MEDIATED FACILITATION OF SYLLOGISTIC REASONING

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The 2nd and 3rd syllogistic figures correspond to stimulus- and response-equivalent mediation paradigms, respectively. It was predicted that increasing the associative strength between the mediating term and the subject and predicate of syllogisms would facilitate validity judgments of the S-equivalent syllogisms but interfere with R-equivalent judgments. 54 college Ss participated in a 3 × 3 × 3 design which showed that errors in reasoning increased as associative strength increased. The R-equivalent syllogisms produced more errors. Association and syllogistic figure interacted as predicted. Increasing the amount of incidental verbiage in the syllogisms tended to improve reasoning, but not significantly. Variation in the time between the 2 premises, and between the last premise and conclusion, did not influence reasoning.

The ability to reason deductively is an important component of intelligence, but reasoning can be influenced by many extralogical factors. Some of the general factors explored previously include the "atmosphere effect" (Sells, 1936), the influence of personal belief in the conclusions (Janis & Frick, 1943), and the effect of emotional content on judging the validity of syllogisms (Lefford, 1946).

In a recent study, Frase (1968) investigated some specific sequential factors in reasoning that mediation theory suggested might be important. He described the four syllogistic figures as being analogous to the forward chain, stimulus (S) equivalence, response (R) equivalence, and reverse chain three-stage mediation paradigms. The first syllogistic figure has the form "All M are P. All S are M. Therefore, all S are P." which can be diagrammed as a forward chain of associations in which M is associated to S and P is associated to M; S-M-P. The association is unidirectional. The fourth syllogistic figure has the form "All P are M. All M are S. Therefore, all S are P," which can be diagrammed as a reverse chain of associations (P-M-S) in respect to the associations asserted in the conclusion that S must judge as being a valid or invalid deduction from the premises. Frase predicted that the forward-chain paradigm (first syllogistic figure) would produce the least errors in reasoning, and the reverse chain (fourth syllogistic figure) the most. In two studies (Frase, 1966, 1968) these predictions were confirmed even though the qualifiers used in the syllogisms had no semantic content (they were letters of the alphabet)—a condition certainly not conducive to mediation.

Differential facilitation of reasoning should be stronger when words, rather than abstract symbols, are used. Our experiment has systematically combined words to produce more or less errors in reasoning, but no paradigmatic effects were under consideration. Frase (1966). Early research has indicated that syllogistic reasoning is facilitated with common words as opposed to abstract symbols or unusual terminology, the latter being most difficult (Wilkins, 1928).

In the present study the associative strength (Bilodeau & Howell, 1965) of the words used in syllogisms was varied using the second (S-equivalent) and third (R-equivalent) syllogistic figures. The second syllogistic figure has the form "All P are M. All S are M. Therefore, all S and P," and can be diagrammed as P > M. The third syllogistic figure has the form "All M are P. All M are S. Therefore, all S and P," and can be diagrammed as M < S. The assumption is that the association M-P (where P is associated to M, but not M to P) corresponds to the first stage of mediation, M-S to the second stage, and S-P to the third stage. Theory and research in verbal learning (Goss, 1961; Jenkins, 1963) suggest that because the third syllogistic figure requires different responses (S and P) to the same stimulus (M), it can produce interference and hence more errors in reasoning. These interference effects should increase as the association between the mediating term M and the terms S and P increases, providing that the initial association between S and P is controlled. Conversely, the S-equivalent (second) figure should facilitate reasoning, and facilitation should increase as the association between the mediating term and S and P increases. One purpose of this study was to determine if this extrapolation from verbal learning processes to deductive judgment is warranted.

Another factor explored in the present study was the influence of irrelevant words interpolated into the prem-
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1 to stimulus- and reply. It was predicted that the mediating term would facilitate validity of the figure with R-equivalent 3 X 3 X 2 design and associative strength and 3 stages of the S-equivalent figure, with the greater the facilitation. The studies of the words used in syllogisms was varied using the second (S-equivalent) and third (R-equivalent) syllogistic figures. The second syllogistic figure has the form “All P are M. All S are M. Therefore, All S and P,” and can be diagrammed as $S \supset M$. The third syllogistic figure has the form “All M are P. All M are S. Therefore, all S and P,” and can be diagrammed as $P \supset M$. The assumption is that the association $M \rightarrow P$ (where $P$ is associated to $M$, but not $M$ to $P$) corresponds to the first stage of mediation, $M \rightarrow S$ to the second stage, and $S \rightarrow P$ to the third stage. Theory and research in verbal learning (Goss, 1961; Jenkins, 1963) suggest that because the third syllogistic figure requires different responses ($S$ and $P$) to the same stimulus ($M$), it can produce interference and hence more errors in reasoning. These interference effects should increase as the association between the mediating term $M$ and the terms $S$ and $P$ increases, providing that the initial decision between $S$ and $P$ is controlled. Conversely, the S-equivalent (second) figure should facilitate reasoning, and facilitation should increase as the association between the mediating term $S$ and $P$ increases. One purpose of this study was to determine if this extrapolation from verbal learning processes to deductive judgment is warranted.

Another factor explored in the present study was the influence of irrelevant words interpolated into the premises and conclusion of the syllogisms. This verbiage, while embedding the task in a more naturalistic setting, also increases the number of possible irrelevant associations. Jensen (1966) found that embedding P-A items in sentences (e.g., the HAT fell off the TABLE) reduces learning time. He also found that the more verbally rich the sentence (e.g., The red felt HAT silently rolled off the TABLE), the greater the facilitation. The studies of the words in syllogisms were obtained even though the words are irrelevant to the validity of the syllogism.

Time relations also were investigated in the present study. Frase (1968) varied the overall time permitted to judge the validity of syllogisms and found that 30 sec. was optimal. In the present study Ss were allowed at least 30 sec. to make judgments, but the time between the two premises, and between premise and conclusion, was varied. Peterson (1965), using nonsense syllables in a paired-associate task, supported the hypothesis that mediation effects decrease as the delay between acquisition stages increases. It was anticipated that reasoning would be more influenced by interacquisition-stage intervals (IAS) — between Premise 1 and Premise 2, and Premise 2 and the conclusion — than by the overall judgment time as used in Frase’s (1968) study.

METHDO

Subjects.—Fifty-four introductory psychology students at the University of Massachusetts participated as a class requirement. An additional 18 Ss were discarded randomly to equalize groups.

Test Items.—Of the following moods$^a$ of invalid syllogisms used in the experiment,

$^a$“Mood” refers to the formal logical words, such as “All,” “Some,” used in syllogisms. Propositions can be expressed as

$$M \supset P, \quad S \supset \text{not } P, \quad \text{and } \text{not } (M \supset S)$$

The following mood is used in the experiment:

$$M \supset P, \quad S \supset \text{not } P, \quad \text{and } \text{not } (M \supset S)$$
EAI, EEI, AOE, III, IEI, all five violate similar logical rules across the two syllogistic figures (S- and R-equivalence). For each of the 10 mood-figure combinations under investigation, two levels of associative strength using words (Bilodeau & Howell, 1965) and a third level using nonsense syllables (Witmar, 1935) were employed. Under the high-associative word conditions, the probability of the first element of a premise eliciting the second element was greater than .10 with a mean across all moods of .30. The associative strength between elements of the conclusion in the high-associative condition as with the other associative conditions was generally zero. Probabilities of first elements of premises eliciting the second term in the low-associative condition generally was zero, with a mean across all moods of .005. In the control nonsense syllable condition, sets of three CCCs of low-associative value (p < .04) and no more than one letter in common between each other (a control for similarity) constituted the syllogistic qualifiers. There was a total of 30 invalid syllogisms. Twelve valid syllogisms of the moods EIO, OAO, and AOO were used as filler items.

Verbal bias was manipulated by varying the amount of words preceding the quantifiers some, all, no, or some/not. The Ss in the low-verbal conditions were shown all figure-associations-mood combinations the basic logical syllogism, e.g.,

No grass is red.
All grass are plants.
Some plants are red.

Four to five words preceded the basic statements in the medium-verbal conditions:

Henry David Thoreau surmised that no grass is red.
He further recorded that all grass are plants.
From this we conclude that some plants are red.

Whereas, in the high-verbal conditions, a string of nine to ten words was added:

by sentences of the form. All X are Y (an A proposition), No X are Y (an E proposition), Some X are Y (an I proposition), and Some X are not Y (an O proposition). Mood AAA then indicates that both premises and the conclusion begin with "All," mood AAE indicates that the two premises begin with "All," but the conclusion must be of the form "No X are Y."

Henry David Thoreau in his leisurely recordings of nature surmised that no grass is red.
Further observations in his isolated paradise led to the recording that all grass are plants.
We, after hearing his works many times, have concluded that some plants are red.

Materials.—Each premise and conclusion was separately typed on 3X5 in. index cards, then photographed on high-contrast copy film. The mounted negatives were displayed by a projector (Kodak Carousel) on a standard high-contrast projection screen so that lettering was 1½ in. high. The Ss were seated at an average distance of 12 ft. from the screen. The IASI was regulated by a three-speed automatic changer. Exposure time was manipulated by a solenoid shutter attachment wired to timers (Hunter Model 111-C).

The sequence of presenting the syllogisms was randomized with the following restrictions: within each of three blocks of 14 syllogisms each mood appeared twice; each figure appeared three to four times in combination with approximately equal numbers of associative strength items. Each S thus viewed 42 syllogisms (30 invalid and 12 valid).

The Ss recorded their validity judgments on paper after each syllogism.

Procedure.—The Ss were directed to a standard classroom equipped with a slide projection screen, where alternate seats were taken. Pencils and answer sheets were placed on the desk tops. The E then read the standard instructions on the method for recording validity judgments. After two practice syllogisms, about which correct answers were not given, E asked if there were any further questions. The experiment then proceeded.

The IASI between Premise 1 and Premise 2, and Premise 2 and the conclusion was independently varied while holding exposure time for each slide constant at 0.0 sec. The three levels of IASI were 2.0 sec., 0.5 sec., and 10.0 sec. Ten seconds elapsed between offset of a conclusion and the offset of the following syllogism to equate for judgment time in all groups. Each of the nine groups was run in a separate session over a period of 24 hr.

Design.—A 3 (Time) X 3 (Verbal Bias) X 3 (Association Value) X 2 (Figure) factorial design with repeated measures on the last two factors was used to analyze number of errors.

RESULTS

Table 1 presents summary data for all conditions. The data report the mean number of errors made on the five experimental syllogisms of each cell of the design. There was a significant figure effect, F (1, 45) = 27.9, p < .001. The mean number of errors for the R-equivalent paradigm was 1.23; for the S-equivalent paradigm, 2.25; for the E-equivalent paradigm, 2.47.

ASSOCIATIVE STRENGTH

Fig. 1. Number of reasoning errors as a function of meaningfulness and syllogistic paradigm.
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TABLE 1
MEANS AND SDs OF ERRORS ON FIVE SYLLOGISMS FOR ALL CONDITIONS

<table>
<thead>
<tr>
<th></th>
<th>S-Equivalent</th>
<th>R-Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>ISI (sec.)</td>
<td>2</td>
<td>2.06</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>1.78</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>1.89</td>
</tr>
<tr>
<td>Verbiage</td>
<td>Low</td>
<td>1.94</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>1.33</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>1.72</td>
</tr>
</tbody>
</table>

Note.—N = 18 for each mean.

RESULTS

Table 1 presents summary data for all conditions. The data reported are the mean number of errors made on the five experimental syllogisms in each cell of the design. There was a significant figure effect, F (1, 45) = 15.64, p < .001. The mean number of errors for the R-equivalent paradigm was 2.25; for the S-equivalent paradigm it was 1.87.

Associative strength was also a significant factor, F (2, 90) = 3.84, p < .05. When association was present, errors increased. Error means under the high, low, and nonsense syllable control conditions were 2.12, 2.19, and 1.86, respectively. There was also a significant interaction between syllogistic figure and associative strength, F (2, 90) = 18.64, p < .001. Figure 1 displays this interaction. It can be seen that interference under the R-equivalent paradigm (syllogistic figure three) was maximal when the mediating term was highly associated with the subject and predicate terms of the syllogism.

The result was not significant, F (2, 45) = 2.42; however, there was a tendency for errors to increase with less verbiage. An average of 2.38 errors occurred under low verbiage, 2.03 and 1.77 under medium and high verbiage, respectively.

The effect of time intervals was not significant, F (2, 45) = .02.

DISCUSSION

The process of deductive reasoning proceeds, at least in part, in accordance with what we know about P-A tasks. The S-equivalent syllogisms resulted in significantly fewer reasoning errors than the R-equivalent syllogisms. The results
REFERENCES


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(Received August 18, 1967)

of the present study also showed that reasoning errors increase as the associative relation between the mediating term and other terms in the syllogism increases, at least for invalid syllogisms.

The fact that there was little difference between the S- and R-equivalent syllogisms under both the control and low-associative conditions confirms the results of Frase (1968), but the differences between the two syllogistic figures under high-associative conditions suggests that he might also have found differences with those paradigms if he had used meaningful words. The nature of the interaction between syllogistic figure and association indicates that competing responses, which are required to some mediating verbal event, interfere with reasoning.

The results of adding extraneous verbage to the syllogisms indicated a slight tendency for the richer verbal context to facilitate reasoning rather than to produce interference, but this did not appear to be a significant factor. The critical verbal units are those that Ss manipulate in deducing the validity of the conclusion, i.e., the subject, predicate, and middle terms of the syllogism. Logically, the semantic content of these words is irrelevant to the validity of the argument; however, as this study has shown, these extralogical factors influence reasoning in a systematic manner.

In summary, the present study has shown that mediated associations play a significant role in deductive reasoning; and that some of our knowledge of basic verbal learning processes is applicable to the associative processes involved in such reasoning.