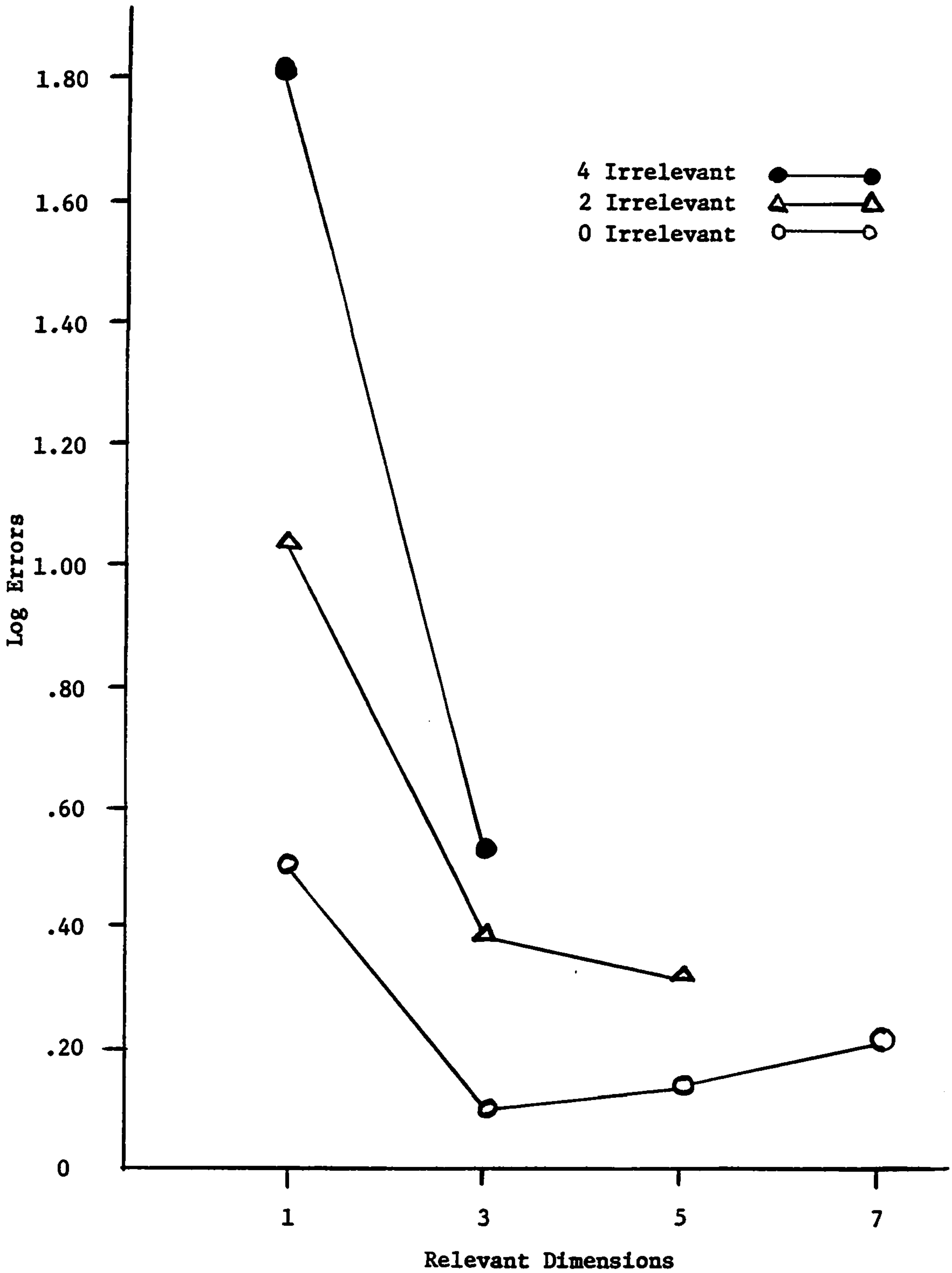

Figure 1. Mean log errors for 0, 2, and 4 irrelevant dimensions at different levels of relevant dimensions. (Irrelevant dimensions by relevant dimensions with groups pooled.) Each point represents an N of 10.

cant (section G). Overall, the results regarding the R main effect and the R x C interaction are consistent with the findings obtained by Bourne and Haygood (1959; 1961).

As expected, the C main effect was significant (section E). This indicated, as does Figure 2, that as the amount of irrelevant information increased, log mean errors progressively increased up to the four irrelevant dimension level. Subsequent analysis with Duncan's (1955) test indicated that there were significant differences in mean errors between complexity levels 6 and 2 ($df = 32$, $p < .01$), 6 and 0 ($df = 32$, $p < .01$), 4 and 2 ($df = 32$, $p < .01$), 4 and 0 ($df = 32$, $p < .01$), 2 and 0 ($df = 32$, $p < .01$), but not between 6 and 4 (df 32, $p > .01$).

Orthogonal polynomial analyses computed for the R main effect and the C main effect reveal interesting differences in the performances of normals and schizophrenics. In terms of the R main effect, trend analysis at the 0 complexity level (section A) revealed a significant guadratic component ($F = 6.784$, 1 and 32 df, $p < .05$) accounting for 59% of the variance and a linear component which did not quite reach significance ($F = 3.645$, 1 and 32 df, $p < .07$) that accounted for 32% of the variance. However, at the 2 complexity level (section B) only the linear component reached significance ($F = 7.379$, 1 and 24 df, $p < .05$). The reason for such findings is that at the 0 level of complexity, Figure 3, normal's performance continues to improve, reaching 0 errors in the 7 relevant redundant condition, whereas schizophrenic's performance becomes progressively inferior as relevant redundancy increases beyond 3 relevant redundant dimensions. A t-test between normals and schizophrenics in the 7 relevant redundant condition

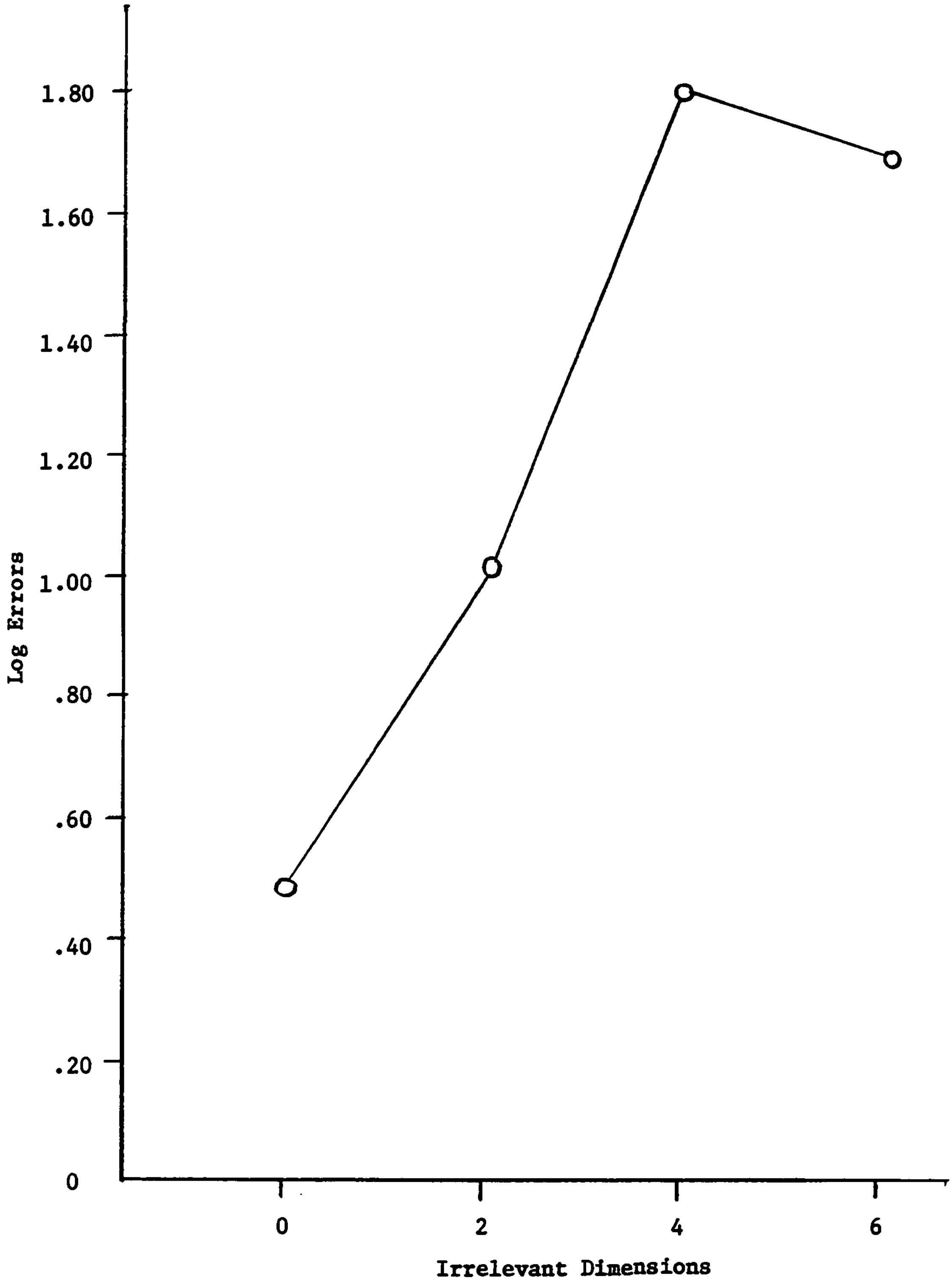

Figure 2. Mean log errors for 1 relevant dimension at different levels of complexity (Groups are pooled). Each point represents an N of 10.

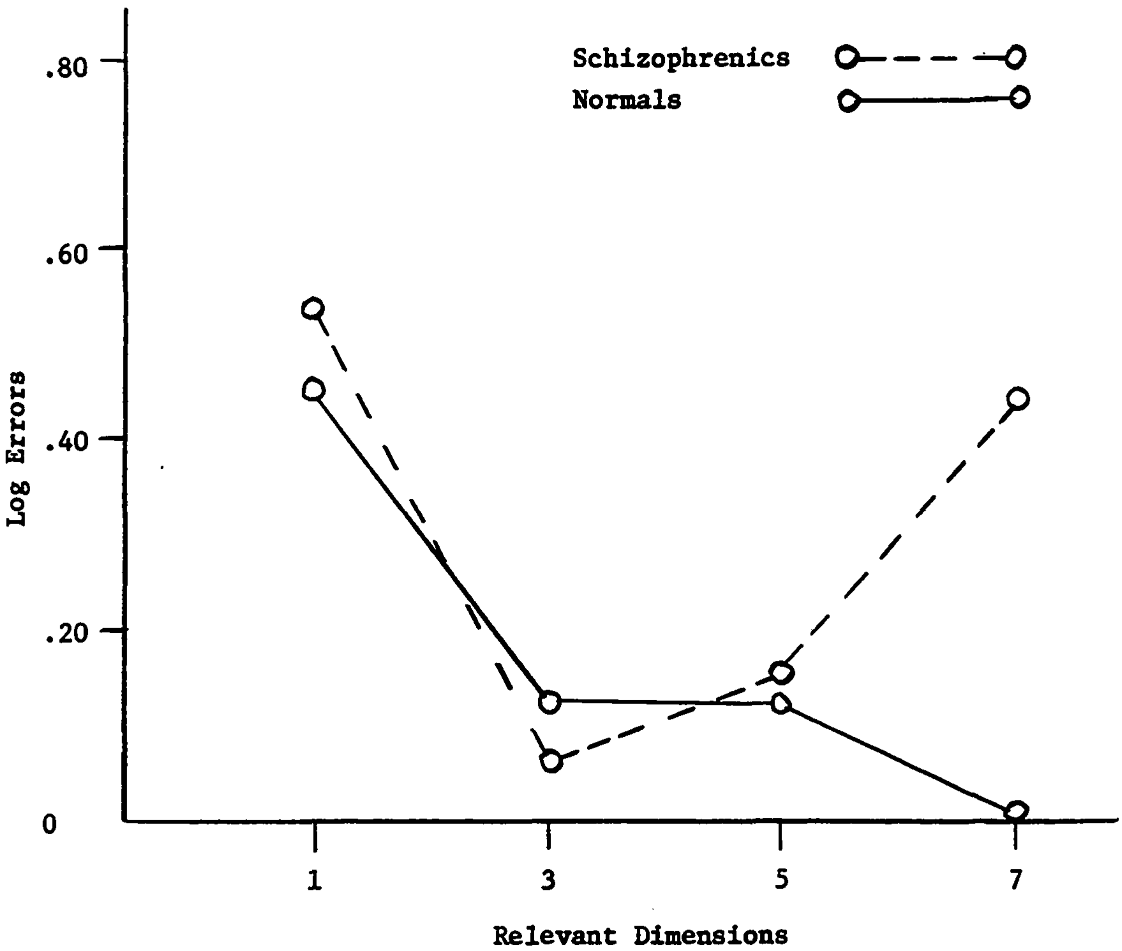

Figure 3. Mean log errors for normals and schizophrenics at different levels of relevant dimensions with 0 bits of irrelevant information. Each point represents an N of 5.

approached significance (t = 1.616, 8 df, p <.08), indicating that schizophrenics had a tendency to make more errors. In terms of the C main effect, trend analysis at the 1 relevant dimension level (section E) revealed a significant linear component (F = 52.167, 1 and 32 df, p <.001) accounting for 85% of the variance as well as a significant quadratic component (F = 5.638, 1 and 32 df, p <.05) accounting for 9% of the variance. As illustrated in Figure 4, both normals and schizophrenics show a linear increase in errors up to the 4 complexity level at which point normals show a decrease in errors. An analysis of variance computed at the 6 irrelevant dimension level (section D) revealed a significant difference between schizophrenics and normals with normals making less errors (F = 7.646, 1 and 3 df, p <.05). In general, the significance of the C source was somewhat consistent with the results obtained by several previous CI investigators (Archer, Bourne, and Brown, 1955; Bourne, 1957; Pishkin, 1960; Burn, 1967).

In terms of the significance of the population (P) source, results in Table 3 indicate significant P main effects at the 4 and 6 levels of irrelevant information (section C and D), at the 1 relevant dimension level (section E), and in the six groups with 1 or 3 relevant dimensions and 0, 2, or 4 irrelevant dimensions (section F). In each case schizophrenics had larger log mean errors than normals, but only at the higher levels of complexity (4 and 6 irrelevant dimensions). Although the hypothesized C x P and R x P interactions were not significant (Table 3), Figures 5 and 3 indicate that schizophrenics had a tendency to make more CI errors than do normals as complexity increased. Furthermore, schizophrenics do not benefit from relevant

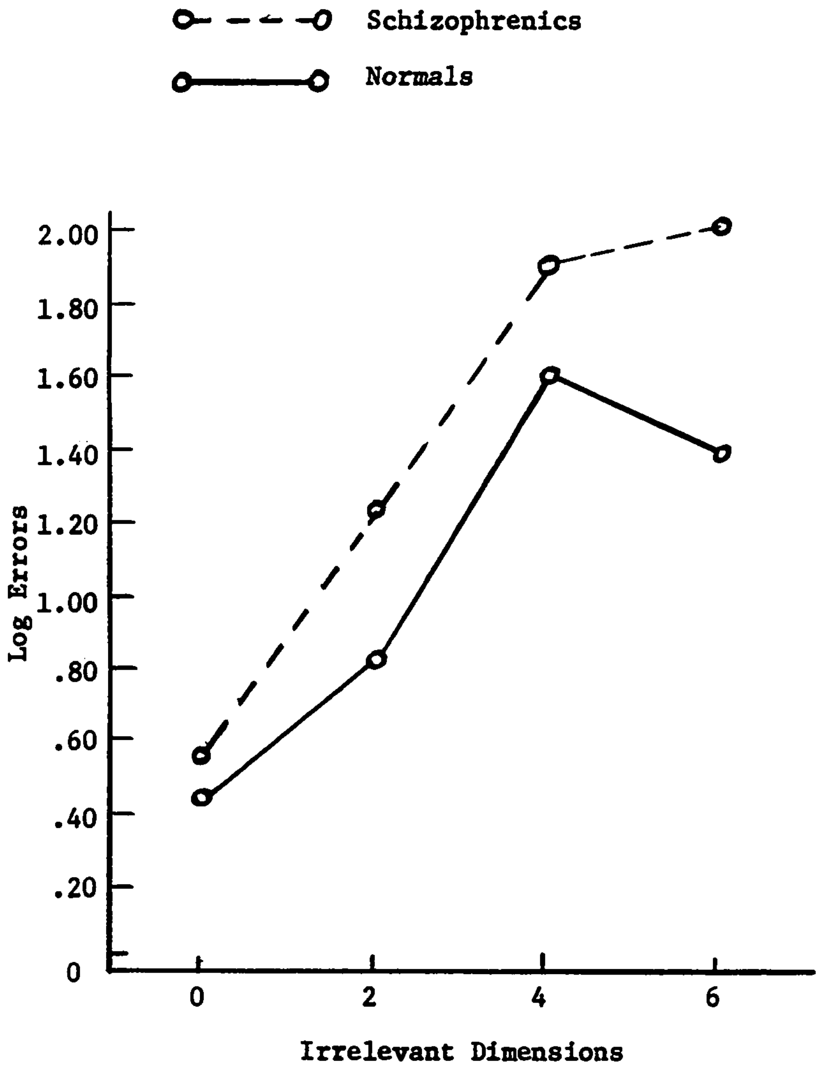

Figure 4. Mean log errors for normals and schizophrenics at different levels of complexity with 1 bit of relevant information. Each point represents an N of 5.

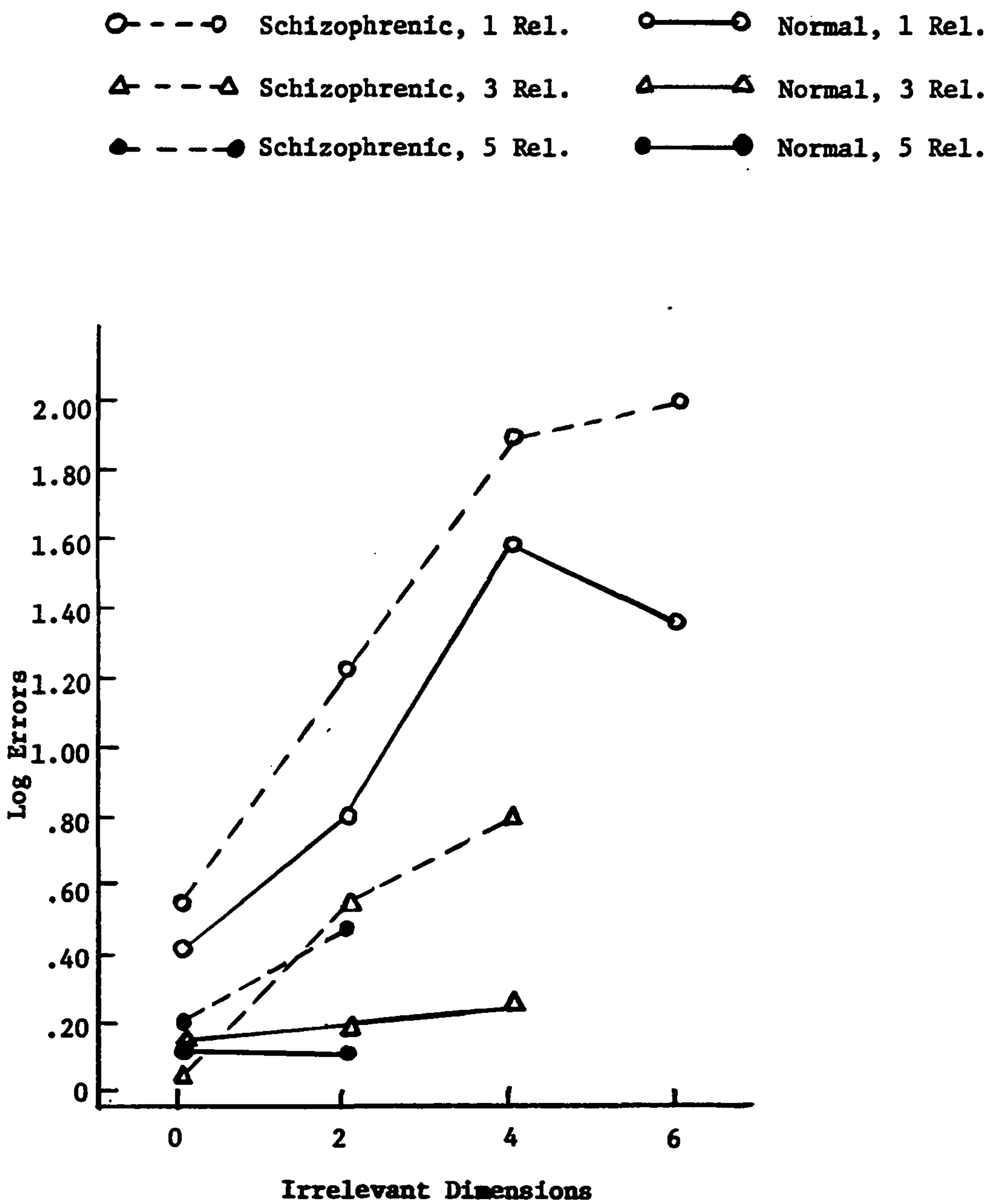

Figure 5. Mean log errors for normals and schizophrenics at different levels of complexity with 1, 3, and 5 relevant dimensions. Each point represents an N of 5.

redundancy as much as normals, particularly with 0 irrelevant dimensions. Finally, a _t_-test computed on the 3 relevant redundant and 4 irrelevant dimension conditions (Figure 5) revealed that schizophrenics make significantly more errors than normals ($t = 2.71$, 8 _df_, $p < .05$). Thus, even though the schizophrenic's performance improved with redundancy in the presence of irrelevant information, there still was a tendency for him to make more errors.

Analysis of Trials

Due to the marked heterogeneity of variance, the $\log_{10}$ of the number of errors per block of 16 trials plus 1 served as the transformed score and was used in the analysis of variance. In accordance with the structure of the design, several analyses of variance were performed following the format of the error analyses. The results of these analyses are presented in Table 4.

In each analysis of Table 4 the _T_ main effect was significant beyond the .001 level. This indicated that log mean errors progressively decreased over trial blocks. The _T_ main effect is further elaborated by certain interactions. First, the significant _C_ x _T_ interaction (section _E_ of Table 4), as does Figure 6, indicates that as complexity increases the number of trials increased. Secondly, the significant _T_ x _R_ interaction (section _A_, _B_, _C_, _F_, and _G_), as does Figure 7, suggests that with increasing relevant redundancy fewer trials occurred as compared to the 1 relevant dimension level (no redundancy). Finally, the significant _C_ x _T_ x _R_ interactions (section _F_ and _G_) emphasizes the significant trends found in the _T_ x _C_ and _T_ x _R_ interaction terms.

Table 4

Analysis of Variance of Log Trials (T)

Source	*df*	*MS*	*F*	*p*
(SECTION *A*) - 0 irrelevant level				
T	11	.15232	65.370	.001
TR	33	.03213	13.789	.001
TP	11	.01081	4.64	.01
TRP	33	.01098	4.712	.01
Error	352	.00233		
(SECTION *B*) - 2 irrelevant level				
T	11	.2364	10.814	.001
TR	22	.03561	1.629	.05
TP	11	.01661		
TRP	22	.02140		
Error	264	.02186		
(SECTION *C*) - 4 irrelevant level				
T	11	.40966	10.671	.001
TR	11	.10457	2.724	.01
TP	11	.01998		
TRP	11	.09029	2.3519	.05
Error	176	.03839		
(SECTION *D*) - 6 irrelevant level				
T	11	.1084	3.589	.001
TP	11	.09134	3.024	.001
Error	88	.03020		

(Table 4 continued on next page)

Table 4 - continued

Source	df	MS	F	p
(SECTION E) - 1 relevant dimension level				
T	11	.64004	18.461	.001
TC	33	.05353	1.544	.05
TP	11	.07032	2.028	.05
TCP	33	.04060	1.171	NS
Error	352	.03467		
(SECTION F) - 0, 2, or 4 irrelevant dimension levels and 1 or 3 relevant dimension levels				
T	11	.62185	27.961	.001
TC	22	.04968	2.234	.01
TR	11	.09553	4.295	.001
TP	11	.00704		
TCR	22	.06508	2.926	.01
TCP	22	.01453		
TRP	11	.02979	1.34	NS
TCRP	22	.04097	1.842	.05
Error	528	.02224		
(SECTION G) - 0 or 2 irrelevant dimension levels and 1, 3, or 5 relevant dimension levels				
T	11	.34467	26.032	.001
TC	11	.02736	2.066	.05
TR	22	.05182	3.914	.001
TP	11	.00937		
TCR	22	.02217	1.674	.05
TCP	11	.00792		
TRP	22	.01390	1.0498	NS
TCRP	22	.01089		
Error	528	.01324		

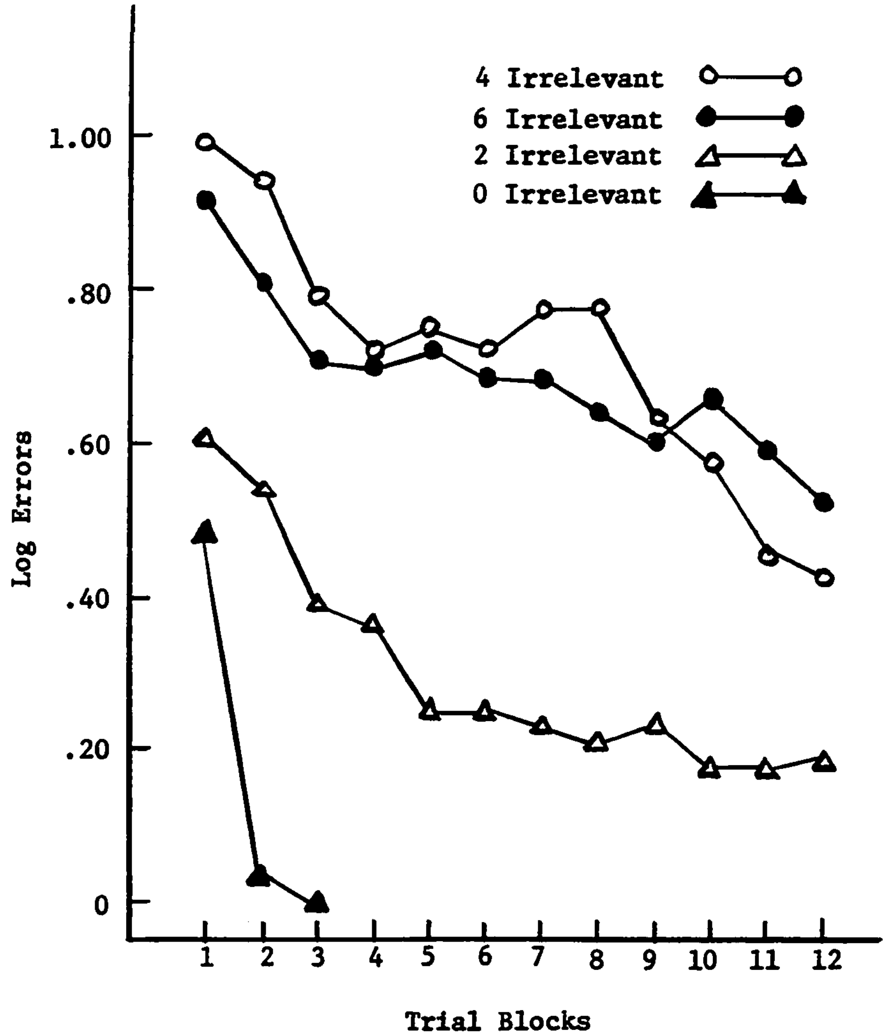

Figure 6. Mean log errors per block of 16 trials as a function of different complexity levels with 1 bit of relevant information. (Groups are pooled.) Each point represents an N of 10.

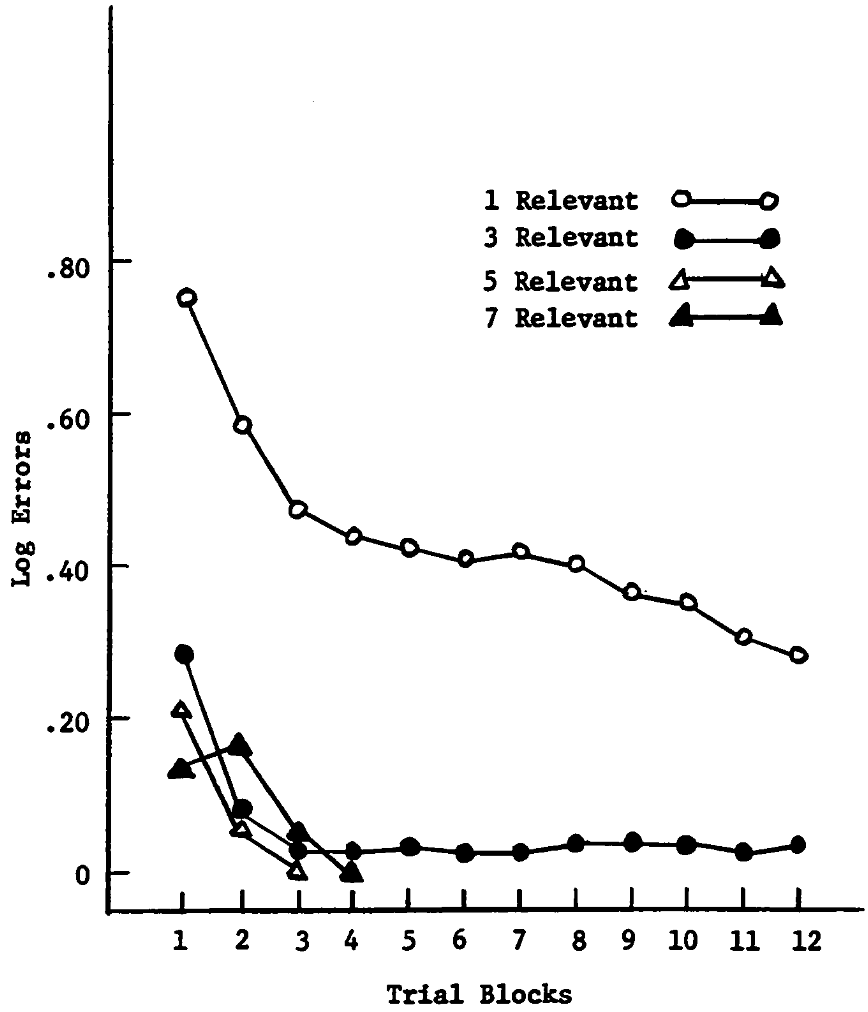

Figure 7. Mean log errors per block of 16 trials as a function of different levels of relevant information. Ns corresponding to the various points are: with 1 relevant dimension = 40, 3 relevant dimensions = 30, 5 relevant dimensions = 20, 7 relevant dimensions = 10.

It is noteworthy that over trial blocks learning becomes progressively slower when there is increasing irrelevant dimensions and no redundant dimensions (1 relevant dimension) whereas learning improves when relevant redundancy is introduced, particularly in the presence of irrelevant information.

In terms of learning curves, Figures 8 and 9 show normal's and schizophrenic's learning curves in each of the ten conditions. As expected, normals (Figure 8) performed consistently better on those conditions which involved relevant redundancy. Furthermore, the learning curves of the normals improved consistently as the number of redundant dimensions exceeded the number of irrelevant dimensions. On the other hand, schizophrenic's (Figure 9) performance was less facilitated by redundancy. In fact, schizophrenics performed poorer as the patterns became more complex (actual stimulus uncertainty) either by adding irrelevant dimensions or redundant dimensions. Additional support can be found in Table 4 where several $\underline{T} \times \underline{P}$ interactions were significant.

First, at the 0 irrelevant information level (section $\underline{A}$) a significant $\underline{T} \times \underline{P}$ interaction ($\underline{F} = 4.64$, 352 $\underline{df}$, $\underline{p} < .01$) indicates that schizophrenics performed poorer than normals across all blocks of trials, particularly on the first two blocks. Furthermore, a significant $\underline{T} \times \underline{R} \times \underline{P}$ interaction ($\underline{F} = 4.71$, 352 $\underline{df}$, $\underline{p} < .01$) emphasizes the trend in the $\underline{T} \times \underline{P}$ interaction. It is noteworthy that the schizophrenic's poorer performance resulted from the 7 relevant redundant condition in which their log mean errors were $\bar{x} = .43166$ as compared to the normal's $\bar{x} = 0.00$. At the 4 irrelevant level (section $\underline{C}$), Figure 10 illustrates the significant trends found in the $\underline{T} \times \underline{R} \times \underline{P}$ interaction

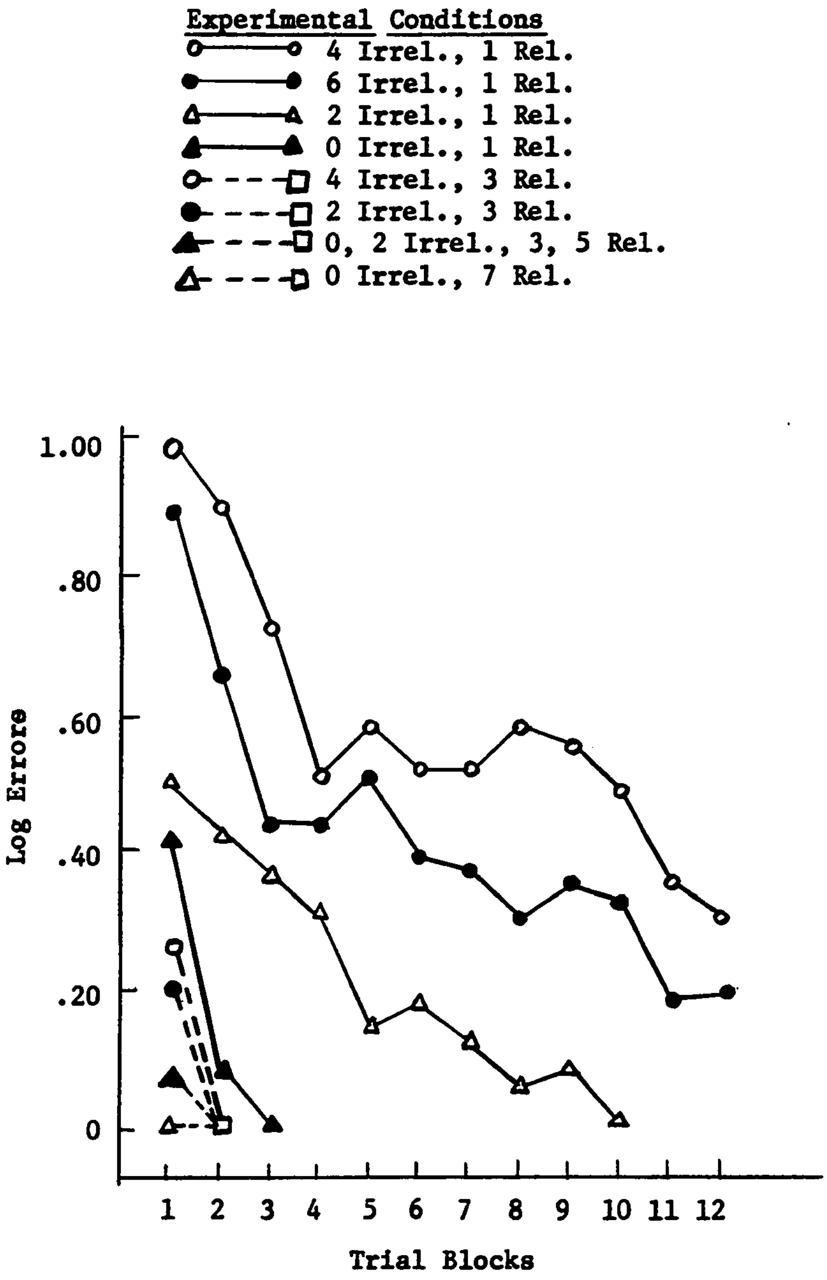

Figure 8. Mean log errors per block of 16 trials for normals as a function of different experimental conditions (See Appendix II). Each point represents an N of 5.

Experimental Conditions

6 Irrel., 1 Rel.
4 Irrel., 1 Rel.
2 Irrel., 1 Rel.
0 Irrel., 1 Rel.
4 Irrel., 3 Rel.
2 Irrel., 5 Rel.
2 Irrel., 3 Rel.
0 Irrel., 7 Rel.
0 Irrel., 5 Rel.
0 Irrel., 3 Rel.

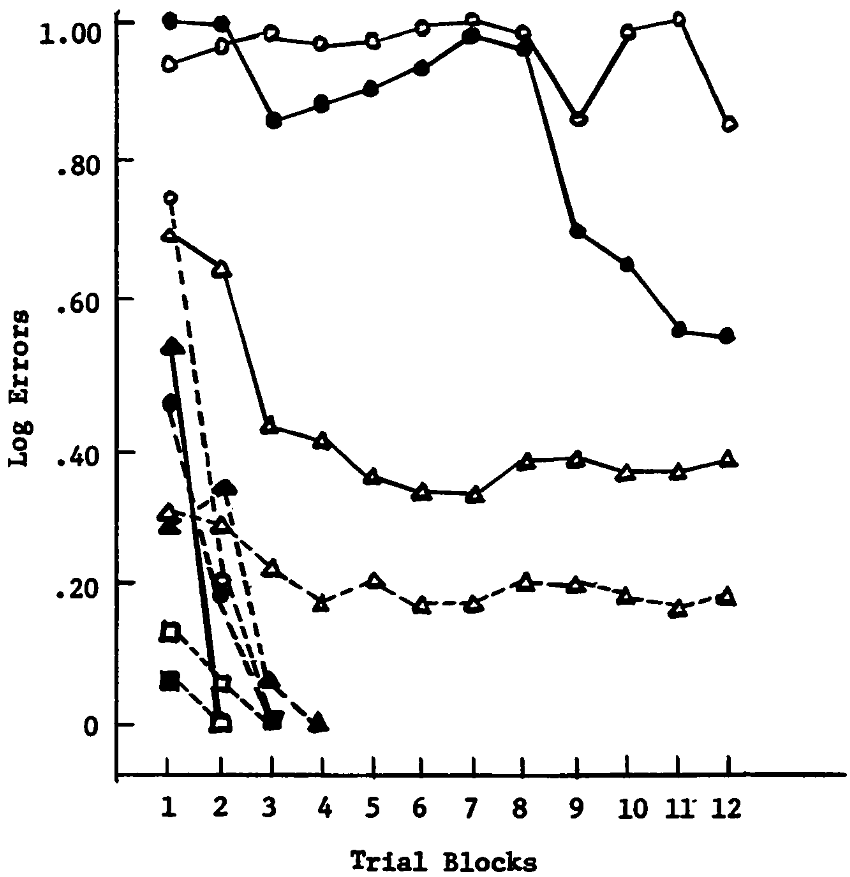

Figure 9. Mean log errors per block of 16 trials for schizophrenics as a function of different experimental conditions (See Appendix II). Each point represents an $\underline{N}$ of 5.

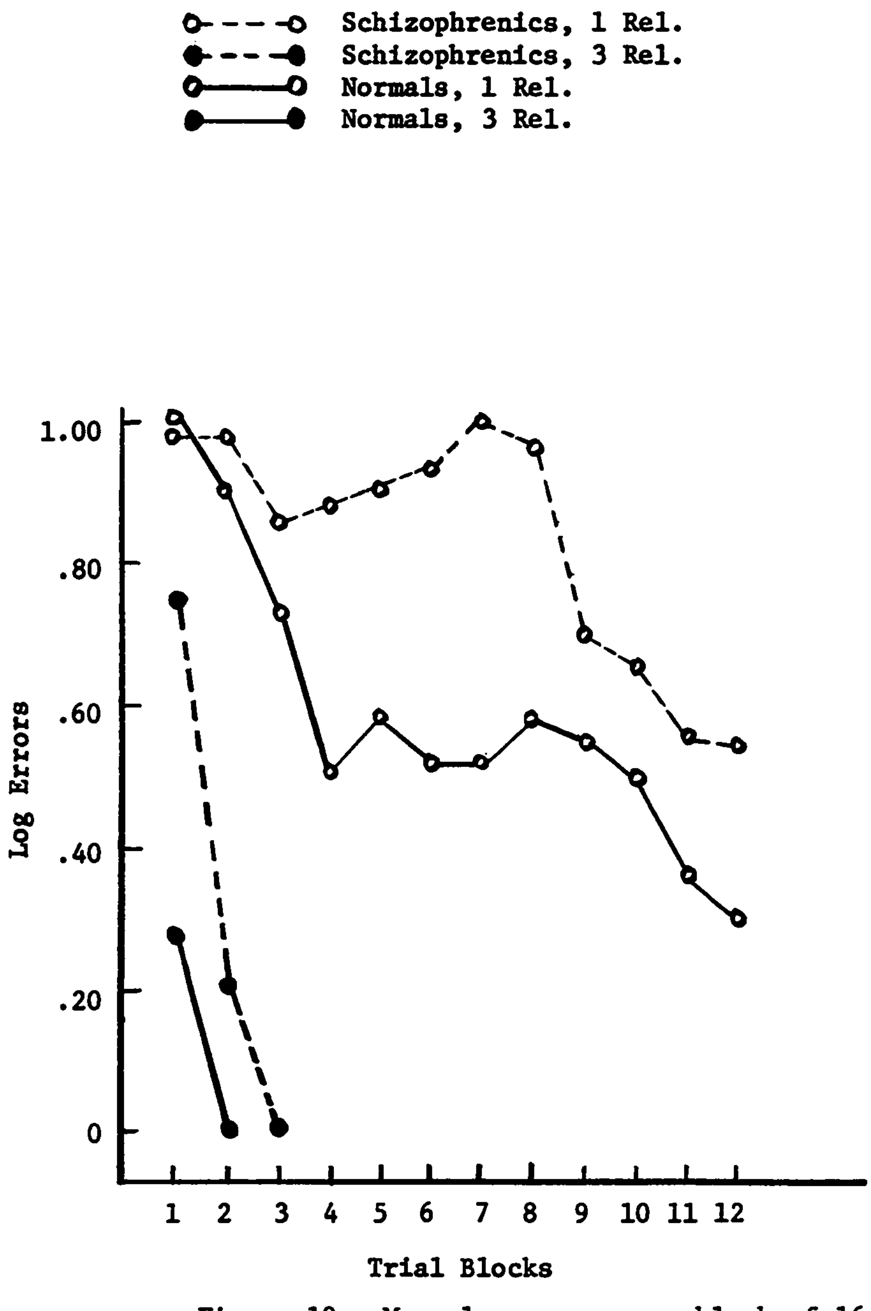

Figure 10. Mean log errors per block of 16 trials for normals and schizophrenics as a function of 1 and 3 relevant dimensions with 4 bits of irrelevant information. Each point represents an N of 5.

(F = 2.35, 176 df, p <.05). As can be seen normals perform consistently better than schizophrenics at both the 1 and 3 relevant dimension levels, even though both group's performances improve as redundancy increases. However, perhaps the clearest demonstration that schizophrenics have difficulty in identifying concepts with increasing irrelevant information is illustrated in Figure 11. As can be seen, at the 6 irrelevant dimension level, schizophrenics show no learning whatsoever as compared to the normal group. This is supported by a significant T x P interaction (F = 3.024, 88 df, p <.001) at the 6 irrelevant level (section D). Other support is found at the 1 relevant dimension level (section E). Here again, a significant T x P interaction (F = 2.028, 352 df, p <.05) indicates that with complexity pooled normals consistently outperformed schizophrenics across all blocks of trials. Overall, the significant trends involving T, C, R, and P found in the several trial analyses are emphasized in the significant T x C x R x P interaction term (F = 1.842, 528 df, p <.05) found in the analysis performed on the six groups involving 1 or 3 relevant dimensions and 0, 2, or 4 irrelevant dimensions (section F). In this case, Figures 12 and 13, as well as 14 (included for comparison only) show the learning curves for both populations at either the 0, 2, or 4 irrelevant levels for either the 1, 3, or 5 relevant dimension levels. It is interesting to note that at the 1 relevant dimension level normals consistently outperform schizophrenics only with the introduction of irrelevant information; however, at the 3 relevant dimension level, with the introduction of relevant redundancy, normals consistently reached solution on the second block of trials whereas schizophrenics did so only with no irrelevant information

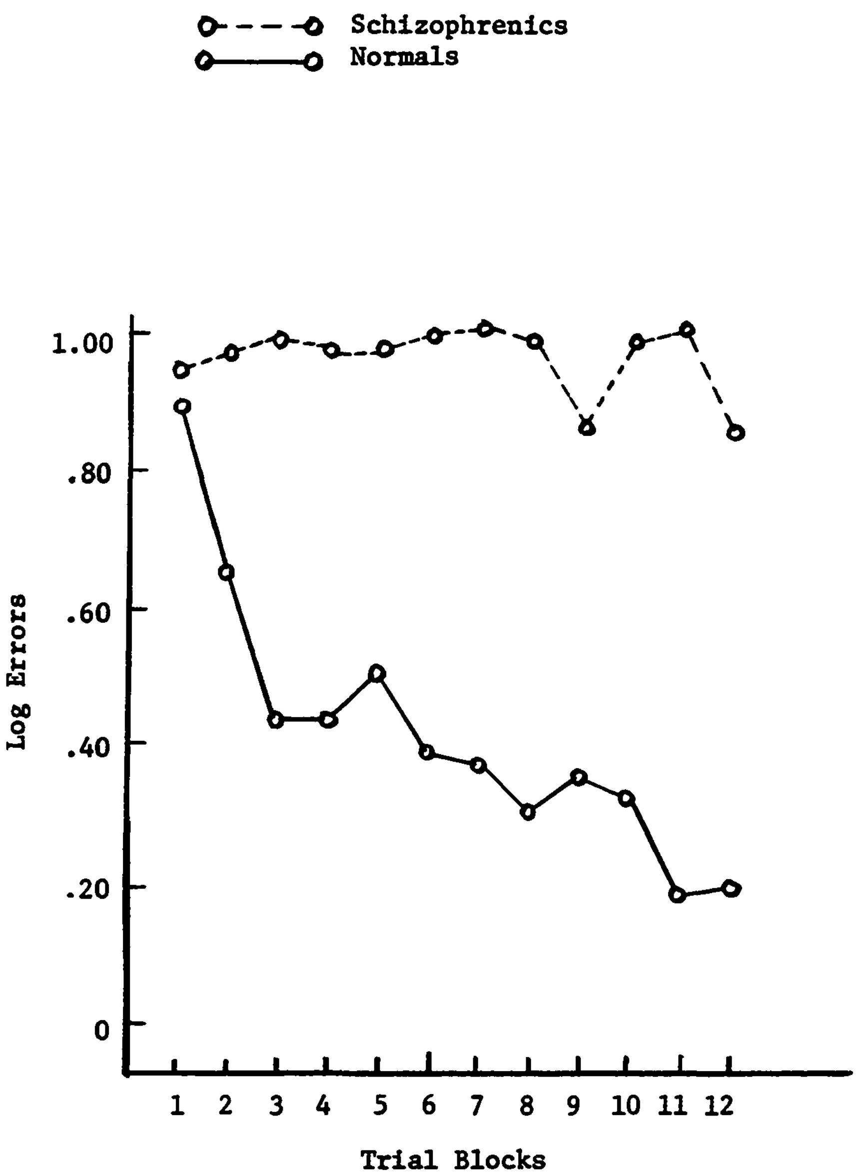

Figure 11. Mean log errors per block of 16 trials for normals and schizophrenics as a function of 6 bits of irrelevant information. Each point represents an N of 5.

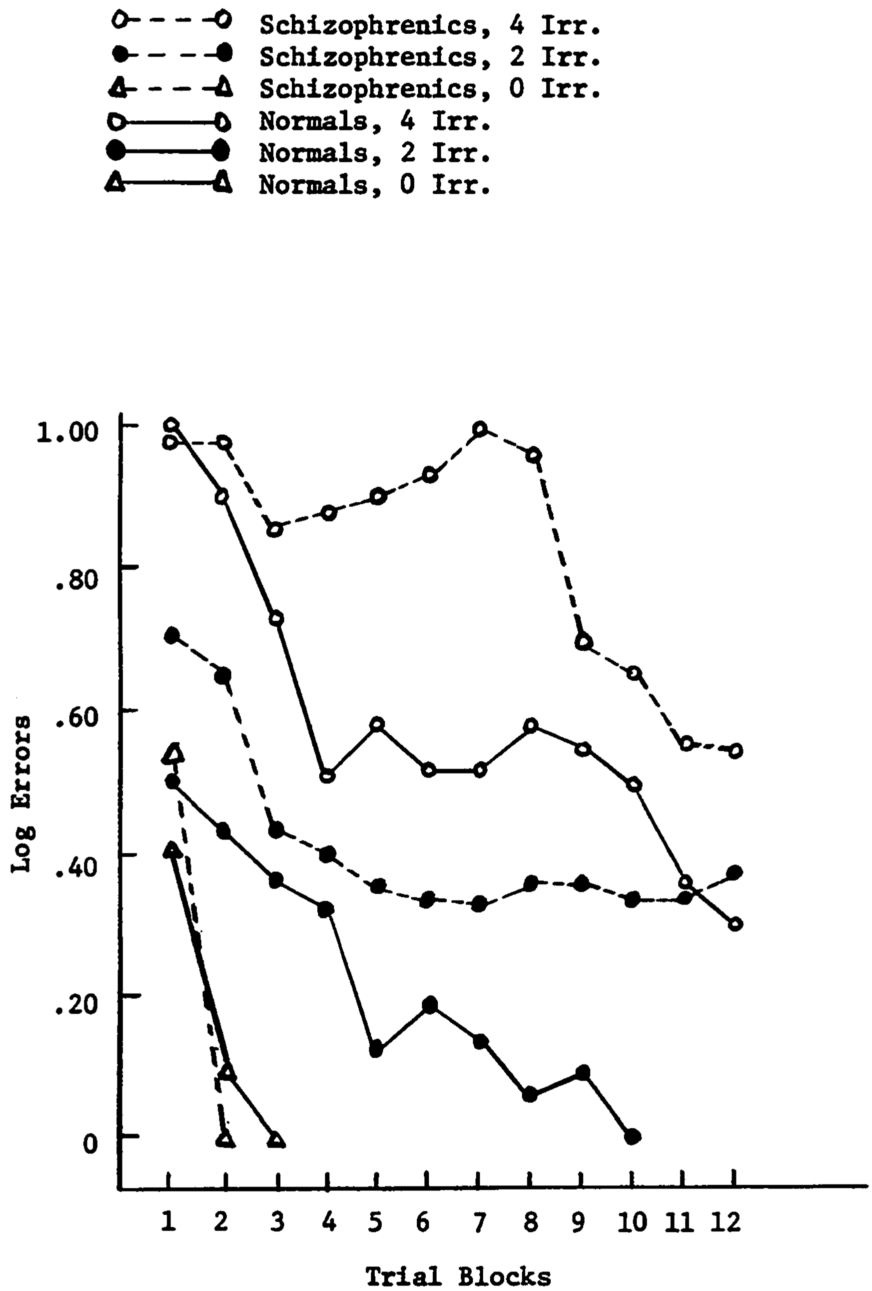

Figure 12. Mean log errors per block of 16 trials for normals and schizophrenics as a function of 0, 2, and 4 bits of irrelevant information with 1 relevant dimension. Each point represents an $\underline{N}$ of 5.

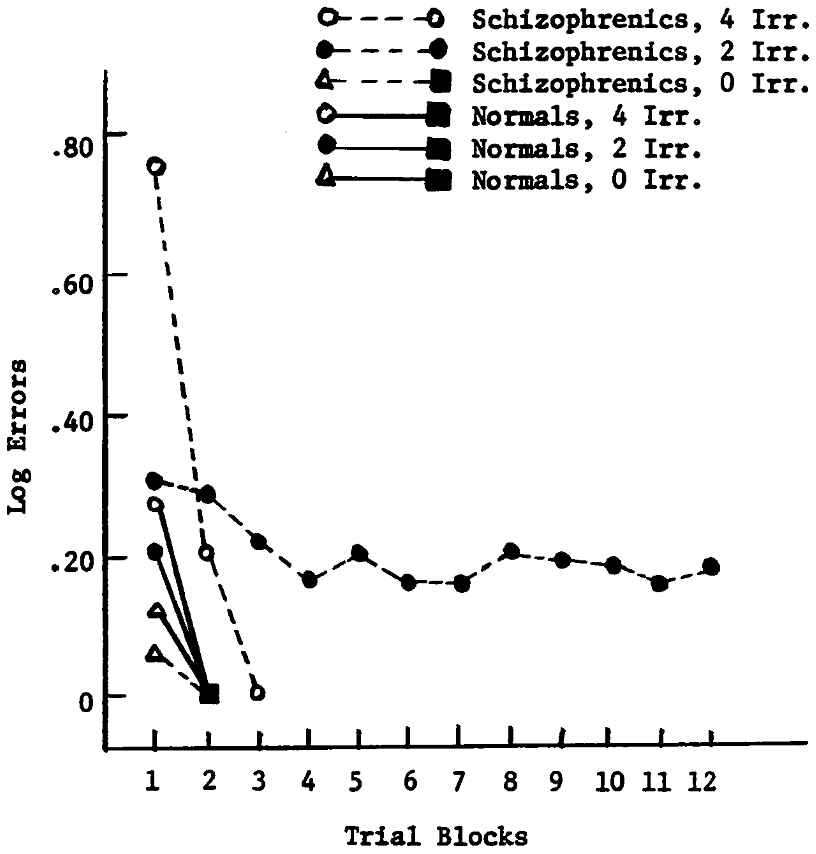

Figure 13. Mean log errors per block of 16 trials for normals and schizophrenics as a function of 0, 2, and 4 bits of irrelevant information with 3 relevant dimensions. Each point represents an N of 5.

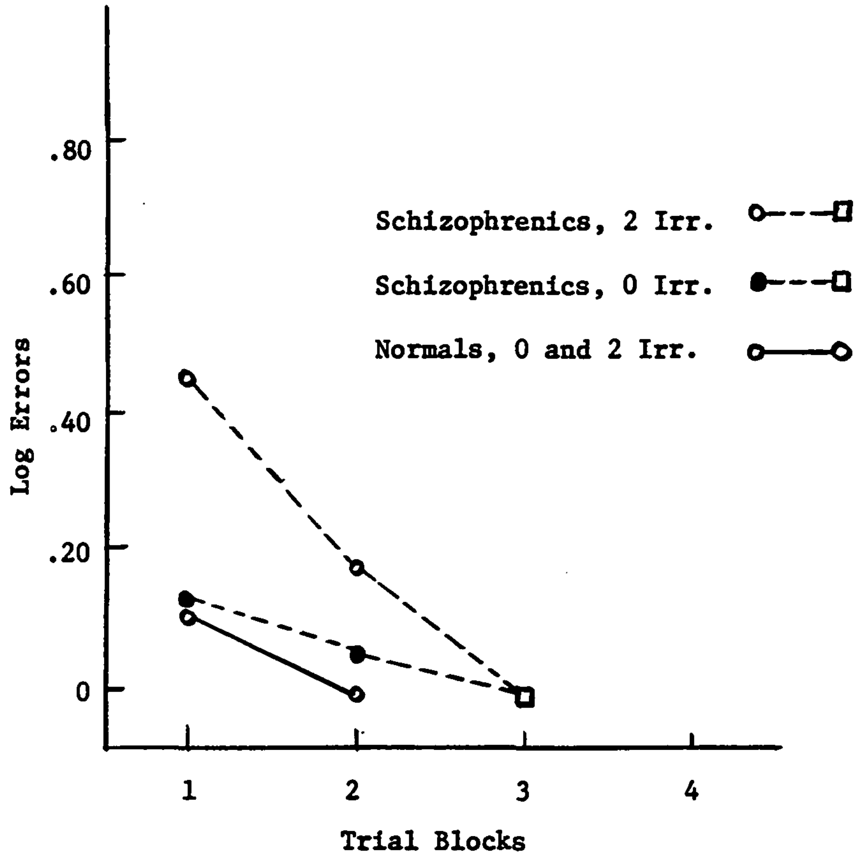

Figure 14. Mean log errors per block of 16 trials for normals and schizophrenics as a function of 0 and 2 bits of irrelevant information with 5 relevant dimensions. Each point represents an N of 5.

present. Finally a similar pattern (Figure 14) is evident at the 5 relevant dimension level.

Analysis of Subvocal and Vocal Activity

Analyses of variance of seconds of vocal activity (Table 5) were performed. Again, the $\log_{10}$ of the number of errors per block of 16 trails plus 1 served as the transformed score.

In terms of task complexity, the results in section *E* of Table 5 show a significant linear *C* main effect ($F = 14.193$, 32 *df*, $p < .001$) indicating that vocal activity increased as the number of irrelevant dimensions increased. Subsequent Duncan's (1955) test revealed that there were significant differences in mean log talk time between complexity levels 6 and 2 (32 *df*, $p < .05$), 6 and 0 (32 *df*, $p < .05$), 4 and 2 (32 *df*, $p < .05$), 4 and 0 (32 *df*, $p < .05$), 2 and 0 (32 *df*, $p < .05$), but not between 6 and 4 (32 *df*, $p > .05$). In addition to the significant *C* main effect, a significant *P* main effect ($F = 6.193$, 32 *df*, $p < .05$) revealed that schizophrenics had a larger vocal activity time than normals. Furthermore, a significant *C* x *P* interaction (sections *E* and *G*) indicated, as does Figure 15, that as the number of irrelevant dimensions increased schizophrenics had a significantly larger vocal activity time as compared to normals. Subsequent analysis with Duncan's (1955) test revealed that at the 2 and 6 levels of irrelevant information schizophrenics had significantly larger mean log talk times ($df = 32$, $p < .05$). The significant difference at the 6 complexity level between schizophrenics and normals receives additional support from an analysis of variance performed at that level (section *D*). Finally, schizophrenics increased

Table 5

Analysis of Variance of Log Talk Time

Source	*df*	*MS*	*F*	*p*
(SECTION *A*) - 0 irrelevant level				
R	3	.302	1.39	NS
P	1	.132		
RP	3	.286		
Error	32	.218		
(SECTION *B*) - 2 irrelevant level				
R	2	.935	3.076	.07
P	1	.988	3.25	NS
RP	2	.483	1.59	NS
Error	24	.304		
(SECTION *C*) - 4 irrelevant level				
R	1	2.061	8.73	.01
P	1	.417	1.77	NS
RP	1	.245		
Error	16	.236		
(SECTION *D*) - 6 irrelevant level				
P	1	1.528	7.35	.05
Error	8	.208		

(Table 5 continued on next page)

Table 5 - continued

Source	df	MS	F	p
(SECTION E) - 1 relevant dimension level				
C	3	2.498	14.193	.001
Linear	1	7.0224	39.9	.001
Quadratic	1	.2619	1.488	NS
Cubic	1	.2108	1.197	NS
P	1	1.09	6.193	.05
CP	3	.861	4.892	.01
Error	32	.176		
(SECTION F) - 0, 2, and 4 irrelevant dimension levels and 1 and 3 relevant dimension levels				
C	2	2.4535	10.423	.001
R	1	1.81	7.689	.01
P	1	.365	1.55	NS
CR	2	.393	1.67	NS
CP	2	1.1365	4.828	.05
RP	1	.009		
CPR	2	.332	1.41	NS
Error	48	.2354		
(SECTION G) - 0 and 2 irrelevant dimension levels and 1, 3, and 5 relevant dimension levels				
R	2	.2885	1.25	NS
C	1	.063		
P	1	.035		
RC	2	.8305	3.611	.05
RP	2	.1325		
CP	1	1.485	6.46	.05
RCP	2	.436	1.90	NS
Error	48	.230		

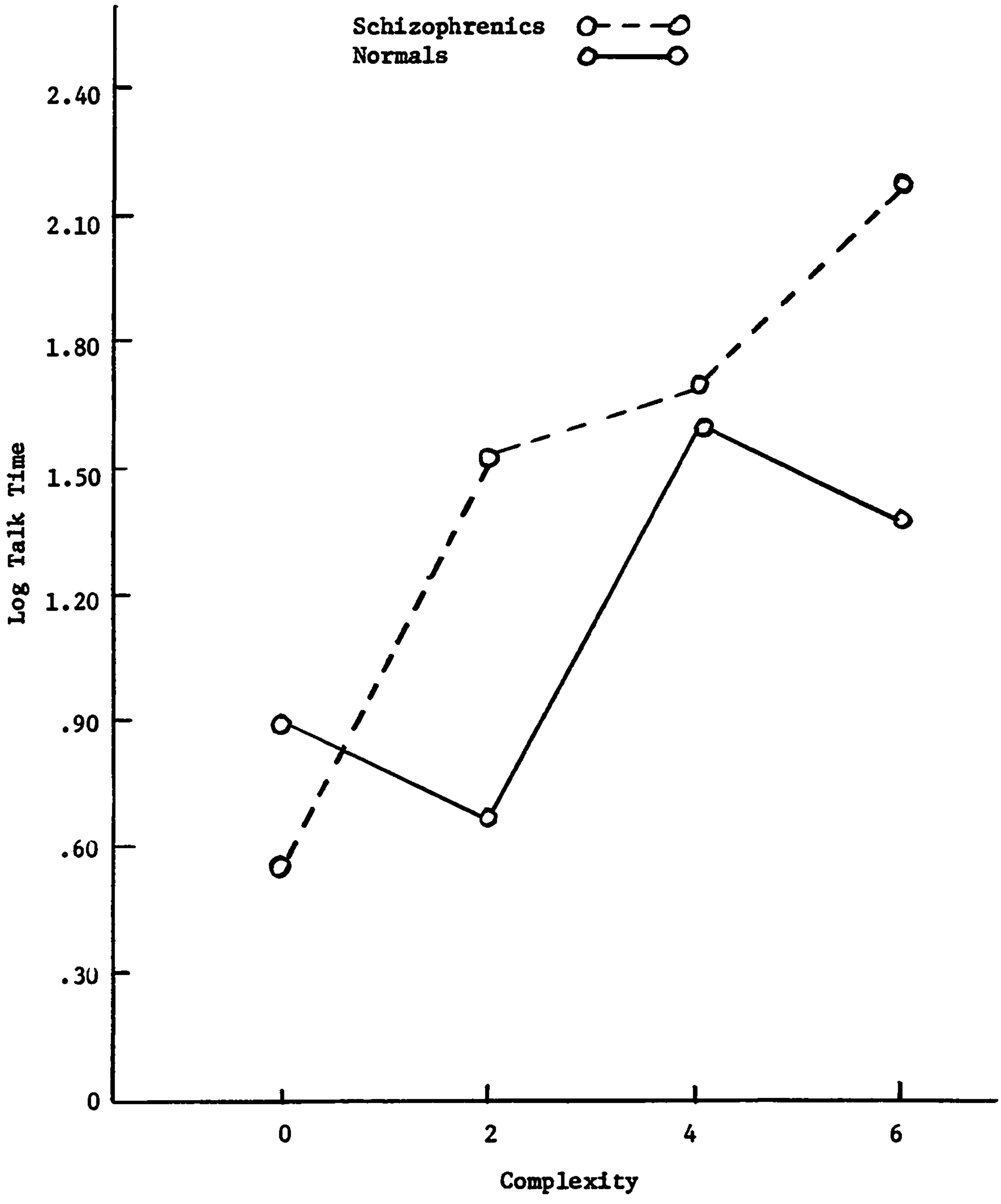

Figure 15. Mean log talk time in seconds for normals and schizophrenics as a function of different complexity levels with 1 bit of relevant information. Each point represents an N of 5.

their mean log talk time significantly so from the 0 complexity to the 2 complexity level, whereas normals increased from the 2 complexity to the 4 complexity level (df = 32, $p < .05$).

In terms of relevant redundancy, the analyses of variance performed at the 2 (section B) and 4 (section C) irrelevant dimension levels revealed that the R main effect approached significance at the 2 irrelevant levels ($F = 3.076$, 24 df, $p < .07$) and reached significance at the 4 irrelevant level ($F = 8.73$, .6 df, $p < .01$). Additional support for the significant R main effect is found in section F ($F = 7.689$, 48 df, $p < .01$). Thus, as relevant redundancy is introduced, vocal activity decreased. Finally, the analysis of variance performed on the six conditions involving 1, 3, or 5 relevant dimensions and 0 or 2 irrelevant dimensions (section G) revealed a significant R x C interaction ($F = 3.611$, 48 df, $p < .05$). This R x C interaction indicated, as does Figure 16, that as the number of relevant redundant dimensions increased vocal activity decreased and the amount of decrease was greater as the number of irrelevant dimensions increased. Subsequent simple effects analysis (Winer, 1962) revealed (Table 6) that there was a significant decrease in talk time across relevant dimensions at the 2 complexity level (df = 48, $p < .01$), but there was no difference in talk time across relevant dimensions at the 0 complexity level (df = 48, $p > .05$). Furthermore, differences in mean log talk time between the 0 and 2 levels of complexity approached significance at the 1 and 5 relevant dimension levels (df = 48, $p < .06$).

When talk time was compared with number of errors, Pearson r's showed significant positive correlations for each population group

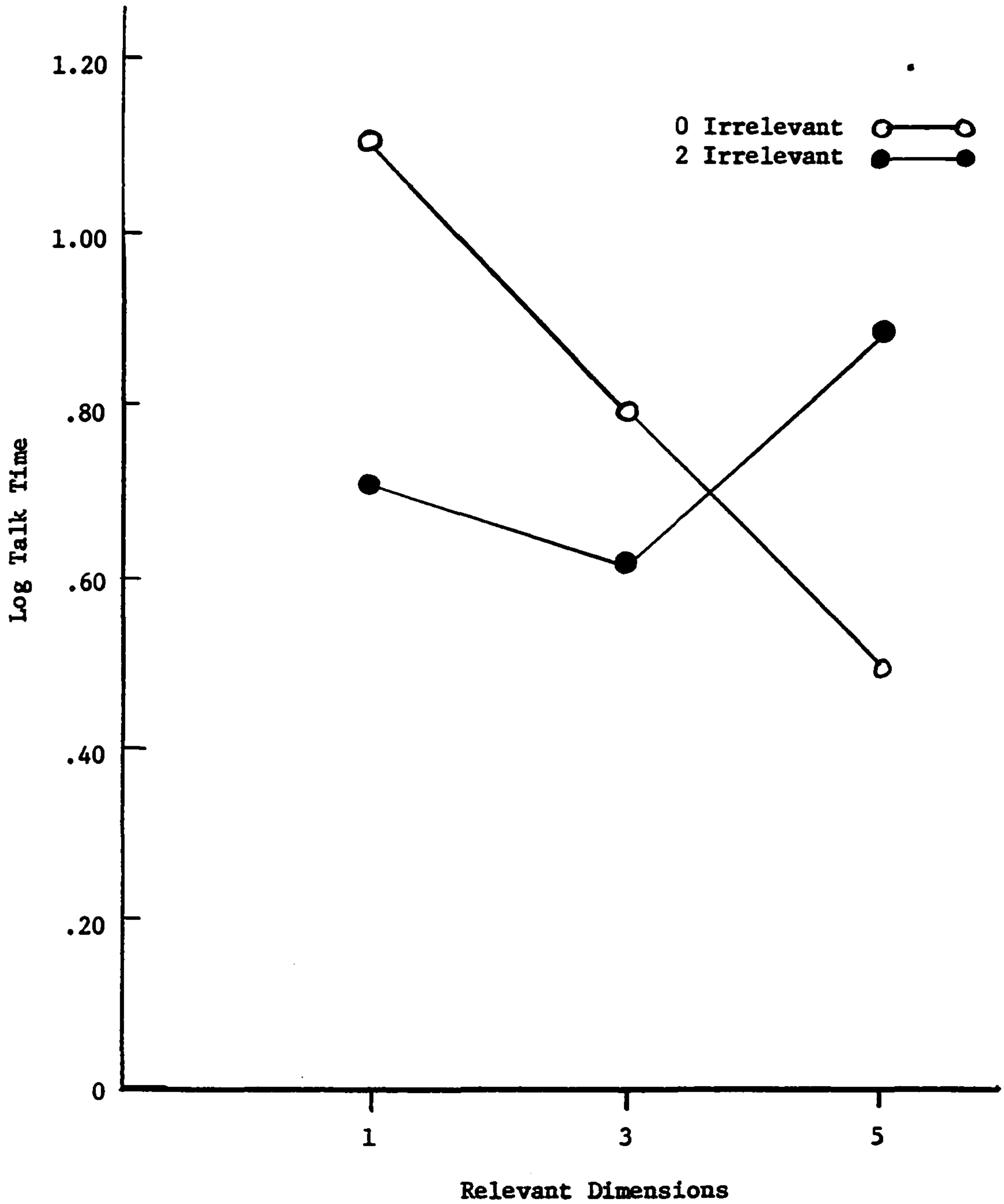

Figure 16. Mean log talk time in seconds for the 0 and 2 levels of complexity at 1, 3, and 5 relevant dimension levels. (Groups are pooled.) Each point represents an N of 10.

Table 6

Simple Effects Analysis of Variance of Talk Time for *R* x *C* Interaction (Section *G* of Table 5)

Source	F^a	p^b
RC_0	1.595	NS
RC_2	8.131	.01
CR_1	3.60	.06
CR_3	.66	NS
CR_5	3.338	.06

NOTE: RC_0 = Relevant dimensions for 0 complexity level
RC_2 = Relevant dimensions for 2 complexity level
CR_1 = Complexity for 1 relevant dimension level
CR_3 = Complexity for 3 relevant dimension level
CR_5 = Complexity for 5 relevant dimension level

[a]MSE = .230
[b]*df* = 1/48

(r = .562, df = 48, p <.001; r = .765, df = 48, p <.001 for normals and schizophrenics respectively). Thus, verbal activity was positively related to errors in CI performance for both population groups.

Analysis of Hypotheses and Hypothesis Shifts

The analysis of hypothesis behavior in the present study was the same as that used by Bourne (1965). Ten basic characteristics of S's hypothesis behavior were determined: the number of dimensions in S's initial hypothesis (I), the number of times S changed his hypothesis in any way after making an incorrect category response (EC), the number of times after an error that S did not change his hypothesis (EN), the number of times S changed his hypothesis after making a correct response (C), the number of times that S did not change his hypothesis after making a correct response (N), the addition (A) or deletion (D) of dimensions from S's hypothesis of the previous trial (Hypothesis shifts), increases in hypothesis size (A or A >D), decreases in hypothesis size (D or D> A), and changes in hypothesis composition only (A = D). These last five characteristics deal with S's hypothesis shifts from a previous trial. Except for I, the frequency of each of the foregoing characteristics was converted to a proportion. This was done by dividing each characteristic by the total number of times that particular characteristic happened in the stimulus sequence shown to S. For example, EC and C were divided by the total number of hypothesis changes displayed by S (in addition, EC and C were divided by the total number of incorrect and correct responses, respectively, resulting in EC_1, and C_1); EN and N were divided by the total number of errors and correct responses respectively; and A, D, A >D, D >A, and A = D were divided by the total number of changes after error. Finally, the proportion of hypothesis shifts (of the various types) that were consistent with previously presented information given to S in the series were computed. Then the mean value for each of these proportions was determined separately for normal and schziophrenic subjects in each experimental conditions.

First of all, the analysis of the hypothesis behavior was conducted separately for normals and schizophrenics by pooling the ten main experimental conditions of relevant and irrelevant information (Table 7). However, since the source of relevant redundancy and irrelevant information proved to be significant in the analysis of errors, further analysis of hypothesis behavior was conducted at each level of irrelevant information (Table 8) and at each level of relevant redundant information (Table 9). In addition, a fourth analysis was conducted across those experimental conditions which involved the same amount of stimulus uncertainty (Table 10).

With irrelevant and relevant conditions pooled (Table 7), normal subjects stayed with a particular hypothesis when they were correct (N) more frequently than did schizophrenics ($t = 1.60$, 98 df, $p < .06$), and they were more consistent with previously presented information when they added a dimension (A) to their hypothesis ($t = 2.26$, 98 df, $p < .05$). It is noteworthy that schizophrenics had higher percentages of shifts in their hypothesis after an error (EC_1) and after a correct response (C_1). In terms of irrelevant dimension levels (Table 8), pooling across relevant dimensions, normals tended to be more consistent with previously presented information when they added (A) a dimension to

Table 7

Analysis of Hypothesis Behavior for Normals and Schizophrenics Across All Experimental Conditions

Characteristics	Normal ($\bar{x}$)	Schizophrenics ($\bar{x}$)	$\underline{P}$*
I	1.18	1.16	NS
EC	.146 (.162)**	.140 (.147)	NS (NS)
EC_1	.150	.247	.075
EN	.390	.433	NS
C	.416	.441	NS
C_1	.206	.289	NS
N	.794	.692	.06
A	.022 (.163)	.046 (.043)	NS (.05)
D	.045 (.064)	.033 (.059)	NS (NS)
A > D	.012 (.010)	.028 (.028)	NS (NS)
D > A	.007 (.016)	.003 (.00)	NS (NS)
A=D	.201 (.287)	.309 (.211)	NS (NS)
Total N	50	50	

* Based on $\underline{t}$-tests between means

** Numbers in parentheses are proportions of changes that are consistent with all previously given stimulus information.

Table 8

Mean Proportions of Each Hypothesis Characteristic at Each Level of Irrelevant Information for Normals and Schizophrenics

(Comparisons between Normals and Schizophrenics within each dimension level are based on _t_-tests)

Hypothesis Characteristics[a]	Normals				Schizophrenics			
	0	2	4	6	0	2	4	6
I	1.25	1.00	1.4	1.0	1.15	1.0	1.3	1.4
	(.033)	(.20)	(.229)	(.426)	(.03)	(.16)	(.285)	(.299)
EC	.055	.069	.363	.304	.041	.117	.228	.431
EC_1	.075	.077	.396	.175	.086	.303**	.396	.427
EN	.325	.390	.304	.825	.364	.364	.604*	.573
C	.40	.531	.337	.298	.409	.487	.372	.569**
C_1	.131	.315	.225	.144	.206	.37	.352	.438
N	.870	.685	.775	.856	.794	.630	.648	.562

(Table 8 continued on next page)

Table 8 - continued

Characteristics	Normals 0	2	4	6	Schizophrenics 0	2	4	6
	(.216)**	(.067)	(.161)	(.241)	(.041)	(.047)	(.01)	(.106)
A	.00	.00	.089	.244	0.0	.023	.045	.300
	(.10)	(0.0)	(.010)	(.217)	(0.0)	(.09)	(.081)	(.139)
D	0.0	0.0	.088	.274	0.0	.03	.076	.091
	(0.0)	(0.0)	(.02)	(.05)	(.05)	(0.0)	(.006)	(.067)
A > D	0.0	0.0	.048	.024	0.0	.069	.035	.004
	(0.0)	(0.0)	(.056)	(.044)	(0.0)	(0.0)	(0.0)	(0.0)
D > A	0.0	0.0	.027	.015	0.0	.003	.007	.004
	(.133)	(.446)	(.421)**	(.159)	(.224)	(.281)	(.156)	(.061)
A=D	.100	.200	.379	.247	.150	.341	.437	.596
Total N	20	15	10	5	20	15	10	5

[a]See page 82 for explanation of hypothesis characteristics

** Statistically significant at .05 level

* Statistically significant at .06 level

Table 9

Mean Proportions of Each Hypothesis Characteristic at Each Level of Relevant Information for Normals and Schizophrenics

(Comparisons between Normals and Schizophrenics within each dimension level are based on _t_-tests)

Hypothesis Characteristics[a]	Normals 1	3	5	7	Schizophrenics 1	3	5	7
I	1.2	1.13	1.0	1.6	1.1	1.2	1.1	1.4
	(.221)	(.178	(.10)		(.131)	(.207)	(.10)	(.12)
EC	.242	.130	.05	0	.266	.124	.045	.038
EC_1	.250	.143	.033	0	.307	.277	.143	.125
EN	.650	.257	.267	0	.693	.256	.257	.275
C	.364	.403	.45	.60	.327	.410	.656	.561
C_1	.199	.194	.261	.162	.259	.329	.345	.362
N	.802	.806	.739	.837	.741	.671	.655	.637

(Table 9 continued on next page)

Table 9 - continued

Hypothesis Characteristics[a]	Normals 1	3	5	7	Schizophrenics 1	3	5	7
A	(.108) .089	(.067) .022	(.20) 0.0	(.60) 0.0	(.032) .103	(0.0) .017	(.120) .00	(.066) 0.0
D	(.109) .096	(0.0) .022	(0.0) 0.0	(.20) 0.0	(.061) .058	(.048) .033	(0.0) 0.0	(0.0) 0.0
A >D	(.025) .013	(0.0) .022	(0.0) 0.0	(0.0) 0.0	(.02) .008	(0.0) .017	(0.0) .10	(.20) 0.0
D §A	(.039)* .017	(0.0) .00	(0.0) 0.0	(0.0) 0.0	(0.0) .007	(0.0) 0.0	(0.0) .00	(0.0) 0.0
A=D	(.20) .355	(.390) .155	(.45) .10	(0.0) 0.0	(.096) .373	(.20) .33	(.432) .20	(.266) .20
Total N	20	15	10	5	20	15	10	5

[a]See page 82 for explanation of hypothesis characteristics

* Statistically significant at .05 level

Table 10

Mean Proportions of Each Hypothesis Characteristic at Each Level of Stimulus Uncertainty (3, 5, or 7 Dimensions) for Normals and Schizophrenics

(Comparisons between Normals and Schizophrenics within each dimension level are based on t-tests)

Hypothesis Characteristics[a]	Normals 3	Normals 5	Normals 7	Schizophrenics 3	Schizophrenics 5	Schizophrenics 7
I	1	1.13	1.25	1	1.067	1.35
	(.10)	(.108)	(.240)	(.087)	(.053)	(.284)
EC	.033	.139	.188	.087	.115	.197
EC_1	.007	.221	.130	.195**	.260	.300**
EN	.593	.379	.270	.404	.273	.450
C	.267	.528	.412	.320	.486	.553
C_1	.089	.406	.148	.215	.349	.397***
N	.910	.594	.852***	.785	.650	.603

(Table 10 continued on next page)

Table 10 - continued

Hypothesis Characteristics[a]	Normals			Schizophrenics		
A	(0.0) 0.0	(.108) .037	(.310)** .078	(0.0) .035	(.041) .013	(.078) .088
D	(0.0) 0.0	(.007) .0365	(.104) .085	(.038) .045	(.010) .017	(.120) .048
A >D	(0.0) 0.0	(.017) .010	(.012) .022	(.00) .003	(.004) .007	(.067) .064
D >A	(0.0) 0.0	(.037) .018	(.011) .004	(0.0) .005	(0.0) .005	(0.0) .001
A=D	(.133) .100	(.404) .231	(.315) .178	(.144) .212	(.229) .291	(.259) .399*
Total N	10	15	20	10	15	20

[a]See page 82 for explanation of hypothesis characteristics

*** Statistically significant at .01 level

** Statistically significant at .05 level

* Statistically significant at .06 level

their hypothesis. This reached significance at the 0 irrelevant level (t = 1.87, 38 df, p <.05). Furthermore, at the 4 irrelevant level, normals were more consistent when they changed the composition (A = D) of their hypothesis (t = 2.548, 18 df, p <.05). On the other hand, schizophrenics at the 2 irrelevant level had a higher percentage of changes after an incorrect response (EC_1) than did normals (t = 2.11, 28 df, p <.05); at the 4 irrelevant level they kept their hypothesis after an error (EN) more frequently than normals (t = 1.65, 18 df, p< .05); at the 6 irrelevant level they changed their hypothesis after a correct response (C) more frequently than did normals (t = 2.01, 8 df, p <.05). It is again noteworthy that schizophrenics, in addition to higher percentages of shifts after errors, tended to have higher percentages of shifts after correct responses (C_1) as well. In terms of relevant dimension levels (Table 9), pooling across complexity levels, normals and schizophrenics showed no significant differences in their hypothesis behavior with the exception that at the 1 relevant dimension level normals were more consistent (t = 1.74, 38 df, p <.05) with previously presented information when they dropped dimensions more than when they added to their hypothesis (D> A). Finally, in terms of those conditions involving the same amount of stimulus uncertainty (Table 10), differences between normal's and schizophrenic's hypothesis behavior emerged mainly in those conditions involving 7 bits of actual stimulus uncertainty. Here, schizophrenics had higher percentages of shifts after errors (t = 1.68, 38 df, p <.05) and higher percentages of shifts after correct responses (t = 2.66, 38 df, p <.01) than normals. The higher percentage of shifts after errors also reached significance in those conditions involving 3 bits of stimulus uncertainty (t = 1.85, 18 df, $p < .05$). Furthermore, schizophrenics changed the composition of their hypothesis (A = D) more frequently than did normals (t = 1.63, 38 df, $p < .06$). On the other hand, normals kept the same hypothesis more frequently when they were correct (N) than did schizophrenics (t = 2.58, 38 df, $p < .01$); also, when normals added a dimension to their hypothesis (A), they were more consistent with previously presented information (t = 2.11, 38 df, $p < .05$). It is interesting to note that most of these significant differences in hypothesis behavior between schizophrenics and normals emerge in those conditions where maximum complexity, either by adding relevant redundant or irrelevant dimensions, is present in the stimulus series presented to each S.

In order to determine if each population group approached the task in a similar manner, percentages were computed based upon each subject's hypothesis responding. Sixty-eight percent of the normals and 62% of the schizophrenic's hypothesis responding was consistent with what each subject felt the solution to the problem was when asked after the task was completed. Furthermore, normals chose response key A 51.7% of the time and response key B 48.3% of the time whereas schizophrenics chose A 52.2% of the time and B 47.78% of the time. There was no preference in either group for response key A or B. Finally, 76% of the normal's hypotheses centered on a relevant dimension for solution to the problem whereas only 62% of the schizophrenic's hypothesis centered on a relevant dimension. Also, when each subject was asked after the task what the solution to the problem was, 94% of the normals stated one or more correct relevant dimensions for solution. This is compared to only 76% of the schizophrenics. This last difference between schizophrenics and normals was the only difference that reached significance ($\underline{t}$ = 1.9243, 18 $\underline{df}$, $\underline{p}$ <.05).

In order to compare the relative salience of each dimension for the two population groups, the mean frequency of each dimension was computed based upon the number of times each $\underline{S}$ responded to that dimension. The mean frequency of each dimension, ranked on the basis of the highest mean, for normals and schizophrenics, are shown in Table 11. In order to determine if the stimulus dimensions were equally salient for normals and schizophrenics, a nonparametric test, Wilcoxin matched-pairs signed-ranks test, was performed. The test indicated that the stimulus dimensions were not equally salient for normals and schizophrenics ($\underline{T}$ = 0, $\underline{N}$ = 7, $\underline{p}$ < .02). As can be seen in Table 11, horizontal position was a more salient dimension for normals than for schizophrenics. On the other hand, number was a more salient dimension for schizophrenics than for normals.

Table 11

Mean Frequencies of Each Stimulus Dimension
for Normals and Schizophrenics

(Means are ranked for each population on the basis of salience.)

Dimension	Normals	Dimension	Schizophrenics
Form	22.96	Form	34.14
Color	21.82	Color	24.26
Horizontal position	4.48	Number	11.86
Size	4.40	Size	11.66
Vertical position	4.14	Orientation	8.62
Orientation	3.84	Vertical position	6.86
Number	3.52	Horizontal position	4.66

Analysis of Demographic and Psychometric Tests

The results of the demographic and psychometric measures for each population group are presented in Table 12. As can be seen in Table 12, there were no significant differences between normals and schizophrenics on age, education, and intelligence (vocabulary and abstract tests). In terms of the rigidity battery, there was a significant difference between normals and schizophrenics on the motor-cognitive portion ($t = 2.78$, 98 df, $p < .005$), but not on the perceptual-personality or psychomotor speed portions. The significant difference on the motor-cognitive test indicated that normals were less rigid than schizophrenics when shifting from one activity to another or making an effective adjustment to shifts in familiar patterns.

In addition to these group differences, several correlations were computed to relate the rigidity quotient scores to CI errors (Table 13) and to the hypothesis behavior measures (Table 14). As can be seen in Table 13, none of the correlations were significant between the rigidity quotient scores and CI errors for either normals or schizophrenics. Thus, rigidity-flexibility as measured in the present study does not relate to CI errors for either group. However, the relationships between rigidity-flexibility and hypothesis behavior measures show quite different results (Table 14). First, on the motor-cognitive portion of the rigidity battery, normals showed significant positive correlations when they added a dimension (A) to their hypothesis as well as when they used a focus gambling approach ($A > D$ or $D > A$). Schizophrenics showed only a significant positive correlation

Table 12

Group Differences on Demographic and Psychometric Tests

Measure	Normal	Schizophrenic	t	p
Age	38.46	38.84	.22	NS
Education	10.7	11.0	.43	NS
Shipley Vocabulary	26.2	25.7	.56	NS
Shipley Abstract	16.32	14.56	.93	NS
Motor-Cognitive (Rigidity Quotient)	88.4	76.28	2.78	.005
Perceptual-Personality (Rigidity Quotient)	90.34	90.38	.11	NS
Psychomotor Speed (Rigidity Quotient)	76.56	76.62	.17	NS

Table 13

Correlations of Rigidity Quotient Scores with
Concept Identification Errors

Rigidity Quotient	Normals		Schizophrenics		Overall	
	r	p	r	p	r	p
Motor-Cognitive	.09	NS	-.259	NS	.116	NS
Personality-Perceptual	-.09	NS	.003	NS	-.03	NS
Psychomotor-Speed	-.205	NS	-.101	NS	-.147	NS

Table 14

Correlations of Rigidity Quotient Scores with Hypothesis Behavior
(Rank Order Correlation Coefficient)

	NORMALS						SCHIZOPHRENICS					
Hypothesis Characteristics[a]	Motor-Cognitive		Perceptual-Personality		Psychomotor Speed		Motor-Cognitive		Perceptual-Personality		Psychomotor Speed	
	r	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*
I	.170	NS	-.011	NS	.262	.05	.042	NS	.013	NS	-.072	NS
EC	.09	NS	.065	NS	-.168	NS	-.09	NS	-.120	NS	.190	NS
EC_1	.159	NS	.08	NS	-.110	NS	-.019	NS	-.008	NS	.240	.05
EN	.084	NS	.09	NS	.260	.05	-.230	NS	-.087	NS	-.172	NS
C	.0004	NS	.173	NS	.175	NS	-.026	NS	.002	NS	.259	.05
C_1	.108	NS	.330	.01	.289	.05	-.013	NS	.143	NS	.314	.05
N	-.09	NS	-.316	.05	-.271	.05	.059	NS	-.157	NS	-.334	.01
A	.349	.01	.258	.05	.356	.01	.086	NS	-.025	NS	.186	NS
D	.194	NS	.207	NS	.212	NS	.135	NS	-.02	NS	.287	.05
A > D	.345	.01	.266	.05	.362	.01	.284	.05	.181	NS	.222	NS
D > A	.262	.05	.194	NS	.280	.05	.185	NS	.184	NS	.154	NS
A=D	.124	NS	.045	NS	-.180	NS	-.250	.05	-.091	NS	.036	NS
Total N	50		50		50		50		50		50	

[a]See page 82 for explanation of hypothesis characteristics

when they added more dimensions than they dropped from their hypothesis (A >D). In addition, schizophrenics showed a significant negative correlation when they changed the composition of their hypothesis (A = D). Secondly, on the personality-perceptual portion, normals showed significant positive correlations between this portion of the rigidity battery and A, A >D, and C_1 of their hypothesis behavior. However, normals showed a significant negative correlation when they kept the same hypothesis after a correct response (N). Schizophrenics showed no significant correlations between this portion of the battery and their hypothesis behavior. Finally, on the psychomotor speed portion, normals showed significant positive correlations between this portion of the battery and A, A >D, D> A, I, EN, and C_1 of their hypothesis behavior whereas schizophrenics showed significant positive correlations on D, EC_1, C, and C_1 of their hypothesis behavior. In addition, both groups showed significant negative correlations between the psychomotor speed portion and N of their hypothesis behavior.

CHAPTER VI

DISCUSSION

Since the analysis of variance of errors was the main dependent variable it will be discussed first. The first six original hypotheses, related to the analysis of errors, will be stated and discussed in order.

1. _A significantly greater number of errors will be observed in the schizophrenic group than in the normal control group._

This hypothesis was partially supported and as such adds to a considerable wealth of clinical and experimental evidence indicating that schizophrenic patients do not perform well on tasks requiring conceptualization. However, this finding is limited by the fact that significant differences between schizophrenics and normals were found only at the higher levels of complexity, 4 and 6 bits of irrelevant information. As noted in Figures 4 and 5 schizophrenics performed as well as normals as long as the information load and number of alternative hypotheses were low, particularly with 0 bits of irrelevant information. But as the irrelevant information and the number of alternative hypotheses increased, schizophrenics performed poorer as compared to the normal control group. To illustrate this last point, in the condition involving the greatest information load, schizophrenics performed at almost chance level (Figure 11) while the normal group showed evidence of learning across trials. To account for the above finding, traditional explanations have often relied upon the "loss of abstract attitude," (Goldstein, 1939a) or Cameron's (1947) "overinclusion" concept as possible reasons for a conceptual deficit in schizophrenics. In this case, the present finding directly contradicts Goldstein's hypothesis. Schizophrenics are capable of forming abstract concepts (39 out of 50 solved the problems) and their performance is similar to normals, particularly with 0 irrelevant information. However, recent investigators (Chapman and McGhie, 1962; Yates, 1966b; Buss, 1966) have offered explanations involving a deficit in the processing of information. This explanation postulates that schizophrenics are unable to attend selectively to stimuli such that only relevant information is processed. That is, irrelevant information, in addition to being a source of distraction, is not effectively screened out by the schizophrenic which results in an overloading of his limited information processing and storing mechanism. On the other hand, in those tasks requiring little information processing, the channel is operating well below capacity and the assimilation of information does not lead to overloading. Consequently, there is no detrimental effect upon performances. Thus, it would seem that the present finding is compatible with this explanation. Yet, it should be noted that the above finding can be explained in terms of other alternative theories, such as motivational theories. That is, it is possible to attribute the poorer performance of schizophrenics to a lack of motivation. To be sure, it is quite difficult in any study for an experimenter to know with certainty that he is extracting maximum performance from his subjects. In the present study, the schizophrenics were thought to be adequately motivated on the basis of several criteria: they volunteered to participate in the study; they were rewarded by extra and special attention; and they frequently expressed interest in the task. In addition, there was the distinct clinical impression that most schizophrenic subjects were trying to do their best and were pleased to be included in the study. When these impressions are combined with the fact that the stimulus situation both encourages and rewards the individual for maintaining his focus of attention on the relevant dimension, it seems reasonable to infer that the inferior performance of schizophrenics is likely to be due to an information-processing dysfunction which does not permit the continual focusing of attention to the same extent that is displayed by the normal individual. Finally, the importance of this finding lies in the fact that the deficit is demonstrated on a task that is characterized by standardized procedures and rigorous stimulus definition.

The importance of this finding should also be viewed in the light of the experimental control variables such as age, education, vocabulary level, and abstraction level. The care that was taken to insure control on these variables makes the effect observed even more unequivocal. It is also important to note that these groups differed only with respect to the motor-cognitive portion of the Test of Behavioral Rigidity. Here, schizophrenics were more rigid than normals when shifting from one activity to another or in making an effective adjustment to shifts in familiar patterns. Thus, there would seem to be little doubt that the presence of schizophrenia in humans does have quantifiable effects and that these effects are shown to be related to higher conceptual activity.

2. With increasing irrelevant information (complexity), a greater number of errors will be expected in both groups.

This hypothesis, as tested and supported by the complexity effect, is one of the most striking results observed in this study. Figure 2 illustrates this finding with both its linear and quadratic components. This finding is most significant in that it confirms a rather extensive number of studies which have consistently shown the linear character of this variable (Bourne, 1957; Bourne and Pendleton, 1958; Pishkin, 1960). However, the fact that a quadratic component was also significant, resulting from a decrease in errors at the 6 irrelevant level (Figure 2), lends support to the quadratic component found in the Archer, Bourne, and Brown (1955) study. These relationships have additional significance in view of the population differences (Figure 4). The fact that a linear relationship was confirmed for the schizophrenic group tends to be consistent with previous studies (Pishkin, 1963; Pishkin and Wolfgang, 1964; Pishkin, Wolfgang, and Bradshaw, 1963; Pishkin, Shurley, and Wolfgang, 1967) whereas the fact that a quadratic relationship was observed for the normal group is inconsistent with most studies. It is interesting to note that the quadratic characteristic resulted from a decrease in errors at the 6 irrelevant level. At this level, the horizontal and form dimensions became the additional irrelevant dimensions as compared to the 4 irrelevant level. It is possible that these dimensions were less salient as irrelevant dimensions, at least for the normal group. Such a possibility is analogous to the Archer, Bourne, and Brown (1955) and Brown and Archer (1956) studies where, in addition to a quadratic relationship, position of a pattern on the screen was a significant source of variance. In this respect, the relative salience of a cue or cues may change depending upon its spatial location in relation to where the subject responds and where the reinforcement is delivered. Indeed, this may have been the case in the problems at the 4 and 6 irrelevant levels. Overall, the concept identification model does provide fairly well defined complexity levels that lead to differential responses. There is some doubt, however, that the dimensions are equally salient, particularly across various populations. Cue salience has only recently received considerable attention (Trabasso and Bower, 1968) and future investigations are needed.

3. With increasing irrelevant information, a relatively greater number of errors will result in the schizophrenic group as compared to the normal group.

This hypothesis was tested by the population by complexity interaction and was found to be insignificant. The assumption underlying this hypothesis is the interpretation that increasing irrelevant information leads to an overloading of the short-term memory system. In terms of its face value, this assumption would appear not to be valid. However, as already pointed out, when irrelevant information increases, schizophrenics do perform poorer than normals although the performance is parallel in trend. Thus, if increasing irrelevant information adds to an overloading of the short-term memory system, it is not apparent here. Then in what way are these parallel effects meaningful?

One possible interpretation is suggested by a combination of events. These are: (1) The finding in the present study that the two groups show no significant differences at the lower levels of complexity, (2) The significant differences between schizophrenics and normals on the motor-cognitive portion of the Test of Behavioral Rigidity, largely a perceptual adjustment task, (3) Yates' (1966b) theoretical formulation that schizophrenics suffer from an inability to effectively process or organize incoming information for orderly sequential presentation to the higher cortical centers, and, (4) Previous findings of similar parallel performances involving brain-damage and control subjects whereby an interpretation was suggested in terms of a non-specific perceptual deficit which leads to a breakdown in processing information rather than a deficit in recalling information (Lawson, McGhie, and Chapman, 1967; Burn, 1967; Parsons, Majumder, and Chandler, 1966). If these events are taken together, they suggest a hypothesized deficit in attention and data processing which may account for the schizophrenic's poorer yet parallel performance. The basic proposition involved in the use of this interpretation centers around a possible deficit in selective attention (Chapman and McGhie, 1962), a breakdown in perceptual mechanisms (Lawson *et al*., 1967; Parsons, *et al*., 1966; Burn, 1967), and the inability to effectively process incoming information for presentation to the higher cortical centers (Yates, 1966b). The deficit does not appear to be a memory function *per se* but rather a defect in the perceptual and processing mechanisms which adversely effect the subsequent levels involved. Thus, many authors and investigators have argued for such concepts as "disturbed phase sequences" (Hebb, 1949), inadequate "filter" between cortical levels (Broadbent, 1958), or "gating" control mechanisms (Cheatham and White, 1952). The main purpose of these mechanisms is to effectively screen out the irrelevant information in order to allow relevant information to be processed and recorded. Consequently, the effects of a defective filtering process could result in psychological terms such as "instability of attention" (Hebb, 1949), or "reduced psychological vigilance" (Shure and Halstead, 1958).

In summary, it has been suggested that the reason schizophrenics perform poorer than normals, particularly as irrelevant information increases, is best explained in terms of a defect in selective attention and in processing or filtering of information rather than in terms of an overloaded memory system. The findings in the present study seem to be consistent with this interpretation, although it should be kept in mind, as mentioned previously, that other alternative explanations are possible. That is, the primary impairment in schizophrenia may not be in cognition *per se*, but probably stems from an interaction of motivational, perceptual, and interpersonal-affective processes. Finally, it can be stated that this deficit is approximately equally evident at each level of irrelevant information (causing distraction) with the exception of the 0 irrelevant level in which the normal control group did not outperform the schizophrenic group.

4. *Increasing redundancy will lead to improved performance (less errors) in both groups.*

5. Due to the hypothesized improved performance with the introduction of redundancy, an interaction between complexity and relevant redundancy is also expected; performance will improve more as there is an increase in complexity.

The 4th and 5th hypotheses were tested by the redundancy main effect and the complexity by redundancy interaction terms. They were both significant and they will be discussed together. The basic assumptions involved here were made on the basis that redundancy of information facilitates encoding and processing of information, particularly in the presence of perturbation in a stimulus brought on by irrelevant information or noise. Figure 1 illustrates the above findings. These findings are important in that they confirm the results obtained by Bourne and Haygood (1959; 1961). This investigation also confirms these relationships on a population that is different from those used in the other studies involving the redundancy variable. Thus, it can be stated that with the addition of the present population the generalizability of this variable is greater. Overall, there is little doubt that the variable of relevant stimulus redundancy facilitates correct performance within the CI framework, particularly as the complexity load increases.

6. The schizophrenic group will be expected to make more errors than the normal group as redundancy increases even though their performance should improve with redundancy, particularly in the presence of irrelevant information.

This hypothesis was tested by the population by redundancy interaction and was found to be insignificant. The prediction was based upon the assumption that redundant elements of a stimulus can be an additional source of distraction to the schizophrenic individual (if he attempts to discriminate and use all redundant details) even though redundancy increases the number of relevant cues available that S can use to identify a set of stimuli correctly, particularly in the presence of irrelevant information. The failure of this hypothesis would seem to bring this assumption into question. As can be seen in Figure 3 and Figure 5, schizophrenics tend to make more errors than normals, particularly in the presence of irrelevant information, even though both group's performance improves as compared to non-redundant conditions. The effect of this redundancy variable upon the group is especially evident at the 0 complexity level (Figure 3). Schizophrenics made about the same number of mean errors in the most redundant condition as in the non-redundant condition resulting in a quadratic relationship, whereas normals illustrated a linear relationship reaching perfect solution each time in the most redundant condition. A Duncan's test revealed that there was a significant decrement in errors between the non-redundant and the most redundant condition for normals (32 df, $p < .05$) but not so for schizophrenics (32 df, $p > .05$). Furthermore, there was a significant difference between schizophrenics and normals on the most redundant condition (32 df, $p < .05$). In terms of redundancy in the presence of irrelevant information (Figure 5), it has been demonstrated that the performance of both groups improves as compared to non-redundant conditions. However, it is also evident that schizophrenics tend to make more errors than normals even with the presence of redundant cues. A t-test applied to the group differences at the 4 irrelevant and 3 relevant condition was significant ($t = 2.71$, 8 df, $p < .05$). Thus, it is obvious, in spite of the lack of statistical significance, there are differential group effects on the redundancy variable.

The interpretation of the overall effects would seem to be within the limits of the hypothesized distraction effects resulting from redundant elements of a stimulus. It would appear that the direction of these effects is interactive and suggests that normals are better able to use redundant elements of a stimulus to encode and process information in order to facilitate economical transmission of information. The schizophrenic group, on the other hand, as a possible result of a defective filter or screening mechanism, was not able to process the redundant information as effectively, particularly when many redundant elements were involved. It is interesting to note that at the 0 complexity level (noise-free situation) the findings regarding the normal control group contradict Rappaport's (1957) study on visual discrimination. However, this contradiction is probably attributable to the fundamental differences between the two types of tasks. A similar finding, that normals improve their performance under redundancy with 0 complexity, was reported by Haygood and Bourne (1961). On the other hand, the findings regarding the schizophrenic group in a noise-free situation tend to lend support to Lawson _et al_. (1964). That is, redundant elements of a stimulus may act as additional sources of distraction for the schizophrenic in that he may attempt to discriminate and use all (redundant) details of the stimulus. Yet, when the source of redundancy is relevant, this source is not as distracting as irrelevant information, and it does help the schizophrenic to process information more effectively. This latter finding lends support to other studies which have shown that schizophrenics benefit from situations in which the same information is available to them more than one time (Johannsen and Testin, 1966; Pishkin *et al.*, 1962; Pishkin, 1966). In this respect, when the same information is viewed more than one time, it is redundant; it is this redundancy from which the schizophrenics benefit.

Trial Analysis Data

With trials to solution being the preformance measure, essentially the same results were obtained as with errors being the performance measure. With this in mind only the significantly more meaningful relationships will be discussed.

The significant trial main effect was interpreted to mean that learning was taking place across all blocks of trials (Table 4). In addition to the significant trial main effect, the *T* x *C*, *T* x *R*, and the *T* x *C* x *R* (Table 4) interactions support the error analysis findings. That is, as complexity increases, more trials are required for solution or learning to take place; as redundancy increases, fewer trials are required; as complexity increases, redundancy becomes more facilitative requiring fewer trials. However, perhaps one of the most significant findings in the present study is the differences found in the learning curves (Figures 8 and 9) for normals and schizophrenics in each of the experimental conditions. It can be observed for normals that as the number of relevant and/or redundant dimensions increases and exceeds the number of irrelevant dimensions, fewer blocks of trials are required to reach solution. This supports the basic prediction in the mathematical theory of Bourne and Restle (1959). On the other hand, schizophrenics show more variability. In fact, it can be observed that as the complexity of the pattern increases, by adding irrelevant and/or redundant dimensions (actual stimulus uncertainty), schizophrenics performed much poorer than normals. Figure 17 illustrates that this was particularly evident in those conditions where seven dimensions made up the actual stimulus uncertainty. Thus, seven bits of actual stimulus uncertainty may represent a limit at which point schizophrenic's information processing begins to break down completely. It is interesting that this finding is consistent with Miller's (1956) magical number seven. That is, it appears that the schizophrenics attempted to process each dimension (irrelevant and relevant redundant dimensions) on a separate and absolute basis such that when the number of dimensions approached seven a breakdown in processing occurred. According to Miller, this breakdown would be expected since the span of absolute judgement and immediate memory impose severe limitations on our information processing capacity. On the other hand, normals did not show such a breakdown in processing of information when the magic number seven was involved. In this respect, it appears that the normals were organizing, or "chunking," the information so as to reduce the strain on the channel capacity. This was particularly apparent when relevant redundancy was introduced. Overall, this interpretation is only tentative until more data is accumulated, but it does lend support for the formulations that schizophrenics suffer from impaired selective attention and impaired perceptual mechanisms. In addition, the present finding

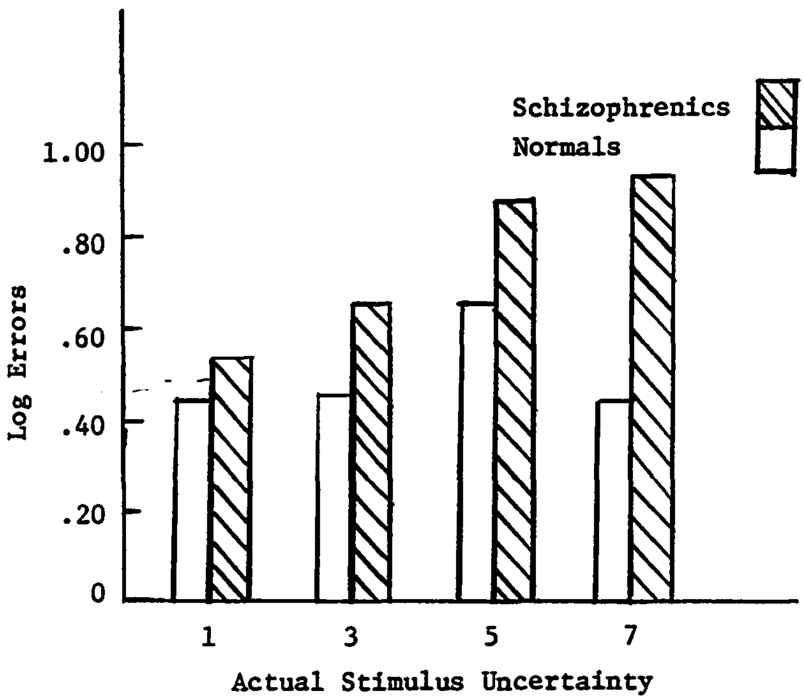

Figure 17. Mean log errors for normals and schizophrenics at different levels of actual stimulus uncertainty (See Appendix II). Ns corresponding to the various levels of actual stimulus uncertainty are: with Level 1 = 5 for both groups, Level 3 = 10 for both groups, Level 5 = 15 for both groups, Level 7 = 20 for both groups.

supports Pishkin's (1966) conclusion regarding the schizophrenic's deficient channel capacity.

The significant T x P interactions at the level of 0 irrelevant information and at the level of 1 relevant dimension lend emphasis to the interpretation that increasing redundant dimensions and increasing irrelevant dimensions, respectively, may act as sources of distraction for the schizophrenic. However, when both types of information are combined or present at the same time in the stimulus source, redundancy facilitates the information processing of schizophrenics by overcoming the noise present in the channel. In this case, even though his performance inproves, he may still not reach the performance level of the normal (Figure 10). There is little doubt that normals consistently outperform schizophrenics across all blocks of trials, but only as the actual stimulus uncertainty increases (Figures 12, 13, 14). Thus, it seems apparent that for the schizophrenic patient redundant cues are only beneficial for processing information when noise or irrelevant information is in the channel. This does not seem to be the case with the normal individual. He can effectively filter out any irrelevant information or surplus information, and he can effectively select or focus on the relevant bit of information needed.

Vocal and Subvocal Data

The analysis of vocal and subvocal activity demonstrated that such activity increased with an increase in complexity (Table 5, section E), but decreased when relevant redundancy was introduced. However, the decrease in talk time for redundancy took place only as irrelevant information increased. Figure 16 reveals that with no irrelevant information decreases in talk time over redundancy were insignificant, but as the problem increased in difficulty talk time decreased with the introduction of redundancy.

It is interesting to note that significant group differences were demonstrated only on the complexity variable. That is, schizophrenics had a significantly larger mean log talk time with complexity pooled and no redundant information than did normals. Furthermore, the significant _C_ x _P_ interaction (Figure 15) revealed that schizophrenics significantly increased their verbal activity with the introduction of irrelevant information, whereas normals showed a significant increase in verbal activity only between the 2 and 4 levels of irrelevant information. Finally, since the analysis of talk time closely resembled the error analysis, correlations were computed between errors and talk time. High positive correlations were found for both groups. This is consistent with a previous study by Wolfgang (1965).

In summary, the finding that spontaneous vocal and subvocal activity is directly related to errors and increases in complexity partially supports previous work. In this respect, it is interesting to note that Wolfgang, Pishkin, and Rosenbluh (1968) reported decreases in speech activity by schizophrenics in two man groups as the problem increased in difficulty. In the present investigation, decreases in verbal activity occurred only when redundancy was introduced in the presence of irrelevant information. Finally, in view of the significant group differences on the complexity variable whereby schizophrenics had larger vocal activity times than normals as the information load increased, it may be possible that increases in vocal activity by the schizophrenics was an attempt at using mediation processes in the solving of the CI problems. This interpretation is based on Kendler and Kendler's (1962) hypothesis that mediational events in the problem solving behavior of adult human subjects are probably verbal. Kendler and Kendler reached this conclusion after performing a series of studies on concept formation involving reversal and non-reversal shifts. In this respect, reversal shifts are considered harder to make than non-reversal shifts. However, results showed that adult human subjects performed the reversal shifts easier than the non-reversal shifts whereas pre-verbal children and lower organisms performed just the opposite. The interpretation of this finding led Kendler and Kendler (1962) to conclude that the mediator in adult human subjects is verbalization and that internal verbalization is a self-generated, cue producing behavior which tends to guide orientation to the relevant attributes. In terms of the present study, if one accepts a regression theory of schizophrenia, then it may be possible that increases in vocal activity by the schizophrenics was an attempt at using primitive mediational processes in order to process the incoming information more effectively, particularly as the information load increased.

Hypothesis Behavior

First of all, the last of the hypothesis in the present study will be stated and discussed.

7. Normal subjects will start with a more encompassing initial hypothesis, keep the same hypothesis after a correct response more frequently, and be more consistent with previously presented information than will schizophrenic subjects.

This hypothesis is partially supported in that normals tend to keep the same hypothesis after a correct response more frequently than schizophrenics (Table 7), and they are generally more consistent with previously presented information, particularly when they add a dimension to their hypothesis (Table 7), or change the composition of their hypothesis (Table 8) or when they dropped more dimensions than they added to their hypothesis (Table 9). However, in all the analysis on hypothesis behavior, there were insignificant differences on the number of dimensions included in the initial hypothesis of normals and schizophrenics. It is interesting to note, however, that 12% of the normals and 8% of the schizophrenics started with a wholist approach. Although, for normals, this is inconsistent with the Bruner et al. (1956) study, it does support Bourne's (1963) study in which 9% of the college students were considered to be wholist. The prediction that normals would start with a more encompassing hypothesis was based upon the assumption that normals being more efficient learners would adopt a wholist strategy more frequently than would schizophrenics. In view of the trial analysis, it was demonstrated that normals were more efficient learners than schizophrenics, particularly with increasing complexity of the patterns. Since the results failed to support the prediction, there are several interpretations possible. One interpretation is that the stimuli contained so few dimensions (in some cases 1, 2, or 3 dimensions) that no

S, regardless of his performance, had any difficulty keeping track of the changes. Furthermore, since redundancy was of the direct contingency type Ss may have tended to group these dimensions together rather than seeing them as separate dimensions to be included in their hypotheses. On the other hand, since the dimensions were always displayed in front of the subject in a row, this may have led the subjects to test one dimension at a time. However, there is little evidence to support this contention.

In analyzing hypothesis behavior at various levels of irrelevant information (Table 8), it is clear that at higher levels of irrelevant information schizophrenics tended to keep their hypotheses after an incorrect response, change their hypothesis more frequently after a correct response, and had higher percentages of shifts after errors as well as after correct responses when compared to normals. In addition, schizophrenics were less consistent with previous information when they changed their hypotheses, particularly when they added a dimension or changed the composition of their hypotheses. In view of these differences, it can easily be seen why normals were more efficient learners. Efficient performance would seem to depend upon proper use of previous information provided in the task, that is, the ability to remember past instances of the concept; it would seem to depend upon, theoretically, not changing a hypothesis after a correct response and changing the hypothesis only after error.

In analyzing hypothesis behavior at various levels of relevant redundant information (Table 9), differences among schizophrenic's and normal's hypothesis behavior dropped out. It is apparent that due to the facilitative effect that redundancy has upon performance, differences in amount of relevant redundant information did not differentially effect the hypothesis behavior. It seems likely that the limits on human memory and information processing ability are not exceeded by a sufficiently large number of redundant dimensions.

When hypothesis behavior was analyzed on the basis of actual stimulus uncertainty (Table 10), significant differences were obtained mainly on those conditions involving 7 bits of actual stimulus uncertainty. Schizophrenics showed higher percentages of shifts in their hypotheses after errors as well as after correct responses when compared to normals. Furthermore, these shifts were primarily changes in composition of the hypotheses. In this respect it appeared that schizophrenics were randomly choosing dimensions among the stimuli presented to them. If it is in fact true that schizophrenics do not attend selectively to stimuli and tend to be more distractable, then, in the face of many bits of stimulus uncertainty (large number of irrelevant and/or redundant dimensions), they may adopt a strategy of shifting back and forth in a vain attempt to organize the information. On the other hand, normals significantly keep the same hypotheses more frequently when they were correct; when they added a dimension to their hypotheses, they were more consistent with previous information. In this respect, normals appeared to be focusers whereby they would adopt a strategy which consisted of retaining the hypothesis that worked better than chance and then introduce corrections into the hypothesis designed to discover the remaining correct solution. This interpretation receives some additional support in that normal's hypotheses centered on a relevant dimension for solution 76% of the time as compared to 62% of the time for schizophrenics. In addition, 94% of the normals identified correctly a relevant dimension in their problems after the CI task was completed as compared to 76% of the schizophrenics.

In summary, it can be suggested that based on the hypothesis behavior of normals and schizophrenics, both groups tended to adopt a partist approach with the normal being more of a focuser and the schizophrenic being more of a scanner. This finding regarding the schizophrenic group lends support to Silverman (1963) who reported that extreme scanning characterizes the attention response styles of most schizophrenics. Furthermore, in the present study, schizophrenic's hypothesis behavior can be characterized by the fact that he does not change his hypothesis after an error, has a higher percentage of changes after a correct response as well as after errors, and is less consistent with previous information when he does make a change. On the other hand, normal's hypothesis behavior is characterized by the fact that he keeps his hypothesis when he is correct, changes it only when he makes an error, and generally changes his hypothesis in one respect at a time (in size). In addition, his hypotheses tend to be more consistent with previously presented information.

The present data suggest two distinct stages of hypothesis behavior or strategy that may occur in a CI task. The first stage is that of changing hypothesis frequently, though not necessarily on every error. This approach seems to be used until some hypothesis is discovered that results in performance better than chance. The second stage consists of retaining the hypothesis which works most often and attempting to discover the complete hypothesis for correct solution by making minor shifts or adjustments to the hypothesis. Once this solution is obtained the S makes no further hypothesis changes. Almost all of the normals appeared to follow such stages, while the schizophrenic subjects appeared to have difficulty with the first stage. This, of course, was dependent upon the amount of irrelevant and relevant redundant information contained in the problem.

Even though both groups approached the hypothesis task in a similar manner and responded to the response keys (A or B) in a similar manner, it is apparent that the stimulus dimensions were not equally salient for both groups. The horizontal position dimension was more salient for normals than for schizophrenics. In fact, the horizontal position dimension was the least salient for schizophrenics. In this respect, it is interesting to note that horizontal position was relevant in six out of the ten experimental conditions. On the other hand, the number dimension was more salient for schizophrenics than for normals. It was the least salient dimension for normals. Again, it is interesting to note that number was relevant in only one experimental condition and irrelevant at all other times. Thus, on the basis of these facts, it is possible that the poorer performance of the schizophrenic individual on the CI task as well as the poor utilization of relevant cues is, in one respect, due to the unequal saliency of the stimulus dimensions. In addition, since color, form, and number as well as size were the most salient for the schizophrenic, it would appear that they were responding to the more detailed aspects of the stimulus situation rather than to the pattern as a whole or configuration which seems to be the case with the normal individual. Finally, it is possible to conclude that due to the unequal salience of the stimulus dimensions for the two populations, an extraneous source of variance was introduced which contributed to the differences in the performances of the two groups. Therefore, it is not enough to assume that the stimulus properties used in a concept task are equally salient for psychopathological and matched control groups. It is up to the researcher to demonstrate that they are.

In summary, while the findings were not entirely unexpected, they do provide an important check on the relationship between measures based on two different types of performance, hypothesis responses and category responses. Overall, the results attest to the importance of measures and detailed analyses of hypothesis behavior in the development of a complete description and understanding of human conceptual functioning.

Hypothesis Behavior, Concept Identification, and Rigidity

Fey (1954), in a study using a card sorting task, reported that schizophrenics were characterized by preseveration and difficulty in maintaining a set when compared to normals. Fey pointed out that the tendency toward greater perseveration resulted from a tendency to continue sorting on the basis of a previously correct category which was no longer correct for solution to the problem. It was felt that on the basis of Fey's study, the perserveration may have resulted in the schizophrenics being rigid. That is, the schizophrenic individual may have had difficulty in being able to shift effectively from one activity to another or to adjust to continuously changing situational demands. On this basis it was felt that a measure of rigidity would cast additional light upon the complex processes in conceptual functioning and hypothesis behavior of schizophrenics and normals. Thus, the rigidity battery used in the present study will be discussed as it relates to the concept identification performance and to hypothesis behavior in relation to category responses.

In terms of the rigidity battery, the only measure which showed differences between the two groups was the motor-cognitive portion. Schaie (1955) interpreted the motor-cognitive score as the individual's ability to shift without difficulty from one activity to another or as a measure of effective adjustment to shifts in familiar patterns. In this sense a high score would indicate a degree of flexibility; a low score reflects a degree of rigidity. Table 11 shows that normals were less rigid ($\underline{t}$ = 2.78, 98 $\underline{df}$, $\underline{p}$ <.005) than schizophrenics on this portion of the battery.

In attempting to establish a relationship between the rigidity scores and concept identification errors, correlations were computed for both groups. As can be seen in Table 12 none of the correlations were significant for either group or overall. Thus, rigidity or flexibility as measured in the present study does not relate to CI errors for either group. However, the relationships between rigidity-flexibility and hypothesis behavior measures show quite different results (Table 13). First, in the motor-cognitive portion, the best predictor for normals was a degree of flexibility when changing their hypothesis, particularly when a dimension was added or when they used a focus gambling approach (A> D or D> A). On the other hand, the schizophrenic group was only flexible when they added more dimensions to their hypotheses than they dropped. In contrast to the normal group, the schizophrenic group displayed a significant negative correlation between rigidity and changing the composition of their hypothesis (Table 13). This lends some support to the previously mentioned finding that schizophrenics make more changes in composition of their hypotheses even though they are not as consistent with previously presented information as the normal individual. Secondly, in terms of the personality-perceptual portion of the battery, Schaie (1955) interpreted this measure as the ability to perceive and adjust to new and unfamiliar patterns and interpersonal situations. Again, there is a positive relationship between the personality-perceptual measure and the normal's adding a dimension or adding more dimensions than they drop from a hypothesis. Furthermore, the normals display a degree of flexibility in making changes after a correct response. Perhaps most interesting is the relationship between keeping the same hypothesis after a correct response (N) and rigidity on the personality-perceptual measure. In this sense a degree of rigidity seems to have helped the normal individual maintain a correct hypothesis. On the other hand, the schizophrenic group showed no significant relationships between the personality-perceptual portion and hypotheses behavior measures (Table 13). Finally, in terms of the psychomotor speed portion, Schaie (1955) interpreted this measure as the rate of emission of familiar cognitive responses. Here, a high score would seem to imply superior functional efficiency in coping with familiar situations requiring rapid responses and quick thinking. Once again, normals show a positive relationship between flexibility in psychomotor speed and changes (A, A > D, D > A) in their hypotheses whereas schizophrenics show such a relationship only when they drop a dimension from their hypotheses (D). Furthermore, normals show positive relationships between flexibility on psychomotor speed and initial hypothesis (I), keeping the same hypothesis after error (EN), and changing the hypothesis more frequently after a correct response (C_1); on the other hand, schizophrenics show positive relationships between flexibility in psychomotor speed and changes in the hypothesis after error (EC_1), and changes in the hypothesis after correct responses (C, C_1). In contrast to the flexibility scores and their respective relationships to the hypothesis behavior measures, both groups displayed a degree of rigidity on the psychomotor speed measure in relation to keeping the same hypothesis after a correct response (N).

In summary, it can be concluded, based on the results (Table 13), that rigidity-flexibility is at least one predictor of performance in the hypothesis behavior of normals and schizophrenics in relation to category responses. In the present investigation, the best predictor for the normal control group, dependent upon the measure of rigidity-flexibility used, was a fairly consistent degree of flexibility when changes were made in the direction of their hypothesis as well as after correct responses. On the other hand, schizophrenics were less consistent. Only the psychomotor speed portion of the rigidity battery appeared to be the best predictor of performance in hypothesis behavior for the schizophrenics. In this respect, the schizophrenics were more flexible when they made changes in their hypotheses after correct responses as well as after errors. Finally, there was a tendency for both groups to be more rigid when keeping the same hypothesis after a correct response. This was most evident for the normal control group.

Suggestions for Further Research

One of the goals of this investigation in terms of further work was to test and evaluate certain predictions regarding the main experimental variables against the characteristics of the groups used. That is, what aspects of the kinds of information presented here might lend themselves to use as a tool to study further specific questions regarding psychological deficit in schizophrenics and their ability to identify abstract concepts. A consideration of the redundancy variable does not allow a definite conclusion. In one respect, redundant information does have a general facilitative effect upon performance, particularly as irrelevant information increases. However, the failure of the population by redundancy interaction term revealed that the schizophrenic group did equally well on most levels of redundancy but only in the presence of irrelevant information. It was with no irrelevant information and many redundant elements that group differences appeared. One possible factor in this finding is the inadequate assumption of a demonstrable cognitive deficit in some of the schizophrenic patients. That is, due to the practical consideration of lack of availability of homogeneous groups of schizophrenic patients, the results were possibly affected by some patients not demonstrating a cognitive deficit by any measure. The heterogeneity inherent within the classification of schizophrenia is well documented (see Lang and Buss, 1965) and requires particular methodological considerations. Thus, the next step should entail the use of patients highly selected in terms of homogenous classification (e.g. acute versus chronic). In this way the within groups variance can be cut down, which may lead to a more unequivocal demonstration of the relationship between the nature of the information to be processed and the conceptual behavior of the groups included.

A consideration of the complexity variable brings forth a basic problem which should receive considerable attention in future investigations. In the present study, the finding of a significant linear effect as well as a significant quadratic effect tended to be inconsistent with many previous studies, particularly the failure to find the linear characteristic of this variable for normals. It was suggested that the reason for this finding may have been due to the finding that the stimulus dimensions in the present study were not equally salient for both populations. Only recently have investigators focused on this problem, and to the author's knowledge no studies have been performed which have attempted to establish cue salience and their relative weights for different psychopathological groups.

Although the present investigation demonstrated that differences do exist in the hypothesis behavior of the two groups included, the assessment of such behavior did not lend itself to study of the role and influences of response sets, periodic errors, and perseveration tendencies. This was due to the nature of the CI task which involves the presence of feedback and complexity of patterns. Furthermore, observations indicated that some Ss tended to overlook a dimension (which may have been relevant), respond to characteristics which never varied, and even introduced a dimension that was not part of the problem. In this respect, it was obvious that the universe of possible hypotheses from which the subject could draw varied from subject to subject. Thus, in order to overcome these deficiencies, it would be interesting to utilize a technique developed by Levine (1963, 1966). This technique involves presenting a controlled series of stimuli such that by observing the pattern of responses, it can be established which of a pool of finite hypotheses (known exhaustively to E) the subject is using. From such a technique it is possible to determine response sets, perseveration tendencies, and inconsistencies with the pool of allowable hypotheses.

In summary, it was demonstrated that the variables used in this investigation confirm to an impressive degree previous work. Although not every prediction was confirmed, the attempt to further investigate conceptual activity with this task should continue. Finally, there is every reason to believe that if all the variables within the concept identification framework were applied to these groups, a better understanding of cognitive functioning of pathological groups as well as normal groups would be a reasonable certainty.

CHAPTER VII

SUMMARY AND CONCLUSIONS

Traditionally, the investigation of higher thought processes has been a prime objective in attempting to understand a psychological deficit in schizophrenia. Based on this objective, evidence in recent years has emerged suggesting that schizophrenics, unlike normals, suffer from impaired selective attention, inability to maintain a set, inability to process relevant cues effectively, and an inability to screen out irrelevant information in a message in order to process relevant incoming data. Furthermore, in the scientific investigation of cognitive processes, the concept identification framework has long been recognized for the value of its standardized procedures and the quantifiability of various dimensions. Here, the specific model involved utilizes a combination of information theory and mathematical models. 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 relevant redundancy variables on a schizophrenic and matched control population.

2. Show that variations among these two variables either support or do not support certain theoretical predictions regarding assumed differences in the information processing capacity of the two groups.

3. Explore the assumed differences in the approaches to processing information and the identifying of abstract concepts of the two groups by studying hypothesis behavior in relation to category responses.

4. Demonstrate for both groups that hypothesis behavior and utilization of relevant cues in concept identification is to some extent related to a rigidity-flexibility dimension.

The rationale of this experiment was based upon an attempt by many investigators to overcome the interference and distraction in the schizophrenic's information processing by utilization of the information theory concept of redundancy. However, reports on this variable have been contradictory. Some investigators report that redundant stimulus information facilitated the information processing of schizophrenics while other investigators report an interfering or distraction effect. Most of these studies have been concerned only with the role of redundant information and have neglected to: (1) systematically vary the amount of redundant information along with the amount of irrelevant information, (2) systematically investigate the schizophrenic's approach as an efficient learner to a perceptual-cognitive task, and (3) evaluate the schizophrenic's ability to effectively utilize relevant cues. Thus, the present study attempted to satisfy these three neglected points. Finally, it was recognized that many variables such as diagnostic classification, length of hospitalization and illness, as well as intellectual level of the patient all must be considered as a source of variance that can influence the outcome.

The results of the error, trial, and hypothesis analyses generally supported the previously mentioned aims. The accomplishment of the first aim and the substantiation of previous work was reflected in the significant population main effect, the significant redundancy main effect, the significant complexity main effect, and the significant redundancy by complexity interaction term. These findings indicated that: (1) the schizophrenic group is significantly poorer on the identification of abstract concepts, but only at the higher information load levels, (2) as the number of irrelevant dimensions increased, progressively more CI errors occurred in both groups, (3) with the introduction of relevant redundant dimensions, progressively fewer CI errors occurred in both groups, and (4) the amount of improvement under redundant conditions increased for both groups as the amount of irrelevant information increased. Overall, these findings lend greater generalizability to the mathematical model of CI with the addition of the present schizophrenic population. Indeed, it is remarkable to find two experimental variables that can be applied with fairly consistent effects across different populations.

The accomplishment of the second aim of this investigation is related to the performance of the two groups across the redundancy and complexity variables, across the actual stimulus uncertainty, and to the findings on the spontaneous vocal and subvocal activity. First, even though the interaction effects of the population by redundancy and by complexity were not significant, differential effects were observed. Although both populations demonstrated a significant facilitation in performance when relevant redundancy was introduced, it is apparant that the schizophrenics did not benefit from relevant redundancy as much as the normal group did, particularly when no irrelevant information was present. In addition, as already pointed out, when irrelevant information increases, schizophrenics do perform poorer than normals although the performance is parallel in trend. Secondly, in terms of the actual stimulus uncertainty, it was demonstrated that the schizophrenics performed significantly poorer than normals as the actual stimulus uncertainty increased to seven bits of information. Finally, it was observed that schizophrenics significantly increased their vocal activity with the introduction of irrelevant information whereas normals showed an increase only as four bits of irrelevant information were present. Taken together, these findings were discussed in terms of a conceptual deficit in schizophrenia resulting from an impaired selective attention, a breakdown in perceptual mechanisms involving the encoding and "chunking" of information, a defect in the screening or "filter" mechanism, and the inability to learn or utilize mediational processes in order to facilitate information processing.

The accomplishment of the third aim of this investigation is related to the performances of the different groups on the hypotheses formulated during category responses. Here, the results demonstrated that differences do exist between schizophrenic's and normal's hypothesis behavior when identifying abstract concepts. Although both groups tended to adopt a partist approach, schizophrenics, when confronted with an increasing information load, tended to sample their hypothesis on a random basis. That is, the schizophrenic seemed to follow a scanning strategy of shifting back and forth in a vain attempt to find a workable hypothesis. On the other hand, normals seemed to be focusers, whereby they would adopt a strategy which consisted of retaining the hypothesis that worked better than chance and then introduce corrections into the hypothesis designed to discover the remaining, correct, solution. Finally, and perhaps most important, is the finding that the stimulus dimensions were not equally salient for two population groups. In this respect, there is little doubt that this finding is at least one of the factors which contributed to the differences observed in the performances of the two groups on the CI task. Indeed, this variable must receive attention and control in future studies. It is not enough to assume that stimulus dimensions are equally salient for different population groups. This must be demonstrated to be the case.

Finally, the accomplishment of the last aim of the present study was done by a psychometric variable. Here, the results demonstrated that while no correlative relationships between rigidity-flexibility and CI performance were found, there were significant correlations between the rigidity-flexibility measures and hypothesis behavior in relation to category responses. In view of the results, the major conclusion here was that although there were significant relationships between measured psychometric rigidity-flexibility and hypothesis behavior, the relationships are contingent upon the tests and the groups involved. In this respect, some caution is necessary in making any generalizations regarding hypothesis behavior based on a particular measure of rigidity-flexibility.

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APPENDIX I

CRITERIA FOR GROUPS

Criteria for Schizophrenic Population

All patients tested were selected according to the following:

1. Diagnosis of schizophrenic (any type) by at least two ward psychiatrists.
2. At least three years duration of disorder.
3. Twenty months or less current hospitalization.
4. Between 20 and 55 years of age.
5. Minimum of eighth grade education.
6. No brain damage, no seizures, no psychosurgery, and no visual impairment.
7. The ability to cooperate and understand instructions as estimated by the psychiatric staff.

NOTE: All schizophrenic patients received various degrees of psychotropic drugs. Since it was not possible to take the schizophrenic patients off the psychotropic drugs they were receiving, it was necessary to make the assumption (in the interest of the design and in relation to the availability of subjects) that "drug effects" could add a source of variation. However, those patients receiving dosages equivalent to 400 mg. thorazine daily or higher were excluded from the group. In addition, those patients showing any severe behavioral reactions to the psychotropic drugs were eliminated from the study.

Criteria for Normal Population

The normal group was selected on the basis of the following:

1. Between 20 and 55 years of age.
2. Minimum of eighth grade education.
3. Twenty months or less current hospitalization.
4. No brain damage, no psychiatric impairment, no seizures, and no visual impairment.
5. The ability to cooperate as estimated by ward nursing staff.

NOTE: Some of the normal patients were receiving various degrees of psychotropic drugs (e.g. Meprobamate) and sedatives.

In general, any patients with the following primary or secondary diagnoses were excluded from both groups:

1. Alcoholism.
2. Arthritis.
3. Parkinsonism.
4. Long-standing and uncontrolled diabetes.
5. CVA.
6. Blood dycrasias.

APPENDIX II

STIMULUS DIMENSIONS

Relevant and Irrelevant Stimulus Dimensions

The ten treatment conditions involving dimensions used as relevant (R) and irrelevant (I) are as follows:

		Number of Relevant Dimensions							
Number of irrelevant dimensions		1		3		5		7	
0	R	C		C,H,F		C,H,F,V,O		C,H,F,V,O,S,N	
	I	ZERO	(1)	ZERO	(3)	ZERO	(5)	ZERO	(7)
2	R	C		C,H,F		C,H,F,V,O			
	I	N,S	(3)	N,S	(5)	N,S	(7)		
4	R	C		C,H,F					
	I	N,S,O,V	(5)	N,S,O,V	(7)				
6	R	C							
	I	N,S,O,V,F,H	(7)						

NOTE: The letters in the cells were the dimensions used; C=color; H=horizontal position; F=form; V=vertical position; S=size; O=orientation; N=number. The number in parenthesis represents the actual stimulus uncertainty.

APPENDIX III

INSTRUCTIONS

Instructions

Each subject was read the following instructions:

This is a throat microphone. When you speak try to avoid speaking in a very loud or a very soft voice. Your normal voice will be fine. (Experimenter puts first example on the screen.)

Listen carefully to these instructions. This is a study of concept learning. On the screen in front of you, you will see a series of patterns, one at a time. (For example, you see the yellow X here, this will be followed by a yellow Y.) Your job is to sort these patterns into two groups, A and B. (Key A and Key B) For example, you could put the X here, group A, and the Y here, group B. Actually it is as if I gave you a deck of playing cards and asked you to put all the number cards in group A and all the face cards in group B.

Now, in the problem I give you, the basis for sorting the patterns into group A or group B will depend upon the characteristic or characteristics of the patterns. (one, more, or all) (Experimenter explains all the characteristics) In the example you see here the correct characteristic is F, form (X & Y). First, you would push button F, then key A. When you have chosen the correct group for sorting, the light just above the key will light up. When you have chosen the wrong group, the light above the other key will light up. Now, in the problem that I will give you, your job is to discover the correct basis for sorting the patterns by using these characteristics so that the light above the key (A or B) that you choose will light up each time. If you are not sure, guess; your guess 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 (like X and Y change) but the basis for sorting will remain the same throughout all the patterns.

Remember, first you choose the characteristic or characteristics (one, more, or all) that you feel is the correct basis for sorting the patterns. (Experimenter explains use of correction button) Secondly, you then decide whether the pattern goes into group A or group B. You may take as much time as you wish in making your decisions. Finally, I will stop you after you have made 16 correct sortings in a row. Any questions before we go through the examples?

Examples

In the following examples, you will see a yellow X with a black line followed by a yellow Y with a black line. The correct characteristic for these examples is button F, or form, and the correct basis for sorting is that all X's go in group A, and all Y's go in group B. Remember, each time a pattern appears, you must first choose the characteristic or characteristics you feel is correct, then push key A or key B, and always try to be correct.

Example I: In this example you see a yellow X with a horizontal black line. Here, the correct characteristic is F and the correct basis for sorting is X goes to key A. You first push button F, then key A. Would you do this now?

Example II: In this example you see a yellow Y with a horizontal black line. Again, the correct characteristic is F and the correct basis for sorting is Y goes to key B. You first push button F, then key B. Would you do this now?

Example III: Here, you see a yellow X with a vertical black line. Again, you first push characteristic button F, and then key A. Go ahead.

Example IV: Here, you see a yellow Y with a vertical black line. Again, button F first, then push key B. Go ahead.

Remember, your task or job is to discover the correct basis for sorting by first choosing the characteristic or characteristics you feel is correct, then sorting the patterns into group A or B. Let's go through the examples again and this time you do them. Any questions? (The experimenter tells the subject that the problem will be different from the examples, and then has the subject begin the experimental problem.)

APPENDIX IV

PRESENTATION ORDER, DEMOGRAPHIC, PSYCHOMETRIC, ERROR, TRIAL, TALK TIME, AND HYPOTHESIS CHARACTERISTICS

Order of Testing

Redundancy	1				3			5		7
Complexity	0	2	4	6	0	2	4	0	2	0
					SCHIZOPHRENICS					
Replications	6	2	3	16	13	27	5	20	1	22
	21	31	19	17	15	28	23	25	4	29
	49	32	61	79	64	35	33	70	56	62
	83	75	111	80	96	101	95	102	99	100
	114	103	112	104	108	106	105	110	107	109
					NORMALS					
Replications	7	18	38	12	10	8	26	42	36	44
	30	47	39	40	46	11	37	52	41	45
	48	66	60	55	54	50	51	68	58	57
	73	82	90	76	72	71	67	77	63	59
	97	91	94	87	86	89	92	81	93	88

Age

Redundancy	1				3			5		7
Complexity	0	2	4	6	0	2	4	0	2	0
					SCHIZOPHRENICS					
	28	51	39	36	47	49	32	36	31	49
	42	47	24	25	38	42	50	38	39	34
Repli-cations	34	34	49	33	46	37	44	33	23	42
	42	29	36	29	44	45	40	47	43	35
	21	54	41	44	36	40	36	45	36	47
					NORMALS					
	48	55	49	36	33	49	46	45	44	52
	21	36	46	48	47	45	40	47	38	50
Repli-cations	37	30	35	25	21	33	49	23	44	25
	39	49	21	27	42	44	36	42	22	41
	25	44	37	40	37	38	44	40	22	36

Education

Redundancy	1				3			5		7
Complexity	0	2	4	6	0	2	4	0	2	0
					SCHIZOPHRENICS					
Replications	12	9	13	11	8	10	16	14	8	12
	15	12	12	12	8	9	12	8	9	8
	12	11	11	15	12	10	8	14	10	8
	12	12	9	10	8	17	13	16	10	12
	10	8	8	12	12	12	8	8	8	16
					NORMALS					
Replications	8	8	11	12	10	16	11	12	10	12
	10	10	12	8	11	10	8	12	10	12
	14	13	10	12	12	11	8	12	9	12
	8	8	13	10	12	9	12	9	11	12
	16	13	10	10	8	8	8	12	10	10

Shipley Vocabulary Score

Redundancy	1				3			5		7
Complexity	0	2	4	6	0	2	4	0	2	0
					SCHIZOPHRENICS					
Replications	24	33	23	24	15	30	31	34	11	33
	34	20	27	23	30	29	31	24	26	3
	31	23	27	31	30	23	28	29	11	27
	21	25	15	25	24	36	34	31	26	27
	30	12	10	31	22	32	28	25	28	38
					NORMALS					
Replications	28	19	19	22	29	37	24	20	21	35
	17	18	27	30	25	30	24	24	25	29
	34	37	39	18	32	31	25	27	29	16
	23	20	29	17	36	26	28	27	18	29
	31	34	26	29	23	32	20	18	23	30

Shipley Abstract Score

Redundancy	1				3			5		7
Complexity	0	2	4	6	0	2	4	0	2	0
SCHIZOPHRENICS										
Replications	14	18	12	20	4	12	24	22	2	28
	22	8	12	20	14	10	6	10	26	8
	6	4	32	24	12	6	0	20	2	4
	10	22	2	2	6	12	26	24	18	22
	32	6	2	16	8	36	20	4	20	38
NORMALS										
Replications	12	4	6	18	28	30	12	6	12	12
	12	18	10	18	6	28	6	16	20	30
	30	28	22	8	30	4	6	24	12	12
	16	10	30	12	24	12	18	28	26	24
	36	22	10	12	8	6	6	6	22	8

Psychomotor Speed Rigidity Quotient Score: Age Scaled

Redundancy	1				3			5		7
Complexity	0	2	4	6	0	2	4	0	2	0
					SCHIZOPHRENICS					
Replications	78	94	74	95	68	79	88	73	47	74
	76	57	75	60	65	68	76	80	68	65
	65	65	68	98	91	70	68	94	68	74
	74	87	87	62	68	92	74	100	76	73
	101	68	68	66	82	94	83	74	97	92
					NORMALS					
Replications	70	65	60	66	59	87	77	66	58	74
	68	80	62	81	66	84	67	74	80	81
	114	111	80	66	83	96	77	83	74	69
	74	51	105	60	92	64	102	68	84	68
	75	94	79	95	71	70	56	88	71	85

Errors (CI): Original Scores

Redundancy	1				3			5		7
Complexity	0	2	4	6	0	2	4	0	2	0
					SCHIZOPHRENICS					
Repli- cations	4	85	102	98	0	84	7	0	16	0
	1	6	95	105	0	0	9	0	0	15
	5	6	72	97	1	0	9	0	4	0
	2	4	59	111	0	7	2	0	0	0
	2	88	90	94	0	0	4	5	3	8
					NORMALS					
Repli- cations	2	29	91	6	0	0	0	0	3	0
	3	1	95	10	1	0	5	0	0	0
	1	0	66	15	0	0	0	0	0	0
	6	48	18	67	0	4	3	1	0	0
	0	3	21	98	1	1	0	1	0	0

Talk Time in Seconds: Original Scores

Redundancy	1				3			5		7
Complexity	0	2	4	6	0	2	4	0	2	0
					SCHIZOPHRENICS					
Replications	5	245	133	157	2	141	56	34	19	0
	0	66	46	234	3	2	5	22	1	20
	8	9	23	141	2	1	20	1	0	10
	6	10	49	67	3	15	2	1	0	43
	0	24	47	160	0	2	132	5	6	70
					NORMALS					
Replications	13	2	41	38	3	0	7	7	1	11
	2	5	54	4	14	8	11	4	13	33
	3	4	222	7	1	0	0	21	1	1
	14	2	12	26	10	11	11	3	1	8
	10	9	24	168	7	18	6	9	2	1

Mean Errors for 12 Blocks of 16 Trials (CI):
Based on 5 Replications

SCHIZOPHRENICS

Redundancy	1				3			5		7
Complexity	0	2	4	6	0	2	4	0	2	0
	2.8	4.6	8.8	8.0	0.2	2.2	5.2	0.8	3.2	2.0
	0	4.4	8.6	8.4	0	1.8	1.0	0.2	1.4	2.4
	0	3.2	6.8	8.6	0	1.4	0	0	0	0.2
	0	3.6	6.8	8.6	0	1.2	0	0	0	0
	0	2.8	7.4	8.6	0	1.8	0	0	0	0
Trial Blocks	0	2.4	7.8	9.0	0	1.2	0	0	0	0
	0	2.4	9.4	9.0	0	1.2	0	0	0	0
	0	3.0	8.2	9.0	0	1.8	0	0	0	0
	0	3.0	5.6	6.4	0	1.6	0	0	0	0
	0	2.6	5.2	9.0	0	1.4	0	0	0	0
	0	2.6	4.6	9.2	0	1.2	0	0	0	0
	0	3.2	4.4	6.8	0	1.4	0	0	0	0

Mean Errors for 12 Blocks of 16 Trials (CI):
Based on 5 Replications

NORMALS

Redundancy	1				3			5		7
Complexity	0	2	4	6	0	2	4	0	2	0
Trial Blocks	2.0	3.0	9.0	7.0	0.4	1.0	1.6	0.4	0.6	0
	0.4	4.4	7.2	5.0	0	0	0	0	0	0
	0	2.8	6.0	3.0	0	0	0	0	0	0
	0	2.2	3.8	3.4	0	0	0	0	0	0
	0	1.0	5.2	4.4	0	0	0	0	0	0
	0	1.4	4.0	3.2	0	0	0	0	0	0
	0	0.8	4.0	2.8	0	0	0	0	0	0
	0	0.2	5.2	2.0	0	0	0	0	0	0
	0	0.4	4.8	2.8	0	0	0	0	0	0
	0	0	4.0	2.6	0	0	0	0	0	0
	0	0	3.0	1.4	0	0	0	0	0	0
	0	0	2.0	1.6	0	0	0	0	0	0

Mean Proportions for the Hypothesis Characteristics:
Based on 5 Replications

SCHIZOPHRENICS

Redundancy	1				3			5		7
Complexity	0	2	4	6	0	2	4	0	2	0
Hypothesis Characteristic										
I	1.00	1.00	1.00	1.40	1.00	1.00	1.60	1.20	1.00	1.40
EC	.10	.17	.20	.43	0	.12	.25	.03	.06	.04
EC_1	0	.39	.31	.49	0	.35	.48	.12	.17	.12
EN	.90	.61	.69	.57	.20	.05	.52	.08	.43	.27
C	.10	.44	.20	.57	.20	.48	.54	.77	.54	.56
C_1	.01	.30	.28	.44	.12	.44	.42	.32	.17	.36
N	.99	.69	.72	.56	.87	.56	.58	.67	.64	.64
A	0	.07	.04	.30	0	0	.05	0	0	0
D	0	.09	.05	.09	0	0	0.10	0	0	0
A>D	0	.01	.02	.01	0	0	.05	0	.20	0
D>A	0	.01	.01	.01	0	0	0	0	0	0
A=D	.20	.42	.27	.59	0	.40	.60	.20	.20	.20

Mean Proportions for the Hypothesis Characteristics:
Based on 5 Replications

NORMALS

Redundancy	1				3			5		7
Complexity	0	2	4	6	0	2	4	0	2	0
Hypothesis Characteristic										
I	1.40	1.00	1.40	1.00	1.00	1.00	1.40	1.00	1.00	1.60
EC	.22	.06	.38	.30	0	.04	.35	0	.10	0
EC_1	.20	.01	.51	.18	0	.15	.28	0	.07	0
EN	.50	.79	.49	.82	.40	.25	.12	.40	.13	0
C	.40	.33	.42	.30	.20	.76	.25	.40	.50	.60
C_1	.07	.16	.41	.14	.01	.53	.04	.27	.25	.16
N	.93	.83	.59	.86	.99	.47	.96	.72	.75	.84
A	.00	0	.11	.04	0	0	.07	0	0	0
D	.00	0	.11	.27	0	0	.07	0	0	0
A >D	.00	0	.03	.02	0	0	.07	0	0	0
D >A	.00	0	.05	.01	0	0	0	0	0	0
A=D	.40	.20	.49	.05	0	.20	.27	0	.20	0