EFFECTS OF MEANINGFULNESS AND FAMILIARIZATION
UPON BACKWARD ASSOCIATIONS IN PAIRED-ASSOCIATE LEARNING

CHIZUKO IZAWA

San Diego State College

Three paired-associate learning (PAL) experiments were conducted with Japanese learning materials and Japanese Ss. Backward associations were tested at various stages of a-b learning. With noun-pairs, backward associations were superior to forward early in learning, but in later stages they were 85%-92% as strong as forward associations. With nonsense syllable- and familiarized nonsense syllable-pairs, backward associations, always significantly inferior to forward, reached the maximum when two-thirds of the a-b list was learned, and later approached an asymptote approximately 50% as strong as forward associations. Facilitating effects of familiarization on backward associations were limited to early stages of learning. A given directionality of training seems to be one of the determinants of PAL. Availability of terms may not sufficiently explain the whole process of associative learning. Asymmetry may be the general rule, and symmetry may be its special case.

Due to the apparent importance of backward associations in understanding verbal learning processes, investigations concerning issues for or against the principle of associative symmetry of paired-associate learning (PAL), proposed by Asch and Ebenholtz (1962), have been on the upsurge during recent years in American psychology. A review of the literature on this topic until the middle of 1965 is attempted by Ekstrand (1966).

Backward associations or backward learning are defined quite simply in terms of experimental operations. In the experimental situations involving backward associations in PAL, two distinctive phases are presupposed. As the first phase, letting a and b respectively be the first and second members of a given paired-associate, the S learns an a-b pair, or a list of a-b pairs. Then, as the second phase, following a-b learning task, he is given b-members and required to supply a-members. If he is successful in supplying the correct a-terms, he has performed backward learning, and thus, backward associations are said to exist. The a-b nomenclature is employed in the present article in order to avoid confusion which might arise in the second phase as to which term is a stimulus, or a response.

Jantz and Underwood (1958), Morikawa (1959), Asch and Ebenholtz (1962), and Leicht and Kausler (1965) showed that backward associations are directly related to the amount of a-b learning of the first phase. If this is universally true, the amount of a-b learning should be systematically varied in order to investigate backward association formation throughout all stages of a-b learning. This was accomplished recently by Izawa (1965), using

1 The present paper is based upon the experiments conducted in 1959–1960, while the author was an undergraduate student of the University of Tokyo. Many thanks are due to Professor M. Sagara and Mr. H. Saiga for assisting the work as advisors. The writing of this manuscript was supported in part by Grant 1 RO1 MH12979–01 of the National Institutes of Health, Public Health Service of the United States Government.

2 Currently at Institute of Human Learning, University of California at Berkeley, California, U.S.A.
Japanese Ss and Japanese words, who terminated the a-b learning of experimental groups when they reached the criteria of either 1/4, 1/2, 3/4 of the list, one perfect trial, or three successive perfect trials. Her results showed that backward associations were superior to forward associations early in learning, but inferior at later stages of learning. Izawa (1965) proposed a hypothesis that the direction of a-b training is one of the determinants of the relative weakness of backward associations obtained so widely. The possibility of an influencing factor from temporal directionality is also mentioned in Morikawa (1959). Directionality in the present series of studies is understood more broadly including all possible single and combined effects from temporal, sequential, ordinal, and spatial factors. Izawa (1965) also demonstrated an impressive amount of positive transfer from a-b to b-a learning.

When a fact is established with certain materials, the next step is to investigate whether the same results can be obtained with different materials varying substantially with respect to a specific psychological variable or factor. A scientific investigation gains an additional value when it is followed up and replicated. In the field of verbal learning, there are two reasonably distinctive classes of learning materials: words meaningful to the Ss, and syllables nonsense to them. If PAL is the product of stimulus differentiation, response learning, and association learning; pairs consisting of easy meaningful words as Izawa’s study (1965) require the least effort to perform stimulus differentiation and response learning. However, if pairs are constructed from difficult nonsense syllables, PAL demands greater effort in learning items together with associations between the stimulus and response terms of the pairs. Because of these differences between words and nonsense syllables, the results of experiments using nonsense syllables as pairs might not be generalizable from the ones with word-pairs. If so, it is necessary to investigate how backward associations are formed when greater effort is required to learn the items comprising the pairs. Therefore, in Exp. II of the present study, pairs were constructed from nonsense syllables in order to answer this question. Exp. I of the present study consisted of learning materials similar to those used by Izawa (1965), in order to replicate the earlier findings and also to provide the base line to make comparisons with the two other experiments in the present study. The Ss were high school students in Izawa (1965), and university students in the present study.

The third experiment was planned to create an experimental situation located at a point between Exp. I with easy noun-pairs and Exp. II with difficult nonsense syllable-pairs. The differences between words and nonsense syllables contain at least the following two factors: familiarity and meaningfulness. That is, nonsense syllables are nonsense to the Ss as they lack both familiarity and meaningfulness, which words possess as their major characteristics. Underwood and Schulz (1960) assume that frequency is the condition fundamental to the role of meaningfulness in verbal learning, and regard familiarity of verbal units as a direct consequence of frequency. Familiarity was induced experimentally in Exp. III of the present study by letting the S familiarize himself with the nonsense syllables prior to the PAL tasks.

The familiarization procedure employed by Morikawa (1959), which was essentially identical to the one utilized earlier by Hovland and Kurtz (1952), requires Ss to supply missing letters when parts of the syllables were presented individually. The above procedure seems to pose some untenable assumptions: (1) A letter of a given syllable presented was assumed to be a stimulus to the remaining part of the syllable, which was tacitly regarded as a response. (2) Thus, a syllable was assumed to be analyzable into its letters, and
therefore a syllable as a whole was assumed to be a sum of its components, namely letters. (3) The definition of familiarization by these investigators seems to be highly artificial compared to familiarization happening in a natural setting, in which a child familiarizes himself with his new words, or a student learns new foreign terms, where both new words and new foreign terms are initially analogous to nonsense syllables. In real life, a word as a whole, not a part of it, is repeated to a learner. In order to investigate some aspects of the differences between words and nonsense syllables, therefore, the procedures used by Morikawa (1959), and Hovland and Kurtz (1952), which were backed with an analytical proposition, are unsuitable. For similar reasons, the method used by Kuraishi (1937) is also to be avoided.

Familiarization in the present investigation is defined operationally as increasing frequency of experience with a given nonsense syllable by exposing it to the S for a certain number of times as a whole, without breaking it down into its component letters.

PAL necessarily involves item learning (stimulus and response terms learning) as well as association learning. It is now an established fact that meaningfulness of a- and b-terms of pairs is an important determinant of PAL. In order to investigate the process of forward and backward associative learning, therefore, it is necessary to minimize the effects arising from the differential meaningfulness or difficulty of a- and b-terms. This was accomplished by equating meaningfulness and familiarity for a- and b-members of the paired-associates in each of the present three experiments. Thus, confounding effects of differential learnability between the two terms of the pairs were precluded in the current investigation.

**Method**

To overcome the shortage of Ss, a 5 x 5 Greco-Latin square was utilized in each experiment of the present study, with five Ss, five conditions, five lists, and five participation orders. Fifteen undergraduate and graduate students in Psychology at the University of Tokyo, five in each experiment, served as Ss.

Each S learned five different lists, each assigned to a different condition, one list per day for five consecutive days.

Five lists for Exp. I were made of 15 pairs each constructed from common nouns (Japanese) selected from the norms by Umemoto, Morikawa, and Ibuki (1955). The meaningfulness of each term was above 140, the means of a-terms and of b-terms being approximately 200 for each of Lists 1, 2, 3, 4, and 5. While keeping the meaning of each word concrete, clear, and distinct, great care was taken to minimize the repetition of the same KANA-letters within a given list, especially among the a-members, or among b-members. For Exp. II five lists contained 10 pairs comprising two-syllable nonsense syllables, whose association values ranged from 30 to 50 (Umemoto et al., 1955). The mean association values of a- and b-terms were equated. In a given list no letter was repeated among the initial letters or among the final letters within a-terms or within b-terms. Meaningfulness and formal similarity among the items were as low as careful inspection would permit. The five lists for Exp. III were the same ones as those in Exp. II, but all items were familiarized prior to the PAL tasks.

In each experiment, Lists 1, 2, 3, 4, and 5 were called a-b lists, and were given to the S as his first PAL task (a-b learning). As his second task, each S then learned b-a lists: Lists 1’, 2’, 3’, 4’, and 5’. These b-a lists were constructed from their appropriate a-b lists by reversing the first and second members of a given pair. For example, Lists 1 and 1’ were identical except that the first terms of the pairs in List 1 (a-b) were the second terms of List 1’ (b-a), and vice versa.

The five conditions were varied with respect to the degree of the Ss’ first a-b PAL task. The criteria of the a-b learning were determined by the minimum number of correct responses on
a single trial. The criteria for Conditions B, C, and D were equivalent to learning respectively one-third, two-thirds, and the entire list (one perfect performance): 5, 10, and 15 out of 15 pairs in Exp. I; and 3, 7, and 10 out of 10 pairs in Exps. II and III. The criterion for Condition E was three consecutive perfect trials. Being a control, Condition A was given no a-b learning task. The summary of all conditions is given in the first column of Table 1. The criterion of the b-a task was identical for all conditions: one perfect performance on a single trial. For all experimental conditions, since Ss were required to anticipate on the first b-a trial, this trial served as a test of backward associations formed during the previous a-b learning. For Condition A, the control, since the Ss did not have a-b PAL, they did not guess on the first b-a trial, but started responding from the second trial.

On the first day of the five consecutive days required for each experiment, each S learned two practice pairs with a-b learning procedure. Following a brief pause, he was assigned, based on the Greco-Latin square, to one of the five conditions with one of the five lists for his first PAL. Each pair was stamped, with HIRAGANA-letters, on a 15 × 20 cm white index card. Experimental apparatus and method of card presentation are described in Izawa (1965). The pairs were presented with a modified anticipation method: for a-b learning, a given a-term was presented on the left side of the aperture for 3 sec and then the corresponding b-term alone for 3 sec on the right. There was a 1 sec interval between each pair presentation. The pairs were presented in random order on each trial, by shuffling them during the intertrial interval of approximately 15 sec.

After all a-b pairs were presented once, the S started to anticipate the response during a 3 sec stimulus exposure. After a-b learning was terminated, a 3 min rest interval followed with light conversation. Then, the S was informed for the first time that the second list contained the same paired-associates as the first, and that each pair was presented backward; and he resumed the PAL. The learning procedure for b-a learning was the same as the ones for a-b learning, and b-a task was completed when each S reached one perfect recitation on a single trial.

Immediately following the b-a task, an unaided free recall test was administered. Each S was instructed to recall freely as many items as possible in any order, and E recorded the responses. Following the free recall test, he was asked to describe his mnemonic devices or associations to each item. For both free recall and associations tests no time limits were imposed.

The experimental procedures of Exps. I and II were identical except for the learning materials: 15 word-pairs in Exp. I, and 10 nonsense syllable-pairs in Exp. II. Identical sets were learned for both Exps. II and III. In Exp. III, however, prior to the a-b task (b-a task for Condition A), each S was familiarized with each item used for the PAL tasks. Familiarization was accomplished by serial presentations of each of the 20 syllables, a- and b-terms being detached and rearranged, in random order by means of a Yagi memory drum. Similar familiarization was administered by Epstein and Streib (1962). No mention was made of relationships between the items of the subsequent PAL tasks. Each item was exposed for 1 sec and presented each S 9 times in total by repeating three 20-item series for three revolutions. There were 2 sec intervals between series. Excepting the familiarization procedure, Exp. III was conducted exactly the same as Exp. II. Since meaningful words were used in Exp. I, nonsense syllables in Exp. II, and familiarized nonsense syllables in Exp. III, for simplicity, let M-, N-, and N'- pairs be the pairs learned respectively in Exps. I, II, and III.

The same experimental procedures in a given experiment were repeated every day for five successive days for each S. Thus, each S in each experiment learned all five lists, each under a different condition. Overall, the present investigation utilized a semi-3 × 5 design, the first factor being the materials (M-, N-, and N'- pairs) and the second, the degrees of a-b learning. The term "semi-" is used
Effects of Meaningfulness and Familiarization upon Backward Associations

TABLE 1

Mean number of trials to reach criterion in each condition in each task in each experiment

<table>
<thead>
<tr>
<th>Condition</th>
<th>Exp. I M-Pairs</th>
<th>Exp. II N-Pairs</th>
<th>Exp. III N'-Pairs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a-b learning (first task)</td>
<td>b-a learning (second task)</td>
<td>Total</td>
</tr>
<tr>
<td>A (0/15)</td>
<td>—</td>
<td>6.2</td>
<td>6.2</td>
</tr>
<tr>
<td>B (5/15)</td>
<td>2.6</td>
<td>4.4</td>
<td>7.0</td>
</tr>
<tr>
<td>C (10/15)</td>
<td>3.4</td>
<td>4.4</td>
<td>7.8</td>
</tr>
<tr>
<td>D (1 perf.)</td>
<td>6.2</td>
<td>2.0</td>
<td>8.2</td>
</tr>
<tr>
<td>E (3 perf.)</td>
<td>8.2</td>
<td>2.4</td>
<td>10.6</td>
</tr>
<tr>
<td>A (0/10)</td>
<td>—</td>
<td>12.0</td>
<td>12.0</td>
</tr>
<tr>
<td>B (3/10)</td>
<td>4.2</td>
<td>10.4</td>
<td>14.6</td>
</tr>
<tr>
<td>C (7/10)</td>
<td>8.4</td>
<td>7.2</td>
<td>15.6</td>
</tr>
<tr>
<td>D (1 perf.)</td>
<td>11.8</td>
<td>6.6</td>
<td>18.4</td>
</tr>
<tr>
<td>E (3 perf.)</td>
<td>19.2</td>
<td>4.8</td>
<td>24.0</td>
</tr>
<tr>
<td>A (0/10)</td>
<td>—</td>
<td>12.0</td>
<td>12.0</td>
</tr>
<tr>
<td>B (3/10)</td>
<td>3.6</td>
<td>8.2</td>
<td>11.8</td>
</tr>
<tr>
<td>C (7/10)</td>
<td>5.2</td>
<td>6.8</td>
<td>12.0</td>
</tr>
<tr>
<td>D (1 perf.)</td>
<td>10.8</td>
<td>7.0</td>
<td>17.8</td>
</tr>
<tr>
<td>E (3 perf.)</td>
<td>18.2</td>
<td>4.8</td>
<td>23.0</td>
</tr>
</tbody>
</table>

due to the fact that the list lengths of Exp. I, and Exps. II and III were different.

RESULTS AND DISCUSSION

Acquisition

Table 1 presents the mean number of trials needed to reach the criteria in each condition for both a-b and b-a learning tasks. An analysis of variance for the Greco-Latin square was carried out for each learning task in each experiment. Highly significant and consistent differences were found among conditions throughout all experiments. The obtained Fs, all with df=4/8, for a-b and b-a PAL tasks were respectively 34.90 ($p < .001$) and 6.74 ($p < .05$) in Exp. I; 15.91 ($p < .001$) and 14.58 ($p < .001$) in Exp. II; and 66.70 ($p < .001$) and 3.54 ($p$ approaching .05) in Exp. III. Other sources were generally insignificant with minor exceptions. The differences among the five lists were insignificant throughout all tasks in all experiments of the present study. Learning-to-learn effects from day to day seemed to exist, especially for the b-a task of Exp. III; but generally, the trend was insignificant. Tangible differences were observed among Ss in Exps. I and II, although no individual differences were obtained in Exp. III. Since all Ss in a given experiment of the current investigation, however, participated in all of the five conditions, it is unlikely that subject variables would destructively distort the results in comparing the present conditions.

The lists of Exp. I were one and one-half times as long as those of Exps. II and III, but learning was significantly faster in Exp. I than in the others for both a-b and b-a PAL tasks ($p < .01$). Obviously noun-pairs were easier than nonsense syllable-pairs with or without familiarization. No differences were found between Exp. II and III, indicating that facilitating effects of familiarization were too slim to be detected in terms of the mean trials to criterion. When an analysis of variance was performed with conditions and tasks as main sources, of course, great differences were observed among conditions, but no
TABLE 2
Mean strengths of forward and backward associations
when criteria for a-b tasks were reached in each experiment

<table>
<thead>
<tr>
<th>Condition</th>
<th>Forward associations (F: a-b)</th>
<th>Backward associations (B: b-a)</th>
<th>Difference (B minus F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exp. I</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B (5/15)</td>
<td>8.0</td>
<td>8.2</td>
<td>+0.8</td>
</tr>
<tr>
<td>C (10/15)</td>
<td>10.8</td>
<td>9.2</td>
<td>-1.6</td>
</tr>
<tr>
<td>M-Pairs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D (1 perf.)</td>
<td>15.0</td>
<td>13.8</td>
<td>-1.2</td>
</tr>
<tr>
<td>E (3 perf.)</td>
<td>15.0</td>
<td>13.2</td>
<td>-1.8</td>
</tr>
<tr>
<td>Exp. II</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B (3/10)</td>
<td>4.0</td>
<td>1.4</td>
<td>-2.6</td>
</tr>
<tr>
<td>C (7/10)</td>
<td>7.2</td>
<td>4.6</td>
<td>-2.6</td>
</tr>
<tr>
<td>N-Pairs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D (1 perf.)</td>
<td>10.0</td>
<td>4.4</td>
<td>-5.6</td>
</tr>
<tr>
<td>E (3 perf.)</td>
<td>10.0</td>
<td>5.2</td>
<td>-4.8</td>
</tr>
<tr>
<td>Exp. III</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B (3/10)</td>
<td>3.6</td>
<td>3.2</td>
<td>-0.4</td>
</tr>
<tr>
<td>C (7/10)</td>
<td>7.8</td>
<td>5.8</td>
<td>-2.0</td>
</tr>
<tr>
<td>N’-Pairs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D (1 perf.)</td>
<td>10.0</td>
<td>4.2</td>
<td>-5.8</td>
</tr>
<tr>
<td>E (3 perf.)</td>
<td>10.0</td>
<td>5.0</td>
<td>-5.0</td>
</tr>
</tbody>
</table>

difference was found between the PAL tasks in a given experiment. However, interactions between conditions and tasks proved to be highly significant: Fs for Exps. I, II, and III were respectively 17.44, 25.57, and 18.60, all with df=4/40, p <.001. Apparently the more trials in the a-b task, the less trials in the b-a task, and vice versa.

The S’s PAL was completed when he reached one perfect b-a trial in each condition. That is, each condition had the equal level of associative strength required in the present study at the end of a given experiment. Therefore, if the level of associative strength is the determinant of learning, all conditions should require an identical number of total trials for a given experiment. However, the data showed that this is not the case, as the number of total trials increased almost monotonically from Condition A to E. Thus, the present study does not seem to support Underwood and Keppel (1963) who interpreted bidirectional learning as representing a simple summation of trials to learn forward and backward associations to the same level of strength.

Backward Associations
Backward b-a associations were measured at various stages of forward a-b learning in the present study. Table 2 gives forward and backward associations when a given learning criterion was reached. Since each criterion was set as the minimum number of correct responses on a single trial attained for the first time by a given S, forward associations actually obtained when he completed his a-b task should be determined: the values were entered in the second column of Table 2.

The first trial of the b-a learning task served as the test trial of the backward associations formed during the prior a-b learning task. The strength of backward associations for each condition is indicated in the third column. In the current investigation, backward b-a tests were always given after the appropriate a-b tasks. The S had, therefore, experienced an additional reinforced trial, which was inbedded in the present modified anticipation method. That is, the S had an opportunity to observe the correct response on the last a-b trial. The separation of reinforcing and testing
phases of an anticipation procedure has seen systematic investigations elsewhere (Izawa, 1966a, 1966b, 1967a, 1967b). This technical impurity of the anticipation method might have led to underestimation of the differences between forward and backward associations, as the backward associations test enjoyed one more reinforcing trial than the forward associations test. On the other hand, during the rest interval of 3 min between forward and backward associations tests some forgetting is bound to occur. Thus, there existed both positive and negative factors which might mitigate each other's influences. Thus, influences of the additional reinforcement might not seriously distort the results. This has ground for support from the following analyses. The forward associations which should have existed when one more anticipation trial was advanced, just as for the b-a test, can be inferred from the control, Condition A, with an appropriate manipulation. When this was done, the results were not significantly different from what is reported in Table 2, although this operation revealed slightly more inferior backward associations in general. When testing trials alone were repeated successively, Newman, Cunningham, and Gray (1965) and Newman and Gray (1964) reported no difference in the effects of the order of a-b and b-a tests whichever came first.

In each experiment, backward associations were significantly different among conditions: F's for Exps. I, II, and III were respectively 58.54, 18.48, and 7.48, all with df=4/8, p<.01. Albeit tangible differences were observed among Ss in Exp. II, all other sources were insignificant in all experiments.

Next, differences between forward and backward associations were investigated closely, condition by condition. In Exp. I, where M-pairs were learned, backward associations were stronger than forward associations early in learning (Condition B), .05<p<.10. This phenomenon was discovered previously by Izawa (1965), and was replicated in the present study. Later in learning, however, backward associations were significantly inferior to forward associations (p<.01) with meaningful word-pairs. In Exp. II, where difficult nonsense syllable pairs (N-pairs) were learned, backward associations were inferior to forward associations in all stages of learning: mostly p<.001. In Exp. III, however, where the same nonsense syllables underwent familiarization treatment (N'-pairs), no significant differences were observed in Condition B, although forward associations were stronger than backward associations at later stages of learning, with p<.001. This bit of evidence implies that by familiarization, N'-pairs became closer to M-pairs with respect to the course of forming backward associations.

When the comparisons were made among the three experiments, the course of formation of forward a-b associations exhibited a very similar trend for both M-pairs in Exp. I and N- or N'-pairs in Exp. II or III. However, when the course of formation of backward b-a associations was scrutinized, meaningful M-pairs and nonsense syllable N-pairs presented considerably different pictures. With M-pairs, early in learning, b-a associations were significantly greater than a-b associations. Although later in learning backward associations were significantly inferior to forward associations, the absolute strength of b-a associations increased as that of their a-b associations increased: backward associations being 85% to 92% as strong as forward associations. The present Exp. I was a close replication of Izawa's experiment (1965) with word-pairs. The relative strength of backward associations was in agreement with such studies as Thornton reported by Feldman and Underwood (1957), Underwood and Keppel (1963), Battig and Koppenaal (1965), and Segal and Mandler (1966) which respectively reported that backward associations were 83%, 85%,
62–81%, and 95% as strong as forward associations, using either adjective- or word-pairs.

With N-pairs in Exp. II in the present study, backward associations were significantly weaker than forward associations at all stages of learning. When \( a-b \) lists were one-third learned, as in Condition B, backward associations were 35% as strong as forward associations, and when the lists were two-thirds learned, backward associations showed the progress, being 64% as strong as forward associations. Nonetheless, this was the maximum backward-forward (B/F) ratio attained; and later in learning, the absolute number of correct backward recall reached an asymptote and B/F ratios remained as low as 44% to 52%. With nonsense syllable-pairs, although Leuba (1966) reported that backward associations were 85% as strong as forward associations following 15 \( a-b \) trials; Hakes (1965) produced backward associations 35% as strong as forward associations with dissyllabic paralogs following two successive perfect trials. With nonsense syllable-adjective pairs, both Feldman and Underwood (1957) and Jantz and Underwood (1958) obtained backward associations approximately 50% as strong as forward associations after two successive \( a-b \) perfect recitations. Nearly the same percentages of backward associations were also obtained by Morikawa (1959) with Japanese nonsense syllable-nonsense syllable pairs. Using trigrams, when \( a-b \) recall was given first and \( b-a \) recall second, Newman and Gray (1964) obtained data showing backward associations 60% to 76% as strong as forward associations if trigrams were easy to pronounce, but only 11% if they were hard to pronounce. The asymptotic phenomenon of backward associations was also obtained by Jantz and Underwood (1958) in which 4, 12, and 24 trials were used as \( a-b \) learning criteria.

The effects of familiarization on the formation of backward associations can be detected by comparing N-pairs in Exp. II and N'-pairs in Exp. III in the present study. Early in learning, familiarization led to better backward recall: the pooled data of Conditions B and C in Exp. III were significantly better than those of Exp. II with \( p \) approximately .10. When Condition B alone was considered, Exp. III produced significantly more backward associations than Exp. II, with \( p < .05 \). However, later in learning, as in Conditions D and E, no differences were found between N- and N'-pairs. Backward associations reached an asymptotic level in Exp. III, as in Exp. II, when two-thirds of the \( a-b \) learning list was acquired (Condition C) and no progress was made thereafter. This evidence implies that the effects of familiarization are limited to early stages of learning. The present findings are consonant with Gannon and Noble (1961) who state that the facilitating effects of familiarization were maximal early in the learning phase. These writers also reported that the influence of relevant \( a \)-term familiarization was positive and significant, but not that of relevant \( b \)-terms. Schulz and Tucker (1962b) observed that pronouncing the terms retarded learning when no familiarization was given. However, with 20 and 60 \( a \)-term familiarization trials the subsequent PAL was better for the group which pronounced terms than for the group which did not pronounce them. In the situations involving some negative transfer paradigms, familiarization inhibits the learning of backward associations as seen by Simon and Wood (1964), Simon and Cerekwicki (1964), and DeBold (1964).

The present findings show that familiarization improved the strength of backward associations significantly early in learning, especially when one-third of the list was learned. However, there still existed a great difference between M-pairs in Exp. I and N'-pairs in Exp. III. The above facts suggest that if familiarization were to alter meaningfulness, the extent
to which this would occur is greatly limited. In this sense, the present investigation seems to support Schulz and Tucker (1962a), Schulz and Thysell (1965), and Riley and Phillips (1959), who feel that meaningfulness, is not likely to be affected by familiarization; and seems to be against Underwood and Schulz (1960) and Gillooly (1966), who hold the position that familiarization would alter the m.

The current investigation took the form of M-M, N-N, or N'-N' pairs. With respect to backward associations M-pairs and N-pairs or N'-pairs differed significantly both in terms of absolute values and relationships between forward and backward associations. Richardson (1960), Morikawa (1959), Hunt (1959), and Jantz and Underwood (1958), among others, reported that a meaningfulness increased b-a learning. However, Cautela (1965) obtained the opposite results: b meaningfulness led to greater b-a learning than did a meaningfulness \(p < .05\) in agreement with the results of a-b learning. The obviously conflicting results of these studies cannot be evaluated from the present study, as its primary experimental purposes demanded the use of identical meaningfulness and familiarity for both terms of the paired-associates.

Newman and Gray (1964) felt that the inferiority of backward associations over forward would be greater at low than at high levels of pronounceability, but their own experiments failed to support this anticipation. Since it is not difficult to regard that M- and N-pairs of this study are considerably correlated to high and low levels of pronounceability respectively, Newman and Gray may have gained indirect support here.

Transfer

Learning curves of b-a PAL task given as the Ss’ second task, following the cor-

![Learning curves of the b-a learning tasks.](image-url)
TABLE 3
Item Analyses:
Relationships between forward associations formed during a-b learning task and backward associations produced on Test

<table>
<thead>
<tr>
<th></th>
<th>Forward associations</th>
<th>Condition</th>
<th>Backward associations (Mean number)</th>
<th>Ratio (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Produced</td>
<td>Not produced</td>
</tr>
<tr>
<td>Exp. I</td>
<td>M-Pairs</td>
<td>Learned</td>
<td>B</td>
<td>5.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C</td>
<td>7.2</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D</td>
<td>13.8</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E</td>
<td>13.2</td>
<td>1.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not learned</td>
<td>B</td>
<td>3.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>C</td>
<td>2.0</td>
</tr>
<tr>
<td>Exp. II</td>
<td>N-Pairs</td>
<td>Learned</td>
<td>B</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C</td>
<td>4.2</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D</td>
<td>4.4</td>
<td>5.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E</td>
<td>5.2</td>
<td>4.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not learned</td>
<td>B</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>C</td>
<td>0.4</td>
</tr>
<tr>
<td>Exp. III</td>
<td>N'-Pairs</td>
<td>Learned</td>
<td>B</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C</td>
<td>4.8</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D</td>
<td>4.2</td>
<td>5.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not learned</td>
<td>B</td>
<td>2.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>C</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Corresponding a-b learning, are given in Fig. 1. Comparisons between the control curve of Condition A, in which the S did not have the a-b learning task, and the experimental curves of Conditions B, C, D, and E, in which he had the a-b tasks, indicate clear positive transfer effects from the previous a-b learning to subsequent b-a learning both in terms of the numbers of correct responses and trials to reach the b-a criteria. In each experiment a family of learning curves was generated showing, with minor exceptions, the more a-b learning, the better b-a learning. Exp. I replicated well the earlier results by Izawa (1965) with like M-pairs. Similar basic learning processes with respect to the rank order of the conditions were observed with N-pairs in Exp. II as with M-pairs. With N-pairs, however, learning required a much longer time to reach the b-a criterion, and thus, the slopes of the curves are much less steep than those with M-pairs. As seen in Fig. 1, there was a consistent trend for each curve in Exp. III, to run higher than its corresponding curve in Exp. II, suggesting that familiarization facilitated b-a learning.

For each experiment an analysis of variance was performed on b-a learning curves with respect to all errors made by each S during all initial trials needed for all conditions: the first 3 trials in Exp. I; and the first 7 trials in both Exps. II and III. The obtained Fs for Exps. I, II, and III were respectively 17.45, 19.80, and 7.12, all being significant with df = 4/20, p < .001. Of course, when t-tests were
carried out between the control and each of the four experimental conditions, all experimental groups were proved to be significantly better than their respective control condition in all experiments, \( p < .001 \). When other analyses were carried out for transfer data as done by Izawa (1965), the present results demonstrated a close replication of the earlier ones. For this reason, the results of these particular analyses are not reported here. With respect to these transfer statistics, M-, N-, and N'-pairs did not seem to exhibit striking qualitative differences among them.

In order to investigate further relationships between forward and backward associations item analyses were made for each pair. For this purpose, in each condition in each experiment, all pairs were classified into one of the two groups: "Learned" or "Not learned" groups. These terms are defined in terms of whether or not the forward association of a given pair was formed when an assigned learning criterion was reached (when a-b learning was completed). Then, each pair was examined in order to determine whether it was correctly produced or not on the backward association test, given as the first trial of the b-a task following a-b learning. The results are shown in Table 3. Of course, forward associations were learned for all pairs in Conditions D and E during a-b learning. The last column indicates the percentages of backward associations of the pairs whose forward associations were learned, or not yet learned. It is interesting to note that in Exp. I where the S learned M-pairs, a considerable amount of backward associations were formed on the pairs whose forward associations were not yet learned. This fact should explain why backward associations were stronger than forward early in Exp. I. Similar results were also demonstrated by Izawa (1965). In Exp. II, where N-pairs were learned, backward associations were unlikely to be produced unless the corresponding forward associations were formed to begin with. However, when the same nonsense syllables were familiarized prior to the PAL tasks as in Exp. III, some backward associations were correct even though the corresponding forward associations were never correct during the a-b learning task. This bit of evidence should elucidate the significant role of familiarization of terms, which might lead to reducing the difference between words meaningful to the S and syllables nonsense to him.

**Free Recall**

A free recall test was given after the PAL tasks were completed, to investigate further the relationships between item availability and associative symmetry proposed by Asch and Ebenholtz (1962). When meaningful words were used for both terms of the pairs, as in Exp. I, almost all recalled items took the form of pairs; only 7 items out of 750 possible terms, including all conditions, were recalled separately without being paired with its corresponding partner. In Exps. II and III where either N- or N'-pairs were learned, however, slightly more separate individual items were freely recalled. For Conditions A, B, C, D, and E of Exp. II, respectively .4, .2, .6, .4, and .2 b-terms; and 1.6, 2.0, 1.4, 1.8, and .8 a-terms were recalled freely on the average. For the respective conditions of Exp. III, .0, .2, .0, .2, and .4 b-terms; and 2.0, 1.4, 1.4, .2, and .0 a-terms were responded. In these experiments, a-terms, which were response terms for b-a learning task, were recalled somewhat more than b-terms, the absolute values of the statistic, however, are too small to merit further theoretical implications. When all recalled terms were analysed, no differences were found between a- and b-terms in each condition in each experiment.

As all items, with negligible exception stated above, were responded as pairs on the free recall test, the pairs were further examined to determine in which direction
they were recalled freely. Fig. 2 contains the relevant results of this analysis. Since most of the freely recalled items were responded as pairs, the number of a- and b-terms were almost identical. Furthermore, including all items recalled, there were no significant differences between a- and b-terms. Thus, availability of a- and b-terms was equal in Asch and Ebenholtz's sense. However, further analyses revealed that the order of recalling each item with a given pair was systematically and consistently different in each experiment as clearly shown in Fig. 2. These facts cannot be expected from the principle of associative symmetry, as it denies the directionality, asserting that both a-b and b-a associations are equally strong provided that a- and b-terms are equally available. Therefore, strikingly systematic differences in the direction of recalling two terms of pairs observed in the present study stand against the principle of associative symmetry. In each experiment, although there were no significant differences among the conditions with respect to the total number of pairs freely recalled, the curve for the b-a order rises monotonically from Condition A to E. However, the curve for the a-b order falls monotonically from Condition A to E. Obviously the more a-b learning trials, the more free recalls in the a-b order; and the more b-a trials, the more recalls in the b-a order. Because of the systematic relationships between trials to criteria of PAL tasks and the number of pairs freely recalled, the correlation coefficients were calculated between the mean number of trials to criterion of each PAL task and the mean total number of pairs recalled on the free recall test. The obtained correlation coefficients, rs, for the a-b and b-a directions were respectively .993 and .966 in Exp. I; .992 and .909 in Exp. II; and .970 and .769 in Exp. III.
The high rs lend support to the directionality hypothesis proposed by Izawa (1965), stating that a given directionality of the items of pairs is one of the determinants of associative learning of PAL.

**Associations**

When the Ss are required to learn words or nonsense syllables as pairs, they often create associations or mnemonic devices in the experimental room to aid on-going PAL. This fact is widely recognized by such writers as Clark, Lansford, and Dallenbach (1960), Bugelski (1962), Runquist and Farley (1964), Goss and Nodine (1965), and Wearing and Montague (1967). Therefore, in the present study, each S was asked, following the free recall test, about how he learned or remembered each item and each pair. In Exps. I all associations created by the S during his PAL tasks were devised as pairs, and not as separate items. The mean numbers of these associations attached to M-pairs were constant throughout all conditions: 86.4% of the pairs (S.D. = 6.26%). With similar learning materials, Izawa (1965) reported that high school students devised associations to 53.8% of the given pairs. Evidently the university students employed in the present study excelled in devising mnemonic associations more than the high school students used previously. In Exps. II and III, where nonsense syllables or familiarized nonsense syllables were learned as pairs, a few separate individual items obtained associations without being paired. Such cases were .44% of the items in Exp. II and 7.40% in Exp. III. Most associations of these two experiments, however, were attached to two appropriate items as pairs. The percentages of pairs tied with Ss' unique associations were constant throughout all conditions: 59.2% (S.D. = 5.74%) in Exp. II, and 60.8% (S.D. = 7.46%) in Exp. III. When the pairs or items recalled freely were examined concerning the Ss' mnemonic associations, the same statistics were 87.4%, 67.8%, and 79.5% for the pairs; and 85.3%, 53.6%, and 56.4% for separate items alone respectively in Exps. I, II, and III. Here exists a trend for more associations to be attached to N'-pairs than to N-pairs. Of course M-pairs were most easily tied with Ss' associations. It is interesting to note that a high school student was able to free-recall better than he could devise mnemonic associations (Izawa, 1965), but that a university student in the present Exp. I exceeded more in attaching association devices than he could recall freely. For Exps. II and III the absolute number of pairs with mnemonic associations and the number of pairs freely recalled were about the same in general.

**Discussion on Associative Asymmetry**

The present results, as well as the previous ones (Izawa, 1965), established that backward associations are closely related to forward associations. At the same time they showed that backward and forward associations might not necessarily be identical, suggesting that associations might be fundamentally somewhat asymmetrical. If not, at least, availability of the two terms of the pairs alone will not explain the whole process of associative learning of PAL. This point is well supported by the data obtained by Battig and Koppenaal (1965) who used double function pairs in which each item of the list served once as the stimulus term of a given pair, and once as the response term of another pair, making both terms equally available. Furthermore, Underwood and Keppel (1963), Voss (1965), Schild and Battig (1966) and Segal and Mandler (1966) demonstrated that learning was more difficult under bidirectional practice than conventional unidirectional practice. These studies argue against the principle of associative symmetry, as it would have to predict equal learning speed for both uni- and bi-directional practice. These studies lend support to the directionality hypothesis (Izawa, 1965), as two direc-
tions have to be learned for bidirectional conditions, but only one direction for unidirectional conditions.

Availability, investigated by Horowitz, Brown, and Weissbluth (1964), might reflect, in part, the frequency of occurrence of each item in the associative structure they devised, as one of the influencing factors. When their data were reanalysed from this point of view for each item which was responded by the S, the average probabilities obtained from all responses for a given item for their combined data (N+W) in Exp. I were .05, .06, .05, and .10 respectively for items A, B, D, and F which served as stimuli only once in their structure; .27 for G which served twice as responses; and .32 and .32 for C and E which had three chances, twice as responses, and once as a stimulus. These statistics are impressively consistent with the frequency hypothesis. When C-E were detached in Horowitz et al.’s Exp. II (1964), the same A, B, D, and F had the mean probabilities .08, .09, .05, and .12 respectively. The new C, E, and G which now had an equal opportunity to appear twice in the structure had the mean probabilities .28, .27, and .29. Perhaps frequency is one of the factors which made C available to E without linkage. When the same analyses were made for the data by Horowitz, Norman, and Day (1966), this frequency hypothesis gained additional support.

The studies reviewed in this section suggest that the whole process of associative-learning may not be sufficiently explained by the equal availability of terms involved in paired-associates alone. It is likely that availability of terms constitutes only part of the whole process of associative learning.

Ekstrand (1966), who reviewed this subject up to the middle of 1965, felt that there was a shortage of evidence against symmetry, concluding "... that difference between forward and backward associative learning has been drastically overestimated and that if symmetry is not the rule, asymmetry will be very small." (p. 60). However, evidence from the more recent studies, such as Battig and Koppenaal (1965), Voss (1965), Weiss (1965), Coutu (1966), Leuba (1966), Schild and Battig (1966), Sedivy and Kausler (1966), and Segal and Mandler (1966), strongly suggests that symmetry is not universally true. It appears, instead, that asymmetry is the general rule, and symmetry is a special case in which many of the determinants coincided to produce the identical associative strength in both directions.

REFERENCES


Gillooly, W. B. 1966 The effect of familiariza-
Effects of Meaningfulness and Familiarization upon Backward Associations


(Received May 22, 1967)