Role of stimulus familiarization in nonverbal selective learning

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The Role of Stimulus Familiarization in Nonverbal Selective Learning

by

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Introduction

Fourteen years ago, Hovland (1951) included only three variables in his review of factors influencing verbal learning. These were: the length, meaningfulness, and difficulty of the verbal material. The defining operations for determining meaningfulness and difficulty were not specified and the possibility of functional relationships between these three variables was not discussed. By 1960, Underwood and Schuls (1960) were able to construct a list of six operationally different definitions of "meaningfulness". These were: (a) "Whether or not a subject 'gets' an association within a limited period of time," (b) "The number of associates which an item elicits in a given period of time," (c) "The number of associates which a subject thinks a given item would elicit," (d) "Ratings of how fast a subject thinks he can learn a unit relative to other units," (e) "Rated familiarity of the units," and (f) "Rated pronunciability of the units" (Underwood & Schuls, 1960, p. 25). In addition, it was possible for these authors to talk about correlations among their several variables.

Three years later, Noble (1963) included four additional response defined variables in a review of factors related to meaningfulness. These were: (a) rated emotionality, (b) deviation scores of judgments of dissyllables on Osgood's semantic differential, (c) proficiency in serial and paired associate learning, and (d) individual differences in ability.

In order for a stimulus word to acquire associations or in some way become meaningful for an individual, that individual must be exposed to the word. That stimulus attribute which is solely a function of the frequency of occurrence of a given stimulus has been named
familiarity (Noble, 1953). Presumably Ss perceive the words when ex­posed to them. One defining operation was to have Ss rate stimuli on a five point scale indicating estimated frequency of contact. It has also been possible to induce familiarity in the experimental laboratory simply by exposing Ss to novel stimuli a specified number of times. Research indicates that rated familiarity \((f)\) is a hyperbolic function of previously induced familiarity \((n)\) (Arnoult, 1956; Noble, 1954, 1960). Familiarity is probably necessary for meaningfulness but meaningfulness need not be necessary for familiarity. It has been proposed that meaningfulness is some monotonic function of frequency (Noble, 1953) and that frequency is the fundamental antecedent condition to many other variables influencing verbal learning (Underwood & Schuls, 1960, p. 44).

There appears to be considerable agreement among investigators that familiarity facilitates serial learning of paralogs (Noble, 1955) and nonsense syllables (Hovland & Kurts, 1952; Riley & Philips, 1959; Underwood & Schuls, 1960, Exp. III). Only one known study reports null effects (Lindley, 1963). The term paralogs, above, refers to dissyllabic pronounceable combinations of letters which make fictitious words (e.g., COHER).

In serial learning by anticipation, familiarity was necessarily induced in Ss by way of both the stimulus and response terms since, in the general paradigm of serial learning the same terms function in both capacities. Similarly, both the stimulus and response terms must be articulated if S responds at all. In the paired associate learning
situation it has been possible to study the influence on acquisition of familiarity with the stimulus and response terms separately. Studies of familiarity using the paired associate paradigm have yielded a mass of conflicting results which authorities have been unable to completely resolve in spite of repeated attempts (Noble, 1963, p. 106; Underwood & Schuls, 1960, pp. 125-126). The problem has been reviewed at length by Cannon and Noble (1961), Noble (1963), and Underwood and Schuls (1960). No effect of familiarization was found by Waters (1939), Nandler and Campbell (1957), and Bailey and Jeffrey (1958). Facilitation of learning with response term familiarity but not with stimulus term familiarity has been found by Sheffield (1944), Weiss (1958), and Underwood and Schuls (1960, Exps. I, IV). Facilitation of learning with stimulus term familiarity but not with response term familiarity has been found by Novikova (1959, Exp. II), Cieutat (1960), Cannon and Noble (1961), Hawks (1961), and Williams and Burke (1963).

It has been proposed that the conflicting results are a function of at least two differences in the several procedures: whether paralogs or nonsense syllables were used as the verbal material and whether they were pronounced or did not pronounce the stimulus terms during the paired associate learning task (Noble, 1963, pp. 105-106). Schuls and Tucker (1962a) have investigated the pronunciation-nonsense dimension with paralogs, finding decremental effects of familiarization in the nonpronunciation situation and significantly facilitative effects of familiarization in the pronunciation situation. Underwood (1964) found that with nonsense syllables, articulation did not influence free recall.
Unfortunately, nobody has executed the 2 x 2 factorial experiment suggested by the problem.

The question arises as to why familiarization should facilitate verbal learning. Goss (1963) briefly reviews three broad classes of mechanisms which have been proposed to explain the effects of meaningfulness and which appear to be relevant to familiarization. These are: (a) stimulus predifferentiation, (b) response patterning, and (c) indirect mediation by perceptual or verbal responses. Goss proposes a detailed analysis suggesting that the presentation of each criterion stimulus elicits two types of responses. The first type is a recognition of the stimulus pattern. The other type consists of responses of the association hierarchy. Establishment of recognition responses results in a similarity among such responses and in a reduction in the variability of response-produced stimuli. The faster and more stable responses become less similar to other responses. Response-produced stimuli from these faster and more stable recognition responses also become less similar to those produced by other stimuli. This results in reduced response generalization based on similarity among responses and in reduced stimulus generalization based on similarity among response-produced stimuli. The more rapid the recognition responses, the more time which is available to rehearse both them and responses of the association hierarchy.

The same reasoning may be applied to the responses of the association hierarchy. Association responses which do occur become more stable. Stability of association responses decreases response similarity and similarity among response-produced stimuli. Faster association
responses increase the opportunity for their rehearsal. Stability and
speed of responses, through frequency, increases the probability of as-

Similar to Goss' recognition and association-hierarchy responses
is Underwood and Schuls's (1960) division of paired associate learning
into a response-learning stage and an associative stage. These authors
go on to devote a large share of their book to the development and dis-
cussion of a theoretical hypothesis regarding the relationship of fre-
quency to verbal learning. The formal hypothesis is that frequency of
experience with particular verbal units determines the speed with which
these units will become responses in new associations, (Underwood &
Schuls, 1960, p. 86). The problem with applying this hypothesis to the
present experiment is that it says nothing about verbal units which act
as stimulus terms in associative connections (Underwood & Schuls, 1960,
p. 100).

Noble's (1955) principle of stimulus constancy appears to be implied
by Goss' hypotheses. The primary hypothesis is that repeated exposure-
articulation sequences will reduce variability in j's perceptual and
identifying responses to the stimulus terms when the paired associate
learning task is encountered. The derivation of this "core assumption"
hinges upon the reduction in variability through practice in pronunca-
tion, of proprioceptive compound conditioned stimulus traces. The more
stable stimulus traces, in turn, exert the greater control during learn-
ing of the various generalized, effective habit strengths. To complete
the reasoning, it is only necessary to suppose that stimulus trace var-
iability is reduced at a decreasing rate (Noble, 1955).
Another mechanism has been suggested by French (1953). The probability of a response to a stimulus is conceived to be a function of the habit strength of that S-R connection. The habit strength of an S-R connection involving a particular complex stimulus may be divided into a proportion attributable to elements of that stimulus which are unique to that stimulus and into a proportion which is attributable to elements of that stimulus which are common to that stimulus and other stimuli in the experiment. It is possible that during familiarization, reinforcement is given for attention to the unique elements of stimuli and considerably less consistently for attention to the elements common to several stimuli (Arnault, 1953).

One of the earlier descriptions of what may happen was suggested by what is now known as communication theory and specifically applied by Novland and Kurtz (1958). The amount of information in a stimulus situation is directly proportional to the uncertainty of that situation. Uncertainty is directly proportional to the number of alternative stimuli in the situation. Research suggests that speed of learning is inversely proportional to the uncertainty of the stimulus situation (Garme, 1962, p. 29). The effect of stimulus familiarization prior to learning may be to reduce the uncertainty about the possible stimuli (alternative stimuli) which actually appear in the learning task. Because of familiarization, S begins the learning task with knowledge of a particular restricted sample from the total population of possible stimuli which might be used. There is less uncertainty, less information per stimulus to be transmitted and learning proceeds at a faster pace.
such as those reviewed by Kimble (1961, pp. 226-234), might be looked upon as one type of research into the effect of familiarisation on motor maze learning. However, most of the work was done with subhuman organisms and the isolation and quantified control of familiarisation, as defined in the present study, was not considered.

The distinction should be made between the familiarisation paradigm of present concern and the typical transfer of training paradigm. In the transfer of training situation, $S$ may learn response $B$ to stimulus $A$, and then be tested in giving response $C$ to stimulus $A$. Schematically this is an $A \rightarrow B$, $A \rightarrow C$ transfer problem. In familiarisation, $S$ is given a stimulus $X$ (usually a verbal visual stimulus) and learns to give a response $Y$ (usually discriminating and pronouncing that stimulus). $S$ is then given another task $Z$ (motor task) to perform in addition to the original task. Schematically this would be $X \rightarrow Y$, $X \rightarrow Y + Z$.

The role of stimulus predifferentiation in transfer of training has been reviewed at length by Arnoult (1957). Most of the criterion tasks used in the studies which were reviewed required motor responses of one sort or another. Thus it would seem that these studies are directly relevant to the present study. Of the studies reviewed, there were 20 in which stimulus predifferentiation facilitated subsequent learning and no studies in which predifferentiation did not facilitate learning. All of the predifferentiation tasks followed the paired associate learning paradigm. Problems arise in drawing too heavily upon these studies because (a) most of the experiments relied upon nonverbal stimuli (Goss, 1963, p. 142); (b) while varying amounts of familiarisation may have been administered, possible preexisting
familiarity was frequently not controlled; and (c) familiarity was
unspecifiedly confounded with meaningfulness, formal similarity, and
learning to learn factors.

Consider now the learning task required in the present study and
the nature of the apparatus. The Mathometer, whose physical descrip-
tion is given elsewhere (Noble, Fuchs, & Thompson, 1965), may be con-
sidered a type of maze. Each presentation of a stimulus on the screen
represents a choice point with the uncovered buttons on the response
panel representing the alternative choices. If just one stimulus and
one button is used, the process would be that of relatively simple
conditioning (forming a single S-R connection). When several choices
must be made from among several possible alternatives, the process
becomes one of trial and error learning (Noble, 1957a). Such multiple
choice learning may be referred to as selective learning because such
learning includes problems of both stimulus selection (discrimination)
and response selection (Noble, 1957a). Thus, the names selective learn-
ing and Selective Mathometer.

Schematic S-R reinforcement accounts of trial and error learning
are given by Hull (1952), Spence (1956), and Noble (1957a). At any
one choice point there is a stimulus (S), a subject (S) with some
degree of motivation (D), a number of possible alternative responses
(R1, R2, R3, etc.), of which, the correct response (R+), leads to some
sort of goal (G). S may begin by responding according to whatever
hierarchy of tendencies he possesses upon arrival at the choice point.
Eventually S hits upon the S-R+ combination which leads to G. "This
results in a hypothetical increment of habit strength (H), which combines
multiplicatively with the strength of D to produce an increase in reaction tendency (R). Conversely, the erroneous responses (R−)
undergo inhibitory weakening (I) due to the failure of reinforcement and possibly also a consequent increase in the level of D (frustration)." (Noble, 1957a, p. 361) Through successive reinforcements and subsequent growths of R+ and R+ relative to R− and R− gradually comes to select R+ to the exclusion of R− whenever the appropriate S appears.

The case of compound trial and error learning is one of a series of S-R problems. The situation becomes complicated by "...the stimulus generalization of positive and negative effects from one manipulandum to another as a result of reinforcements and non-reinforcements." (Noble, 1957a, p. 361)

From the results of the previous research and the explanations of these results cited, it was possible to formulate the following hypotheses for the present study. (a) The trials main effect would be significant; i.e. practice would result in a significant increase in the number of correct responses per trial for all groups. (b) Stimulus familiarization prior to learning will significantly facilitate subsequent motor learning. This follows from the hypothesis that practice in discriminating and pronouncing the stimuli reduces variability of recognition responses. This, in turn, would result in both a decrease in stimulus generalization and hence less interstimulus interference and also an increase in the time available to make the motor response.
(c) Pronouncing the stimuli during the learning task would significantly facilitate learning. Pronouncing the stimuli would have two effects. First, it would make the learning task more similar to the familiarization
task. This would lead to a greater transfer of the discrimination or recognition training acquired during familiarization. Second, it would help hold the continued attention of $A$ during learning. (d) The effect of familiarization would be an initial effect so that there would be a significant interaction between familiarization and trials. If the effect of familiarization is that of improving discrimination or recognition, this improvement should be acquired prior to the learning task. The improvement of the familiarized group during the practice of the learning task should be less than the improvement of the unfamiliarized group. Hence a significant interaction would result. (e) Pronouncing the stimuli during learning will produce an initial effect which will interact with trials. All groups should start at chance and reach the same asymptotic level of performance. If pronouncing enhances transfer from the familiarization procedure, the pronounce groups should approach asymptote more rapidly than the non-pronounce groups. This would result in an interaction.
Method

Subjects. The 152 Ss were students enrolled at Montana State University during Spring Quarter and Summer Session and at the University of Georgia during Fall Quarter of 1964. Seventy three of the 152 Ss used in the final analysis were males. Ages ranged from 15 to 58 yrs. with a mean of 22.7 yrs.

Apparatus. The learning device used for the matching and criterion tasks was the Selective Mathemeter, described in detail by Noble, Fuchs, and Thompson (1963). This was an automatic multiple choice apparatus with which stimuli were presented by an electronically controlled slide projector and to which S responded by pressing one of the available buttons located on the perimeter of a semicircular response panel. All but one of the time variables were the same as in the Farese and Noble (1960) study. The values were: stimulus duration, 2.0 sec.; inter-stimulus interval, 2.0 sec.; intertrial interval, 8.0 sec.; reward delay, 0 sec.; and reward duration, 0.75 sec. During the matching task, six buttons were available (one for each stimulus) and all were relevant to the task. These buttons were nos. 3, 5, 9, 11, 15, and 17. All other buttons were covered with wooden blocks. During the criterion task, ten buttons were available (nos. 1, 3, 5, 7, 9, 11, 13, 15, 17, and 19), but only four (one for each stimulus; nos. 1, 7, 13, and 19) were relevant to the task. The buttons for both tasks were chosen because they made a symmetrical pattern on the response panel. The irrelevant buttons were used during the criterion task in order to make the task more difficult and possibly more sensitive to treatment effects.
Rehearsal consisted of the presentation of a list of 6 or 8 word pairs, each containing one of the physical pairs. Each pair consisted of two words; one word was presented on the right side of the screen while the other was on the left. An equal number of repetitions of each list was used (columns A, B, C, and D). Total response and correct response times were recorded automatically by a computer and computer.

Materials and Procedures. The materials for the matching task were the physical pairs which have been used in previous priming studies (e.g., Coltheart & Coltheart, 1982; Coltheart & Coltheart, 1983). The odd pairs were chosen because they were immediately to the physical task on the experimental task.

Twelve pairs were used to make the lists of eight words each.

The lists consisted of the same pairs used in the experimental task: pairs were presented in the same order as in the experimental task.

The physical material was used to be equally exposed to the physical task. The two lists are given in Table 1.

The order of the lists for the matching task was random for each list. The order of each list was reversed with the second list for the second time. The experimental task consisted of a total of 10 trials each. The second and third trials had the same effect as the first. The matching task consisted of the same number of the same numbers of the same numbers.

During the matching task phase, the words were shown with a
Table 1
Stimulus Words

<table>
<thead>
<tr>
<th>List 1</th>
<th>List 2</th>
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<td><strong>f</strong></td>
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<td>XYLEM 1.24</td>
<td>KUPOD 1.55</td>
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</table>

**Mean m** 1.26
**Mean f** 0.31

* Relevant words (Mean m = 1.26; Mean f = 0.28)
Stoelting memory drum set to present stimuli at the rate of one every 2 sec. The words were typed in black pica capital letters on white strips of paper. The memory drum permitted three columns of 20 lines each. With eight words plus two intertrial lines in each sequence, six different orders of words in each list were used. The low scale values of the words in the familiarization list, the irrelevant filler words, both mentioned above, and the several different orders of words were all used to avoid the formation of specific S-R connections during familiarization, to reduce the number of S-R connections which may have been formed before testing, and to increase comparability with previous verbal learning studies (e.g., Gannon & Noble, 1961; Noble, 1955).

Procedure. The experiment was divided into three parts for each S; a matching task, a familiarization period, and the criterion learning task. The matching task was a compound trial and error learning problem on the Selective Mathometer. Each S was given ten trials on an invariant sequence of six stimuli and six response buttons. The probability of correct first responses reaches about 50 per cent by the tenth trial under these conditions (Noble, 1957b). The task was chosen because of its similarity to the criterion task in an effort to reduce within-groups variance.

Each S was assigned to one of six ability levels according to the total number of correct responses made during the matching task. Within each ability level, most Ss were then randomly assigned to one of the eight treatment conditions. Approximately ten per cent of the Ss
were systematically assigned to one of the treatment conditions in order to keep the average of the matching task scores for each condition approximately equal.

The four familiarization procedures were as follows: In procedure 40R, S received 40 exposures to each of eight paralogs, four paralogs of which were the stimuli in the criterion task. In procedure 20R, S received 20 exposures to the same list of eight paralogs. The third procedure (40I), consisted of administering 40 exposures to a list of eight words made up of the four irrelevant words in the list given in 40R and 20R, plus four other irrelevant words. The fourth procedure was to not administer any familiarization but to proceed directly from the matching task to the criterion task.

During familiarization, all Ss were required to pronounce all words out loud as they appeared. Any pronunciation approximating that appropriate to the particular stimulus was accepted provided it was consistent over trials. This was to insure reception of the stimuli and to enhance the establishment of stimulus-trace constancy. If was verbally corrected by E if he was not consistent.

The criterion task was a mixed selective learning problem similar to that described by Fares and Noble (1960). Each S was tested with a variable sequence of four stimuli. The variable sequence was used to avoid the possibility of a serial position effect even though no such effect is usually found (Noble, 1957b). Ss were run either to a criterion of five successive perfect trials or for forty trials, whichever occurred first. Those Ss who reached the criterion of five successive perfect trials before they reached 40 trials were given credit
for correct response for the remainder of their trials. Half of the JU from each illumination condition were required to pronounce (P) the stimulus during the criterion test. The other half were not instructed to pronounce (P) the stimulus. Thus, there were eight different treatment groups.

In JU were automatically rejected from the study if he made three consecutive late or omitted responses. The specific instructions given to the JU are in Appendix I.

The total number of possible permutations of the four relevant response buttons taken four at a time was four factorial of 26. Similarly, the total number of possible permutations of the four stimuli is 26. These stimuli and response permutations are given in Tables 2 and 3 respectively. Each particular stimulus permutation represented a particular temporal order of stimulus presentation. For example, stimulus permutation No. 17 (2-4-1-3) meant that the paradigm were presented as 2413, 4123, 1324, and 3241. Each response permutation represented a particular spatial and temporal order of correct buttons on the response panel. For example, response permutation No. 19 (7-4-3-12) meant that the initial correct order of buttons was 7, 4, 3, and 12.

By employing two slide cartridges, 36 of the 26 stimulus permutations were used. However, any one particular JU received only the eight permutations in the cartridge assigned to him. The particular 36 stimulus permutations used were chosen by means of a table of random numbers. All 36 response permutations were used although only one initial permutation could be used per JU. As we decided that the
### Table 2

**Stimulus Permutations**

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1. LATUK
2. TAROP
3. GOKEM
4. ZUMAP
Table 3

Response Permutations

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<td>7 - 1 - 19 - 13</td>
<td>20</td>
<td>19 - 1 - 13 - 7</td>
</tr>
<tr>
<td>9</td>
<td>7 - 13 - 1 - 19</td>
<td>21</td>
<td>19 - 7 - 1 - 13</td>
</tr>
<tr>
<td>10</td>
<td>7 - 13 - 19 - 1</td>
<td>22</td>
<td>19 - 7 - 13 - 1</td>
</tr>
<tr>
<td>11</td>
<td>7 - 19 - 1 - 13</td>
<td>23</td>
<td>19 - 13 - 1 - 7</td>
</tr>
<tr>
<td>12</td>
<td>7 - 19 - 13 - 1</td>
<td>24</td>
<td>19 - 13 - 7 - 1</td>
</tr>
</tbody>
</table>
straight left-to-right and right-to-left response permutations might be too easy to use as initial patterns. Thus, no S received either of these permutations (Nos. 1 and 24) on an initial trial. Table 4 shows the order of stimulus permutations in each cartridge and the initial response permutations randomly assigned to each S.

There originally were 22 Ss in each treatment group distributed over the six ability levels. The design approximated that appropriate for a randomised blocks trend analysis (Edwards, 1960) except for the systematic assignment of approximately ten percent of the Ss to the treatment groups. Because of this, pairs of ability levels were combined so that there were only three ability levels of Ss. It was then assumed that this more coarse grouping of Ss would counter-balance or average out any effects that the prior systematic assignment of Ss may have had.

The numbers of correct responses were summed over blocks of five trials for each S. This allowed the data to be arranged in a 3 x 8 x 8 matrix with ability blocks, treatment conditions, and trials as the factors. It was necessary to discard three Ss from each treatment condition in order to obtain a proportional number of Ss in each treatment condition at each ability level. Discarding was done by means of a table of random numbers. This resulted in 19 Ss in each treatment group with two Ss in the high ability level, twelve Ss in the middle ability level, and five Ss in the low ability level.
Table 4
Stimulus and Response Permutations Randomly Assigned to the Ss in the Learning Phase

Cartridge I

<table>
<thead>
<tr>
<th>Subject Number</th>
<th>Initial Cartridge Positions</th>
<th>Initial Stimulus Permutations</th>
<th>Initial Response Permutations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 2</td>
<td>1</td>
<td>12</td>
<td>3, 18</td>
</tr>
<tr>
<td>3, 4</td>
<td>7</td>
<td>20</td>
<td>12, 9</td>
</tr>
<tr>
<td>5, 6</td>
<td>13</td>
<td>18</td>
<td>4, 13</td>
</tr>
<tr>
<td>7, 8</td>
<td>19</td>
<td>2</td>
<td>23, 2</td>
</tr>
<tr>
<td>9, 10</td>
<td>25</td>
<td>15</td>
<td>21, 17</td>
</tr>
<tr>
<td>11, 12</td>
<td>31</td>
<td>19</td>
<td>6, 15</td>
</tr>
<tr>
<td>13, 14</td>
<td>37</td>
<td>3</td>
<td>19, 10</td>
</tr>
<tr>
<td>15, 16</td>
<td>43</td>
<td>17</td>
<td>11, 5</td>
</tr>
</tbody>
</table>

Cartridge II

<table>
<thead>
<tr>
<th>Subject Number</th>
<th>Initial Cartridge Positions</th>
<th>Initial Stimulus Permutations</th>
<th>Initial Response Permutations</th>
</tr>
</thead>
<tbody>
<tr>
<td>17, 18</td>
<td>1</td>
<td>7</td>
<td>8, 7</td>
</tr>
<tr>
<td>19, 20</td>
<td>7</td>
<td>9</td>
<td>14, 20</td>
</tr>
<tr>
<td>21, 22</td>
<td>13</td>
<td>5</td>
<td>22, 16</td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td></td>
<td>31</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>37</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>43</td>
<td>14</td>
<td></td>
</tr>
</tbody>
</table>
Results

The parametric analysis of variance assumes independent observations from normally distributed populations which have equal variances. A Bartlett's test for heterogeneity of variance (Edwards, 1960, pp. 125-128) was made for the ability levels by treatments matrix (correct responses summed over trials). The test indicated that heterogeneity of variance was present ($x^2 = 53.513$, df = 23, $p < .01$). The Norton studies, cited by Lindquist (1953), indicate that the normal-theory $F$ tables may be used to evaluate $F$ ratios in which marked heterogeneity of variance is involved provided allowances are made for the heterogeneity of variance. The direction of the allowance is to require that $F_{cor}$ be significant at a more stringent level of confidence. Because of this heterogeneity of variance, it was decided that the .025 significance level would be used to evaluate the $F$ ratios for the ability levels, treatments, and levels by treatments interactions in the subsequent analysis of variance as suggested by Lindquist (1953, pp. 78-86).

Over repeated measures, it is assumed there will be equal variances and equal intertrial correlations (Lana & Lubin, 1963). Table 5 summarizes three correlations between pairs of trial blocks. All of the correlations were significantly greater than zero. A test for homogeneity of these three correlations (Edwards, 1960, pp. 83-85) indicated that the correlations were not homogeneous ($x^2 = 18.584$, df = 2, $p < .01$). According to Lana and Lubin (1963), the effect of heterogeneous correlations between repeated measures is to reduce the
Table 5
Correlations Between Trials

<table>
<thead>
<tr>
<th>Correlation Between Trial Blocks</th>
<th>r</th>
<th>df</th>
<th>t (r&gt;0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 and 2</td>
<td>.68</td>
<td>150</td>
<td>11.439*</td>
</tr>
<tr>
<td>4 and 5</td>
<td>.82</td>
<td>150</td>
<td>17.774*</td>
</tr>
<tr>
<td>7 and 8</td>
<td>.58</td>
<td>150</td>
<td>8.769*</td>
</tr>
</tbody>
</table>

*p<.005
effective degrees of freedom by some unknown amount. Because of these heterogeneous correlations between trials, it was decided that a conservative degrees of freedom of $1/N-1 = 1/151$ would be used to evaluate $F$ ratios involving trials as suggested by Lana and Lubin (1963).

A parametric analysis of variance was made of the sums of correct responses (Edwards, 1960, Chapter 14). The test is summarised in Table 6 where it can be seen that the trials main effect was the only $F$ ratio to reach significance. This trials effect is also shown in Fig. 1 where it can be seen that the number of correct responses increased with practice.

The use of a matching task to reduce within-groups variability on a criterion task makes a high correlation between the matching and criterion tasks desirable. The correlation between the matching task and criterion task performance for the two zero familiarisation groups in the present study was significantly greater than zero ($r = .337$, $t = .148$, $df = 36$, $p < .05$).
Table 6
Summary of the Analysis of Variance

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (P-NP)</td>
<td>0.003</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>B (Familiar)</td>
<td>71.318</td>
<td>3</td>
<td>23.772</td>
<td>1.109</td>
</tr>
<tr>
<td>C (Ability Blocks)</td>
<td>139.087</td>
<td>2</td>
<td>69.543</td>
<td>3.214</td>
</tr>
<tr>
<td>A X B</td>
<td>34.360</td>
<td>3</td>
<td>11.453</td>
<td>-</td>
</tr>
<tr>
<td>A X C</td>
<td>77.403</td>
<td>2</td>
<td>38.701</td>
<td>1.805</td>
</tr>
<tr>
<td>B X C</td>
<td>317.556</td>
<td>6</td>
<td>52.926</td>
<td>2.469</td>
</tr>
<tr>
<td>A X B X C</td>
<td>8.836</td>
<td>6</td>
<td>1.472</td>
<td>-</td>
</tr>
<tr>
<td>error (a)</td>
<td>2743.671</td>
<td>128</td>
<td>21.434</td>
<td>-</td>
</tr>
<tr>
<td>D (Trials)</td>
<td>3123.865</td>
<td>7</td>
<td>4446.266</td>
<td>801.129*</td>
</tr>
<tr>
<td>A X D</td>
<td>3.523</td>
<td>7</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>B X D</td>
<td>151.998</td>
<td>21</td>
<td>7.238</td>
<td>1.304</td>
</tr>
<tr>
<td>C X D</td>
<td>119.812</td>
<td>14</td>
<td>8.558</td>
<td>1.541</td>
</tr>
<tr>
<td>A X B X D</td>
<td>66.797</td>
<td>21</td>
<td>3.180</td>
<td>-</td>
</tr>
<tr>
<td>A X C X D</td>
<td>54.608</td>
<td>14</td>
<td>3.900</td>
<td>-</td>
</tr>
<tr>
<td>B X C X D</td>
<td>252.491</td>
<td>42</td>
<td>6.011</td>
<td>1.083</td>
</tr>
<tr>
<td>A X B X C X D</td>
<td>100.747</td>
<td>42</td>
<td>2.398</td>
<td>-</td>
</tr>
<tr>
<td>error (b)</td>
<td>4973.159</td>
<td>896</td>
<td>5.550</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>40239.234</td>
<td>1215</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* p<.005
SUM OF CORRECT RESPONSES

BLOCKS OF FIVE TRIALS

Fig. 1. Correct responses increasing as a function of practice.
Discussion

There are two factors which can be noted as possibly having contributed to the significant Bartlett's test for heterogeneity of variance. The variances of the high ability level cells in the levels by treatment conditions matrix appear to be slightly but consistently smaller than those for the low ability level cells. A cursory inspection of the ages of the Ss divided according to ability levels indicated that the Ss in the high ability level tended to be slightly younger than the Ss in the low ability level. It is possible that, for numerous reasons such as decreasing reaction time, manual dexterity, and intelligence, older people as a group tend to be more variable in their performance on the Mathometer than do younger people.

The boundaries for the ability levels were set arbitrarily. Since it appears that there is a consistent difference in the variances between ability levels, it is possible that the use of other boundaries may have reduced the heterogeneity of variance between cells. One other way of dividing Ss might have been to have an equal number of Ss in each ability level. This would have required the elimination of only one S from each group (21/3 = 7). A test for heterogeneity of variance in an ability levels by treatment matrix with seven Ss in each cell was still significant ($\chi^2 = 36.081$, df = 23, $p < .05$). Although still significant, this Chi square is considerably less than the one obtained using the former division of ability levels.

The only factor in the analysis of variance considered to be significant was the trials main effect. This may be interpreted as supporting the hypothesis that learning would occur. The data fail to support the
other hypotheses stated in the introduction. Neither stimulus familiarization prior to learning nor pronouncing the stimuli during learning significantly facilitated mixed selective motor learning. The treatments by trials and the pronunciation by familiarization interactions were not significant.

The results of the present study are clearly at variance with the expectations based on theory and previous research, particularly the Gannon and Noble (1961) and the Schuls and Tucker (1962a) studies. Further detailed consideration of the criterion task suggested at least three ways in which the effects of familiarization and pronunciation could have been masked or negated in the present study.

Each stimulus was presented for two seconds. During this time S had to perceive and in some conditions pronounce the stimulus, choose a button, and press it. One hypothetical effect of stimulus familiarization is to decrease the time required by Ss to perceive and pronounce the stimulus, leaving more time for Ss to choose and make their responses (Goss, 1963; Schuls & Tucker, 1962a). Consider the two sec. as being the nominal response interval and that part of the two sec. after the stimulus has been perceived and pronounced as being the effective response interval. Research by Schuls and Tucker (1962b) suggests that the effects of stimulus familiarization and pronunciation are dependent upon the length of the nominal response interval in paired associate verbal learning. When the nominal response interval becomes sufficiently long, small variations in the effective response interval make no significant difference. Noble and Noble (1959) have shown that there is no difference in learning on the
Mathometer when the stimulus remains on the screen for two sec.
or until S presses a button. This suggests that a two sec. response
interval is probably quite long for learning on the Mathometer. It
is possible that the two sec. response interval used in the present
study was sufficiently long to mask the effects of familiarization
and pronunciation as Schulz and Tucker (1962b) have shown is possible.

If the nominal, and hence effective, response intervals were
too long in the present study, one would expect to find very few
late and omitted responses for all groups and no differences in
late and omitted responses between groups. A tabulation of late
and omitted responses showed that less than three per cent of the
total possible responses were late and omitted responses for all
groups and that there was less than a two per cent difference
between groups. (see Appendix II)

A second possible source of masking may be derived from a
consideration of the irrelevant responses available during the
criterion task. In order to make correct responses, S had to
first find out which buttons were relevant to the task and then
connect the relevant buttons to the correct stimuli. Due to the
large number of irrelevant buttons, the elimination of a button
as irrelevant or incorrect for one stimulus gave S little informa-
tion about which buttons were irrelevant or incorrect for other
stimuli.
"Discovery" of a button as being relevant and correct may be defined as the first reinforced response of pressing that button. A detailed consideration of trials to discovery and of errors after discovery showed that all groups discovered and learned the relevant buttons with about equal speed. Discovery and learning after discovery did not appear to reflect any systematic effects of familiarization or pronunciation. (see Appendix III)

One must consider the stimulus presentations during the criterion task before, at, and after discovery as additional trials of stimulus familiarization. Schuls and Tucker (1962a) have shown that stimulus familiarization prior to learning interacts with the pronouncing factor on subsequent paired associate verbal learning. Learning is a negatively accelerated increasing function of familiarization when the stimuli are pronounced during learning. Learning is a negatively accelerated decreasing function of familiarization when the stimuli are not pronounced during learning. Assume, for example, that it took about five trials to discover a button as being relevant. This is actually about the mean number of trials taken to discover the second button. These represent five stimulus familiarization trials prior to discovery. Because the initial familiarization trials have more effect on learning than do later familiarization trials, these five familiarization trials would
influence the performance of the previously unfamiliar groups more than they would influence the performance of the groups which had previously received 40 familiarisation trials. This is true for both the pronounce and nonpronounce conditions and this differential effect would be in the direction of reducing the expected differences between groups. This extra familiarisation is present to some extent in all familiarisation studies. However, the writer would suggest that the irrelevant responses made explicitly available in the present study permitted more "extra" familiarisation than is usually found in such studies. The writer was unable to find in the literature other studies in which stimulus familiarisation and explicit irrelevant responses were involved in the same task.

The two sec. interstimulus interval employed in the present study suggests a third means by which treatment effects could have been masked. The facilitation of learning via rehearsal occupies a central position in Goss' (1963, p. 136) explanation of the effects of meaningfulness and familiarity. During the two sec. interstimulus interval, Ss had nothing to do but wait for the next stimulus and it is certainly possible that they rehearsed the task during this time. If Ss did rehearse the task, one would expect the data to show very few errors after the initial discovery of the correct buttons. A tabulation of median errors after discovery (shown graphically in Appendix III) indicated that buttons were missed a median of less than once after they
were discovered. Even assuming equal rehearsal in each group, it is conceivable that this rehearsal would have had differential effects on the experimental groups in the direction of masking differences between groups. That is, rehearsal would be expected to facilitate learning for originally unfamiliarized S's more than it would facilitate learning for thoroughly familiar S's.

The known and possible flaws in the present study suggest that further investigation of the same experimental factors could be worthwhile. The stimulus interval could be shortened to perhaps 1.5 sec., the intersubject interval could be shortened drastically, and the irrelevant buttons could be reduced in number or eliminated. With the reduced time intervals and without a matching task, the criterion task complexity would probably be sufficient with the variable sequence of four stimuli and four buttons.

Investigations of the time intervals, of transfer of training, and of correlations between tasks on the Mathometer would seem profitable. The use of matching tasks to reduce within-groups variance makes a high correlation between matching and criterion tasks desirable.

It was noted in the introduction that cue selection takes place during paired associate verbal learning. It was suggested that such cue selection might reduce stimulus recognition time and variability in stimulus traces from the recognition responses, resulting in a facilitation of learning. It seems reasonable that cue selection might be a function of stimulus complexity. It is possible that familiarization furnishes the time and experience for cue selection to take
place. An investigation of the effect of familiarisation as a function of stimulus complexity and the opportunity for cue selection seems worthwhile.
Summary

The concept of stimulus familiarity was operationally defined as the number of exposures which Ss received to originally novel stimuli. Previous research has shown that stimulus familiarity can significantly influence paired associate verbal learning. The nature of the influence depends upon whether or not Ss articulate the stimulus terms in the paired associate criterion task. It has been hypothesized that stimulus familiarization reduces stimulus discrimination time and reduces variability in proprioceptive stimulus traces from orientation to and identification of the stimuli.

The present study investigated the influence on mixed selective meter learning of familiarization with verbal stimuli prior to learning. Four levels of familiarization (zero, 40 irrelevant, 20 relevant, and 40 relevant exposures) and two levels of pronouncing (pronounce and nonpronounce) were used in a randomized blocks design with three levels of matching task performance and 40 trials on the criterion task. An analysis of variance of sums of correct responses on the criterion task showed that the only significant term was the trials main effect after allowances were made for heterogeneity of variance and heterogeneous correlations between trials.

Possible reasons for the lack of treatment effects on performance in the criterion task were discussed. The long response interval may have made variations in stimulus discrimination time of little importance. The long interstimulus interval afforded an opportunity for rehearsal. The available irrelevant responses may have resulted in
additional stimulus familiarization, the effects of which would have been differential. Suggestions were made for improvements over the present method and possible variables for future study were noted.
References


French, R. S. Number of common elements and consistency of reinforcement in a discrimination learning task. J. exp. Psychol., 1953, 45, 25-34.


Noble, C. E. Human trial and error learning. Psychol. Rev., 1957, 3, 377-398 (Monog. Suppl. 8). (a)


Appendix I: Instructions read to the subjects.

Appendix II: Tabulation of late and omitted responses.

Appendix III: Tabulation of trials to discovery and errors after discovery.
Matching Test Instructions

This is a test of your ability to learn. Six symbols will appear one at a time on this screen. Here are a number of buttons. As each symbol comes on the screen, your job will be to find out which button is connected with the symbol on the screen. In order to do this, you must press down a button like this. If the button you press down is connected with the symbol, this green light will flash on. If the green light does not flash on when you press on the button, it means that particular button is not connected with the symbol on the screen. Now remain here at the keyboard, and I will go into the next room and talk to you through this intercom.

Can you hear me clearly? It is important that you make a choice every time a symbol appears, but only one choice. You must make this one choice while the symbol is on the screen. Do not press any buttons when there is nothing on the screen. Try to find the correct button for each symbol as quickly as possible. The same series of symbols will be shown over and over a number of times. Between each series there will be a short rest interval. The object is to press the correct button as quickly as possible, but — and this is important — you should try to do so with as few mistakes as possible. This part of the experiment will take about ten minutes. Are there any questions? When the test begins I cannot answer any questions, but I will be glad to answer any you may have when the test is completed.
Here is your first chooses. Make your first choice.

on the screen. You must work fast to keep up. Here you read.

Find out which button is connected with each symbol as it appears.

be correct for that symbol. But remember that your job will be
to find out which button is connected with each symbol.

and the button that is correct for a particular symbol will always
be correct for that symbol, but remember that your job will be

the test. The skeleton will be shown at a constant rate of speed.

Your goal is to turn on as many green lights as possible.

the metal piece at the bottom of the keypad panel.

not hold the button down. Between strides keep your forefinger on

a button. When pressing a button, press it lightly and do

same hand. Now stick out your hand as if you were pointing.

same hand as the forefinger of either hand but always use the

Next I want to show you how to press the buttons. Then press
Familiarization Instructions

Now I am going to show you some words with this other machine. The words will be shown over and over at a constant rate of speed and in several different orders. As each word appears in the window, I want you to pronounce it out loud as best you can. Do not try to memorize the list of words; simply concentrate on pronouncing each word as correctly and consistently as possible. Are there any questions?
Criterion Test Instructions

Now I am going to give you another learning task similar to the one you just did. First I have to readjust the projection machine. Remain seated here at the keyboard and I will talk to you through this intercom.

Can you hear me clearly? This time there will be four words as symbols and ten buttons. Again, the same words will be shown over and over a number of times; they will be shown at a constant rate of speed; and the button that is correct for a particular word will always be correct for that word. This time however, the slides will be shown in several different orders so that you must pay close attention to which word is on the screen. (To help, I want you to pronounce each word out loud as it appears. Be sure to pronounce each word as correctly and consistently as you can.)

Remember that you must respond quickly and only while the word is on the screen. Remember also, to make one and only one choice each time a word appears; to return your forefinger to the metal disc after each response; and that you should not hold a button down while making a response.

Are there any questions? Here is your first word, make your first choice.
SUM OF LATE RESPONSES AND OMISSIONS

PERCENT OF TOTAL POSSIBLE
MEDIAN TRIALS TO DISCOVERY

TRIALS

10

5

5

1

1

TRIALS

1

2

3

4

BUTTON

1

2

3

4

BUTTON

O

40I

20R

40R

P

NP
MEDIAN ERRORS AFTER DISCOVERY

ERRORS

1.75
1.50
1.25
1.00
0.75
0.50
0.25
0

1  2  3  4
BUTTONS

1  2  3  4
BUTTONS