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AUTHOR Logan, William L.; Palmer, Michael
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ABSTRACT

The present study attempted to identify and describe individual differences in concept learning. It was hypothesized that if a significant portion of the reliable individual variation in a complex learning situation could be identified and described, it would be reasonable to expect that subsequent predictions could be made about the conditions necessary to maximize efficiency in learning for various categories of subjects. Scores were obtained for thirty-nine subjects (nineteen male, twenty female) on twelve references tests representing measures of fourteen intrinsic individual difference variables. The implication being that those people who are susceptible to response competition will do poorly on conceptual learning tasks that are high in concept complexity. The basic hypothesis here is that those people who manifest resistance to response competition are less suceptible to interference with the consolidation of visual information, and are therefore able to form the necessary association needed to develop a short-term visual memory structure. (Author)

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William L. Logan and Michael Palmer
University of Northern Colorado
Greeley, Colorado 80631

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U.S. DEPARTMENT OF
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I. Statement of Problem

A. General Background of the Present Study

An analysis of the experimental literature in the area of conceptual learning points up two (2) basic methodologies used in the investigation of learning processes as they relate to conceptual behavior. The first of these methodologies falls into what might be broadly termed "ecological conditions"; the second deals with the characteristics of the performing subject (S) as he solves a conceptual problem.

Studies investigating the effects of various ecological conditions on concept learning have generally been concerned with the manipulation of such factors as: 1) the utilization of positive instances (Freibergs & Tulving, 1961), 2) the number of relevant or irrelevant dimensions presented to a subject in a concept identification task (Walker & Bourne, 1961), 3) the logical structure of concepts (Haygood & Bourne, 1965), and other functional relationships identified as task variables.

The methodologies followed by experimental psychologists utilizing the characteristics of the performing S as experimental variables has produced a reasonable amount of useful information (e.g., Bourne, Goldstein, and Link, 1964; Dickstein, 1968). However, an examination of the research literature concerned with these "organismic" or "subject variables" suggests two (2) inadequacies. In the search for general behavioral laws, investigators in comparative studies have been preoccupied with means of avoiding error variance and have tended by design to randomize out the effect of individual differences (IDs) rather than studying their influence on behavior.

In addition, the research has been relatively unsystematic and therefore has tended not to be programatic in design.

1. The Basic Problem

Recently, a high degree of interest has been shown in the individualization of instruction. If the goal of education is to bring each student to a common level of mastery in cognitive or instructional tasks, then a major requirement would be the adaptation of the mode and method of instruction to individual variation. It would seem to follow that the success of an individualized instructional program would be dependent upon a complete understanding of the IDs contributing to the learning of complex tasks.

The present state of knowledge is such that given sufficient data, experimental or instructional psychologists enjoy a reasonable degree of success in the prediction and control of behavior. For example, if a group of Ss are presented a series of digits and instructed to recall them in the exact serial order that they were presented, it is safe to predict that they will recall the first and last parts of the series better than the central portion of the series.

However, in relation to conceptual abilities and the learning of complex tasks (i.e. conceptual learning) the degree of predictive success that has been demonstrated is in advance of the understanding of the underlying IDs that produce the behavior. It would seem reasonable to assume, that if the knowledge of these IDs as they relate to conceptual learning could be acquired it would provide "...both a source of hypotheses about the nature of learning processes and a means of testing certain deductions from theoretical formulations [p. 142], (Jensen, 1966)".

In a recent review, Glaser (1967), supporting this line of thought, has pointed out the importance of developing techniques which will allow the identification of individual learning functions. In addition he has deemphasized the practice of averaging data as a method of demonstrating learning in performance terms. Given the identification of these individual learning functions, it would seem to follow that subject variables could then be defined as initial state measures. This concept of a behavioral baseline is prevalent in the area of physiological psychology; Skinner in studies of individual behavior, defines this procedure as the description of an "operant level". In either case, qualifying conditions are baing placed on the general behavioral laws.

In consideration of this position, the direction of future research should be towards the identification of differences in performance that are directly dependent upon IDs in learning processes. If these performance measures can be identified, then a "Taxonomy of Processes" (Melton, 1967) as they relate to cognitive tasks can be developed.

These individual performance funtions, as initial state measures, must be considered as variables in the learning process. When the point is reached at which these variables can be included as givens in the experimental paradigm, it will in effect, increase the level of information obtained from the data and consequently the generalizability of the results.

(a) Categories of IDs in Learning. Jensen (1964) in studies of IDs has introduced two useful concepts into the literature, 1) intrinsic and extrinsic sources of IDs, and 2) phenotypic and genotypic variables. In conceptualizing the importance of a) the production of individual functions and b) a taxonomy of processes, the preceding section has been an attempt to develop the initial structure of a model in terms of IDs which are inherent in the learning process. Jensen terms these Ids which cannot exist as functions independent of learning, as "intrinsic individual differences". The differences "...consist of intersubject variability in the learning process [p. 122], (Jensen, 1967)." On the other hand, "Extrinsic individual differences" are variables which may influence performance on a learning task. These variables that may be identified as extrinsic sources are sex, IQ and personality.

Phenotypic variables are defined in terms of the ecological conditions, i.e., task variables. Operationally a phenotypic source of variance is defined as any significant interaction between the Ss and a task variable. A genotype is defined as the underlying process variable that is the causal factor for the pattern of relationships between the phenotypic variables. For example, the process of "retroactive inhibition" is by definition an intrinsic source of IDs. The construct that is posited as an explanation of this process is interference with the consolidation of the stimulus trace and is considered to be the underlying genotype. In the "retroactive inhibition" paradigm (i.e., learn A, learn B, test A) the observed behavioral measure taken during the testing of material A, is considered to be the phenotypic aspect of the "retroactive inhibition" process. An S who scores high on the testing of material A is said to have little susceptibility to retroactive inhibition and therefore is resistant to interference affecting the consolidation of the stimulus trace. Though extrinsic IDs seem to contribute to the between - subjects variation in learning, within the constructs of the model as it is defined by Jensen (1964, 1967), the majority of the phenotypic variation of IDs in learning will ultimately be explained in terms of genotypic - intrinsic factors.

Common to both concepts, as they are presented above, is the basic distinction between task and process. At the present, there seems to be a concensus among a number of experimental psychologists that a more fruitful approach to the understanding of IDs can be found in the study of process variables. Melton (1967) makes this point in saying, that "what is necessary is that we frame our hypotheses about individual differences variables in terms of the process constructs of contemporary theories of learning and performance [p. 239]."

In accordance with this the present study is designed to determine some of the characteristics of the performing S (i.e. IDs) in terms of the relative contribution of intrinsic factors to the variation found in the type of performance error the S commits while performing the task, and the decision processes of the performing Ss as they relate to conceptual learning and relevant process variables.

(b) Definition of Concept Learning: Classification Scheme. Before investigating the effects of intrinsic IDs on conceptual behavior we must in some systematic fashion define the specific learning behaviors with which we will be concerned.

Concept learning has been chosen as the task in this study for the following considerations. First, the task structures are similar in form to school learning and natural learning situations. Second, there is a large body of definitive literature that is well documented in relation to the relevant task and subject variables. Third, the designs of concept learning tasks lend themselves more to experimental control than other complex learning behaviors. Lastly, concept learning is particularily well suited to the goal of identifying intrinsic individual differences as subjects can be presented with a series of many different concept learning tasks whose relationship to one another may be clearly specified.

The area of conceptual learning manifests distinctions in phenomena that defines a number or specific classes and/or levels of behavior. However, a taxonomic analysis of conceptual learning has been fully explicated elsewhere (e.g., Kendler, 1964; Jensen, 1966; Haygood & Bourne, 1965) and the classification scheme will be concerned only with those classes of behavior that are immediately related to the problem under study.

The first distinction that we will be concerned with relates to the type of conceptual task. Basic to all learning is the process of simple discrimination; within the taxonomy of conceptual behavior a type of concept learning is found which depends largely upon discrimination learning. The laboratory learning task designed to investigate this behavior requires the S to divide a series of complex stimuli into two mutually exclusive sets labeled positives and negatives. Positives are classified as being exemplars of a concept, negatives as non-exemplars of the same concept; the relevant attributes and the relational rule are defined by the experimenter (E). The process of definition is fully explained in Procedures: section (IV C-3). The second distinction, related to the conceptual task, is made between "attribute identification" and "rule learning". Haygood & Bourne (1965) make this distinction in relation to the task requirements of the learning condition. In the former the S is given the relational rule with the task instructions and must discover the relevant attributes. In rule identification the S is told what the relevant attributes of the concept are and must discover and verbalize the rule of relationship between the attributes.

If sources of intrinsic IDs can be found in this simplistic form of concept learning, research should then lead to the discovery of their effects in more complex forms of learning behavior.

B. Approach of the Present Study

The present study is an attempt to identify and describe intrinsic sources of IDs in concept learning. As mentioned above there is a consensus that the most fruitful approach to the understanding of IDs will be found in the study of process variables. More specifically, it is highly probable that the greatest source of ID variance in learning can be found in the interaction between the process variables and the procedural variables of the learning condition.

1. Procedural Variables. Procedural variables are a class of task variables dealing with the procedure of the learning condition, excluding the content and the sensory modality of the presentation. This particular class of variables would include such factors as CS-UCS interval, pacing, distribution of practice, type and amount of stimulus available to the *S* from previous events, task complexity, and stage of learning. The last three variables are of particular importance to this study.

The importance of the type and amount of past information as well as task complexity as procedural variables is well documented in the literature (e.g., Walker & Bourne, 1961; Bourne, et. al., 1965) and are used as independent variables in this study.

2. Stage of Learning. Previous research in concept learning has involved the *S* at most one to three hours in a laboratory task. It is well known that if a learner is presented with a series of related learning tasks, his performance, in addition to showing a greater stability in the final stages of the series, is more efficient than in the initial stages of learning. Therefore, it would seem that previous research is inadequate in so far as it has been investigating basically the initial

stages of learning and not the more stable behavior found in the final stages of practice.

In addition, Fleishman (1962, 1967) in developing a taxonomy of IDs as they relate to perceptual-motor skills, has found changes in the factorial composition of the IDs contributing to the performance, at different stages of learning. The changes are systematic and do stabilize in the later stages of practice.

In consideration of these factors the study follows a program suggested by Jensen (1965, 1967). The first step in a systematic approach to the identification of these intrinsic ID sources is to limit the area of research to one type of learning. It is assumed, that by limiting the focus of study to a single type of learning and manipulating relevant process variables within this narrow class of behavior it should make the interpretation of any evolving structure a simple process.

Within the design of this study two additional methodological or procedural innovations have been added. The first departure from earlier procedures will be the use of long term experimentation. The Ss will be tested on the laboratory tasks, three hours a week for a period of approximately five weeks. This extended period of testing allowed the investigator to collect data on the reliable performance measures found in the final stages of practice.

The second procedural change will be in the methodology used in the selection or development of the tests for the reference battery. Earlier studies have attempted to explain individual variation in complex tasks through the use of psychometric tests designed as indexes of general ability (e.g., general reasoning, induction, deduction, and verbal comprehension). The approach of this study is much simpler in structure, the emphasis being on the identification of intrinsic sources of IDs. As stated above, it is expected that the greatest source of ID variance will be found in the interaction between the process variables and the procedural variables. In consideration of this, two types of test instruments were utilized in constructing the reference battery.

Wherever possible the reference tests were selected from the methodology of established studies in literature, the procedures of which were designed to assess process functions. The second type of test included in the reference battery was selected from standardized psychometric instruments. The criterion of selection for an instrument is to be its relationship to the relevant process variables, and its factorial simplicity.

3. Overview. The intent of the study is the identification and description of intrinsic sources of IDs in concept learning. The general structure is atheoretical in concept but the design of the study is systematic in its approach to the problem. The reference battery is comprised of two types of test instruments. In addition to standardized tests selected for their factorial simplicity, the instruments were selected with consideration given to tested procedures found in the literature.

The *Ss* were tested on various forms of concept learning materials, similar to those used by Bruner, et. al., (1956). The procedural variables that have been selected are the difficulty of the task (concept complexity), and the type and amount of stimuli available to the *S* from previous events (memory).

II. Review of Related Research

At present, psychologists have rejected the definition of intelligence as being a unitary learning ability. Using the process of factor analysis it has been demonstrated that there is little evidence to support the concept of a general learning factor and a large number of group factors have been identified.

Woodrow (1946), began a trend in the research of IDs that has been labeled the psychometric approach. The goal of this method has been the identification of IDs in learning in terms of group factors or abilities as they are defined through the factor analysis of psychometric reference tests. Examples of such a battery would be the "Kit of Reference Test for Cognitive Factors" (French, Edstrom and Price, 1963) or Thurstone's tests of Primary Mental Abilities (PMA). Typical factors included in this type of reference battery are verbal fluency, perceptual speed, general reasoning, numerical ability, etc.

A number of criticisms can be directed of this general approach. With few exceptions, studies of IDs though quite competent in design in relation to the psychometric method have encountered the same problems. The difficulities most consistently found were the following:

(1) The reference test as a measure of an ability factor does not present in a simple form the initial state of the S. A great deal of transfer from prior learning is involved in this type of assessment.

(2) In many instances in terms of the processes and procedures involved in the reference test, the assessment is more complex than the task. In terms of scientific explanation, it would seem more logical, in relation to the initial states of the learner, that specific

factors relating to performance are more basic and therefore necessary to the understanding of the learning process. It would seem more likely that the aptitude or ability could be defined by the interaction of the intrinsic sources of IDs. Unless the interaction of these specific factors can be explicated, using an aptitude measure to explain IDs in learning is using one incomplete construct to explain another.

(3) When the reference battery and the learning tasks have been factor analyzed little or no common variance has been evidenced between the two measures. The usual result was two distinct factor types, one for the reference tests and one for the learning tasks.

A number of studies have been conducted to investigate IDs in learning. The review will be concerned only with those correlational studies that directly deal with the cognitive factors of learning, as opposed to psychomotor learning. Illustrative of such investigations are Stake (1958), Allison (1960), Duncanson (1966), Lemke, Klausmeier, and Harris (1967), and Dunham, Guilford, and Hoepfner (1966).

Stake (1958) investigated the relationships between learning tasks, ability factors, and scholastic achievement. The learning tasks were categorized as to their verbal or non-verbal content, and as to whether rote or relational learning was required. The instruments used in the reference battery are subject to the first criticism in that the assessment involved a good deal of transfer from prior learning experience. In fact the criterion for selection was that they parallel some scholastic learning experience. In addition the factor analysis yielded two factor groupings: (1) reference and achievement factors, and (2) learning factors. The intercorrelations between factors within these two groupings were negligable, as well as the intercorrelation of the learning factors. Lastly, the majority of what might be labeled as specific factors, (e.g., verbal reasoning) seem to be complex in themselves and are in need of explication.

Allison (1960) administered 13 learning tasks which were representative of three types of learning: rote, conceptual and motor learning. Thirty-nine reference measures of aptitude and achievement were used by Allison in an attempt to assess any relationships between the learning process and human abilities. As with Stake (1958) the instruments used by Allison in the reference battery involve a great deal of transfer from prior learning. The psychological processes and/or procedures involved in the reference assessment (e.g., deduction, verbal knowledge) are as complex as the learning tasks. The investigation carried out by Allison yielded factors that were common to both factor domains, the reference and learning. Nonetheless, like Stake (1958), the factors interpreted by Allison such as "Spatial Conceptual Learning", or an inter-battery factor "Conceptual Process Factor", did not yield much information about the learning process.

Duncanson (1966) investigated the interrelationships of ability and learning measures by administering a battery of ability tests in conjuntion with learning tasks. The tasks included three types of learning, paired-associate, rote-memory, and concept-formation. Following the psychometric method the reference tests were taken from a battery of available instruments (French, et. al., 1963). The ability measures and learning scores were then combined and the resulting correlation matrix factor analyzed. Seven factors were extracted and then rotated to an equimax solution. Three factors were common to both the learning an ability measures, verbal ability, reasoning ability and rote-memory ability; three factors were restricted to the learning measures, concept formation, verbal learning, and nonverbal learning; and one factor was restricted to the ability measures, speed. Though three factors are common to both domains little of the variance in the learning tasks is explained by the reference tests.

Lemke, Klausmeier, and Harris (1967), following the psychometric method encountered the same difficulties. The selected sixteen psychometric tests representing eight ability factors. Scores obtained from each of the Ss on these instruments were intercorrelated with eighteen scores obtained from the same Ss on series information-processing (IP) and concept attainment (CA) tasks and the resulting matrix factor analyzed. Low correlations were found between the CA factors, IP factors and the set of cognitive abilities. The CA and IP tasks were seen as relatively distinct activities. As with the other investigations little of the variance in the learning tasks is accountable for by the ability measures.

The investigation by Dunham, Guilford, and Hoepfner (1966) though similar to the other studies is quite different in procedure. The study was carried out within the structure-of-intellect model (SI), the selection of tests being made in relation to this systematic theory. We find common agreement between this study and the others in that factors were found that were common to the learning tasks but not to the reference tests, and others that were common to both domains. In addition, the abilities identified as factors (e.g., cognition of figural classes) seem to be as complex as the learning task.

III. Selection of Tests

The reference battery is comprised of two types of instruments. The first group consists of standardized psychometric tests that have been selected for their ability to measure the organismic variables of interest as well as for their factorial simplicity.

A. Group I

(1) Raven Progressive Matrices - the progressive matrices are purported to be a pure measure of the general factor "g", common to most intelligence tests. With the college sample used by Jensen (1964) very little spread in the scores was found among Ss and therefore the matrices proved to have low discriminatory power. In an attempt to overcome this problem a thirty minute limit was placed on the time allowed to complete the test. This restriction should make the test sufficiently difficult and therefore add some spread to the scores of the college sample used in the study.

(2) The Stroop Test - yields a measure of response competition. This measure provides an index of interference (response competition) between two unequal habit strengths, in this case color naming and word reading, and is distinguished from other measures such as retroactive and proactive interference. Though it is not a formally standardized test a basic format has been developed and its extensive use has been well reviewed by Jensen and Rohwer (1966). The procedures of testing and the obtained measures used here will be in the same format as those used by Jensen (1964).

(3) Eyesenck Personality Inventory (EPI) - Since the EPI carries the label of personality inventory permission to administer the test was solicited from all Ss before administration. The general form and purpose of the inventory was explained to all Ss and in addition they were told that if after taking the test they objected to its format they may personally destroy the answer sheet. All Ss granted permission and did not object to the format and question. Though the test carries the label of "Personality Inventory", it is only the hypothesized underlying genotypic aspect and the intrinsic aspect of learning that are of importance to this study. The inventory measures two independent dimensions; extraversion - introversion (E), neuroticism - stability (N). The E factor is hypothesized as being closely related to the magnitude of excitation and/or inhibition found in the central nervous system (CNS), while the N factor is hypothesized as being closely related to the degree of lability of the autonomic nervous system (Eyesenck, 1960). For example, Ss who score low on the E scale are postulated as having strong excitatory and weak inhibitory potentials, whereas Ss who scores high on the E scale are characterized as having weak excitatory and strong inhibitory potentials (Eyesenck and Eyesenck, 1968b).

(4) Witkins Test of Field Independence: Embedded Figures Test (EFT) - The EFT gives us a measure of the trait or characteristic that has been labeled field independence or field articulation in some factor analytic studies (Gardner, Et. Al., 1960). Field Independence defines the ability of an individual to differentiate the figure from the ground in a visual structure. Witkin (1962) characterizes the typical field-dependent person as one who takes a long time to locate a familiar figure hidden in a complex background. Whereas, the field-independent person is more

analytical in his approach to his environment and tends to impose structure on a field which lacks it. The importance of this characteristic as a subject variable in concept learning has recently been demonstrated by Dickstein (1968).

(5) Kagan's Matching Familiar Figures Test (MFF) - The MFF is a measure of the trait labeled reflection-impulsivity. The trait is descriptive of two discrete cognitive styles, and in this fashion is somewhat less simplistic than some of the other factor measures included in the reference battery.

B. Group II

The second group of reference tests were devised using the methodologies and procedures found in the experimental literature as guidelines. Selection again is based upon the factorial simplicity of the measures and the judgement of the experimenter as to their relevance as organismic variables. Respective to this, all measures derived from the tests included within Group II meet the criterion of falling within the definition of "intrinsic sources of IDs" as it is stated above. The reference tests in Group II were designed to assess the following functions:

(1) Immediate Digit Span Memory (IDs) - is a measure of short-term memory (STM) where the S is required to recall a series of stimulus items immediately after their presentation. Basically, the S is presented a set of stimulus items in serial order, one at a time. Depending upon the experimental requirements, the S is required to reproduce the items in their exact serial order or reporduce as many items as they can in any order (i.e. free recall). The number of items that the S is able

to recall is considered to be a measure of the S's ability to retain and recall material in their STM. This ability is hypothesized to be dependent upon the strength of the initial registration of the stimulus trace(s).

(2) Delayed Digit Span Memory (DDS) - is also a measure of STM and follows the same basic paradigm as IDS with the exception that an unrelated task is interpolated between the learning and recall phases of the experimental trial. The interpolated task is of a specific time duration and therefore inserts a measured delay between the learning and recall phases. Primarily, in addition to causing a delay between learning and recall, the interpolated task prevents covert reheraal of the stimulus item presented in the learning phase. The measure of retention of the stimulus items in this paradigm is hypothesized to be dependent upon the decay of the stimulus trace that takes place during the time delay between learning and recall.

(3) Proactive Inhibition of Digit Span (PI) - The basic paradigm for PI is: learn list A, learn list B, test retention of list B. PI takes place when interfering stimulus items occur before the acquisition of the criterion items. The interfering items are said to act forward or proactively in effecting the retention of the criterion items. The measure of retention of the criterion stimulus items in this paradigm is postulated to be dependent upon the weaking of the stimulus trace due to the persistance of the trace of the previous list.

(4) Retroactive Inhibition of Digit Span (RI) - The basic paradigm for RI is: learn list A, learn list B, test retention of list A. In this paradigm a list of stimulus items is interpolated between the learning

of the criterion items and a test for their retention. The interfering items (i.e. interpolated list) are said to act backward or retroactively on the remembering of the criterion items. In the RI paradigm, retention of the criterion items is dependent upon the amount of interference with the consolidation of the stimulus trace of the criterion list.

Actually, the terms proactive and retroactive are somewhat misleading in suggesting that in the one sense list A works forward in time, while list B works backwards in time. In effect, the acquisition of the lists are successive in time, and it is the interaction of the two traces that produces any decrement found in retention.

(5) Immediate Visual Memory (VMI) - VMI is a measure of visual short-term memory. Sperling (1967) presented a model of STM which emphasized the acquisition and storage of visual stimulus materials. Basic to his model was a component given the label of Visual Information Storage (VIS), which is similar in concept to the sensory memory component of Atkinson and Shiffrin (1965, 1968). VIS is a very brief visual storage system that is capable of holding a great deal of information for a short duration. The decay time of the contents of VIS vary from a fraction of a second to several seconds (Sperling, 1963). Though the visual sensory data is transformed for storage in VIS, the information is then scanned and encoded in a verbal form in a component labeled Auditory Information Storage (AIS). AIS is similar in concept to the Primary Memory component of Waugh and Norman (1965). The relevance of a concept of VIS to the processing of visual information is obvious. In relation to conceptual learning, involving the processing of visual information, it would seem that the efficiency with which a S is able to retain and recall sensory data in VIS

could be considered to be an intrinsic source of variation. The procedures followed in measuring VMI are explicated in a later section (IV B-2C).

(6) Delayed Visual Memory (VMD) - VMD is also a measure of visual short-term memory and will follow the same basic procedural format as VMI with the exception that an unrelated task is interpolated between the presentation of the visual data and its recall. The interpolated task is of a specific time duration and therefore inserts a measured delay between the presentation and recall phases. Primarily, as in the DDS paradigm, in addition to causing a delay between presentation and recall the interpolated task prevents covert rehersal of the visual items presented in the acquisition phase. It was stated that storage in the VIS lasted at best for only a few seconds, after which time the material has decayed. Within the structure of the model it is assumed that the information is quickly recoded and stored in a somewhat more permanent form of memory, the AIS. Once in the AIS the information may be rehersed, discarded or placed in long-term memory. The ability of a S to scan his VIS and store information in the AIS is a process that is intrinsic to learning and therefore by definition a probable intrinsic source of variation.

The effect of the delay on the recall phase raises a theoretical question. If the mode of presentation of the interpolated task was visual it would undoubtedly interfer with the retention of the stimulus materials and therefore cause a decrement in the recall measure. But, if the mode of presentation of the interpolated task was in a non-interfering auditory mode two outcomes are possible. The first probable result is that the delay may cause the visual information to decay without being transfered to AIS, at a partial loss and storage in AIS result in a decrement in recall. The second probable result is that since visual memory is not susceptible to auditory interference (Sperling, 1963) it is possible that a S is able to encode and transfer the visual information from VIS to the somewhat more permanent AIS while he is performing the interpolated delay task. In this case, the resulting recall measure would be dependent upon a respective S's ability to encode and transfer visual information from his VIS to AIS. It would be expected the S's recall measure would be at least equal to or better than his performance on the VMI task.

IV. Method and Procedures

A. Selection of Subjects

The subject sample to be used in this study is the group of students enrolled in the introductory general psychology course at the University of Northern Colorado. This course being a general education requirement for the undergraduate degree presents a fairly representative cross section of the college population. From the initial group of volunteers forty Ss were selected for participation in the study (twenty males and twenty females). The basic criterion for selection was that the Ss demonstrate a willingness to participate in the study and to maintain a strict testing schedule for an extended period of time. One S was dropped from the study after the second week of testing because of his frequent absences during his alloted testing time.

B. Administration and Scoring of Reference Tests

1. Group I

(a) Raven Progressive Matrices (RPM) - The advanced progressive matrices Set II was administered to all thirty-nine subjects in a single session. The Ss were given a thirty minute time limit within which to finish the test. All Ss required the full thirty minutes with six Ss completing all thirty-six items in the set. The mean score of the group placed it at the 90th percentile according to the norms provided by Raven (1965). Though no test-retest reliability measures were made, the re-test reliability for college student is reported by Raven (1965) to be r_{tt} = [illegible]. Since a limiting time factor was added to the testing procedure, rather than using the absolute number of correct items a S received as a score on the matrices, the original score for each S was transformed into the per cent correct of these items attempted.

$$\% \text{ correct} = \frac{\text{no. of correct items}}{\text{no. of items attempted}}$$

A Pearson Product - Moment Correlation calculated between the original scores and the transformed score, yielded an r_{xy} of .75.

(b) Stroop Test - Though the Stroop test is not a formally standarized test a basic format has been developed and its extensive use has been well reviewed by Jensen and Rohwer (1966). The procedures of testing and the obtained measures used here will be in the same format as those used by Jensen (1964). There were three cards - the color card (C) on which there were 100 patches of five different colors, the word card (W) on which the names of the colors were printed and the color-word card (CW) on which were printed the names of colors, but they were printed in a color conflicting with the printed color name (e.g. the word yellow printed in red, green or blue ink). Each card has 100 items to be named. The S's task on card C is to verbally state the names of the color patches, reading from left to right as fast as he can.

On card W the <u>S's</u> task is to read aloud the color names as fast as he can. On card CW the <u>S's</u> task is to name the color of the inks that the words are printed in, while ignoring the conflicting printed color names.

<u>Card C</u> consisted of ten rows and ten columns of evenly spaced colored dots. The dots were all 5/8" in-diameter and 1½" center to center. The five colors used were red, orange, green, blue and yellow. The placement of all color within the 10 x 10 matrix was random except for the following restrictions:

(i) Adjacent dots (reading from left to right) were never of the same color.

(ii) All colors appeared at least once in a row of dots .

(iii) All colors appeared an equal number of times.

<u>Card W</u> consisted of twenty rows of five columns. The words were printed in off-white on a flat gray background. All letters were in block capitals 7/8" high. Their line width was 1/8". All rows and columns were in exact line with the words being distinctly separated. The word names were in random order except for the same restriction applied to Card C (above), with the additional restriction that the color names were never in the same order as the color dots on Card C.

<u>Card CW</u> consisted of the same word format as was used with Card W, but with the words colored with the five colors, the actual color conflicting with the color name. The order of the colors was the same as with the color dots.

<u>Administration</u> - The cards were placed on an easel five feet from the <u>S</u>, with the cards being approximate with the <u>S's</u> eye level. The order of Administration was Card C, Card W and Card CW. The task was explained to the <u>S</u> by the experimenter (E), in addition the five colors to be used were

named. When the S indicated that he understood the task Card C was presented, E said "Go", and simultaneously started a stopwatch. The procedure was similar on cards W, and CW. Prior to the presentation of each card, S was told what was expected of him. On Card W he was told to read the color names, on Card CW he was told to name the color and ignore the printed words.

Scoring - Each S received a score as to how many seconds it took him to complete each task. Jensen and Rohwer (1966) in reviewing the literature on the Stroop Test found no less than sixteen scores derived from the three basic time scores on cards C, W, and CW. When factor analized (Jensen, 1965) only three factors emerged from all the stroop scores. These factors were identified as:

(i) color difficulty factor (C_d)

(ii) speed factor (Sp)

(iii) interference factor (Intf)

The scores which most ambiguously represented the factors were chosen for use in this study. The scores are as follows:

$$C_d = C/C + W$$

$$Sp = W$$

$$Intf = CW - C$$

The test, re-test reliabilities of these scores as reported by Jensen (1965) are respectively, C_d: $r_{tt} = .97$, Sp: $r_{tt} = .98$, and Interference: $r_{tt} = .93$.

(c) Eyesenck Personality Inventory (EPI) - Form A of the EPI was administered to all thirty-nine Ss in a single group session. Whereas in standardization norms for American College Students (Eyesenck and Eyesenck, 1968) the correlation between the E and N scales was zero (i.e., $r_{EN} = .00$)

the correlations found for Form A between the two scales in this study was $r_{EN} = -.13$. This indicates that at least in the college sample used in this study there is some relationship between the two scales. In respect to the stability of the scales the test-retest reliabilities are quite satisfactory, with the reported reliabilities on Form A being, E-scale, $r_{tt} = .82$, N-scale, $r_{tt} = .84$.

(d) Witkins test of Field Independence: Embedded Figures Test (EFT) - The EFT was administered by the E to individual Ss following the standardized format of Witkin (1971). The tests were conducted as part of a normal weeks testing schedule. The test-retest reliabilities reported by Witkin (1971) are as follows:

males: $r_{tt} = .82$

females: $r_{tt} = .79$

Three basic scores may be derived from the EFT, a measure indicating the average amount of time required by the S to complete an item (X_t), the number of errors a S makes in performing the task (e), and number of times a S request that the simple forms be shown after their initial presentation (X_s). The intercorrelations of the three scores are as follows: X_t with X_s, $r = .70$; X_t with e, $r = .72$; X_s with e, $r = .69$, all were significant at $p < .01$. It is felt that X_s, in addition to being a measure of field independence also contains a visual memory component, and therefore for the purposes of this study would be the best measure of the three scores to use. The magnitude of the reliability correlation coefficients indicate that the measure of field-independence is a stable construct.

(e) Kagan's Matching Familiar Figures (MFF) - The MFF was administered by the E to individual Ss. The stimulus cards used were ones modified by Shulman (1968) for use with adults.

Stimulus Cards - The set consisted of one pretest example card and twelve test cards. Each card contained one sample figure and eight test figures (two rows of four), with one of the eight test figures being a match of the sample. The S's task was to choose the test figure that matched the sample figure.

Administration - The format of test was explained to the S by E. The S was then given the pretest example card, if there were no questions on the part of the S and E was assured that S understood the task, the S was then presented the other twelve cards in succession. On each card the S was given three minutes within which to correctly choose the matching figure. If the S did not make the correct choice within the three minutes the trial was terminated and a new card presented.

Scoring - The obtained measured on the MFF is the amount of time required to correctly match the sample figure. For the purposes of analysis in this study, a S's score was the average time it took him to correctly match the sample over the twelve test cards.

Reliability - Using the stimulus cards, modified by Shulman (1968) for an adult population, Lezotte (1969) found an internal consistancy reliability using an analysis of variance procedure of $r = .71$.

2. Group II

(a) Immediate Digit Span (IDS and Delayed Digit Span (DDS) - In the first test (IDS), the S would hear a series of digits spoken by a female voice at a one-second rate and would write down the series on his answer sheet immediately after the presentation. In the second test (DDS), the S's recall was delayed by ten seconds. The delay interval was filled by the verbal presentation, of pluses (+) and minuses (-), spoken by the female voice at a one-second rate. There were eight delay items in all, and the S was required to write down on his answer sheet, in the spaces provided, the corresponding symbol as it was spoken. In almost all cases, without exception, the Ss were conscientious in attending to the spoken (+) and (-) and writing them down. In all cases thirteen seconds were allowed for the S to write down the digit series.

The IDS and DDS series were randomly interspersed within sets of eight; there were ten such sets in all. Each answer sheet provided space for the eight series, with the addition of eight spaces for the writing down of the delay items.

The digit series varied in length from two to nine digits. Each length of a series was replicated five times throughout the entire test. To summarize:

2 conditions (IDS and DDS)

8 series lengths (2, 3, 4, 5, 6, 7, 8, 9)

5 replications

Administration - The test was administered to the Ss in groups of five. The Ss sat around a semicircular table with a tape recorder containing the recorded digit series placed in the center, equi-distant from all Ss. The task was explained to the Ss and an example task was presented. When the E was sure that the task was understood the tape recorder was started. To summarize the sequence:

Immediate Digit Span

Events	Time
1. "ready" command	1 second
2. pause	1 second
3. digits (2 to 9)	2-9 seconds

Immediate Digit Span (cont'd)

Events	Time
4. "write" command	1 second
5. blank for writing response	13 seconds
6. etc.	

Delayed Digit Span

Events	Time
1. "ready" command	1 second
2. pause	1 second
3. digits (2-9)	2-9 seconds
4. pause	1 second
5. + and -	8 seconds
6. "write" command	1 second
7. blank for writing response	13 seconds

Scoring - In both IDS and DDS, the serial order position method of scoring was used. This method consists of giving one point credit for every item recalled in the serial position it occupied in the order of presentation. For example, if a S recalled the series 12345 as 23451, his score would be zero, whereas if he recalled it 13425 his score would be two.

The test-retest reliabilities of IDS and DDS using the same format as was used in the present study, were found to be satisfactory (Jensen, 1965). This would indicate that these phenomenon as they are investigated in this paradigm are quite stable. To summarize these:

IDS: $r_{tt} = .70$

DDS: $r_{tt} = .79$

(b) Retroactive Inhibition (RI) and Proactive Inhibition (PI) - This test grouping consisted of two conditions:

i. Digit span with retroactive inhibition (RI) for digit series lengths of from four to seven digits. In this paradigm the S heard one series of digits, then a second series, and then was asked to recall the first series.

ii. Digit span with proactive inhibition (PI) for digit series lengths of from four to seven digits. This paradigm is formally the same as the one above, except that the S is asked to recall the second series.

Administration - The administration followed the same basic format as used with the IDS and DDS paradigm. The Ss were presented with sixteen RI and sixteen PI conditions, which were randomly interspersed over the thirty-two conditions. In both conditions ten seconds always intervened between the last digit of the series-to-be-recalled and the "write" signal. In both conditions the S did not know until time of recall whether he would have to write the first or second series. The sequence is summarized as follows:

RI

Events	Time
1. "ready" command	1 second
2. pause	1 second
3. first digit series (4-7)	4-7 seconds
4. pause	3 seconds
5. second digit series (4-7)	4-7 seconds
6. + and -	8 minus 2nd series
7. pause	1 second
8. "write" command	1 second
9. blank for writing response	13 seconds

PI

Events	Time
1. "ready" command	1 second
2. pause	1 second
3. first digit series (4-7)	4-7 seconds
4. pause	3 seconds
5. second digit series (4-7)	4-7 seconds
6. + and -	9 seconds
7. pause	1 second
8. "write" command	1 second
9. blank for writing response	13 seconds

Scoring - As with the IDS and DDS paradigm, serial order position scoring was used with this test series.

Using the same format and procedures as were used in this study, Jensen (1965) found the measures of RI and PI to be reasonably stable phenomenon. This is indicated by the test-retest reliabilities which are summarized as follows:

$$\text{RI: } r_{tt} = .60$$

$$\text{PI: } r_{tt} = .58$$

(c) Visual Memory: Immediate (VMI) - The VMI was administered by E to Ss in groups of two as part of a normal weeks testing schedule. During the VMI condition a S saw a stimulus pattern flashed on a screen for the duration of 250 ms (1/25 seconds). The S's task was to view the image while it was projected on the screen and immediately write down on his answer sheet what he saw during the brief exposure. The answer sheet contained a check list indicating the possible choices of stimulus items. This format was as follows:

Border		Figures			
_____one	_____red	_____one	_____red	_____large	_____circle
_____two	_____blue	_____two	_____blue	_____small	_____ellipse

This format enabled the S to quickly indicate his recall responses without any memory loss due to the time that would be needed to write them down in long hand.

Stimulus Materials - The stimulus materials were twenty-four 35 mm transparencies of geometric designs. The stimulus materials were of the same format as the stimulus patterns used in the concept learning phase of the study. A stimulus pattern could contain any one of the possible (64) designs generated by using all possible combinations of levels within the following six binary dimensions: one or two, red or blue, solid borders; one or two, large or small, red or blue, circular or ellipitical, solid figures. The twenty-four transparencies were divided into three groups of eight, the group division being respective to the number of stimulus elements each transparency contained. The group divisions were: (i) two elements, (ii) three elements, and (iii) four elements. For example, if a transparency contained two borders and one figure, it would belong to the same stimulus group as one which contained one border and two figures. The target to background contrast of the projected image, measured by a digital photometer (Gamma Scientific Instruments) was 80%. During the testing phase the twenty-four transparencies were randomly interspersed in order to avoid any chance of a perceptual response set being developed in the Ss.

Apparatus - The duration of exposure was controlled tachistascopically using a model T-AP Tachistascope, manufactured by Lafayette Instrument Company. The transparencies were projected on to the screen using a Viewlex Projector, with a five inch Luxtar lens.

Administration - The Ss were seated side by side, approximately three feet from each other and five feet from a flat gray screen upon which the stimulus image was projected. Each S was shown a card containing samples of the visual materials that he was to view. The dimensions of the stimulus patterns were pointed out and explained to the Ss by the E. The task was explained to the Ss by the E, if there were no questions a pretest example was presented. If there were no further questions after the example was presented and the E felt the Ss understood the task the normal testing session was begun. In all trials the Ss were allowed ten seconds to make their recall responses.

Scoring - The total number of recall errors committed by a S over the twenty-four trials was used as the VMI measure.

Using a seven day interval between sessions the test-retest reliabilities (n=20) computed for the VMI paradigm yielded an r_{tt} of .69 (i.e., r_{tt} = .69). The magnitude of the correlation coefficient would indicate that the VMI performance is a stable phenomenon.

(d) Visual Memory: Delayed (VMD) - The VMD followed the same basic format as was used in VMI with the exception that a ten second delay interval was interpolated between presentation and recall. The delay interval was filled by the verbal presentation of pluses (+) and minuses (-), spoken by the E at one-second rate. The S was required to write down on his answer, in the spaces provided, the corresponding symbol as it was spoken. In almost all cases without exception the Ss were conscientious in attending to the spoken (+) and (-) and writing them down. In all cases the Ss were allowed ten seconds to make their recall responses.

Scoring - The total number of recall errors committed by a S over the twenty-four trials was used as the measure of VMD.

Because of scheduling problems test-retest reliabilities were not made on the VMD paradigm. However, computed Spearman-Brown split-half reliabilities resulted in an $r_{tt}=.71$. This would indicate that within one administration of the test a S's performance was relatively stable.

C. Laboratory Tasks

The format to be used in this series of tasks is a modification on a procedure suggested by Bourne, et. al., (1964).

1. Procedural Variables

(a) Stimulus Availability (SA) - is operationally defined in terms of the number of previously presented stimuli to which the subject has access on any trial. The design matrix will include three levels of SA, two available stimulus cards - SA2, four available - SA4, and six available - SA6.

(b) Concept Complexity (CC) - is defined by the number of relevant attributes defining a particular concept. There are two conditions of complexity, two relevant attributes - CC2, and four relevant - CC4.

2. Apparatus

The apparatus consists of three "memory boards" constructed of clear [illegible], one board is assigned to each SA level. On the front of the boards are pegs on which the S can hang the stimulus cards, the number of pegs available are equal in number to the assigned SA level. In addition, in order to aid the subject in remembering the identities of the instances on the board, each peg has a bi-colored disc (red - positive, black - negative). For example, if the subject were to hang a positive instance on a particular peg he would then rotate the disc so that the red portion of the disc was showing above the stimulus card.

3. Stimulus

The stimulus patterns to be used in the experiment are geometric designs printed on 2 x 2½ inch white cardboards. Each card contains one of the possible (256) designs generated by using all possible combinations of levels within the following eight binary dimensions: one or two, red or blue, solid or broken borders; one or two, large or small, solid or spotted, red or blue, and circular or ellipitical figures.

In a technical sense, those dimensions which are important to the definition of a concept, are labeled as "relevant", and those which are not as "irrelevant". The levels or different values of a dimension are referred to as "attributes", and therefore, in relation to the relevant dimension those attributes which specify a concept are termed "relevant attributes". A stimulus event which contains all of the necessary relevant attributes in their proper relationship is referred to as a "positive instance" (PI), those events which do not as "negative instances" (NI).

D. Problems

The variables SA and CC being crossed produce six independent problem conditions. The stimulus arrays generated for each were selected from the

256 possible designs. Each series begins with a positive focus card and contains an equal number of positive and negative instances. The number of trials presented to a subject in any one problem series is equal to the assigned SA level plus twenty. This will result in stimulus arrays of 22, 24 and 26 trials in length. Irrespective of the CC in a problem condition the amount of information presented up to and including trial (SA level + 1) will leave sixty-four possible hypotheses remaining until solution, with the final hypothesis being eliminated on the last trial. The resulting design matrix is summarized:

	CC Level	
SA Level	2	4
2		
4		
6		

E. Procedure

The procedure was patterned after Bourne et. al., (1964). Preliminary instructions given to S concerning the concept learning task included: (a) a description of all the stimulus dimensions and their levels, (b) an explanation of the information contained in positive and negative instances, (c) he was told that all of the concepts are to be conjunctive but was given no indication as to how many attributes were relevant to the concept he was to attain, and (d) respective to the SA level to which he has been assigned the S was told that he may retain as a maximum only the SA level number of cards, and after SA level + 1 trials he must discard at least one of the previously presented cards, and after each successive presentation the maximum number of cards that a S may retain is controlled by the SA level. In addition to the initial instructions concerning the SA level and discard procedure, the S was instructed to arrange the cards in any order or fashion that he may choose on the memory board placed in front of him. After the instructions the Ss were shown examples of what would be positive and negative instances of a given concept.

During each problem the stimulus was placed before the S one at a time and he was allowed to arrange them in any order he chooses. The experimenter described the first trial presentation (focus card) as a positive instance of the concept. On every successive trial, within fifteen seconds of the stimulus presentation S was required to verbalize whether or not he thought the stimulus card was a positive or negative instance, his response was then confirmed or invalidated by the experimenter. After the subject identified the instance he was given fifteen seconds in which to hang the card on the memory board and study it.

Therefore, in each of the treatment cells, a number of previously presented stimuli, vis., 2, 4, or 6 remain before S as he responds to each stimuli. In treatment SA4, for example, stimuli which have been presented on the four preceding trials (except for the first four trials of the problem), plus the particular stimulus instances just presented were available to S for inspection. Each time a new stimulus is presented the S is required to identify it as a PI or NI and discard one of the exposed cards within 30 seconds of the presentation of the stimulus card on that particular trial. An additional criterion requirement such as the identification of the relevant attributes, was required of the subjects. A trial by trial record was kept of the identification error, the order in which S discards the stimulus cards relative to their order of presentation, and the cards which he retains.

Each of the thirty-nine Ss were tested on the concept attainment task for a period of five weeks. The testing sessions were designed such that a S would be presented with all nine problem conditions within any one week's testing program. Under these conditions ninety independent stimulus arrays were developed and were presented to each S in a random order over the five week period.

1. Procedural Modifications. It became evident after one week's testing and the Ss had become familar with the task procedures, that the thirty seconds allowed for each trial was much too long. The Ss were making their identification responses, on the average, within five seconds and felt that they needed only an additional five seconds to study the cards. It was further evident that the procedure of having the E present the stimulus cards to the S was unnecessary. Therefore, the original procedure was modified as follows:

(a) The stimulus cards were arranged in their prescribed order and placed face down on the table in front of the S.

(b) The S was allowed to select a single card at a time, identify its class (i.e., PI or NI) and study it if he wanted to.

(c) The time restriction that a S must identify the card within fifteen seconds and that only fifteen seconds was allowed to study it after identification was still imposed.

2. Scoring. The dependent measures in the CA task were a) memory errors, b) judgement errors, and c) identification of relevant attributes. A memory error is operationally defined as the type of error a S commits when he has had sufficient information to properly classify an instance, as a PI or NI, but does not. A judgement error is when a S is presented with a

stimulus card that contains new information and he makes an error in classifying it (i.e., an error in judgement). At the end of the CA task the Ss were asked to identify the relevant attributes of the concept and they were given one point for a correct answer and zero for an incorrect answer.

In addition to the measures mentioned above, during the CA task a record was kept as to what type of information (i.e., PI or NI) the Ss retained or discarded respective to each trial. Using this information, conditional probabilities were computed for each S under all conditions. These probabilities, given the label "decision probabilities", are a measure or indication of the decision processes that a S goes through in solving a CA task. The decision probabilities that were chosen to be used as measures in this study are summarized as follows:

1. The probability that a card is retained, given it is a PI, it is incorrect, and it is a change in the level of information: P(R/PI·Inc·CI).

2. The probability that a card is retained, given it is a NI, it is incorrect, and it is a change in the level of information: P(R/NI·Inc·CI).

3. The probability that a PI is discarded, given a PI was presented, it was incorrect and it was retained: P(PI·D/PI·Inc·R).

4. The probability that a NI is discarded, given a NI was presented, it was incorrect and it was retained: P(NI·D/NI·Inc·R).

V. Analysis and Interpretation of the Data

The statistical analysis of the data was performed in two phases. The first phase incorporated factor analytic procedures and the second utilized multiple regression procedures.

A. Factor Analysis

1. Rationale

Previous to this investigation the twelve reference tests employed in this study had never been used concurrently in any one study. Therefore, a determination of their empirical relationship had not been made. Respective to this, though the reference measures are considered to be indices of individual process variables that are at least phenotypically different, one could speculate that some of the measures share a common variance. Factor analysis, as a statistical procedure, supplies a sound method of determining the covariation or inter-relationship among a number of variables and reducing them to a generally more fundamental and lesser number of variables. If, through the procedures of factor analysis, a number of phenotypically different kinds of variables demonstrate an inter-dependence one could hypothesize that they represent a single common factor (i.e. the same intrinsic source of variance and/or genotype).

2. Factor Analysis Procedure

An intercorrelation matrix was computed between the S's scores on the fourteen reference measures. The resulting correlation matrix was first subjected to a principal components analysis. The principal component solution was then rotated to a varimax solution, with unities placed in the diagonal of the correlation matrix and only factors having eigen values of one or greater being rotated.

3. Factor Analysis of Reference Tests

Presented in Table 1 are the means and standard deviations (SDS) of the measures of the twelve reference tests that represented the fourteen variables which entered into the factor analysis.

TABLE 1

MEANS AND SDs OF FOURTEEN REFERENCE VARIABLES

Variable	Mean	SD
1. EPI: E	13.23	3.36
2. N	8.46	4.45
3. EFT: X_s	5.38	3.16
4. MFF: $\overline{X}_t$	60.83	24.33
5. RPM	75.07	15.44
6. Stroop: C_d	58.00	5.89
7. Intf	46.43	12.40
8. S_p	40.28	5.42
9. VMI	22.92	10.55
10. VMD	17.30	8.63
11. IDS	161.79	18.71
12. DDS	118.25	22.77
13. RI	37.48	10.12
14. PI	30.43	11.41

The correlation matrix (Table 2) was first subjected to a principal components analysis (Table 3).

a. Varimax Rotation Factors. An orthogonal varimax rotation yielded five factors which accounted for sixty-sixty percent of the variance. Interpretations of the rotated factors are based on loadings equal to .40 or greater. The five factors are presented below. The same format will be followed throughout. The variables are listed in descending order respective to the magnitude of their factor loadings. An asterisk following the factor loading indicates that the variable had its highest loading on this factor. Table 4 presents the factor analysis.

Factor A

Variable	Loading
14 Proactive Inhibition	.84*
12 Delayed Digit Span	.77*
11 Immediate Digit Span	.66*
13 Retroactive Inhibition	.66*
6 Stroop Color	44*

Interpretation: Strength of the initial registration of the stimulus trace.

Discussion: Proactive inhibition (PI) has its largest loading on this factor, and in addition it also has the highest loading in the rank ordering of the factor loadings. The factor was not called a PI factor because of the substantial loadings of other variables on this factor. Factor A is interpreted as the strength of the initial registration of the stimulus trace. Respective to this, the stronger the initial registration, the more trace is left to be

TABLE 2

CORRELATIONS AMONG FOURTEEN REFERENCE VARIABLES (DECIMALS OMITTED)

	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	
1.	EPI: E	-													
2.	N	-13	-												
3.	EFT: X_s	43	-02	-											
4.	MFF: $\bar{X}_t$	-29	07	03	-										
5.	RPM	-15	-11	-30	01	-									
6.	Stroop: C_d	00	-07	08	-13	-11	-								
7.	Intf	-20	03	-14	14	-05	10	-							
8.	S_p	19	-20	08	15	01	-23	17	-						
9.	VMI	12	-00	14	-24	-04	24	05	-14	-					
10.	VMD	-01	09	-12	04	-24	-04	50	11	04	-				
11.	IDS	10	-15	17	-25	-01	15	-28	-12	-17	-29	-			
12.	DDS	12	-01	24	-20	01	21	-31	-16	00	-37	56	-		
13.	RI	-04	-22	29	-12	-00	20	-30	-24	37	22	28	46	-	
14.	PI	-00	-00	33	-25	-21	27	-11	-19	18	-16	42	66	61	-

48/A

TABLE 3

PRINCIPAL COMPONENTS AND COMMUNALITIES (h^2) OF THE FOURTEEN REFERENCE VARIABLES
(DECIMALS OMITTED)

	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	h^2
1.	EPI: E	22	-21	74	-19	28	-19	13	13	22	18	-08	15	-20	01	100
2.	N	-15	-11	-27	57	57	-00	-11	41	-05	05	12	-10	-10	-05	100
3.	EFT: X_s	45	-34	54	19	04	33	10	10	19	-30	-02	-22	15	-01	100
4.	MFF: $\bar{X}_t$	-38	13	03	38	-27	65	24	03	15	18	10	19	-03	08	100
5.	RPM	-09	59	-22	-47	-06	06	-07	45	32	01	-01	-16	00	07	100
6.	Stroop: C_d	35	-37	-32	-11	-20	-15	67	16	-11	16	01	-17	-00	00	100
7.	Intf	-48	-48	-21	03	-45	-14	-04	29	11	-29	-09	17	-11	-11	100
8.	Sp	-31	01	61	-10	-40	05	-21	29	-39	12	13	-12	-01	-02	100
9.	VMI	24	-55	-19	-53	26	27	-11	14	-09	-03	25	21	10	06	100
10.	VMD	-47	-58	-04	08	-16	-22	-27	-14	32	29	09	-15	11	03	100
11.	LDS	64	27	08	20	-24	-38	02	-03	13	-12	44	05	-05	03	100
12.	DDS	79	15	-02	21	-12	-09	-11	26	02	20	-13	20	23	-15	100
13.	RI	72	-10	-19	-17	-14	40	-21	-17	07	10	04	-13	-21	-21	100
14.	PI	78	-22	-15	21	-21	00	-27	-07	-08	00	-18	-01	-10	29	100

TABLE 4
VARIMAX ROTATION SOLUTION (DECIMALS OMITTED)

Variable	A	B	C	D	E	h^2
1. EPI: E	-14	-21	76	-25	-22	76
2. N	-15	11	05	02	85	76
3. EFT: X_s	30	-04	74	-03	-02	65
4. MFF: $\bar{X}_t$	-10	56	-09	23	01	39
5. RPM	-16	-05	-59	-39	-32	64
6. Stroop: C_d	44	-37	-07	28	00	42
7. Intf	-12	06	-15	81	-11	72
8. S_p	-25	34	30	15	-59	65
9. VMI	01	-85	09	14	02	75
10. VMD	-26	-01	10	72	05	61
11. IDS	66	17	08	-33	-10	60
12. DDS	77	00	11	-33	04	72
13. RI	66	-39	-01	-12	-08	63
14. PI	84	-16	15	02	10	77
Percent of Variance Accounted for	19	11	12	13	09	

consolidated, and the less susceptible it is to decay because of delay. In the PI paradigm the persisting trace of list 1 presumably weakens the registration of list 2.

Factor B

	Variable	Loading
9	Visual Memory: immediate	-.85*
4	Matching Familiar Figures	.56*
6	Stroop-color difficulty	-.37

Interpretation: Visual Memory: Immediate

Discussion: The interpretation of this factor is quite clear. VMI has its largest loading on this factor as well as occupying the highest ranking. Since the Matching Familiar Figures (MFF) test has its highest loading on this factor, it suggests that a major portion of variance on the MFF might be due to a visual memory factor.

Factor C

	Variable	Loading
1	EPI: E Scale	.76*
3	Embedded Figures: X_s	.74*
5	RPM: % Correct	-.59*

Interpretation: Field-Independence

Discussion: The interpretation of this factor is relatively clear, with the EFT having its highest loading on the factor. With the RPM having its highest loading on this factor it suggests that a major portion of the variance found on the RPM is due to a field-independence factor. The loading of the EPI: E might have been expected. It has been found that people scoring low on the E scale do better on visual performance tasks (e.g. Raven Progressive Matrices and Embedded Figures Test) than those who score high on the E scale (Eysenck and Eysenck, 1968).

Factor D

Variable	Loading
7 Stroop: Interference	.82*
10 Visual Memory: Delayed	.73*

Interpretation: Susceptibility to response competition.

Discussion: With the Stroop: Interference measure having its largest loading on this factor, its interpretation is quite clear. The substantial loading of VMD adds clarity to its definition. It suggests that in the VMD paradigm, a S who manifests resistance to response competition is able to perform the interpolated delay task while simultaneously encoding and transfering visual information from his VIS to AIS for consolidation, with a minimal loss in information. Specifically, a person who exhibits resistance to response competition is able to a) process two levels or modes of information which are presented simultaneously or in immediate succession with each requiring a different response pattern and b) inhibit the response pattern required by one level of information and perform the other. The S's control over his response pattern in this fashion, might be construed to be a measure of cognitive control.

Factor E

Variable	Loading
2 EPI - N Scale	.85*
8 Stroop - Speed	-.60*

Interpretation: Neuroticism

Discussion: The definition of Factor E is clearly Neuroticism. The loading of Stroop: Speed with the N scale might be used as the definition of a cognitive style. In relation to this we would expect people scoring high on the N scale being able to perform a simple task, such as word naming much better than complex ones.

A summarization of the identifying factor labels are presented below:

Factor	Interpretation
A.	Strength of the initial registration of the stimulus
B.	Visual Memory: Immediate
C.	Field Independence
D.	Susceptibility to Response Competition
E.	Neuroticism

B. Multiple Regression Analysis

1. Rationale

The approach of this study was to identify and describe intrinsic sources of IDs as they relate to conceptual learning and relevant process variables. In accordance with this, the study was designed to determine some of the characteristics of the performing S in terms of the relative contribution of these intrinsic factors to the variation found in his performance measures. Multiple regression, as a statistical procedure, provides a sound strategy for determining these empirical relationships.

2. Procedures

Normalized factor scores, for each S, were obtained from the Varimax factor analysis solution computed in the first phase of the analysis. Multiple regression, using the factor scores as predictor variables, simultaneously tests the contribution of each of the predictor variables (intrinsic sources of IDs) in accounting for IDs in the criterion measure.

3. Results

(a) Decision Probabilities. Decision probabilities were computed for weeks one and five under the six conditions of the design matrix. Table 5 presents the means and SDs of the six conditions for weeks one and five. A series of multiple regression analyses were computed on all conditions of the matrix using the decision probabilities as criterion variables with the factor scores as predictors. This resulted in 48 individual analyses. The multiple regression procedure tested the hypothesis that the true value of the squared multiple correlation coefficient (R^2) is equal to zero. All analyses were tested at an alpha of .05, with four and thirty-four degrees of freedom. The fourty-eight analyses yielded only three significant F-ratios.

TABLE 5

MEANS AND SDs OF DECISION PROBABILITIES FOR WEEKS ONE AND FIVE

Conditions	Decision Probabilities	Week One		Week Five	
		Means	SDs	Means	SDs
SA2: CC2	(R/PI·Inc·CI)	0.35	0.46	0.06	0.23
	(R/NI·Inc·CI)	0.45	0.42	0.40	0.36
	(PI·D/PI·Inc·R)	0.42	0.46	0.05	0.22
	(NI·D/NI·Inc·R)	0.11	0.26	0.04	0.15
SA2: CC4	(R/PI·Inc·CI)	0.22	0.41	0.21	0.38
	(R/NI·Inc·CI)	0.54	0.40	0.09	0.22
	(PI·D/PI·Inc·R)	0.22	0.39	0.22	0.41
	(NI·D/NI·Inc·R)	0.31	0.40	0.08	0.27
SA4: CC2	(R/PI·Inc·CI)	0.35	0.41	0.35	0.47
	(R/NI·Inc·CI)	0.55	0.46	0.31	0.45
	(PI·D/PI·Inc·R)	0.24	0.36	0.13	0.33
	(NI·D/NI·Inc·R)	0.28	0.37	0.05	0.19
SA4: CC4	(R/PI·Inc·CI)	0.54	0.50	0.13	0.33
	(R/NI·Inc·CI)	0.60	0.46	0.36	0.43
	(PI·D/PI·Inc·R)	0.21	0.39	0.10	0.30
	(NI·D/NI·Inc·R)	0.29	0.43	0.16	0.33
SA6: CC2	(R/PI·Inc·CI)	0.40	0.47	0.52	0.45
	(R/NI·Inc·CI)	0.71	0.40	0.21	0.40
	(PI·D/PI·Inc·R)	0.31	0.41	0.23	0.39
	(NI·D/NI·Inc·R)	0.24	0.34	0.03	0.11
SA6: CC4	(R/PI·Inc·CI)	0.50	0.49	0.13	0.33
	(R/NI·Inc·CI)	0.81	0.26	0.62	0.38
	(PI·D/PI·Inc·R)	0.27	0.42	0.26	1.07
	(NI·D/NI·Inc·R)	0.24	0.28	0.32	1.06

Table 6 presents a summary of the significant analyses and their probability levels. The relative contribution of the five factors representing the intrinsic variables and the direction of their relationship are summarized in Table 7.

(b) Conceptual Learning Task Measures. Three dependent measures were obtained for weeks one and five under the six conditions of the design matrix. Namely these measures were 1) memory errors, 2) total errors (i.e. the sum of memory and judgement errors) and 3) number of correct identifications of relevant attributes. Table 8 presents the means and SDs of these dependent measures for the six conditions. As with the decision probabilities a series of multiple regression analyses were computed on all conditions of the matrix using the three dependent measures as criterion variables with the factor scores as predictors. This resulted in thirty-six individual multiple regression analyses. All analyses were tested using an alpha of .05. with four and thirty-four degrees of freedom. The thirty-six analyses yielded six significant F-ratios. A summarization of the significant analyses and their probabilities are presented in Table 9. The relative contribution of the five factors and the direction of their relationship are summarized in Table 10.

TABLE 6

SUMMARY OF SIGNIFICANT MULTIPLE REGRESSION ANALYSES

Conditions	Week	Decision Probabilities	R^2	F	df	Probability
SA2: CC4	one	(NI·D/NI·Inc·R)	.5802	11.75	4,39	.0001
SA4: CC2	five	(R/PI·Inc·CI)	.1484	14.56	4,39	.0001
SA6: CC4	five	(R/NI·Inc·CI)	.2874	3.43	4,39	.01

TABLE 7

SUMMARY OF THE SIGNIFICANT MULTIPLE REGRESSION EQUATIONS
PREDICTING DECISION PROBABILITIES FROM INTRINSIC VARIABLES

Conditions	Decision Probabilities	Week	Amount of Criterion Variance Associated w/Intrinsic Variables				
			Factor A	Factor B	Factor C	Factor D	Factor E
SA2: CC4	(NI·D/NI·Inc·R)	one	+ 2.6%	+ 1.3%	+ 28.1%	- 0.6%	- 27.1%
SA4: CC2	(R/PI·Inc·CI)	five	+ 0.8%	- 4.4%	+ 0.0%	- 1.4%	- 8.0%
SA6: CC4	(R/NI·Inc·CI)	five	+ 19.7%	+ 1.6%	+ 3.4%	- 3.8%	+ 0.0%

+ Positive relationship
- Negative relationship

TABLE 8

MEANS AND SDs OF THE DEPENDENT MEASURES OF THE CONCEPTUAL LEARNING TASKS FOR WEEKS ONE AND FIVE

Conditions	Dependent Measures	Week One		Week Five	
		Means	SDs	Means	SDs
SA2: CC2	Memory error	1.90	2.04	0.82	0.93
	Total error	4.33	2.61	3.23	1.79
	Rule	0.51	0.50	0.72	0.45
SA2: CC4	Memory error	1.51	1.77	1.85	1.12
	Total error	3.87	2.58	4.72	1.68
	Rule	0.44	0.50	0.49	0.50
SA4: CC2	Memory error	1.46	2.21	0.41	0.54
	Total error	3.77	2.81	2.26	1.10
	Rule	0.77	0.42	0.59	0.49
SA4: CC4	Memory error	0.36	0.66	0.62	0.74
	Total error	2.15	1.21	2.23	1.27
	Rule	0.49	0.50	0.69	0.46
SA6: CC2	Memory error	0.82	1.17	1.31	0.85
	Total error	3.26	1.66	3.05	1.43
	Rule	0.62	0.49	0.79	0.40
SA6: CC4	Memory error	0.95	1.40	1.62	0.89
	Total error	4.21	1.64	3.56	1.39
	Rule	0.51	0.50	0.85	0.36

TABLE 9

SUMMARY OF SIGNIFICANT MULTIPLE REGRESSION ANALYSES

Conditions	Week	Dependent Measures	R^2	F	df	Probability
SA2: CC4	one	Memory error	0.2297	2.53	4,39	.05
SA2: CC4	one	Total error	0.2451	2.76	4,39	.04
SA4: CC2	one	Rule	0.2632	3.04	4,39	.03
SA4: CC4	one	Memory error	0.2818	3.33	4,39	.02
SA4: CC4	one	Total error	0.2953	3.56	4,39	.01
SA6: CC4	five	Rule	0.3141	3.89	4,39	.01

TABLE 10

SUMMARY OF THE SIGNIFICANT MULTIPLE REGRESSION EQUATIONS
PREDICTING DEPENDENT MEASURES FROM INTRINSIC VARIABLES

Conditions	Dependent Measures	Week	Amount of Criterion Variance Associated w/Intrinsic Factors				
			Factor A	Factor B	Factor C	Factor D	Factor E
SA2: CC4	Memory error	one	+ 0.6%	- 3.8%	+ 0.6%	+ 17.8%	+ 0.9%
SA2: CC4	Total error	one	+ 1.1%	- 5.1%	- 0.1%	+ 18.1%	+ 0.1%
SA4: CC2	Rule	one	+ 2.4%	- 3.0%	+ 1.7%	- 16.9%	- 2.3%
SA4: CC4	Memory error	one	+ 5.9%	- 5.3%	- 0.1%	+ 15.2%	+ 1.7%
SA4: CC4	Total error	one	+ 5.7%	- 5.7%	- 2.2%	+ 12.5%	+ 3.4%
SA6: CC4	Rule	five	+ 24.1%	+ 0.0%	- 0.3%	+ 6.6%	- 0.4%

+ Positive relationship
- Negative relationship

C. Discussion

1. Decision Probabilities

To summarize, forty-eight multiple regression analyses were performed using the following variables:

a. Criterion Variables. The criterion variables used in the analyses were four decision probabilities reflecting the decision making procedures a S went through in performing the conceptual learning task.

b. Predictor Variables. The predictor variables used in the analyses were the five factor scores calculated for each S; the factor scores represent the intrinsic ID variables as they were defined by the factor analysis.

The results of the analyses indicate that, with the exception of the three significant multiple regression equations summarized in Tables 6 and 7, the intrinsic variables have no relationship with the decision processes as they are measured in this study.

Respective to the three significant multiple regression equations, because of the lack of any trend between the three equations and the absence of any apparent interaction between the process variables and procedural variables, the writer hesitates to make any categorical hypotheses in regards to the meaningfulness of the reported statistical significance.

There are two possible inferences that may be made in relation to the results of this phase of the study. The first is that though intrinsic sources of IDs may exist they have little or no relationship with the decision processes of a S performing a conceptual learning task; the second, is that these relationships, as phenomenon, do exist but the methods for assessing the decision processes used in this study were such that they prohibited these relationships from manifesting themselves in the statistical analyses.

If the former is accepted, it has at least two implications for future research; 1) there are no relationships between the intrinsic sources of variance and conceptual learning and therefore our research efforts should be directed elsewhere; or 2) that the relationships between intrinsic variables and the decision processes do exist but they are to be found at a higher order task level than was investigated in this study. This would mean directing our research efforts towards higher forms of conceptual learning or principle learning.

The writer chooses to make the latter inference. The choice is made in relation to what might be termed an article of faith. The rationale being that: 1) if intrinsic sources of variation can be identified within the learning domain it is logical to assume that relationships may be found between these intrinsic sources and different types of learning, from the basic to the complex; if this assumption is accepted then it follows that one would expect to find these relationships manifesting themselves between intrinsic sources and processes found in conceptual learning (viz. decision processes in CA task).

Why weren't these relationships found to a significant degree in the present study? In looking at Table 5 it is readily seen that in terms of the SDs the variance of the measures is quite low. The nature of the conditional probability statistic is such that the range of possible scores is restricted and therefore the discriminability between Ss reduced. Consequently the correlational relationships upon which the multiple regression analyses are founded are minimized. Respective to this, the implication is that the direction of future research should be towards finding new methods of scaling and measuring the decision processes in concept learning that will provide the variance necessary to describe the relationship between intrinsic sources of variance and decision processes.

2. Conceptual Learning Task Measures

Thirty-six multiple regression analyses were performed using the same procedures and predictor variables as were used with the decision probability measure. The criterion variables were the three dependent measures of the CA task.

Within the task measures the existence of a definite trend within the data is evident. This is indicated by the apparent interaction between the intrinsic process variables (i.e. predictors) and the procedural variables, namely the task conditions. Under the condition of high problem difficulty level (i.e. CC4), Factor D, interpreted as susceptibility to response competition, consistently manifests a positive relationship with the criterion variables (viz. memory error and total error), whereas we find no relationship at the low problem difficulty level. There appears to be an additional interaction between the process variables and procedural variables in that the significant relationships are found only at the lower SA levels.

For predictive purposes, the immediate implication is that those people who are highly susceptible to response competition will do poorly on concept attainment tasks that are high in conceptual complexity. The high loading of the VMD variable on Factor D helps to explicate the importance of the relationship. It was hypothesized earlier that those people who manifest resistance to response competition are less susceptible to interference with the consolidation of visual information. The hypothesis seems to find support in the significant positive relationship between Factor D and the criterion variables of memory error and total error. The rationale here being that those Ss who are susceptible to interference with the consolidation of visual information are less likely to be able to form the necessary associations needed to develop a short-term visual memory structure. Because of their incomplete or weak memory structure they are more likely to make memory errors or judgement errors in a CA task such as was used in the present study.

Under the condition of SA4: CC2 the significant relationship between Factor D and the correct identification of the relevant attributes (i.e. Rule) is in the direction one would predict given the significant relationships between Factor D and the error measures. It would seem to follow from the discussion of the resistance to response competition, that a person who is able to consolidate visual information is more likely to develop a more complete memory structure and therefore be able to identify the attributes relevant to the definition of a concept.

With the exception of the relationship between the predictor variables and the measure of the correct identification of the relevant attributes within condition SA6: CC4, there were no significant multiple regression equations in relation to the data of week five.

Under the condition of SA6: CC4 where the memory load is the lowest for the three SA levels, we find that the emphasis or weighting of the factors has changed within the multiple regression equation. Whereas during week one, the SA4 level Factor D manifests a strong relationship with correct attribute identification, at SA6: CC4 its relationship is greatly reduced and Factor A now appears to have the major relationship. The conclusion to be made here is that as the procedural condition allows the S to develop informational aids less stress is placed on the internal memory structure and response competition as an inference factor plays a less important part. Looking at the structure of Factor A, (Section VA-a) it is seen that the major loading on the factor is PI. The implication of this fact for the present discussion is that though

Factor D still plays an important role in the multiple regression relationship, PI, as it relates to Factor A, accounts for the major portion of variance found in the criterion measure, namely correct attribute identification. The inference being that when the S is allowed to develop an information structure external to his own memory the consolidation of the internal visual memory information becomes less important and the effects of PI on the external structure play a major role.

VI. Summary

The present study was undertaken for the purpose of identifying and describing individual difference variables that are intrinsic to the learning situation. In addition, an attempt was made to determine the relationship between the intrinsic ID variables and selected dependent measures taken while the Ss were performing a concept learning task.

The first phase of the study involved the factor analysis of fourteen variables selected as measures of intrinsic sources of IDs. The factor analytic procedures were used in order to determine the inter-relationships of the variables and reduce them to a lesser number of more fundamental variables. The analysis yielded five factors the interpretations of which are summarized as follows:

Factor	Interpretation
A	Strength of the initial registration of the stimulus trace
B	Visual Memory: Immediate
C	Field Independence
D	Susceptibility to Response Competition
E	Neuroticism

The second phase of the study utilized multiple regression procedures to determine the relationship between the intrinsic ID variables, defined by the factor analysis, and the dependent measures. The dependent measures were of two types; 1) statistical conditional probabilities that reflected selected decision making procedures followed by the Ss while solving the conceptual learning task; 2) error scores computed for each S during the concept learning task and the number of correct attribute identifications made by each S, respective to a specific problem.

The multiple regression analyses yielded a limited number of significant relationships between the intrinsic variables and the measures of the decision processes. It was posited that though significant relationships were not manifested in this study this does not deny their existence. The implication being that future research efforts should be directed toward finding new methods of scaling and measuring the decision processes in concept learning.

Respective to the task measures, the multiple regression analyses indicated that there is a definite relationship between the ID variables and task conditions. The implication being that those people who are susceptible to response competition will do poorly on conceptual learning tasks that are high in concept complexity. The basic hypothesis here is that those people who manifest resistance to response competition are less susceptible to interference with the consolidation of visual information, and are therefore able to form the necessary associations needed to develop a short-term visual memory structure.

Though the analyses yielded a limited number of statistically significant relationships, the author believes strongly in the validity of the procedures used. It is again emphasized that the success of an individualized instructional program is dependent upon a complete understanding of the IDs contributing to learning. It is hoped that future researchers will take note of the short comings of this study and continue towards the goal of filling this void in the knowledge of instructional methodology.

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