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THE EFFECTS ON TRANSFER OF TIME DELAY AND TASK SIMILARITY: A LITERATURE REVIEW

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Behavioral Sciences Laboratory
6570th Aerospace Medical Research Laboratories
Aerospace Medical Division
Air Force Systems Command
Wright-Patterson Air Force Base, Ohio

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Contract Monitor: Dr. T. E. Cotterman
Project No. 7183, Task No. 718306

(Prepared under Contract No. AF 33(616)-6408
by
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FOREWORD

This report was prepared in the Department of Psychology, Florida State University, Tallahassee, Florida under Air Force Contract No. AF 33(616)-6408. The research was accomplished during the period 1 June 1959 to 28 February 1961 by Dr. Joel Greenspoon, the principal investigator.

The work is a portion of that being accomplished under Task 718306, "Research on Human Learning and Related Methodology" of Project 7183, "Psychological Research on Human Performance." The contract was initiated and monitored by Dr. T. E. Cotterman of the Operator Training Section, Training Research Branch, Behavorial Sciences Laboratory.

ABSTRACT

A review of selected literature pertinent to the effects of similarity and delay on transfer is reported. Emphasis is given to the more recent research and that which seems to make a greater contribution to knowledge of these effects - especially studies in which similarity and time delay were manipulated jointly. Although considerable research has been accomplished, the effects of similarity and time delay (either singly or jointly) are not known with sufficient precision to enable satisfactory use outside of the narrowly constrained laboratory contexts, if even there. Effective prediction on the basis of similarity will depend on the development of a rigorous and reliable technique for its measurement. The effects of delay can only be adequately determined after this is accomplished.

PUBLICATION REVIEW

This technical documentary report has been reviewed and is approved.

Walter F. Grether
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Technical Director
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INTRODUCTION

The problem of transfer of training has been attacked by research and theoretical and applied psychologists and related scientists for many years. This strong interest in transfer of training arises from two major sources, the theoretical and practical implications of transfer of training. The theoretical interest stems from the fact that any effort to develop a theory of behavior or learning will require an effective treatment of transfer of training. The practical implications reflect the fact that much training in many areas must be conducted under conditions or at a time that may differ from the conditions in which the training will be used. For all practical purposes the entire educative process demands extensive transfer of training if the education is to have any value. The dependency of the educative process on transfer of training is reflected in the development of the doctrine of formal discipline that prevailed in American education at the turn of the twentieth century. Though the doctrine of formal discipline fell into disrepute, the underlying problem of transfer of training continued to be important in psychological research and theory. This interest in transfer of training has continued unabated to the present time.

Two problems that gained and held the attention of investigators in transfer of training are the problems of similarity of stimulus and response and the time interval between original learning and the test of learning. The problem of similarity has maintained the interest of investigators for many years because it has tremendous applied, as well as theoretical, value. Given a task that is to be performed, assuming that training cannot be conducted on the task itself, one is immediately confronted with the problem of designing the training situation to maximize performance on the task. The problem of similarity of many features of this situation soon becomes apparent.

At the same time it may be quickly recognized that the training on an activity may not be used immediately in the performance of another activity. That is, there may be an interval of time that elapses between the original training on an activity and the application of that training to another activity. As a consequence, similarity and time of test have become and remain two variables in transfer of training that have attracted considerable attention from psychologists.

The discussion of similarity and time of test, the two variables that are being examined in this report, will be divided into five sections. The first section will be concerned with similarity of task elements; the second section will be concerned with the manipulation of the stimulus component; the third section with the manipulation of the response component; the fourth section with theoretical conceptualizations of the similarity variable, and the final section with the time of test variable in transfer of training.

SIMILARITY OF TASK ELEMENTS

One of the major issues in transfer of training which quickly arose was the role of similarity of stimulus and response in the amount and kind of transfer of training. The doctrine of formal discipline tended to emphasize either positive transfer or no transfer. Research efforts tended to provide data indicating that negative transfer may occur as well as positive transfer. It became apparent to many of the early investigators that similarity of stimulus or response elements may be a critical variable in determining not only the amount of transfer but the direction of transfer. The formalization of the relationship between amount of transfer and similarity initially appeared as the Skaggs-Robinson hypothesis.

The Skaggs-Robinson hypothesis was based upon data collected by Robinson (ref 47, 48) and Skaggs (ref 50). The essence of the hypothesis is that the amount of transfer decreases as the degree of relationship between the stimulus materials decreases from complete identity to similar and then increases as the relationship between the stimulus components goes from similar to dissimilar. Thus, the greatest amount of transfer occurs when the stimulus materials are identical or dissimilar.

Robinson (ref 48) conducted several experiments to test this hypothesis. An interesting feature of these experiments was the recognition by Robinson of the need to quantify the concept of similarity. The method of quantification involved the manipulation of the number of common consonants in the two lists of consonants that Ss were required to learn. With four consonants in each list, the range of similarity was from zero to four. Thus, the second list of four consonants included zero, one, two, three or four consonants from the first list.

The results of the three experiments were very similar. As the number of common consonants in the two lists decreased, the amount of recall decreased. The data tended to support the first half of the Skaggs-Robinson hypothesis.

Robinson's method of quantifying similarity leaves much to be desired. His method of quantifying similarity results in discrete magnitudes of similarity since he has no way of measuring units smaller than one. However, the Skaggs-Robinson hypothesis is presented in a manner that indicates that the units of measurement of similarity are continuous. The difference in the units of measurement used in the experimental and theoretical hypotheses raises some questions about using the results of the research to discuss the testing of the theoretical hypothesis. The discrepant units of measurement may allow for sufficient error to question the validity of any generalizations from the research to the theory and vice versa.

There was considerable interest in the problem of similarity following the publication of the Skaggs-Robinson hypothesis. There were two major facets of the problem subjected to experimentation. One area of experimentation involved the similarity of the stimulus component and the other was concerned with the similarity of the response component. The experimental issues were concerned with the effects of similarity of stimulus components, similarity of response components, and the manipulation of similarity of both stimulus and response components on the kind and amount of transfer of training.

SIMILARITY OF STIMULUS COMPONENTS

Several experiments have been concerned with the manipulation of gross stimulus components. That is, the materials to be learned were not manipulated, but the stimulus conditions of learning were investigated to determine their effect on transfer.

In most psychological research, not just transfer of training research, the general stimulus conditions in which an experiment is conducted are not considered as an independent variable. The emphasis is usually on maintaining the stimulus conditions "constant" and manipulating one or more isolated variables. However, several experiments in transfer of training have manipulated gross stimulus environments as the independent variable.

Nagge (ref 41) found that the amount of retroactive inhibition (RI) was not reduced when interpolated learning occurred in a room which differed from the room in which original learning occurred. However, Bilodeau and Schlosberg (ref 2) and Greenspoon and Ranyard (ref 21) found that the physical conditions of original and interpolated learning played a significant role in determining the amount of RI. Greenspoon and Ranyard (ref 21) found that if the physical conditions of original and interpolated learning were markedly different there was very little RI. However, if original learning (OL) and interpolated learning (IL) occurred in the same physical conditions and relearning (RL) occurred in different physical conditions there was maximum RI.

None of the experiments in this facet of manipulating physical conditions of learning made any effort to quantify the degree of similarity of the physical conditions of OL, IL, and RL. There were attempts to make the two physical conditions of learning as different as possible. Despite the lack of quantification, these experiments, especially the ones by Bilodeau and Schlosberg (ref 2) and Greenspoon and Ranyard (ref 21) suggest that efforts to consider the measurement of similarity should include the physical conditions in which the learning occurs. There may be a definite interaction between the similarity of the learning material and the physical conditions of learning which may account for a large portion of the variance of either positive or negative transfer.

The kinds of materials used in transfer experiments have varied considerably. Both verbal and nonverbal tasks have been used in research on transfer. There has been some research which has involved the use of infrahuman Ss. In many experiments the stimulus component has been nonverbal and the response component has been verbal. The reverse of this relationship has been relatively infrequent. An attempt will be made to discuss separately research involving verbal and nonverbal stimulus components.

Verbal Stimulus Component

The formulation of the Skaggs-Robinson hypothesis provided an impetus to research on the effect of the similarity component on transfer. Harden (ref 25) investigated the second half or dissimilarity portion of the Skaggs-Robinson hypothesis. She was interested in investigating the similar-dissimilar points of the identical-dissimilar continuum. Her procedure, learning materials, and method of measuring similarity were the same as Robinson's. Though her results did not completely conform to the Skaggs-Robinson hypothesis, she found a sharp increase in recall at the point of greatest dissimilarity. The efforts of other investigators, especially Kennelly (ref 31) to replicate successfully Harden's results have failed.

Siipola (ref 52) attacked the problem of similarity through complexity of tasks. She considered the possibility that the role of similarity in transfer may reflect the complexity of the tasks. That is, similarity of tasks may involve the similarity of complexity of the tasks as well as the materials to be learned. A simple task was called subordinate, and a combination of simple tasks was called superordinate. Similarity was defined in terms of serial order of numbers and/or letters. The learning activity was the manipulating of a lever in response to the numerical or alphabetic stimuli. Positive transfer was obtained on the IL task for all groups, but the greatest effect was obtained when the stimulus components of OL and IL were identical or dissimilar. On relearning the OL task, the dissimilar superordinate stimulus components resulted in the greatest improvement over OL learning and similar stimulus components resulted in the least improvement. An analysis of superordinate reversions in a second experiment demonstrated that similar stimulus components produced the greatest number of reversions. When the relationship between superordinate similarity and subordinate reversions was investigated, dissimilarity of the superordinate stimuli resulted in the fewest subordinate reversions and identical stimuli resulted in the greatest number of such reversions. Generally, in the three experiments performed by Siipola (ref 52), dissimilarity of superordinate stimulus components resulted in the greatest amount of transfer and the least amount of inhibition.

McClelland and Heath (ref 38) investigated the relationship between similarity of the stimulus component in the classical RI framework, the sequence of OL, IL, and RL. All Ss learned the same list of paired-associates in OL. Then Ss were assigned to two different groups for IL. For one group, the stimulus component in IL was a commonly associated response to the stimulus component in OL. For the other group, the stimulus component in IL had a very low association to the stimulus component in OL. Both groups relearned the original list of paired-associates in RL. The results showed that the high similarity group had a poorer performance than the low similarity group on the first two trials of RL. By the third trial of RL there was little difference between the two groups, and there was not a significant difference in the number of trials to relearn the list.

Attneave (ref 1) manipulated variations of a verbal (alphabet) matrix to which S learned a common proper name. Letters of the alphabet were used to fill most of the cells of a 6 x 5 matrix and form a pattern. There were three prototypes and eight variations of each prototype. Variations of the prototypes were created by changing the letters in the cells. Experimental Ss were shown the prototype on the screen for 15 seconds and then asked to reproduce it. Control Ss did not have any experience with the verbal matrix until the test situation, but spent an equal amount of time reproducing an irrelevant figure. The transfer task consisted of Ss learning to associate a common proper male name with each of the eight variations of the prototype. Though the task appeared to be too difficult for all Ss, as measured by the number of errors made on the last test trial, experimental Ss who received training with the verbal matrix were superior to control Ss. The similarity variable was involved in the variations of the verbal matrix.

Heath (ref 26) found that the deviation of expectancy tended to decrease as similarity decreased. Ss were asked to state the percentile rank they expected to receive on a test. One group of Ss then took the test and another group of Ss did not take the test. Six additional tests had been judged in terms of varying degrees of similarity to the original test. All Ss were asked to state their expected percentile scores on the six generalization tests but only half of the Ss actually took these tests. The difference between expected score and the attained score on the test decreased as the degree of similarity of the transfer test to the original test decreased.

A summary evaluation of the research involving the similarity of the verbal stimulus component fails to provide strong support for the Skaggs-Robinson hypothesis. There appears to be some difficulties involved in measuring similarity of the verbal stimulus component to provide an adequate test of the hypothesis. The efforts to develop a scale of similarity of the verbal stimulus have tended to rely on judgment of similarity by a small number of judges. The use of recently developed scaling techniques has not been very frequently reported in the literature. Moreover, it appears that when negative transfer effects were obtained, the effects were very short-lived, usually not exceeding two or three relearning trials. It would appear that the effects are more in terms of recall than in relearning, since the groups tend to require about the same number of trials to relearn the material to the original criterion regardless of the interpolated task.

Nonverbal Stimulus Component

McKinney (ref 40) manipulated the similarity of geometric designs as the stimulus component by reducing either the size of the total design or one of the components of the design. He found that the locus of the reduction affected the transfer of the response more than the amount of the reduction in the size of the design.

An attempt to test the Skaggs-Robinson hypothesis by Watson (ref 57) involved the psychomotor task of card sorting. The traditional RI design was used in which the interpolated task was varied to provide a rough continuum of similarity. The degree of similarity was manipulated by varying the sequence of boxes into which the cards were sorted. Response measures were obtained for differences in original and interpolated performances and original and relearning performances. There was positive transfer to the interpolated activity for all groups except the one in which all of the boxes were changed. As the number of changed boxes increased, there was a decrease in the amount of positive transfer. In the groups in which letters were substituted on the boxes for numbers, there was little difference in the amount of positive transfer. In general, positive transfer decreased as similarity decreased from identical to similar. As dissimilarity increased, the amount of positive transfer decreased. As similarity decreased, the amount of RI increased and as dissimilarity increased, the amount of RI decreased. Thus, the results of this research tend to support the Skaggs-Robinson hypothesis with respect to RI.

Buxton and Henry (ref 13) manipulated the degree of similarity of an interpolated motor activity relative to the original learning task. The OL task was a pursuit-rotor activity. The ABA design of RI was used in which the degree of similarity of the interpolated task was varied through three values. The three experimental groups showed greater improvement on retest of the OL activity than the control group. The least similar interpolated task resulted in the smallest amount of improvement on retests. Similarity was defined on the basis of a priori judgments of similarity and by correlation between the performance on the OL and IL tasks. The results of this experiment suggest that similarity is related to positive transfer in much the same way as it is related to negative transfer. The more similar the IL task is to the OL task, the greater will be the positive transfer.

Gibson (ref 19) made an effort to quantify the degree of similarity of the stimulus component. The stimulus component consisted of a series of geometric forms. One series was the standard and the other forms were evaluated by judges and placed into three categories relative to the standard series. There were two degrees of similarity and one of dissimilarity. Ss then learned a list of nonsense syllables that were paired with the forms of the standard series. The degree of generalization was determined by the relative frequency with which a standard form or a variation of it would elicit the nonsense syllable previously paired with the standard form.

A conventional RI experimental design was used in which the IL task included the standard form and variations of it. The results showed that the amount of RI was directly related to the degree of generalization of the stimulus component of the OL and IL tasks. In a second experiment Gibson (ref 19) obtained similar results. She found that the amount of RI was directly related to the degree of generalization of the stimulus components of the OL and IL task. Gibson provided the first effort to scale the similarity variable, though her efforts leave much to be desired. However, she recognized the problem and made a more rigorous effort to quantify similarity, or generalization value as she designated it.

Hamilton (ref 24), following the theoretical and methodological formulation of Gibson (ref 18, 19), found that an increase in the degree of generalization of the stimulus components of OL and IL was positively related to an increase in the trials required to learn the IL task. There was also a positive relationship between degree of generalization and the number of correct responses on the first RL trial. The number of trials to relearn all of the responses failed to show any significant differences among the groups.

Duncan (ref 15) defined the similarity of task of OL and IL in terms of the number of pairings of slot and light hues that were the same on the two tasks. The fewer pairings that were changed, the greater was the similarity. All of the experimental groups demonstrated positive transfer when compared to a control group, but demonstrated poorer performance on the initial trials of RL than on completion of OL. When compared to the control groups, the experimental groups demonstrated a positive relationship between amount of transfer and degree of similarity. A similar experiment by Kogan (ref 33) using rats and measuring similarity in terms of the number of choice points that were changed from OL to IL produced similar results. As the degree of similarity of the conditions of OL and IL decreased, the number of errors increased.

Briggs and Waters (ref 3) manipulated similarity of the stimulus component by increasing or decreasing the similarity of the component interaction of a task. They found that the amount of transfer increased as the similarity of component interaction increased between training and test conditions. Kurtz (ref 34) hypothesized that the same distinguishing characteristics of two tasks would produce positive transfer and differing characteristics would produce negative transfer. As the stimulus materials were designed, it was possible to differentiate designs in terms of one or more distinguishing characteristics. The results of the research tended to support the experimental hypothesis, increasing similarity of the materials of OL and IL resulted in increased positive transfer. Attneave (ref 1), in a similar experiment using class-schemas and variations of prototype nonsense shapes, found that increasing the degree of similarity between the training and test stimuli produced an increase in positive transfer.

RESPONSE COMPONENT

Many different response variables have been considered within the framework of response similarity. Osgood (ref 44) used the meaningful relationship between the response adjectives of the OL and IL lists. Discriminations in one form or another, e.g., S-R discriminations (Kurtz, ref 34) and transposition phenomena (Kluver, ref 32), have been the responses varied along some continuum. Mediated associations were presumed to be involved in a transfer experiment by Norcross and Spiker (ref 43). Adjectives scaled for similarity were used as responses in experiments by Underwood (ref 55), Morgan (ref 37, Morgan and Underwood (ref 36), Glades and Brown (ref 20), and Haagen (ref 22). Noble and Bahrick (ref 42) investigated response to a force in a response generalization experiment. Nonsense syllables were used as the response component by Bugelski (ref 6). Perceptual set was used as the response component in an investigation by Eckstrand and Wickens (ref 17). Young (ref 59) used two-syllable adjectives that were rated for similarity.

The measurement of response similarity has received some attention from researchers in transfer of training. Various kinds of scaling techniques have been used, but most of them have been rather crude. Osgood (ref 44) had judges rank or rate the degree of similarity of common adjectives on a three-point scale. The most extensive use of scaling of verbal materials was done by Haagen (ref 22). He had a word-list of 480 two-syllable adjectives which were arranged into 400 different word pairs. A list finally consisted of six words that were related in meaning. One word was considered the standard and the other five words in the list were related to it. The first step in the procedure was to prepare a tentative word list of common two-syllable adjectives that could be incorporated into series of six words related in meaning. This word list was presented to 35 judges who selected from each series of related words that one word that most completely represented the meaning of the group and also eliminated unfamiliar or inappropriate words. Each of the 400 word-pairs was typed on cards and photographed in four different serial orders to control for practice, fatigue, or other serial effects. Groups of 80 judges scaled the word-pairs in terms of one of the four dimensions, synonymity, vividness, familiarity and association value, on a seven-point scale. The terminal positions were described and the intermediate points were indicated as being spaced at equal distances along the dimensions. Scale values were derived from the medians of the 80 judgments of each word-pair. The points of the scale were taken as the upper units of their respective intervals so that the scale values extended from 0.5 (maximum) to 6.5 (minimum). This effort by Haagen represents the most extensive application of scaling techniques to the problem of measurement of similarity.

Noble and Bahrick (ref 42) utilized scaling procedures to scale a motor response. They used a semi-rigid control stick that required varying force to move. Their efforts were oriented toward the development of a scale of similarity of force derived from the physical scale of pounds of force. In developing the scale of similarity of force, they used 10 Ss who served under each of the 10 conditions of force measured in pounds. Each S made 80 responses to each of the 10 forces. S was instructed to exert the desired amount of force and was fed back information on the accuracy of each response. The asymptote of learning was achieved after 10 trials, so the scale of similarity of force was derived from the last 70 trials. Means and standard deviations of the distributions of responses were calculated for each S for each physical force value for the last 70 trials. Constant errors were small and normally distributed among Ss for each physical force value. Equal discriminability units on the abcissa were obtained from an equation relating average standard deviation and standard pressure in pounds. The average standard deviation for each distribution of responses was computed as the square root of the within-group mean square for each of the 10 forces. In constructing the scale of similarity of force, they separated the forces by the square root of the sum of squares of their respective average standard deviation. The resulting scale approximated an equal interval scale.

Other experimenters interested in response similarity have tended to use a physically based measurement of similarity of response. Hoffield (ref 27), for example, used angular movement as the basis for defining and measuring similarity. The greater the angular disparity and hence, the greater the difference in the movements involved, the less was the similarity of the two responses. It would appear that the measurement of similarity in this case was assumed to be directly related to the physical scale. Such an assumption may be rather tenuous.

The results of research involving response similarity indicated that there is a positive relationship between amount of transfer and degree of similarity. Osgood (ref 44) found that there was less proactive inhibition (PI) from OL to

IL as the degree of similarity increased. Similar results were obtained when RL was measured. Morgan and Underwood (ref 36), Underwood (ref 55), Morgan (ref 37), and Glades and Braun (ref 20) obtained similar results in experiments using verbal materials. As the degree of response similarity increased, the amount of positive transfer increased. However, Young (ref 59) found that there was a decline in the amount of PI as the degree of similarity increased from low to medium, but there was an increase in the amount of PI as the degree of similarity increased from medium to high. Similar results were obtained for RI when the number of correct responses on all recall trials was evaluated.

Motor response similarity was involved in an experiment by Eckstrand and Wickens (ref 17). They obtained results that were similar to the major findings on verbal materials, an increase in response similarity resulted in an increase in the amount of positive transfer. Hoffield (ref 27) obtained similar results in an experiment using a mirror drawing task. Ss were given verbal pre-training and then tested on a mirror drawing task in which the angle of the pathways varied with respect to the original verbal pre-training. The results indicated that positive transfer increased as the similarity of the verbal pre-training and the angle of the pathways increased.

The simultaneous manipulation of similarity of both stimulus and response components was the major effort in the classic experiment by Bruce (ref 5). He attempted to manipulate the degree of similarity of both components in his investigation of the conditions of transfer. He found that there was some negative transfer at all levels of initial practice when a new response was learned to an old stimulus. There was some positive transfer when S_1 R_1 were similar and when R_1 R_2 were similar and S_1 S_2 were identical. When the response components were identical, there was a definite tendency for positive transfer to occur regardless of the relationships between the two stimulus components. Norcross and Spiker (ref 43) investigated facilitation and interference on RL by manipulating the relationships between S and R. The response of OL was the stimulus of IL in some groups but not in others. Thus, the response to S_1 of OL may be the S_2 of IL. The response of IL may then be learned to S_1 of OL. On the other hand, the stimulus of IL may be the response to S_2 of OL. In relearning, the response of the IL that was learned to S_1 of OL tended to result in facilitation of RL. However, when the relationships of OL and IL were altered in OL, there was a definite tendency to produce interference. This experiment was somewhat similar to Bruce's (ref 5), and the results tended to be similar.

THEORETICAL FORMULATIONS

The initial theoretical formulations with respect to the relationship between similarity and transfer were embodied in the hypotheses of Skaggs (ref 50) and Robinson (ref 48) and have come to be known as the Skaggs-Robinson hypothesis. The essence of the Skaggs-Robinson hypothesis is that there is a continuum of similarity which goes from identity as maximum similarity, through similar to dissimilarity of the components of OL and IL. It was further hypothesized that transfer would be maximum at identity, falling off at similar and rising again at dissimilar. This hypothesis was presumably derived from experimental results of both Skaggs and Robinson. Subsequent researches tended to obtain results which would support one part or another of the hypothesis, despite the lack of rigorous measurement of similarity. Moreover, there was not a clear-cut distinction between stimulus and response similarity, a criticism made by McGeoch and Irion (ref 39). Generally, however, the Skaggs-Robinson hypothesis has been accepted in one form or another by many psychologists, despite the recognition of some of the difficulties in the hypothesis.

It is interesting to note that the direction and amount of transfer are always determined with respect to a control group that does not receive any prior training on the original learning task that serves as the relearning task. Thus, when experimenters are discussing the direction and/or amount of transfer, they are discussing these measures with respect to a control group that has had no prior experience with the learning task. The commonly used designs in transfer experiments require the subject to learn the original task to some criterion that suggests complete learning on the part of the subject. As a consequence, a comparison of his original learning performance with his relearning performance shows his relearning performance to be poorer. That is, his performance on the first relearning trial is usually poorer than his performance on the last trial or original learning. If he has perfect performance on the last trial of original learning, he can do no better on the first trial of relearning. Thus, the subject may do as well or poorer on the first relearning trial, but he cannot improve on his performance of the last trial of original learning. It may be interesting to include some of the features of the design of reminiscence experiments into the designs of transfer experiments, especially manipulating the criterion of original learning such that it would be possible for the subjects to improve on their final trial of original learning. As it now stands, the Skaggs-Robinson hypothesis states that the degree of similarity of OL and IL is related to the amount of impact on recall and relearning of originally learned material. Thus, dissimilar IL material has less effect on recall and RL than similar IL material. In one sense, the Skaggs-Robinson hypothesis is concerned only with negative transfer if subjects are considered as their own control. It is only when compared to a naive control group that positive transfer can be demonstrated. At the same time, many areas of applied psychology are concerned with the direction and amount of transfer with a group of subjects who have practiced certain kinds of activities.

Ritchie (ref 46) raised a very serious objection to the Skaggs-Robinson hypothesis. He contended that the hypothesis is an artifact and is not based on consistent experimental results. Moreover, this artifact has arisen because of the inadequacy of the definition of response. As a result, no one has conducted an experiment in which reliable increasing and decreasing effects have been obtained using the same experimental design. The author contended that the Skaggs-Robinson hypothesis was based on the concept of identical elements. The ABA design has been used primarily in testing for interference effects. In this design the stimulus components for A and B are the same or "functionally identical." The response component for A and B are presumed to represent some kind of scale of similarity. When the two responses are very different, the discrimination between the two is very easy. As the two responses become more similar, the discrimination becomes more difficult and the amount of interference increases. Therefore, as the two responses become more and more similar they should become more and more indiscriminable and interference should become maximal. But it is at the point of complete indiscriminability that the conditions for continued learning have been created. The ABA design has become an AAA design. Continued usage of the ABA design should result in an increasing amount of interference as response similarity increases. This result would tend to refute the Skaggs-Robinson hypothesis.

The observation of McGeoch and Irion (ref 39) that there was not a clear distinction between stimulus similarity and response similarity in the Skaggs-Robinson hypothesis may be more appropriate than Ritchie's criticism. His criticism is based on the definition of response, but the Skaggs-Robinson hypothesis may be concerned primarily with the definition of stimulus. Ritchie discussed the identical element concept which is usually applied to the consideration of stimulus, though it may be applied to the response. Ritchie discussed discriminable responses, ahd it appears to the present author that it may be more profitable to discuss discriminable stimuli. If two sets of stimuli initially elicit two different responses, then as the two sets of stimuli become more difficult to discriminate, the response that may be elicited will depend on variables other than the eliciting stimuli, e.g., relative strength of the two responses produced by reinforcement. Ritchie placed much amphasis on the confusing of ABA and AAA designs with respect to response. However, there may not be a confounding of designs if we recognize that the ABA and AAA refer to stimulus. The present author believes that the emphasis in the Skaggs-Robinson hypothesis is on similarity of stimuli, not responses. There is nothing in the ABA design that limits the relationship between A and B, even to the extent that A and B are the same stimulus complexes.

At the same time, the issue of response cannot be completely ignored. It must be recognized, however, that the issue of response in psychology has not been adequately resolved. Most conceptualizations of response do not involve measurement of the behavior of the organism, but rather measure the resultant of the behavior of the organism. For example, in most RI and PI experiments, the dependent variable is the number of nonsense syllables, adjectives, etc. that are correctly recalled by the subject on the first, second, etc. trials of relearning. A second dependent variable frequently used is the number of trials required by the subject to relearn the list to the original criterion of learning. Neither of these measures directly reflects activity of the organism. Instead, they measure the resultant of activity of the organism as determined by someone else, usually the experimenter. This state of affairs, the inadequacy of measurement of activity of the organism, may be a source of variability in the results of transfer studies. It may be advisable that the entire concept of response be re-examined to provide a closer relationship between the activity of the organism and the dependent variable.

An effort to develop a conceptualization of transfer of training within the framework of learning concepts was made by Gibson (ref 18). Learning for Gibson is essentially discrimination. The rate of learning will be directly related to the ease of discriminating stimuli. If the same discrimination may be used in two tasks, then there will be positive transfer. If there is a high degree of generalization between two tasks and it is necessary to discriminate between two tasks, then there will be negative transfer. Generalization and differentiation are two critical concepts in her theoretical formulation. Differentiation is brought about by differential reinforcement. As differentiation increases, generalization decreases. Thus, differentiation is the opposite process of generalization. Generalization is the tendency for a response learned to one stimulus to be made to another stimulus with which it has not been previously associated. Similarity is defined as the relationship between stimulus items which can be indicated and measured in terms of their tendency to generalize.

Gibson's theoretical formulation sounds rather impressive. However, the present author has some difficulty in seeing how her formulation facilitates understanding the phenomenon of transfer. Her position does not allow for determining the degree of generalization between two tasks, except after the fact. If two tasks tend to elicit the same response, then there is a high degree of generalization. Presumably, if you are desirous of having two tasks elicit the same response, high degree of generalization, then it would be desirable to have two tasks that would tend to elicit the same response. In other words, the system appears to be highly circular. If two tasks tend to elicit the same response but it is desirable to have two different responses, there will be negative transfer because the response made to the first task will tend to be made to the second task. It appears as though there is no independent determination and measurement of the stimulus. Similarity of two stimuli is defined solely in terms of the tendency to elicit the same response. Thus, positive and negative transfer evolve into whether it is desired to have the same or a different response made to the second stimulus. It appears to the present writer that Gibson's approach is merely another way of describing the observable phenomena of positive and negative transfer.

Osgood (ref 45) developed theoretical formulations to resolve the "similarity paradox" in learning. He contended that "the greater the similarity, the greater the interference" created the paradox of ordinary learning being the condition for maximal interference and, at the same time, the practical condition for maximal facilitation. The paradox is based on the notion that maximum similarity is continued prac'ice on the activity to be learned. Osgood pointed out that identical stimulus situations and responses are not possible as there is always some change as a function of time. But the maximally similar stimuli and responses are the conditions of ordinary learning, and at the same time they are the conditions of maximum interference. Thus, the paradox is created and he has proposed theoretical formulations to resolve this paradox.

Osgood noted that three basic designs have been used in transfer research. The first design is one in which the responses are functionally identical in the two tasks but the stimuli are changed. He points out that in this design the results invariably show either positive transfer or retroactive facilitation. On this basis he formulated the empirical law that when responses are functionally the same and the stimuli varied, there is positive transfer or retroactive facilitation, the magnitude of both increasing as the similarity among the stimulus members increases.

The second design involves maintaining stimuli functionally similar and varying the responses. On the basis of the available research, Osgood formulated his second empirical law in which he stated that "where stimuli are functionally identical and responses are varied, negative transfer and retroactive interference are obtained, the magnitude of both decreases as similarity between the responses increases."

The third empirical law involves research in which both stimuli and responses are varied. This law states that "when both stimulus and response members are simultaneously varied, negative transfer and retroactive interference are obtained, the magnitude of both increasing as the stimulus similarity increases."

Osgood's approach consists primarily of attempting to relate the three sets of consistent experimental results. This relationship is formulated via a three-dimensional figure. The abcissa represents the response variable, the ordinate the degree and kind of transfer and the functions are three degrees of stimulus similarity, ranging from identical through neutral to similar. The essence of the relationships is one of interaction between identical and similar stimuli and the various gradations of response. If the two stimuli of the two tasks are neutral in their relationship, there is no transfer regardless of the change in the response relationships. If the stimulus relation is similar there will be positive transfer when the responses are identical but shifts to a medium amount of negative transfer when the responses are similar. The transfer in this situation remains negative throughout the response changes. In the case of identical stimuli the transfer phenomenon is the same as in similar stimuli except that the amount of negative transfer is greater. Thus, increasing the amount of stimulus similarity produces both maximum interference and facilitation, depending on the response relations.

Osgood's theory fails to shed much light on the process of transfer. He has brought together a number of empirical results into one "theoretical" structure. Though he has clarified the picture of transfer, he has not added materially to an understanding of the issues of transfer. He has clearly stated the S-R relationships, but provides no resolution of the critical issue of measurement of similarity, an issue that is critical to his own formulations. The research in this area has used a wide variety of definitions and measurements of similarity. Osgood has tended to commit the same error that he has attributed to others. He has combined data that may or may not be combinable. Most of the research to which he refers, i.e., Melton and vonLackum (ref 35), Johnson (ref 30), etc. have used different, or possibly different, a priori bases for measuring similarity. There is not an adequate basis for determining if there is a similarity of measurements of similarity.

The development of any theory must reflect the data, at least at some stage of the theoretical formulation. The collection of meaningful data is dependent on measurement. Measurement is the starting point for any scientific endeavor. The efforts to define and measure similarity have been rather crude. In the case of physical stimuli, researchers have been able to use the physical continua. In some cases they have been on relatively secure grounds. In other cases, however, they have treated discrete measurements, number of slots that were the same in OL and IL, as continuous measures. Response similarity has rarely been in terms of physically continuous measurements. Efforts to scale response similarity have been minimal. These measurements of stimulus and response similarity may include considerable error. There is little, in many cases no, information on the reliability of the measure of similarity. There is the possibility that theories are being formulated about similarity without an adequate definition or mode of measurement of the variable about which the theory is constructed. At the present time it is difficult to know if the Skaggs-Robinson hypothesis, Gibson's theoretical formulation, McGeoch's hypothesizing or Osgood's theorizing is tenable. It is conceivable that each of these positions may depend more on the measurement of similarity than any other factor.

Osgood also recognizes that no two stimuli or responses are identical. This position has been recognized by many psychologists, notably Skinner (ref 51). However, the recognition of the problem does not resolve the problem at all. There is the definite question of what is the significance or importance of the condition that no two stimuli or responses are identical. There may be need for specifying the rules by which various stimuli or responses are included within the particular class of stimuli or responses. These rules for designating stimuli as members of the same class may be a determinant of what stimuli are identical, similar, neutral, dissimilar, etc. There is the question of whether similarity refers to two stimuli or two stimulus classes. If the stimulus class is very narrow and restrictive, one kind of result may be obtained in transfer research. On the other hand, if the stimulus class is very broad and all inclusive, a different result may be obtained. Osgood fails to develop the implications of his comments on the nature of the stimulus. It appears to the writer that this issue must be resolved before one is able to move in the direction suggested by Osgood.

Another important consideration is the scale(s) of similarity used in the research on transfer. As mentioned above, the scales of similarity that have been used in the research on transfer have run the gamut from an a priori determination of scale to simplified scaling techniques. With such inadequate measurement it is difficult to develop a relationship between degree of similarity and kind and amount of transfer. It may be necessary to develop scales of similarity via scaling techniques and then determine the range of conditions in which the scale provides reliable results. The scales of similarity that may be developed will not give reliable results in all conditions. It must be recognized that scales of similarity will be limited, just as any measuring scale is limited, to certain conditions. The fact that celestial distances cannot be measured by a yardstick has not resulted in discontinuing the use of the yardstick in those situations where it is appropriate. The yardstick as a measuring instrument may reflect many conditions of the user of the scale. There are conditions in which the yardstick may produce unreliable measurements. On the other hand, the range of conditions in which the yardstick produces highly reliable measurement is fairly broad. It must be recognized that the same situation may prevail with respect to the so-called scaling techniques used in psychology. No scale, whether it be a scale of attitudes, similarity, etc. will have applicability in all kinds of conditions. Therefore, in the development of a scale or scales of similarity, it is necessary to state the conditions in which the scale will provide reliable measurements. Until this condition has been met, it will not be possible to indicate clearly the results that may be attributed to similarity of stimuli and responses or the reliability of the scale. If the scale of similarity will reflect learning, for example, it may be difficult to attribute the results of a transfer experiment to the similarity variable or to the learning that occurs with respect to the scale itself.

It appears that efforts to develop theory and/or hypotheses about the similarity variable are dependent on the development of adequate measures of similarity. The theoretical and experimental controversies that have appeared in the literature may be more a reflection of different definitions and measurements of similarity than the issues that have been discussed. Different definitions and measurements of similarity may easily give rise to seemingly contradictory results. However, if the relations between the measurements of similarity can be determined, the seemingly contradictory results may not be so contradictory.

TIME OF TEST FOR TRANSFER

Another variable that has received some attention from researchers in transfer of training has been the amount of time that has elapsed between OL and the test of transfer. This variable is particularly significant in applied psychology, especially in the development of training programs. A considerable amount of time may elapse between the original learning of an activity and the use of the learning.

Though the time between learning and test of transfer is an important variable, it must be recognized that unfilled time is essentially an impossible condition. That is, the time between original learning and test of transfer will be occupied with behavioral events. The amount and kind of behavioral events that fill the time interval may be a critical determiner of the amount of transfer. It may have been this consideration that led Bunch and his associates (ref 7, 8, 10, 11, 12) to conduct a series of experiments using rats as subjects. The use of infrahuman subjects permits greater control over the environment during the time interval between OL and test of transfer.

Bunch and Magsdick (ref 7) conducted an experiment in which rats were given six guided trials in a multiple unit water maze. Intervals of time, varying from 0 to 48 hours, were interspersed between the guided trials and additional unguided trials during which the rats continued training until the criterion of learning was attained. Time delays of one hour or more resulted in better performance than no guided trials or no time interval between guided and unguided trials. This experimental design and procedure fit the classical transfer paradigm since the guided trials represent training on an original task and the unguided trials represent test on another task. The fact that the guided and unguided trials were conducted in the same maze does not alter this point because the guided trials did not provide experience with blind alleys, but the guided trials did.

In a second experiment, Bunch and Rogers (ref 8) obtained similar results in that rats that received a one day interval between training and test on different mazes learned the test maze faster than rats that had no time interval or longer time intervals between original and test learning. Thus, the amount of positive transfer increased as the interval between the two learning tasks increased up to one day. After a one day interval, the amount of positive transfer decreased. The data suggested that if the delay were greater than 14 days, there may not be any positive transfer.

This suggested hypothesis was investigated by Bunch and Lang (ref 10) who had time intervals between the two tasks ranging from 0 to 120 days. In this experiment, the rats that had a one day interval showed the greatest amount of positive transfer when transfer was measured by trials to criterion and number of errors. When performance was measured in terms of time spent in the maze, the rats that had a 30 day interval showed the greatest amount of positive transfer. The groups that had 0 day or 120 day intervals between the two tasks were similar on all three response measures and superior to the control group that received no training on the first maze. It is interesting to note that the response measure was a critical variable in determining the amount of positive transfer.

In previous research, Bunch and his associates had investigated the effects of time interval between two tasks that were seemingly related. In another experiment, Bunch (ref 11) investigated the effects of time between two tasks on the direction and amount of transfer when the two tasks were antagonistic. The original task required the animals to make a right turn to escape from a water maze, and the second task required the animals to turn left to escape from the water maze. The elapsed time between learning the two tasks ranged from 0 to 28 days. The group that learned the second maze without any time interval between the two mazes gave evidence of negative transfer when evaluated against a control group that received training only on the second maze. All groups that had a time interval between the two tasks required fewer trials to learn the second maze than the control group, indicating positive transfer. There was little difference among the experimental groups on this response measure. However, positive transfer as measured by number of errors was demonstrated only by the groups that had an elapsed time between the two tasks of 14 and 28 days.

As in the previous research, this experiment demonstrated the importance of the response measure as a determinant of both the direction and amount of transfer. The response measure, therefore, must be analyzed carefully in making any generalizations about the effects of time between the learning of two tasks on the direction and amount of transfer.

A comparison of the effects of time between training and test on retention and transfer was made by Bunch (ref 12). One group of rats was trained on a given maze and tested on the same maze after varying intervals of time. Another group of rats was trained on one maze and then tested for transfer to another maze, the same maze as the retention group, after the same varying lengths of time. The retention groups that were tested for retention after 14 and 30 days were superior to their counterparts in the transfer groups when trials to criterion on the second maze was the response measure. When the time interval was 60 days or more, there was little difference between retention and transfer. The retention groups tended to be superior to the transfer groups on errors and time spent in the maze up to a 90 day time interval. If the time interval between the two learning activities was 90 days or more, the retention and transfer groups were comparable in terms of the total number of errors and total time spent in the maze.

The effect of time between training and test has been investigated using human subjects in both verbal and nonverbal learning activities. Britt (ref 4) had subjects learn two different stylus mazes. One group learned the two mazes in immediate succession. A second group learned the first maze, 48 hours later relearned the same maze, and then learned the second maze. A control group learned only the second maze. Both experimental groups demonstrated positive transfer when compared to the control group. The group of subjects who learned and relearned the first maze over 48 hours was superior to the other experimental group and the control group.

Though Britt's experiment has some inadequate controls for amount of practice on the first task, it provided results that indicate that unspecified time may be a variable worthy of investigation with respect to the problem of transfer and human motor learning.

Research in reminiscence, a problem that may be construed within the rubric of transfer, has tended to support the generalization that the amount of reminiscence is an increasing function of the time interval between training and test. Irion (ref 28) found that a 5 minute interval between training and test produced the greatest amount of reminiscence. In addition, this effect tended to prevail over all five relearning or test trials. However, the data suggested that time intervals greater than 5 minutes would not result in a greater amount of reminiscence.

Reminiscence followed a similar pattern in bilateral transfer. Irion and Gustafson (ref 29) found that a 5 minute interval between training on the pursuit-rotor with the right hand resulted in greater bilateral transfer than a 5 second interval. However, this superiority was dissipated after two trials with the left hand.

Rockway (ref 49) obtained similar results in an experiment on bilateral reminiscence on the pursuit-rotor. However, his results were complicated by a significant interaction between length of rest and amount of pre-rest practice. Thus, the level of pre-rest performance may be a critical variable. The results of an experiment by Walker et al (ref 57) suggested that the time interval variable in the pursuit-rotor activity may reflect more of a warm-up than a transfer effect. They found that the length of the rest interval did not affect the amount of transfer when subjects were given a warm-up trial immediately prior to the test for transfer. However, this experiment has introduced the additional variable of distributed practice since there was a time interval between the last and next to last training trial. The effects of distributed practice and/or time on amount and kind of transfer represent another experimental problem.

Duncan and Underwood (ref 16) investigated the effects of elapsed time on the recall and relearning of a motor task. All subjects learned the first motor task and then learned a second motor task. The two tasks utilized the same equipment but differed with respect to the relationships between the stimuli and responses. In this way, the degree of similarity of the two was manipulated. The subject recalled and relearned the second task 24 hours and 14 months later. The recall performance after 24 hours was not significantly poorer than terminal training performance and relearning was very rapid. The recall performance after 14 months was little better than the performance of naive subjects. Relearning, however, was more rapid than for naive subjects. Thus, long periods of time may have a deleterious effect on the retention of a transferred motor skill.

There has also been research on the effect of the time period on the amount and kind of transfer in verbal learning. Underwood (ref 53) investigated the amount of retroactive and proactive inhibition after 5 and 48 hours. The 5 hour time interval between training and test showed a significantly greater amount of RI than PI. This relationship prevailed until the third relearning trial. The amount of RI and PI did not differ when the test was conducted 48 hours after OL. The longer time period between training and test appeared to have a beneficial effect on RI because it required fewer trials to relearn after 48 hours than 5 hours. It is interesting to note that there were more intrusions in the PI condition after 48 hours. The increase in the number of intrusions after a longer time interval between training and test was supported in another experiment by Underwood (ref 54). The two time intervals, 20 minutes and 75 minutes, were much shorter than in the previous experiment, but the results involving intrusions were the same. At the same time the difference in time between training and test did not affect the amount of PI as measured by recall scores.

Hamilton (ref 23) found that the mean number of correct anticipations on the test list decreased as the time between training and test lists increased, but the amount of additional decrement was very small after 60 minutes. However, subjects were given a warm-up list after the rest interval and prior to the test list.

Doten (ref 14) found that an interpolated activity interferred more after 24 hours than 30 seconds in the case of a well established reading habit. However, there was more rapid recovery from the effects of the interpolated activity after the longer time interval. The results of Morgan's research (ref 37) were not in accord with Doten's. Morgan found that the length of time between two tasks did not affect the amount of transfer, though the longest time interval resulted in the least amount of transfer.

This review of the research on the time interval between training and test leaves the issue very much in doubt. The infrahuman research suggests that some time interval between training and test may produce greater positive transfer. Similar results seem to dominate the motor learning of human subjects. When verbal materials are used the results become very confused. The rather consistent results in motor learning and the inconsistent results in verbal learning may be a function of the relationship between the experimental tasks and the kind of activities that may be involved in the time between training and testing. Many of the motor tasks used in transfer research do not have a direct counterpart in everyday activities so that extinction of the responses could not occur. In verbal learning, however, there may be many opportunities for the responses to extinguish during the time interval. The type of verbal material may be critical in that verbal material that would be associated with unique responses may provide less opportunity for extinction to occur. It is safe to assume that time in and of itself does not constitute a rigorous variable because time does not pass in a vacuum, but always has some activities in it. But the events that occur in time may be a critical variable in determining how much, if any, transfer will occur. It is questionable if research using time as a variable will be too profitable in understanding the phenomena of transfer. It is conceivable that a more detailed experimental attack on the variables affecting transfer may generate principles that will enable predictions to be made about the effect of time that is filled with given activities. In the final analysis, the effect of time will be the same transfer problem because the activities and behavioral events of the elapsed time may facilitate or interfer in the recall or transfer effects of the originally learned task.

SUMMARY

An effort has been made to review some of the pertinent literature on the effects of similarity and time of test on the kind and amount of transfer. No attempt was made to review every experiment on these two variables. Instead, there was an effort made to select more recent research that seemed to add to the knowledge of the effect of these two variables on transfer.

The review of the research and theoretical formulations about the effects of similarity on transfer has led the reviewer to conclude that the issue is not resolved. Despite a large amount of research on this problem, there have been so many definitions and measurements of similarity that it is difficult to develop any meaningful generalizations. It is difficult to evaluate the theoretical formulations in the absence of a rigorous, reliable measurement of similarity.

The review of the literature on the effect of time of test on transfer leaves the problem unresolved for the same reason. Time is rarely devoid of stimuli and responses. As a result, until the issue of similarity is resolved, it will be difficult to evaluate the effects of time of test on transfer. If the similarity problem can be satisfactorily resolved, it should be possible to formulate meaningful hypotheses about the time variable.

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Unclassified report

A review of selected literature pertinent to the effects of similarity and delay on transfer is reported. Emphasis is given to the more recent research and that which seems to make a greater contribution to knowledge of these effects - especially studies in which similarity and time delay were manipulated jointly. Although considerable

(over)

research has been accomplished, the effects of similarity and time delay (either singly or jointly) are not known with sufficient precision to enable satisfactory use outside of the narrowly constrained laboratory contexts, if even there. Effective prediction on the basis of similarity will depend on the development of a rigorous and reliable technique for its measurement. The effects of delay can only be adequately determined after this is accomplished.

UNCLASSIFIED

1. Transfer of Training
2. Learning
3. Psychology
4. Memory

I. AFSC Project 7183, Task 718306
II. Behavioral Sciences Laboratory
III. Contract AF 33(616) 6408
IV. Florida State University, Tallahassee, Florida
V. J. Greenspoon

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Aerospace Medical Division, 6570th Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio
Rpt. No. AMRL-TDR-63-22. THE EFFECTS OF TRANSFER OF TIME DELAY AND TASK SIMILARITY: A LITERATURE REVIEW. Final report, Mar. 63, iv + 21 pp., incl. 59 refs.
Unclassified report

A review of selected literature pertinent to the effects of similarity and delay on transfer is reported. Emphasis is given to the more recent research and that which seems to make a greater contribution to knowledge of these effects - especially studies in which similarity and time delay were manipulated jointly. Although considerable

(over)

research has been accomplished, the effects of similarity and time delay (either singly or jointly) are not known with sufficient precision to enable satisfactory use outside of the narrowly constrained laboratory contexts, if even there. Effective prediction on the basis of similarity will depend on the development of a rigorous and reliable technique for its measurement. The effects of delay can only be adequately determined after this is accomplished.

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