PAIRED-ASSOCIATES LEARNING AS A FUNCTION OF THE NUMBER OF
RESPONSE ALTERNATIVES IN THE TRAINING LIST

by

DONALD GENE ANDERSON

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INTRODUCTION: EXPERIMENTAL AND THEORETICAL BACKGROUND

All education, from formal training such as in the classroom
or in military and industrial programs to the more informal train-
ing in the home and through every day experience, is based upon
the assumption that the training will have an influence upon
later behavior, that is, that transfer of training will occur.
Yet, while psychologists and educators have conducted research
on transfer of training since the initial experimental investiga-
tions of Muller and Schumann (McGeoch, 1942, p. 402), the analysis
of the important dimensions involved and the construction of an
adequate theory to handle this problem continue to be among the
most pressing tasks for the psychology of learning. A number of
important variables have been isolated and systematically studied,
but the frequent inability of the psychologists to predict accur-
ately either the direction or the amount of transfer of training
is testimony to the complexity of the problem and the inadequacy
of our knowledge. The research reported here was concerned with
one aspect of the problem, the influence of the number of alter-
native responses learned in a first task upon the later learning
of a second task having the same stimulus terms but new response
terms.

Transfer of training refers to any effect a prior learning
has upon a later learning. This is best illustrated by the
experimental paradigm:

    Experimental Group: learn Task A--------- learn Task B
    Control Group------------------------------ learn Task B

If it can be assumed that the only essential difference between

the two groups in their ability to learn Task B is whether or
not Task A has been learned earlier, then any difference between
the groups in the learning of Task B is designated transfer of
training. If prior learning of Task A facilitates learning Task
B, a positive transfer effect is said to have occured. Similari-
ly, if the prior learning of Task A hinders the learning of Task
B, there has been a negative transfer effect.

According to these definitions, negative transfer effects
are present only if there is a difference between the experi-
mental and the control conditions in favor of the control condi-
tion. Yet, several writers (Morgan and Underwood, 1950; Lewis
et al, 1951; Osgood, 1949) have presented evidence that in any
transfer of training situation there are both facilitating and
interfering processes involved. Whether the experimental group
is more or less efficient in learning Task B in the above para-
digm would appear to depend upon whether or not the net effect
of these opposed processes is interference or facilitation. In
the present paper, then, the terms interference and facilitation
will refer to inferred tendencies, and the term positive transfer
and negative transfer will be reserved for over-all differences
between an experimental group and a control group as shown by
the number of correct responses, trials required to learn to
criterion, and similar measures.

Important Dimensions of Transfer of Training

A brief review of some of the more important dimensions of
transfer of training and the result of investigation of the

influence of different variables on transfer follows. Much of
this work has been done by McGeoch and his associates in the
1930's (McGeoch, 1942). Since McGeoch's death this tradition
has been continued by only a few investigators, among whom are
Underwood (1949); Osgood (1949); Deese (1952); and McGeoch and
Irion (1952).

Similarity Relations

As Osgood (1949) has indicated, the effects of varying the
similarity between training and transfer task can best be under-
stood by the use of paired-associates learning (paired-associates
refers to the learning of specific stimulus and response pairs,
that is, the subject learns to give a certain response to a given
stimulus). There are three paradigms for the study of similarity
relations in paired-associates learning:

A. Experimental Group: S_1-R_1 ------------------- S_2-R_1
   Control Group: ----------------------------- S_2-R_1

B. Experimental Group: S_1-R_1 ------------------- S_1-R_2
   Control Group: ----------------------------- S_1-R_2

C. Experimental Group: S_1-R_1 ------------------- S_2-R_2
   Control Group: ----------------------------- S_2-R_2

In these paradigms S_1 and R_1 represent the stimulus and response
terms used in first task learning; and S_2 and R_2 represent any
new (different) response terms used in second task learning.

Positive Transfer. Several studies have shown that Paradigm
A, in which stimulus terms are altered from training to transfer
lists, results in positive transfer effects. The magnitude of
the positive transfer effects increase as some function of

increase in similarity of the stimuli of the training and transfer lists. This characteristic of transfer was first shown by Yum (1931). While holding the response terms constant, he systematically varied the stimulus terms of two paired-associates lists. Positive transfer was the result on all lists, but the magnitude increased as the similarity of the stimuli increased. Similar results have been obtained by Gibson (1939) who varied the similarity of tactual stimuli. Her subjects were taught to respond with a verbal response to a vibratory stimulus. Other vibratory stimuli separated spatially from the training stimuli also evoked the verbal response, with progressively fewer responses being evoked as the amount of separation of the stimuli increased.

Bruce (1933) also got more positive transfer from conditions in which similar stimulus words were used in a transfer task as compared to conditions in which different (as contrasted with similar) stimulus words were used.

Negative Transfer. As shown by Osgood (1949) in his review of the literature, in situations in which stimuli are held constant and responses are varied in the transfer task (Paradigm B), negative transfer usually results in verbal learning studies. This effect will become progressively greater as the similarity between the responses decreases from high to low similarity to no similarity (as long as the responses are of the same general type, e.g., both training and transfer task responses are words) to responses having a meaning opposite or opposed to those in the training task. Porter and Duncan (1953) have recently

demonstrated that maximum negative transfer occurs when the
transfer task has the same stimuli and responses as in the
training task, but new stimulus-response pairs must be formed,
i.e., if response #1 was learned to stimulus #1 in the training
task, in the transfer task response #2 is paired with stimulus
#1, etc.

Gagne, et al, (1940) and Lewis and his associates (1951)
have demonstrated that in many motor tasks negative transfer
occurs only in the situations analogous to that employed by
Porter and Duncan (1953). Furthermore, in the same study, Duncan
failed to find negative transfer effects in a condition employ-
ing verbal stimuli and responses (two-syllable adjectives). In
this condition the lists employed had identical stimuli but
different responses. It should be noted, though, that in these
studies the relative amount of interference accords with Osgood's
(1949) findings for negative transfer, that is, interference
decreases as a function of increased response similarity between
the training and transfer tasks.

A further finding when negative transfer is obtained in such
situations is that the negative transfer effect is relatively
transitory and lasts for the first few repetitions of the trans-
fer lists only.

The effect upon transfer of varying both the stimuli and
the responses (Paradigm C) was investigated by Gibson (1941).
Her results showed that this paradigm also produces negative
transfer, the amount of which increases with increasing similar-
ity of stimuli.

Degree of Learning

The degree of learning or the amount of training in the training list is another important dimension of transfer. In situations resulting in positive transfer effects, an increase in the number of trials or the amount of learning of the training list will increase the amount of positive transfer effect. Bruce (1933) gave 0, 2, 6, or 12 repetitions of the training list in conditions in which the training and transfer lists had the same responses and similar stimuli, and found that the increase in the number of training repetitions resulted in a progressive increase in the amount of positive transfer. Similar results were obtained by Mandler (1954), who varied degree of overlearning in a paired-associates motor task. He found that learning to make an old response to a new stimulus (Paradigm A, above) showed increasing positive transfer as the degree of original learning on the training task was increased.

Under the condition which tends to yield negative transfer (Paradigm B, above) Underwood (1945), and Siipola and Israel (1933) both found that with an increased amount of initial training the sign of the transfer shifts from negative toward positive. Mandler (1954) found that learning under this condition showed an initial increase in negative transfer followed by a return to zero transfer for the highest degree of overlearning of the training task.

Time Between Training and Transfer Lists

Evidence concerning the time interval between training
and transfer is for the most part inconclusive. Bunch and
McCraven (1938) found that time interval had no apparent effect.
On the other hand, Ray (1945) found that the magnitude of neg-
ative transfer was an inverse function of the length of time
between training and transfer lists.

Number of Training List Responses

The number of prior training lists affects the amount of
transfer. A study which varied the number of prior training
lists was reported by Underwood (1944). In this study, four
experimental conditions were used. Subjects learned 0, 2, 4,
or 6 lists of paired-adjectives presented for four trials each.
Following this, another list was learned to a criterion of six
correct anticipations. All lists had the same stimuli but dif-
ferent responses. The analyses were concerned primarily with
the relative amount of interference and with the direction of
transfer effects as a function of the number of prior training
lists. It was found that the greatest amount of negative trans-
fer was obtained on the first trial of the second training list,
that is, when only one prior training list had been learned.
Relative interference decreased with an increase in the number
of prior lists. Underwood's data do not permit a detailed
analysis of the first trials on the transfer task, and it is
impossible to determine whether or not a significant difference

among the groups existed during the first few transfer trials. The analyses do indicate, however, that there was a tendency for an inverse relation to exist between the number of prior training lists and the number of trial to criterion, particularily for a criterion of five or six correct anticipations within one trial.

Twining (1940) also varied the number of lists presented, but, as Underwood (1944) pointed out, Twining's data do not permit detailed analyses of the transfer effects of increasing number of lists learned.

Sand (1939) found that increasing the length of the training list increased the relative interference on learning of another task. However, the studies cited by Sand confound several variables and do not permit the effects of number of response alternatives to be isolated from the effects of other variables.

Statement of the Problem

The present investigation was designed to explore further interference effects as a function of number of training list responses. The principal difference between this study and Underwood's (1944) is that Underwood held the number of trials constant during training lists for the various conditions while in the present study the number of correct responses was held constant. In a previous section, studies were reviewed that demonstrate that degree of training list learning is one determining factor in the amount of interference (and in the direction

as well as amount of transfer effects). The procedure followed
by Underwood permitted the degree of learning, i.e., number of
correct responses, to increase on successive training lists.
Thus, Underwood's results may have been due in part to a differ-
ence in degree of training task learning as well as to a differ-
ence in number of responses learned to each stimulus.

There are also several procedural differences between the
present study and Underwood's. In the present study, instead of
learning several different training lists, the procedure describ-
ed by McClelland (1942) and by Riley (1952) was followed. In
this procedure the training list differed in the number of re-
sponse alternatives per stimulus for the different conditions.
That is, there were one, two, or four different response words
associated with each stimulus word in the paired-associates
lists. Only one of these responses was "correct." Since the
basic problem of both studies is the influence of the number
of different associations formed to each stimulus, it is assum-
ed that this difference in procedure was not a basic difference.
The present procedure has the disadvantage that it is impossible
to control as adequately the number of reinforcements of the
different response alternatives as with Underwood's procedure,[1]
but has the practical advantage of requiring much less time of
each subject.

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[1] Data presented in a subsequent section entitled Results
demonstrate, however, that several of the alternative responses
are used to any stimulus in the two-response and four-response
lists.

More minor differences in procedure include (a) each sub-
ject served in only one condition instead of in all conditions
as in Underwood's study, and (b) the amount of time between
trials was different in the two studies.

As indicated earlier, the principal problem in the concep-
tualization of transfer of training is the analysis of the pro-
cesses involved in the transfer phenomena. For basic theoreti-
cal purposes the important problem is the identification and
analysis of the inhibitory and facilitative factors, not whether
or not the net effect of these opposed processes is positive or
negative.

While little work has been done that permits adequate con-
ceptualization of these opposed processes, there are several
theories that make some hypotheses about them. One of these has
been expressed by McGeoch (1942) and Underwood (1944), who
hypothesize that the increased facilitation as a function of
increased number of prior lists is due to the positive effects
of general practice. General practice effects are described as
"learning how to learn." Also included are the constant factors
in the experimental situation, e.g., learning about the time
intervals between successive pairs, that all words are homogenous
in the sense of being two-syllable adjectives, but have no other
relationship to one another, etc.

Another explanation of Underwood's results comes from Gibson's
theory (1940). She asserts that, in learning lists by the paired-
associates method, generalization occurs among the stimulus items
so that different stimulus items tend to evoke the same response

term. The responses tending to occur by virtue of this general-
ization will block the correct responses. Learning of the list
occurs as the stimulus items become differentiated. Furthermore,
in any two lists learned in succession in which the stimulus
items of the two lists are similar, inter-list generalization
may occur. That is, the similar stimulus items in the second
list tend to evoke the response items of the first list. With
increased differentiation of the stimulus items the rate of
learning the second list will increase. It can be hypothesized
that with an increase in the number of response alternatives
in training tasks the amount of differentiation increases more
rapidly than does generalization, and that this differentiation
transfers to the transfer task. While Gibson (1940) considered
only stimulus generalization and differentiation, this concep-
tualization may be extended to include response generalization
and differentiation as a factor in the relative amount of inter-
ference in paired-associates lists and in transfer of training.

The present study was not designed to be a critical test of
any theory. It was designed only to give information on the
question of whether an increase in the number of response alter-
natives during a training task results in a greater relative
increase in the facilitation processes than in inhibitory pro-
cesses when these effects are independent of the effects of
degree of learning on the training task.

METHOD AND PROCEDURE

Experimental Conditions

There were three experimental conditions and one control condition; in each condition separate matched groups of eighteen subjects learned ten paired-associates by the anticipation method. In Condition C, no training list was learned prior to learning the transfer list. In Condition I each stimulus term of the training list was accompanied by one response term. In Condition II each stimulus term of the training list was accompanied by two response terms, only one of which was correct. In Condition IV each stimulus term of the training list was accompanied by four response terms, only one of which was correct. The first trial of a transfer list common to all four conditions was started approximately sixty seconds after the criterion trial on the training task. The transfer list contained the same stimulus words as in the training lists, but these stimuli were paired with new response terms. In the transfer lists each stimulus term was accompanied by only one response term under all experimental conditions. These four conditions are shown in Table 1.

Table 1. Schematic outline of experimental conditions

Condition	:	Training Lists		:	Transfer List	
	: Stimulus	:	Response	: Stimulus	:	Response
C		none	none	A		B
I		A	C	A		B
II		A	D, E	A		B
IV		A	G, H, I, J	A		B

Materials

Transfer List. A total of sixty two-syllable adjectives[1]
were used. These were selected to have little meaningful or
formal similarity to one another. Ten adjectives were selected
by means of a table of random numbers to be stimulus terms,
with the restriction that no two of them could start with the
same letter or end with the same syllable. These stimuli were
common to all training and all transfer lists. The response
words for the transfer list were selected by means of a table
of random numbers from the fifty adjectives remaining after the
selection of the stimulus terms. The selection of these words
had the restrictions that no more than two of the total of twenty
stimulus and response words now selected could start with the
same letter and that no two could end with the same syllable.

Training Lists. The response words for the training lists
were selected for each subject separately from the forty adjec-
tives remaining after the selection of the stimuli and the re-
sponse words for the transfer list. The selection of these
words had the restrictions (a) that no two terms in any stimulus-
response pair started with the same letter or ended with the same
syllable, (b) that no response could appear more than once in
any one list, and (c) that each response must appear at least
three times when all lists in any condition were combined.

For Condition I a further restriction upon random selection

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[1]The adjectives were from unpublished lists prepared by
A. W. Melton.

was imposed. Of the twenty adjectives obtained by combining the ten stimulus and the ten response terms, no more than two began with the same letter or no more than two ended with the same syllable. For Conditions II and IV it was impossible to impose the latter restriction, but in no list did any of the response terms accompanying any given stimulus begin with the same letter or end with the same syllable.[1] In no list in any conditions did any of the ten correct responses begin with the same letter or end with the same syllable.

Practice Lists. A total of five practice lists were used. Each subject learned three of the five lists. The preliminary practice (List A) consisted of ten paired-associates, using common female first names for stimulus terms and male nicknames as response terms. The four remaining practice lists consisted of ten paired-associates employing three-letter nouns for both stimulus and response terms. In Practice Lists B and C each stimulus term was accompanied by one response term. In Practice List D each stimulus term was accompanied by two response terms. In Practice List E each stimulus term was accompanied by four response terms. Common stimulus terms were used for Practice Lists B, C, D, and E.

All subjects were given six trials on Practice List A. All subjects then learned Practice List B to a criterion of one

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[1]For Conditions II and IV no more than four of the thirty, or fifty, stimulus and response terms in any list began with the same letter and no more than two terms ended with the same syllable.

errorless trial, with the restriction that no subject would be given fewer than eight trials. Subjects assigned to Condition I then learned Practice List C to a criterion of six out of ten correct responses. Similarily, subjects assigned to Condition II then learned Practice List D to a criterion of six out of ten correct responses, and subjects assigned to Condition IV learned Practice List E to the same criterion.

Subjects assigned to Condition C, the control condition, were divided into three sub-groups; each of these received training either on Practice Lists C, D, or E following the learning of Practice Lists A and B.

Subjects

Separate groups of each with eighteen elementary psychology students were assigned to the four conditions, making a total of seventy-two subjects. The subjects were matched on the basis of the number of correct responses in the first eight trials of Practice List B.[1]

Procedure

Each subject served for two sessions. The practice lists were learned during the first session and the training and transfer list were learned during the second session. The two sessions

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[1]The within-groups correlation obtained by this matching procedure was .40 between matching scores and number correct on the first transfer trial, and -.43 between matching scores and number of trials to criterion on the transfer list.

were separated by not less than twenty hours nor more than
ninety-six hours. Training lists were learned to a criterion
of six out of ten correct responses. Transfer lists were learn-
ed to a criterion of one errorless trial.

All lists were presented on a modified electronic Wichita
memory drum at a 2:2-sec. rate, i.e., the stimulus term was
presented alone for two seconds and the stimulus and response
terms were then presented together for two seconds. Each list,
whether training or transfer, was presented in four different
orders to minimize serial effects. For Conditions II and IV
the response terms associated with each stimulus term appeared
equally often in each of the two (four) positions for both prac-
tice and training lists. In all instances there was a twenty
second interval, filled by symbol cancellation (Underwood, 1952),
between trials.[1] The non-correction method was used throughout.
Under all conditions, whether learning practice, training, or
transfer lists, when the subject responded correctly during the
anticipation period the experimenter turned on for approximately
one second a small light located six inches directly above the
center of the aperture of the memory drum. This was done in
order that the subjects of Conditions II and IV would be informed
that they had located the correct response.

Prior to practice on the first practice list and preceding
each individual list, the subjects were given rather elaborate
instructions (see Appendix). The instructions were designed to

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[1]
    A trial consisted of one repetition of each of the ten
paired-associates.

keep the motivation level as constant as possible from list to list, and to minimize inter-subject differences within conditions.

All responses given by the subject were recorded on individual data sheets.
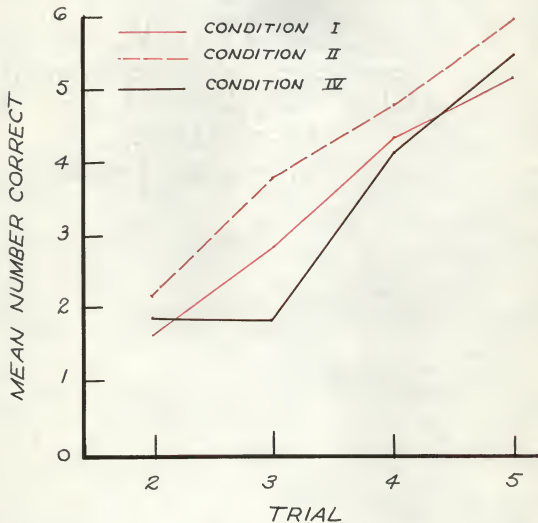

Fig. 1. Mean number correct during first five trials for the three sub-groups of the control condition.

RESULTS

It was possible that the different types of practice given to the sub-groups of the control condition might have had an effect on performance on the transfer task. Consequently, a separate analysis of performance on the transfer task was made for these sub-groups. Figure 1 shows the mean number of correct responses during Transfer Trials 2-5.[1] An analysis of variance failed to indicate a statistically significant variation among the means for these trials (F of .52; $\underline{df}$ 2 and 15). Neither were any F-ratios found to be significant in analyses of the separate trials or in an analysis of the total number of trials to a criterion of one errorless trial. Accordingly, these three sub-groups were combined into one group for all further analyses.

The degree of learning on the training list was equalized by having each subject learn this task until he had achieved a criterion of six correct anticipations during a given trial. Fig. 2 shows the mean number of trials for each group to reach successive criteria, i.e., correct anticipations. It is to be noted that as the number of response alternatives increased the mean number of trials to reach each successive criterion also increased. Inspection of Fig. 2 also indicated a tendency toward a linear relationship between number of trials and

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[1] In this and subsequent analyses the first trial is not considered because no responses are possible; subjects were instructed to memorize only during this trial. The second trial and all others given on any list are referred to as anticipation trials.

successive criteria for each condition. Such a relationship was also present in Riley's (1952) study, which yields data on learning as a function of number of response alternatives.
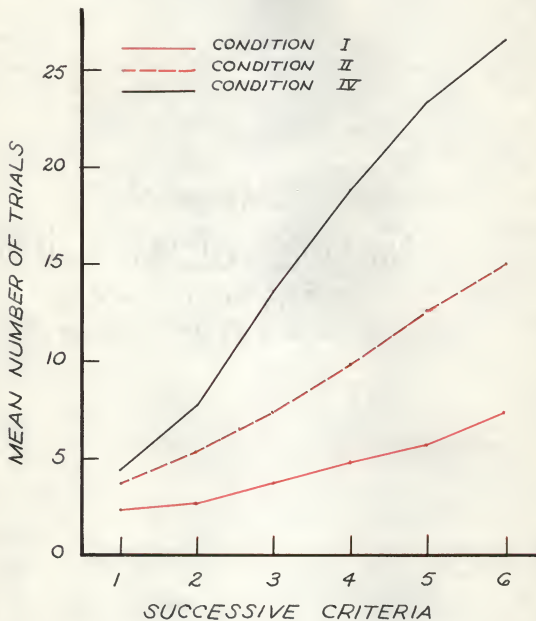

Fig. 2. Trials to successive criteria during training list learning.

The mean number of different response terms utilized by the subjects increased as the number of response alternatives

in the training was increased. The subjects in Condition I
used an average of 8.05 different response terms to reach the
criterion of 6 correct anticipations in a single trial; the
subjects in Condition II used an average of 12.61 different
response terms to reach the criterion, and the subjects in
Condition IV used an average of 13.28 different response terms
to reach the same criterion.

The mean number of correct anticipations for each of first
four anticipation trials during transfer list learning are shown
for each condition in Fig. 3. Analysis of variance indicated
statistically significant variation (p less than .01) among
group means for the first anticipation trial, but no significant
variation for any other single trial. Table 2 summarizes the
analysis of variance for Trial 2 (the first anticipation trial).

Table 2. Analysis of variance for the first anticipation
trial of the transfer task

Source	:	d.f.	:	Mean Square	:	F
Conditions		3		10.83		6.52**
Subjects		17		2.63		
Residual (Error)		51		1.66		

**p < .01

Inspection of Fig. 3 indicates that Condition I (one
response alternative during training) suffered a relatively
great amount of interference on the first anticipation trial
during transfer list learning as compared to the other con-
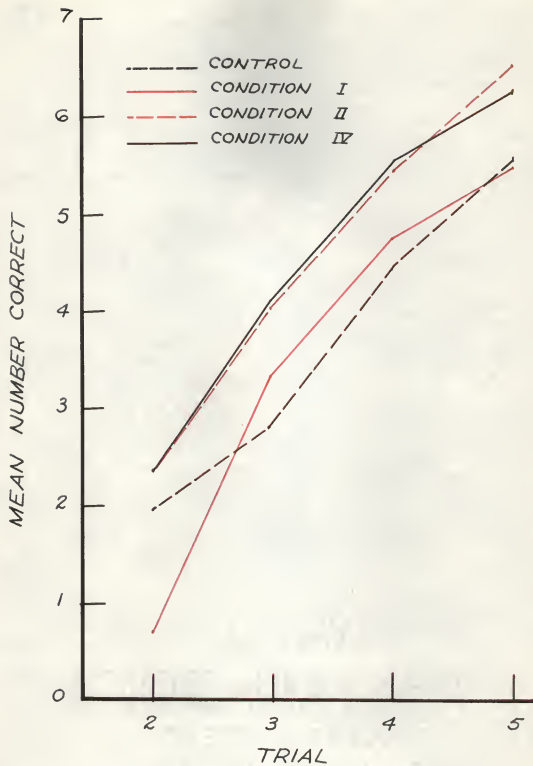ditions. This difference, while statistically significant

Fig. 3. Man number correct during the first four anticipation trials for the four conditions.

for only the first anticipation trial, persisted throughout
learning relative to Conditions II and IV. Condition C (control)
serves as a reference for the determination of transfer effects.
Inspection of Fig. 3 shows that on the first anticipation trial
Condition I resulted in a negative transfer effect. Conditions
II and IV (having two and four response alternatives, respec-
tively, during training), on the other hand, resulted in posi-
tive transfer effects. On subsequent trials, there was essen-
tially zero transfer for Condition I, but a continued (non-sig-
nificant) tendency for positive transfer effects for Conditions
II and IV.

Fig. 4, which shows the mean number of trials required to
achieve successive criteria of number of correct responses
during transfer list learning, also indicates that the relative
amount of interference decreases as a function of the number of
response alternatives in the training list and as a function of
the amount of learning on the transfer task. Inspection of Fig. 4
indicates that performance on Condition I does not differ greatly
from that of the control condition, while Conditions II and IV
show facilitation rather than interference. As shown in Table 3,
analysis of variance of the number of trials required to achieve

Table 3. Analysis of variance for number of trials to criterion
on the transfer task

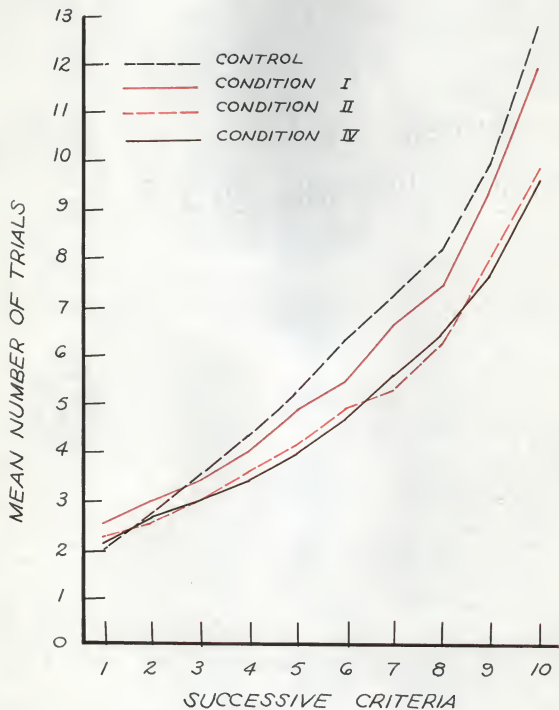| Source	:	d.f.	:	Mean Square	:	F
Conditions		3		36.11		2.50^{*}
Subjects		17		18.84		
Residual (Error)		51		14.45		

$^{*}.05 < \underline{p} < .10$

Fig. 4. Mean number of trials to successive criteria during transfer task learning.

the criterion of one errorless trial indicates that the dif-
ference among the means for the various conditions have reached
significant proportions (p greater than .05, but less than .10)
at the end of learning.

The importance of analyzing the intrusions[1] that appear in
the transfer list after prior learning has been increasingly
stressed as a means of arriving at a better understanding of the
conditions that produce associative inhibition and facilitation.
It is generally believed that such analyses are more analytical
than analyses of total errors. Most theories of transfer attempt
to account for the conditions which result in variation in the
frequency of different kinds of intrustions.

Table 4 gives the frequencies and means for different kinds
of intrusions for all trials on the transfer task. An analysis
was made of four different types of intrusions. These were (a)
erroneous responses from the list being learned, i.e., responses
paired with the wrong stimulus term (intra-list intrusions); (b)
stimulus words used as responses to other stimuli of the same
list (stimulus intrusions); (c) response terms from the training
list (inter-list intrusions); and (d) responses that had not
been on any prior list (extra-list intrusions).

Of primary interest in these data is the decrease in the
mean number of inter-list intrusions per trial as the number of
response alternatives on the training list increased. Also of
interest is the approximately equal number of intra-list

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[1]Intrusions refer to overt erroneous responses as contrasted
with failures to respond.

intrusions per trial among the three experimental conditions
(Conditions I, II, and IV). Stimulus intrusions, although
relatively infrequent, did occur, and inspection of Table 4
indicates that as the number of response alternatives on the
training list increased, the number of intrusions of this type
decreased.

Table 4. Total (S) and mean (M) number per trial of different
types of intrusions for the four conditions during
transfer list learning

Condition	:	I	:	:	II	:	:	IV	:	:	C	:
	:	S	:	M	:	S	:	M	:	S	:	M	:	S	:	M

	On all anticipation trials					
Type of Intrusion								
Intra-list	68	.33	56	.32	69	.39	192	.84
Stimulus	13	.063	8	.046	3	.017	33	.14
Inter-list	15	.073	3	.017	3	.017	0	.00
Extra-list	3	.015	2	.011	5	.028	4	.017

	On first anticipation trial					
Intra-list	4	.22	6	.33	5	.28	11	.61
Stimulus	0	.00	0	.00	0	.00	4	.22
Inter-list	0	.00	1	.055	1	.055	0	.00
Extra-list	1	.055	1	.055	0	.00	1	.055

In the control condition, the frequency of both intra-list
intrusions and stimulus intrusions was greater than in the
experimental groups. While the number of intrusions on the
first anticipation trial of the transfer list is of importance,
there were so few intrusions of any type on this trial that no
inferences were possible. No attempt was made to test the
statistical significance of differences in frequency or mean
number of intrusions. These data were used only to indicate

tendencies.

DISCUSSION

The results indicate that the relative amount of inter-
ference decreased as a function of an increase in the number
of response alternatives in the training task. This relation-
ship, however, was statistically significant only for the first
anticipation trial on the transfer task. This finding is in
agreement with the data of most other investigators (Underwood,
1944) who also have found that interference effects as measured
by the number of correct responses is transitory. In view of
this, it is surprising that a variation among the means approach-
ed statistical significance when number of trials to criterion
was considered. A partial survey of the literature revealed no
other studies that reported a similar result.

No differences in performance were found between the two-
alternative conditions and the four-alternative condition.
Whether or not differences would appear if a greater number of
response alternatives had been used is of considerable theoreti-
cal interest, but the present data do not permit inferences to
be made.

The major finding as revealed by the results of the present
study is that an increase in number of response alternatives in
the training list resulted in a decrease in the net amount of
interference on the transfer task. The data indicate that there
was evidence of relatively less interference for Conditions II
and IV than for Condition I. This would indicate that although

the degree of prior learning on the three conditions was the same, the overall facilitating effects resulting from the greater number of response alternatives in Condition II and IV was greater than the inhibitory effects usually resulting from the transfer paradigm followed. Along with this difference in performance there was a decrease in the number of overt inter-list intrusions as a function of the increased number of response alternatives in the training list. There also was a decrease in the number of overt stimulus intrusions as the number of response alternatives increased in the training list.

In recent years evidence has been presented that indicate that in any transfer of training situation there are two opposed processes present: facilitation and interference (Morgan and Underwood, 1950; Lewis, et al. 1951). It usually is assumed that these processes summate algebraically. Any theory of transfer has to account for the apparent greater rate of increase in facilitation relative to interference as the number of response alternatives is increased. It has been suggested by Underwood (1944) that this was due to unspecified practice effects or a "learning how to learn." General practice effects may, according to Underwood, include learning how to dissociate each new response from the old response and do it with greater speed the greater the number of responses that have been associated with the stimulus term, how to form associations more rapidly, and that the subject becomes less distracted by non-essential factors in the environment. This interpretation suffers from the lack of definitiveness of the concept of general practice effects;

that is, the concept is not anchored to observable or manipulable antecedent conditions and consequent conditions. The concept is therefore essentially undefined in any sense that permits prediction and verification.

Gibson's (1940) hypothesis asserts that a major necessity of verbal learning is the establishment of discrimination among the items to be learned, and that this process of discriminating is a fundamental part of the learning process. This hypothesis is stated in terms of stimulus differentiation and generalization, using the terms as conceptualized in conditioning studies. It is assumed that when learning any paired-associates list, generalization occurs between the stimulus terms within the list, so that a response learned to one stimulus tends also to occur to other stimulus items in the list. This generalization of the stimulus terms tends to block the correct responses; this tendency becomes less and learning occurs as the stimulus terms become more and more differentiated. Furthermore, if differentiation of the stimulus items has occurred, it will be easier to differentiate them again later, according to Gibson, even though they are paired with new responses. This would result in a decrease in overt inter-list intrusions from a prior list and a decrease in intra-list intrusions in the second list by virtue of increased stimulus differentiation, as well as in more rapid learning of the second list.

Beginning with the ideas presented by Gibson (1940) it may be inferred that when learning successive paired-associates lists following the associative interference paradigm there are several

processes going on that can be expressed in terms of general-
ization or differentiation. The subject is learning to differ-
entiate among the stimulus items within the lists; that is, they
become distinct from one another and also distinct from the re-
sponse items of either list. While Gibson does not discuss re-
sponse generalization and differentiation, her theory can be ex-
tended so as to postulate that the subject is also learning to
differentiate among the response items within the lists in a
manner analogous to stimulus differentiation. If the amount of
stimulus and response differentiation is relatively great, then
the task of learning to associate each stimulus item with the
right response item is relatively simple.

The extension of Gibson's theory to include response gener-
alization and differentiation as a factor in the relative amount
of interference in transfer of training leads to the prediction
that inter-list response generalization would result in inter-
ference tendencies. That is, such generalization should result
in a tendency for a given stimulus term to elicit the training
task response as well as the transfer task response now being
learned. This tendency should increase as a function of the in-
creased number of response alternatives learned to the stimulus
terms. The theory would also predict, however, that there would
be opposed facilitating processes transfered to the transfer list
because learning the training list consists in part of learning
to discriminate among response terms and among stimulus terms.
This facilitation also would be expected to increase as a func-
tion of (a) an increase in number of response alternatives, and

(b) an increase in the similarity of training and transfer list
responses. The theory does not make any statements about the
parameters of these processes; consequently, it offers no pre-
dictions about the relative strengths of these opposed pro-
cesses assumed to be present. Both Underwood's (1944) and the
present data indicate that the facilitating process increases
relatively more than interfering processes as number of response
alternatives is increased.

In the present experiment the decrease in the number of
stimulus intrusions that accompany an increase in the number of
response alternatives in the training task can be explained by
the fact that the greater the number of response alternatives,
the greater the number of trials required to learn the training
task; that is, Conditions II and IV resulted in a relatively
greater amount of differentiation among the stimulus items.

Although the processes hypothesized in the above theories
are assumed to be important factors contributing to the results
of this experiment, either the Underwood (1944) or the Gibson
(1940) theory has difficulty in accounting for the present find-
ing of a decrease in associative interference without a parallel
decrease in the number of overt intra-list intrusions with an
increased number of response alternatives in the training task.
In explaining this the following hypothesis is offered. Subjects
in Conditions II and IV learned to differentiate among the res-
ponse items of the training list to a greater extent than did sub-
jects of Condition I, but, because of the relatively low degree of
similarity between the response terms of the training and transfer

lists, the learning to discriminate among the specific response terms of the training list did not lead to an immediate benefit in discriminating among the response terms of the transfer list. A more general ability to discriminate among any and all response items was established, however, as the number of response terms in the training lists was increased. This, together with the increased differentiation among stimulus terms referred to earlier, would result in fewer errors and in more rapid discrimination among response terms for Conditions II and IV than for Conditions I or C. The data provide some evidence for this hypothesis. While the mean number of intra-list intrusions was approximately the same for all conditions, these intrusions tended to disappear earlier in transfer learning for Conditions II and IV than for the other conditions. Conditions II and IV made forty-five and forty-two per cent respectively of their total intra-list errors during the first one-third of the transfer trials, while Conditions I and C made thirty-one and thirty-three per cent of such intrusions respectively in the first one-third of the transfer trials. This indicates that Conditions II and IV resulted in a relatively greater amount of interference tendencies initially, but that these tendencies were outweighed by facilitating tendencies which increased in relative strength as learning continued.

SUMMARY

This experiment was designed to investigate the effects on transfer of training produced by the learning of prior lists with 1, 2, or 4 response alternatives with the degree of prior learn-

held constant. All lists consisted of ten paired associate, two-syllable adjectives, learned by the anticipation method. In the training lists the stimulus items were paired with one, two, or four response items. Four matched groups of eighteen subjects were used. Each group served under one of the above three experimental conditions or in a control condition in which no training was given. Training list learning was carried to a criterion of six correct anticipations after which the subjects in Condition I, who had training with one response alternative, learned a transfer list to a criterion of ten correct anticipations, the subjects in Condition II who had training with two response alternatives, learned the same transfer list to the same criterion, and the subjects in Condition IV, who had training with four response alternatives, learned the transfer list to a criterion of ten correct anticipations. In each case the training and transfer lists had the same stimulus terms, but different response terms.

The results showed:

1. Net interference decreased as the number of response alternatives in the training list increased. There were fewer errors per trial during transfer learning in Conditions II and IV than in Condition I. This relationship was statistically significant for the first anticipation trial only.

2. Fewer trials were required to achieve a criterion of one errorless trial for Conditions II and IV than for Conditions I and C.

3. There was a decrease in number of inter-list and stimulus intrusions as a function of increase in the number of response

alternatives in the training list, but the mean number per trial
of overt intra-list intrusions during the learning of the trans-
fer list was approximately the same regardless of the number of
response alternatives in the training list. However, there was
a greater tendency for these intrusions to occur late in trans-
fer learning for Conditions I and C than for Conditions II and IV.

The results were discussed in connection with contemporary
theories of transfer of training.

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APPENDIX

Instructions to Subject

We are conducting an experiment on memorization. The kind
of memorization we are investigating is similar to that in learn-
ing foreign words. I will tell you more about the exact purpose
when you have finished your two sessions.

In this window (point) will appear words. First, one word
will appear alone, like this (demonstrate). Then a short time
later the same word will appear with a second word beside it.
(Demonstrate). Then another word will appear alone (demonstrate)
and a short time later this word and another word will appear
together. (Demonstrate). The word that appears alone is called
the stimulus word of the pair in each case. This procedure will
continue until we have gone through a list of several words in
this way. Your task is to memorize the pairs so that when the
stimulus word of each pair appears alone, you can call out the
word it is paired with before both words appear together. In
other words when this word appears (demonstrate) you would call
out VIC before VIC comes into the window (demonstrate). Then
when this stimulus appears (demonstrate) you would call out HAL
before HAL comes into the window. (Demonstrate).

The words I just showed you are only for demonstration and
will not appear in any list you will learn, and we will use this
machine. (Point). When we actually start, you will have only
two seconds to call out the correct words; that is, a stimulus
word appears alone for two seconds, then it appears with the word
you are to call out for two seconds, then a new stimulus word

comes in for two seconds, and so forth. Remember, you are to
memorize the words so that during the two seconds that a stimulus
word appears by itself you can call out its pair before it ap-
pears. Obviously, the first time we go through the list you will
not be able to call out any words. You should concentrate on
memorizing as many as you can the first time through, though.

Beginning with the second time through the list, and at all
other times, you should try to call out as many words as you can.
You will be scored on the basis of the number of times it takes
you to go clear through the list until you get them all correct
twice in a row. You are not scored on errors otherwise, so don't
hesitate to try a word even if you aren't sure of it.

Don't get ahead of the machine--in other words, don't call
out a word until the proper stimulus word appears alone in the
window.

The order of the words will vary every time we go through
the list. That is, a pair always remains together, but the pair
of words that comes into the window first the first time through
the list may come in the middle of the list the next time through,
so don't try to memorize them in order--just memorize the pairs.

Every time you call out a word correctly, I will turn on
this light (point) for a second. However, I won't turn on the
light until the drum turns so that both words are in the window.
Also, if you happen to call out the correct word too late--after
it appears in the window--the light will not come on and you will
not get credit for it since it must be called out before the drum
turns.

One thing more, each time after we go through the list there
will be about a one-half minute period before we go through it
again. Each time this interval occurs you are to work on another
task, which you will also be scored on. (Show sample symbol
cancellation task). You task is to cross out the symbols in each
row that correspond to these in the margin (demonstrate for two
rows). Your score will be the total number that you cross out
correctly minus those crossed out that you should not have cross-
ed out. Thus, to get a good score on this task you have to work
fast but accurately. As soon as you have finished one sheet,
start on the sheet under it. I will tell you when to go back
to the words you are memorizing (point to memory drum).

Any questions? (Repeat instructions if appropriate, other-
wise either ad lib instructions or say that you are not permitted
to answer the question).

For Conditions I, II, and IV, on Second Practice List.

Now, we will have a new list. In this list, we have all
new words, both stimulus and response words are new, but the
task is the same. Again, don't try to call out any words on the
first time through the list, but beginning with the second time
through the list, call out as many as you can. And again, you
are to cross out symbols during the intervals between trials.
Any questions?

For Condition I, on Third Practice List.

Now, we will have a new list. In this list, the stimulus
words in the list you just finished remain the same, and are
still the ones that appear first in this new list. They are

paired with new words, however. You are to memorize these pairs
in the same way as before. Again, don't try to call out any the
first time through the list, but beginning with the second time
through the list, call out as many as you can. And again, you
are to cross out symbols during the intervals between trials. Any
questions?

For Conditions II and IV, on Third Practice List.

Now, we will have a new list. In this list the stimulus
words in the list you just finished remain the same, and are
still the ones that appear first in this new list. Now, however,
they are paired with two (four) words instead of only one. Only
one of these is correct; your task is to learn to call out the
correct word before it comes into the window. You will have to
discover by trial-and-error which is the correct word to call out
to each of the stimulus words. Again, when you call out the cor-
rect one, the light will go on when the drum turns. Just as be-
fore, don't try to call out any words the first time through the
list, but beginning with the second time through the list, call out
as many as you can. Again, you are to cross out symbols during
the interval between trials.

First Experimental List.

The task is much the same as last time. The only difference
is that all new words will be used; both stimulus and response
words are new. Otherwise it is just the same as the last list
you learned before. And again, cross out symbols during the time
between trials. Any questions?

Transfer List.

Now we have another list. The stimulus words are identical to those you just had, but each paired with a (one) new response word. Otherwise everything is the same as before, including the task of crossing out symbols between trials. Any questions?

Experimenter.

If you can, answer any questions about procedure by repeating part of the instructions. If this does not make it clear, ad lib instructions so that they understand their task. Put off any questions about the purpose of the experiment until they have finished both sessions, then tell them something on this order: "Many times in learning a foreign language, or something similar, the time between trials is important. You had twenty seconds between trials; other people had either six seconds or two minutes between trials. We haven't collected enough data yet to see which of these is best, but your instructor will tell you how it came out after the experiment is finished."

Also, if a subject asks how he did as an individual, tell him that you don't keep account of individual scores, that we are interested in averages, but that you think he did better than average.

PAIRED-ASSOCIATES LEARNING AS A FUNCTION OF THE NUMBER OF
RESPONSE ALTERNATIVES IN THE TRAINING LIST

by

DONALD GENE ANDERSON

B. S., Kansas State College
of Agriculture and Applied Science, 1954

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Among the factors that affect the direction and amount of transfer of training effects are the number of alternative responses learned prior to the transfer list. Underwood investigated this problem by giving subjects four trials practice on 0, 2, 4, or 6 training lists. His results showed a decrease in negative transfer effects with an increase in the number of training lists. The present study was designed to explore further this factor and its effects on transfer. The principal difference between the present study and Underwood's is that in the present one a performance criterion of learning of the training list was held constant for all conditions, while the number of trials given on training lists was held constant by Underwood. Underwood's procedure thus permitted the degree of learning to vary, a factor known to affect transfer.

In this experiment the experimental groups were given prior training on a list with either 1, 2, or 4 alternative response terms paired with each stimulus term. All lists consisted of ten paired-associate two-syllable adjectives, learned by the anticipation method. Four matched groups of eighteen subjects were used. Each group served under one of the three experimental conditions or in a control condition in which no prior training was given. Training list learning was carried to a criterion of six correct anticipations after which the subjects in Condition I, who had training with one response alternative, learned a transfer list to a criterion of ten correct anticipations; the subjects in Condition II, who had training with two response alternatives, learned the transfer list to the same criterion,

and the subjects in Condition IV, who had training with four
response alternatives, learned the transfer list to a criterion
of one errorless trial. In each case the training and transfer
lists had the same stimulus terms but different response terms.

The results showed that interference in learning the trans-
fer list decreased as the number of response alternatives in the
training list increased. There were fewer errors per trial dur-
ing transfer learning in Conditions II and IV than in Condition I.
This relationship, however, was statistically significant for the
first anticipation trial only. Also, fewer trials were required
to achieve a criterion of one errorless trial for Conditions II
and IV than for Conditions I and C. An analysis of the various
kinds of intrusions showed that there was a decrease in number of
inter-list and stimulus intrusions with an increase in the number
of response alternatives in the training list, and that the mean
number per trial of overt intra-list intrusions was approximately
the same in the three experimental conditions. However, there
was a greater tendency for these intrusions to occur late in trans-
fer task learning for Conditions I and C than for Conditions II and
IV.

The finding that an increased number of response alternatives
in the training list resulted in an increased number of correct
responses per trial and a fewer number of trials to criterion is
comparable with Underwood's results. Also, in both studies nega-
tive transfer effects were present in the first anticipation
trial of the transfer list only.

It has been suggested that in a transfer of training

situation there are two opposed processes present, facilitation and interference. Underwood suggested that in the present type of situation the increase in facilitation relative to the amount of interference is due to general practice effects. Gibson's theory suggests that facilitation is due to transferred differentiation of the stimulus terms. The present results suggest an extension and modification of Gibson's theory which includes the concept of response generalization as well as stimulus generalization.