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Individual Differences in Human Learning

Arthur R. Jensen

The purpose of this article is to give an overview of a long-term program of research on individual differences in human learning. This research is one of the programs being carried out in the Center for Human Learning at the University of California in Berkeley. So that the results of numerous single experiments in this program may be seen in relation to the research program as a whole, this paper serves to describe in general terms the investigator's total program of research with regard both to its aims and its methodology. The main objective of this research is to discover the basic "dimensions" underlying individual differences (IDs) in a limited realm of learning phenomena.

Traditionally the experimental study of human learning has been of the S-R variety, directed at discovering the relationships between stimulus (or conditions-of-learning) variables and response (or performance) variables. In this type of experiment a larger part of the variance in performance may often be attributed to IDs among subjects than to variations in the conditions of learning. We know that a large part of what is usually labeled "error variance" in learning experiments is not actually error in the sense of unreliability of measurement, but is due to reliable IDs among subjects.

Research has already made it clear that a unidimensional concept of general learning ability is not at all adequate to account for the

variability among individuals under a variety of learning conditions. A multidimensional description of learning abilities is called for. Up to the present time, however, no long-term, systematic research has been directed at IDs in learning. In this area experimental psychology and differential psychology must work closely together. In addition to the traditional S-R type of experimentation aimed at the formulation of general laws of learning, there is clearly needed a correlational or R-R type of analysis aimed at discovering the structure of individual variability. Many S-R laws of learning will have to include statements regarding IDs if they are to be of value in the applied field. Individual prediction of learning abilities and disabilities in various tasks depends largely upon an understanding of the structure of learning abilities. Since it has been found possible to account for the variance of scores in a large number of cognitive tests in terms of relatively few factors or "primary mental abilities," or to describe a good deal of the manifest variety of human behavior in terms of a limited number of basic personality traits, it also seems reasonable to hypothesize that there are "traits" that operate in the realm of learning.

The fundamental assumption underlying the present research is, of course, that variability due to IDs is not specific to each and every learning phenomenon. There is good reason to believe that IDs in many phenomena covary, and appropriate multivariate analysis of the correlations between various learning phenomena should reveal the underlying structure of learning "traits."

The present research is of theoretical, methodological, and practical significance. Reliable measures of IDs in various learning phenomena may be used to test certain deductions from theories of learning. For example, if different phenomena are theoretically attributed to the same underlying process, as Hull attributes both reminiscence and spontaneous recovery to the dissipation of reactive inhibition, one would predict a significant positive correlation between measures of these phenomena. The correlation, of course, must be based on IDs measured with a known degree of reliability, so that it may be corrected for attenuation. The nature of the so-called intervening variables or hypothetical constructs in learning theory may thus be investigated through the pattern of correlations obtained from IDs in a variety of learning phenomena. Also, reliable, standardized measures of IDs in various learning phenomena, along with a knowledge of their dimensional structure, are a necessary adjunct to research in a number of closely related fields, such as automated teaching, the effects of aging on learning ability, the effects of drugs on behavior, and the relationship between learning and cognitive and personality variables.

Methodological Considerations

Past studies of IDs in learning have been fragmentary, unsystematic, and generally inconclusive. A survey of the field leaves one with the impression that over the years very little progress has been made. It is the investigator's belief that this discouraging picture is the result of inappropriate methodology. Research in this field has not had the benefit of a methodology which adequately combines the techniques both of experimental and of differential psychology. Impressions made

by earlier research in this field make it advisable to orient the reader by stating first what the present research does not consist of.

The research at this stage does not attempt to determine the factorial structure of learning abilities by analyzing intercorrelations between measures of scores obtained on a large variety of different learning tasks. This approach always meets defeat by the great amount of "method variance" which obscures the structure of IDs. Past researchers have often used learning tasks as psychometric tests of "ability" and have, therefore, been concerned with the content or the stimulus-response modality of the learning rather than with variables directly related to the process of learning, such as pacing, distribution of practice, schedules of reinforcement, etc. The present research, on the other hand, does not use learning measures as psychometric test scores to supplement or to be correlated with other kinds of test scores, or to predict performance on some external criterion. Also, the emphasis of the present research is on IDs in the learning process rather than in the content of learning. The research at this stage does not seek to analyze IDs in learning in terms of factors derived from the realm of cognitive or aptitude tests or from personality inventories. The analysis remains within the system of learning phenomena under investigation.

At a later stage it may be possible to find linkages with other systems of measuring IDs, but at present our lack of knowledge concerning IDs in the learning process itself makes such an approach unpromising.

The first requirement of this research is a highly standardized learning situation within which a number of learning phenomena may be reliably measured under controlled conditions. The learning situation should be such as to make possible the manipulation of those independent variables which experimental research has found to be important sources of variance in performance. By working within this standard situation we may attain a relatively complete knowledge of the performance variance contributed by independent variables. Also, the learning task should be capable of being varied over a wide range of complexity without altering the other parameters of the learning situation. Finally, the types of learning allowed by this standard situation should bear sufficient resemblance to learning found in "natural" conditions to permit us reasonably to assume that measurements obtained within the experimental situation will have considerable relevance to a variety of "real" learning situations. This assumption, of course, remains to be tested, but it is believed at the outset that the experimental learning situation used in the present research, while still permitting rigorous experimental control of the most important independent variables, is much more representative of complex human learning as it occurs outside

the laboratory than would be the case, for example, with classical conditioning, the operant conditioning of a single response, or performance on the pursuit rotor. As will be seen in the following section, the relevance of our method for automated teaching is quite obvious (Jensen, 1960).

Apparatus

To meet the above-mentioned requirements the investigator has devised a "multiple stimulus-response learning apparatus," which is described in detail elsewhere (Jensen, 1961). Briefly, this apparatus does essentially three things: it presents visual stimuli to the subject (S); it permits the S to respond by pressing buttons; and it reinforces the S's responses, when "correct," with a tone or light signal. The sequence of stimuli and the schedule of reinforcement are programmed on teletype tape, which insures uniformity in the learning task for all Ss.

The apparatus as it is used in our research presents up to twelve different stimuli in any one learning task, and the S can be required to learn up to twelve S-R connections. (Six to nine S-R connections have been found to be most suitable for college students if they are to learn to a criterion of mastery in a single practice period which is short enough to avoid fatigue or boredom.) The machine presents stimuli

singly at any rate set by the experimenter. The sequence of stimuli may be programmed to appear in any desired order.

The advantages of this apparatus for our research are several:

a. Since learning is generally conceptualized in terms of the acquisition of associations between stimuli and responses, the apparatus has the advantage of presenting learning tasks and of yielding data which clearly lend themselves to analysis in S-R terms.

b. The apparatus permits us to clearly define and delimit the S's response repertoire. "Irrelevant" responses can be included in the S's response repertoire by having response alternatives (push-buttons) which never are associated with any of the presented stimuli and are never reinforced. This arrangement permits a degree of control and analysis of the competing, "irrelevant" responses in the learning experiments.

c. Since learning can be most precisely defined, described, and measured in terms of changes in response probability, one of the most important features of this method is that it permits an exact determination of response probabilities at the beginning of learning. One can determine the changes in response probability from the initial baseline probabilities throughout the course of learning. Increments and decrements in the associative strengths of various S-R connections may thus be treated quantitatively with satisfactory precision.

d. The method yields a complete record of the course of learning

the stimulus presented on every trial, the S's response, and the occurrence of reinforcement. Thus every aspect of S's performance is available for analysis.

e. Without altering other parameters of the learning situation, the apparatus permits variations of task complexity from the learning of a single S-R connection to the simultaneous learning of twelve S-R connections. "Irrelevant," non-functional response alternatives also may be added to the task, so that, for example, there may be only six S-R connections to be learned but the S is presented with twelve response alternatives, six of which do not correspond to any stimulus and are never reinforced. This permits an analysis of how irrelevant, competing responses are eliminated from the S's performance throughout learning.

f. Up to twelve "equivalent forms" of the same learning task are possible by means of a switch which "randomly" changes the connections between the stimuli and the response buttons. Since the task remains the same in all other particulars, repeated retesting of the same Ss on "equivalent" tasks is possible, permitting the determination of test-retest reliability of the various measures derived from the S's performance. This feature also makes possible the study of "learning-to-learn" when the S is repeatedly tested on equivalent forms of the same type of task.

g. The stimulus display unit of the apparatus can present any kind of stimuli that can be photographed--words, symbols, colors, pictures, etc. In this respect it somewhat resembles a teaching machine. The response buttons may be varied in number or put into any desired spatial arrangement and may be labeled in any way desired. Thus it is possible to vary both stimuli and responses along a number of different dimensions

as, for example, degree of similarity along stimuli and responses. This particular feature can be used in the measurement of IDs in stimulus and response generalization and in interference effects resulting from varying degrees of similarity among stimuli or among responses.

Theoretical Orientation

Though the present research is intended as a systematic, inductive, empirical approach to the study of IDs in learning and is not based on any particular theory of learning, some of the questions it seeks to answer are based on certain theoretical conceptions concerning the nature of the learning process. Some of the dimensions of IDs may correspond to certain learning constructs such as habit strength, inhibition, generalization, interference, and behavioral oscillation.

Inhibition. The hypothetical construct on which attention is first being directed is that of inhibition. One of the issues over which current theories of learning are divided concerns the need for hypothesizing an inhibitory process in addition to an associative process to account for a number of learning phenomena, such as differences between spaced and massed learning, and between acquisition and extinction. Uniprocess theories try to comprehend these phenomena in terms of a single process of association or habit strength and the interference or competition between associations. The duo-process theories postulate two opposing processes, habit strength (or excitation) and inhibition. The duo-process theories derive some advantage from the fact that an inhibitory process seems to have been quite convincingly demonstrated in a number of Pavlovian or classical conditioning phenomena. Also, neurophysiologists have identified inhibitory processes directly at the

neural level. It is still far from certain, however, whether an inhibitory process can actually be identified in complex human learning. Effects that might be attributed to inhibition might just as well be attributed to interference. One aim of the present research is to throw some light on this question. If measures of IDs in a number of phenomena theoretically attributed to inhibition are highly intercorrelated and show at the same time relatively low correlations with effects that are theoretically identified with interference, this would be interpreted as supporting a duo-process theory. Then we could begin to refine measures of the "inhibition dimension," so that IDs could be reliably measured along this dimension independently of other dimensions. The "construct validity" of such measures can be further established by testing groups of high and low scorers on the inhibition dimension under other learning conditions which are hypothesized to involve the build-up of inhibition.

If, on the other hand, it is found that the pattern of correlations between "inhibitory" and "interference" phenomena was such as not to be able to distinguish between the two types of phenomena, this would be interpreted as favoring a uniprocess theory as regards the excitation-inhibition controversy as it applies to complex human learning. Still another possibility, of course, is that the pattern of correlations might support a duo-process theory even though we were originally mistaken as to which phenomena should be attributed largely to inhibitory effects and which to interference effects. The working-out of such problems, of course, involves a great deal of testing under many variations of experimental conditions and often requires that we measure a number of different phenomena on the same individuals. The search for an inhibitory factor as distinct from interference seems highly worth while, however, in view

of the relatively secure status of the inhibition construct in classical conditioning and in neurophysiology.

Experimental extinction will be studied with reference to the inhibition problem. The negative correlation generally found between rate of acquisition and rate of extinction in classical conditioning will be investigated. Whether extinction of operant human learning of the non-motor or verbal variety is a matter of inhibition or of interference or of some combination of the two is a problem to be investigated. The relation of experimental extinction to forgetting will also be studied.

Interference. We know nothing at present concerning the relationship between IDs in the speed or ease of acquiring associations ("habit strength" factor) and IDs in susceptibility to interference among a number of S-R associations, which has been hypothesized as the cause of proactive and retroactive inhibition, forgetting, and certain decremental effects which result when suddenly changing from the part method to the whole method in learning a complex S-R task. Can we isolate what might be called a "susceptibility to interference" factor? If so, groups differing on this factor should show differences in performance on tasks involving competing S-R associations. On the other hand, it could be that degree of interference is strictly a function of degree of learning (which may be related to a "habit strength factor") and that there are no reliable IDs in interference, in which case, of course, no independent "interference factor" could be established.

Generalization. Degree of intra-task similarity among stimuli or responses is known to be a factor in difficulty of learning. What we do not know is the degree of correlation between IDs in rates of learning

under different degrees of intratask similarity. If individuals do not remain in the same rank order in rates of learning under different degrees of intratask similarity, we would hypothesize a "generalization factor" on which individuals differ. This factor may or may not interact with the "interference factor." The contribution both of the stimulus and of the response to the "generalization factor" will be investigated. If a "generalization factor" were isolated, one would expect measures of it to correlate, for example, with differences in degree of retroactive inhibition under varying degrees of similarity between the original task and the interpolated task.

Acquisition or Habit Strength. Correlations between measures of rate of acquisition or speed of learning taken under a variety of conditions may be attributed to an acquisition or "habit strength" factor. The generality of this factor over different types of learning is a point of interest. The investigator has found, for example, a near zero correlation between IDs in paired-associate learning and in serial learning, even when the content of the learning has been the same and the measures have reliabilities close to .80.

Behavioral Oscillation. Hull's theory of learning postulates "behavioral oscillation" as an intervening variable to account for the fact that individuals vary from moment to moment in their performance even of well-learned acts. This intra-individual variability may be a trait on which it is possible to obtain reliable measures of IDs. If oscillation were established as a trait, it could be expected to be of importance in the S's accuracy and consistency of performance after he had reached his asymptote of learning, and it may be highly relevant to

the S's ability to attain a certain criterion of mastery if the criterion depends heavily upon stability of performance.

Order and Complexity. IDs in rate of learning under one degree of task complexity (defined as the number of S-R connections in the task) may not be highly correlated with IDs under a different degree of task complexity, and the lack of a perfect correlation, it is possible, may not be attributed entirely to IDs in the "interference factor." Thus we would hypothesize a "task-complexity factor." While the "interference factor" would be expected to correlate highly with the phenomenon of associative interference (increased difficulty in the learning of a task due to the prior learning of a similar task), for example, we would not expect the complexity factor to show much correlation with the phenomenon. Findings such as this would help to establish the independence of the two factors. And, of course, an interaction between these factors may be found.

If ID's in rate of learning were not highly correlated between tasks having different degrees of order (e.g., paired-associate and serial learning), one could hypothesize an "order factor." Individuals high on this factor would perform relatively well on highly ordered tasks. Another explanatory possibility for the insignificant correlation between serial and paired-associate learning is in terms of a memory-span factor, which the investigator has already shown to play a part in serial learning but which may not contribute to the variance in paired-associate learning.

Pacing. Do IDs in rate of learning show a different rank order under different task-pacing conditions? These IDs may not be associated

with the "inhibition factor." What is the effect on efficiency in learning when task-pacing is either slower or faster than the rate at which the individual performs when allowed to work at his own pace? Is there a "performance tempo" factor, independent of other hypothesized factors, which may contribute to the ID variance in learning? How is rate of self-pacing affected by a period of practice under more rapid forced pacing?

Reinforcement. IDs in rates of learning under different schedules, if not highly intercorrelated, would suggest the existence of a "reinforcement factor." Investigation along these lines would begin with correlating learning rate under 100 per cent reinforcement with rates under various schedules of intermittent reinforcement. The "reinforcement factor" would, of course, have to be investigated for its independence of the inhibition or interference factors.

Learning-to learn. Individuals may show different rates of improvement over a series of related tasks ("equivalent faorms"); this measure of improvement may not be highly correlated with rate of learning within any one task, in which case we would hypothesize a "learning-to-learn factor." It would have to be shown that this factor is not reducible to the "interference factor" which could very well account for some of the variance in rate of improvement over a series of similar tasks. The investigation of learning-to-learn will probably not be investigated in its own right for quite some time, but it is on the agenda for future study. At present not enough is known about the task variables to formulate fruitful hypotheses about what is involved in learning-to-learn.

The same may be said to hold true for the study of IDs in transfer of training, which should be more amenable to investigation after some progress has been made along the lines of the present research.

Retention. Present evidence indicates a negligible correlation between measures of learning and of retention, which suggests that different factors may underlie these functions. A study of retention factors must go hand-in-hand with the investigation of proactive and retroactive inhibition. Of direct theoretical relevance is the relationship between IDs in retention and IDs in the "interference factor." We must find out how much of the variance in retention can be attributed to factors identifiable in the acquisition phase. Also the factorial nature of retention measured after different intervals and by different means (e.g., recognition, reconstruction, recall, and savings in relearning) must be investigated. But before we can get very far in the study of retention, the structure of IDs in acquisition and experimental extinction will have to be clearly delineated.

Motivational Factors. The role of motivation in laboratory tasks with human Ss is so poorly understood at the present as to discourage the investigator from attempting to study IDs in this realm for quite some time. Standard procedures for eliciting the cooperation of Ss will be used in the proposed experiments, and whatever variance may be due to "motivational" factors will, for the present, have to be assumed under "error variance" in the analysis of our experiments. Eventually motivational sources of variance in learning will have to be subjected to dimensional analysis, probably by using different motivating instructions

to the Ss and by borrowing techniques from personality research for classifying Ss according to such supposedly motivational traits as manifest anxiety, n achievement, cooperativeness, etc.

Research Strategy

The strategy of the present research is based on a hierarchical conception of the structure of IDs in learning. It attempts first to discover single learning phenomena which clearly reveal the existence of reliable IDs, then to develop and intercorrelate measures of these phenomena (these measures here being referred to as tests) in order to find group factors. The tests, in a sense, are first-level factors; that is, they underlie IDs revealed by variations in specific independent variables. If our fundamental hypothesis that IDs are not specific to each and every learning phenomenon is true, the matrix of intercorrelations between the tests will yield higher-order factors. The tests are defined in terms of the independent variables chosen by the experimenter to reveal IDs. The factors derived from the matrix of intercorrelations among the tests, on the other hand, are determined by the inherent structure of learning abilities.

Reliability. One of the most important problems in this research concerns the reliability of our measures. Since every S must be tested on at least two tasks or under two sets of conditions, we also have the problem of associative interference and of learning-to-learn entering into the second task. This problem is handled by having two control groups in almost every experiment. One control group learns two equivalent forms

of the first of the two tasks learned by the experimental group and the other control group learns two equivalent forms of the second task learned by the experimental group. The correlations between equivalent forms serve as reliability coefficients for each task, so that the correlations between the tasks of the experimental group may be corrected for attenuation. It seems advisable to establish reliability (which must be equivalent forms reliability in order to include the effects of associative interference and learning-to-learn) by repeated testing of the Ss in the experimental group, for then the interference and the learning-to-learn would be accentuated to an unknown degree. Thus the reliability is usually determined on different groups of Ss from those used to develop tests of IDs. Of course, Ss in both the experimental and the reliability control groups are always drawn randomly from the same population. The data of the control groups is also used in many other parts of the analysis and not just for determining reliability.

Independent Variables. The independent variables which define our tests are as follows:

A. Variables in acquisition and extinction.

1. Pacing. (Self-pacing vs. forced-pacing at 3 sec. rate.)
2. Distribution of practice. (Continuous vs. spaced with "rest" periods.)
3. Complexity. (Many vs. few S-R units. Some of the complexity problems involve "dead" response buttons, i.e., irrelevant response alternatives which are never reinforced.)

4. Stimulus similarity. (Homogeneous vs. heterogeneous stimuli.)
5. Response similarity. (Response buttons with homogeneous vs. heterogeneous labels.)
6. S-R interference. (Buttons labeled the same as stimuli but so as not to correspond to S-R connections vs. button labels having no resemblance to stimuli. The first condition maximizes interference, the other minimizes it.)
7. Schedule of reinforcement. (100% reinforcement vs. intermittent, e.g., 75% reinforcement.)
8. Whole-Part learning. (Learning all 12 S-R connections simultaneously vs. practicing only 6 connections for a set number of trials before being presented with the next 6 S-R units.)
9. Degree of order. (Stimuli presented in random order vs. stimuli presented in serial order.)

B. Variables in retention and forgetting.

1. Relation of acquisition variables to retention.
2. Interference effects in retention.
 - a. Proactive inhibition.
 - b. Retroactive inhibition.

Stimuli. The stimuli used in every experiment (other than those of condition #4 above, where stimuli must be varied) consist of colored geometric forms: triangles, squares, and circles colored red, blue, yellow, and white. A number of studies by the investigator have already shown

these stimuli to have certain advantages for this research. No time need be spent by S in integrating the stimuli or in becoming familiar with them, as is necessary with nonsense syllables, and the simple colored forms minimize unwanted variance due to idiosyncratic verbal associations, meaningfulness, and discriminability.

Experimental Paradigm. The plan of research is most easily explained with a specific example. We will start with the variable of distribution of practice. In the first stage of our research, we want to know whether people remain in the same relative position on a learning measure under variations in distribution of practice. If there is an interaction between individuals and distribution of practice, we wish to know under what conditions in our experimental set-up this interaction is most strongly manifested. To answer these questions, we perform the following type of experiment. (For simplicity massed practice is designated as M, spaced practice as S; the subscripts a and b indicate equivalent forms of the learning task.)

	<u>Experimental Groups</u>	<u>Control Group I</u>	<u>Control Group II</u>
Day 1	M _a	M _a	S _a
Day 2	S _b	M _b	S _b

In actual practice, the order of the tasks is reversed for half the Ss in each group to permit analysis of the effect of order on performance. For simplicity we will assume for the present that order of tasks is unimportant.

The Ss learn to a designated criterion. The score is the number of trials to attain the criterion. Using these scores, the following intercorrelations are obtained: r_{MS} , r_{MaMb} , r_{SaSb} . We then correct r_{MS} for attenuation to find the "true" correlation between learning under spaced and massed practice. Thus,

$$\text{Corrected } r_{MS} = \frac{r_{MS}}{\sqrt{r_{MaMb} r_{SaSb}}}$$

If the corrected r_{MS} is above .70, we will say, for the present, that we do not have good evidence for a distribution of practice factor, and if such a factor exists, our test is not a very good measure of it. If the corrected r_{MS} is below .50, on the other hand, we have evidence for a distribution practice factor and a potentially good test for measuring it.

We perform the above paradigm for massed vs. spaced practice under every set of the 9 conditions listed above under A.

	Group I		Group II		Groups 3, 4, etc.
	1. Pacing Self-P. vs. Forced-P.		3. Complexity High vs. Low		Variations 4,5,6,etc.
Day 1 Massed	M_a	M_a	M_a	M_a	M_a
Day 2 Spaced	S_b	S_b	S_b	S_b	S_b

It is highly probable that certain conditions will reveal IDs in massed vs. spaced practice to a greater extent than other conditions,

and that is why a number of variations in conditions must be tried. Under every condition we use the control groups in order to be able to correct the r_{MS} for attenuation due to unreliability including effects of learning-to-learn and associative interference.

The same procedure is applied to every one of the 9 variables listed above. We are concentrating first on those variables theoretically associated with inhibition, viz. pacing and distribution of practice.

The second stage of investigation consists of intercorrelating the best measures of each of the variables (i.e., 1 to 9 listed under A above). The matrix of intercorrelations is subjected to a factor analysis to find group factors underlying the covariation of IDs in the specific tests. Also to be included in the correlation matrix will be measures of phenomena hypothesized as representing certain underlying factors, such as measures of extinction and reminiscence, IDs in which are hypothesized as being a function of IDs in a general inhibition factor. In practice, we will determine whether the hypothesized inhibition factor exists by intercorrelating measures on the variables of pacing, distribution of practice, rate of extinction, reminiscence, and rate of decrease in errors on irrelevant (consistently not reinforced) response alternatives, which theoretically are eliminated by the build-up of inhibition due to responding without reinforcement. Tests with the highest saturation on a factor will be used in subsequent studies as measures of IDs on the factor. For example, say that distribution of practice was the variable most heavily saturated on the inhibition factor. An individual's factor score on inhibition could consist, then, of the difference between his

standardized scores (z scores) on learning under distributed practice and under massed practice. This factor score would indicate the degree to which a person's performance improves or deteriorates in massed as compared with distributed practice, and, if it truly represents an inhibitory factor, it should be significantly related to other phenomena which are hypothesized to be a function of inhibition. Through this line of reasoning further experiments are designed which may confirm or infirm the construct validity of the inhibition factor.

Every one of the nine variables listed under A will be studied under every one of the other eight sets of conditions. How long this will take cannot now be determined, since all the possible difficulties cannot be foreseen. Rate of progress will depend upon matters such as test reliability; for example, if in a number of experiments our tests prove highly reliable and the effects of learning-to-learn and associative interference between equivalent forms are slight, we can dispense with our reliability control groups in many instances. Also, the number of Ss needed in each experiment can be adjusted in terms of the reliabilities of our measures.

Extinction. All Ss after learning a task to a set criterion then undergo experimental extinction by continuing to perform on the task for a certain number of trials without further reinforcement. Relationships between variables in acquisition and in extinction are studied. For example, we wish to know how the "history" of reinforcements of a particular S-R connection in a complex task consisting of several S-R units is related to its "history" during extinction. Hull's

theory would predict that the greater the number of reinforcements of the S-R connection, the greater its resistance to extinction. It should also be determined whether the point in the course of learning at which a particular S-R connection is first reinforced is related to its subsequent rate of acquisition (in terms of increased probability of responding correctly on succeeding trials) and to its resistance to extinction.

Some of the learning tasks also include irrelevant response alternatives ("dead" buttons), since it is believed that their rate of elimination during the acquisition phase as compared with the rate of elimination of errors on task-relevant (i.e., reinforced) response alternatives may afford a means of distinguishing between interference (response competition) and inhibition.

Retention and forgetting will not be studied until the factors underlying acquisition and extinction have been satisfactorily delineated. The first objective is to establish the main dimensions underlying IDs in acquisition and extinction. Once these have been established, their roles in other types of learning, such as verbal and perceptual-motor learning, may be investigated in experiments being carried out by other investigators in the Center for the Study of Human Learning.

Though the aims of the proposed research are entirely feasible, their achievement is admittedly difficult. Since this is something of a pioneering effort in the study of IDs in learning, there is inevitably a certain amount of trial and error in our procedures. This will be so especially in the early stages of our work. But the investigator takes a long view of this program. As progress is made, the implications and

applications of this research should increase at a positively accelerated rate.

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