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THE EFFECT OF COMPLEXITY OF NATURAL LANGUAGE MEDIATORS AND THE ASSOCIABILITY OF PAIRS ON PAIRED-ASSOCIATE LEARNING

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The Effect of Complexity of Natural Language Mediators and the Associability of Pairs on Paired-Associate Learning

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Abstract

Natural language mediators (NLMs) are widely used by Ss in paired-associate learning. Experiments which have documented their effect on learning have, however, largely ignored qualitative differences between them. Two large groups each learned a different CVC-word list after which they reported any NLMs they had used. Judges rated the complexity of NLMs using a scale developed by Martin, Boersma and Cox (1965) with different materials. The results agree with theirs in that complex NLMs produced fewer errors in learning. However, some categories on the scale were used infrequently which may indicate that, at least with highly meaningful material, a simpler dichotomous categorization (NLM or Rote) may be preferable.

Because the two lists were different in learning difficulty, a second experiment was carried out in which the probability of NLM formation for each of the stimulus pairs was determined, as this variable, called associability (AS), has been shown to be related to the rate of paired associate (PA) learning, (Montague and Kiess, 1966). An independent group of 50 Ss were presented with the CVC-word pairs used in the first experiment, and the Ss wrote down any NLM they had for each pair in 15 seconds. The proportion of Ss giving an NLM for a pair was defined as its AS value. It was found that for the items in both lists

the correlation between acquisition errors and AS value was -.64.

A subject (*S*), in a paired-associates (PA) learning task, often tried to integrate pairs into the structure of his language behavior. Underwood and Schulz (1960), Clark, *et al* (1960) and Bugelski (1962), among others, all report that *S*s frequently use associate devices, even with items low in meaningfulness. Since these devices presumably come from an *S*'s own language experience, we will refer to them as natural language mediators (NLMs). There is some agreement that NLMs are related to facilitation of learning (Dallett, 1964; Jensen & Rohwer, 1963; Kiess and Montague, 1965) and, are important in retention (Groninger, 1966; Montague, Adams & Kiess, in press; Reed, 1918).

Most experimenters have been content merely to contrast the use of NLMs with rote learning. Little attention has been given to qualitative differences in NLMs. One exception is due to Martin, Boersma and Cox (1965), who attempted to evaluate differences in NLM complexity and relate them to PA learning. They required that judges examine each associative strategy reported by an *S* and assign it to one of seven categories depending on its complexity. Martin *et al* (1965) found a significant relationship between complexity and performance during learning trials, more complex mediators being associated with superior acquisition performance. The purpose of the first experiment in this study was to examine the adequacy of the scaling method used by Martin *et al* (1965) in predicting errors in PA learning using different stimulus materials. In contrast to the low meaningful disyllabic paralogs they used, the present experiment employed CVC-word pairs.

Differences in error rates in learning two lists that were presumed to be similar with respect to learning difficulty necessitated a second experiment. In this second experiment, the relationship between errors in learning, and an independent measure of the likelihood of NLM formation was examined.

Experiment 1

Method

Subjects and materials. Two unequal groups of undergraduates served as Ss in the experiment. Each group (n = 95 or 70) learned a different 12-item PA list (List 1 and List 2 respectively). Stimuli were CVCs of 24-30% association value (Archer, 1960) and the responses were familiar words selected from Thorndike and Lorge (1944). The pairs are shown in Table 1.

Procedure. Items were presented automatically under the control of a computerized teaching system entitled PLATO (Programmed Logic for Automatic Teaching Operation), which is described in detail by Bitzer, Lyman and Easley (1966). This apparatus enabled a group of 20 Ss to be run at a single time while still maintaining precise control over the procedures for each S. The use of the system allowed the employment of a modification of the recall or study-test method that was developed by Gillette (1936) and Battig (1965) which provides conditions for more efficient learning determined, in part, by a S's own progress. In this procedure, all items must be responded to correctly once in order to complete a trial. To accomplish this, when an S responds incorrectly

Table 1

List Pairs, Scaled Association Value of the Stimulus (AV)[1], Response Word Frequency (WF)[2], Mean Number of Errors Per Pair to Criterion, and AS Value

Items List 1	AV	WF	Mean No. Errors (n=70)	AS Value[3]	Items List 2	AV	WF	Mean No. Errors (n-95)	AS Value[3]
BIJ-THIEF	25	28	1.46	.84	VAH-QUIET	27	A	2.31	.74
ZOK-EARTH	24	AA	1.10	.74	ZAS-WHERE	25	AA	2.01	.70
JEH-FRUIT	25	AA	1.90	.84	CUY-BIBLE	29	25	1.52	.60
FIY-TABLE	25	AA	1.56	.88	GIK-EAGLE	30	38	2.04	.64
RUQ-MUSIC	24	AA	1.87	.78	PUJ-CARRY	28	AA	2.19	.66
TOV-GREEN	25	AA	1.23	.60	YOD-DOORS	25	AA	2.11	.80
XAR-BLACK	25	AA	1.94	.88	LEQ-SHORT	28	AA	1.58	.88
QES-OCEAN	26	AA	1.37	.82	BUH-STAND	24	AA	2.21	.68
MAJ-SWEET	26	AA	1.66	.78	XIP-SHEEP	26	A	1.77	.80
KEB-HEAVY	25	AA	2.24	.66	MIB-STOVE	27	40	2.32	.34
WUG-SHOES	27	AA	1.64	.78	QOM-CHILD	27	AA	1.66	.80
NAX-DREAM	27	AA	2.40	.70	SEJ-SPEAK	24	AA	1.89	.62
MEAN	25.3		1.70	.79		26.7		1.95	.69

[1] Archer, 1960

[2] Thorndike and Lorge, 1944

[3] See Experiment 2

to a pair, it is presented again until a correct response is made. When a correct response is given, the pair is dropped out and only pairs responded to incorrectly are presented for the remainder of the trial. Hence, each S may proceed through a trial in a unique manner which makes the technique difficult for an experimenter to use. To facilitate the employment of this procedure, Webber and Montague (1966) developed a program for the PLATO system that can be readily adapted to present paired-associates in this fashion.

All pairs were presented on the CRT display for 4 seconds. Then, using a different item order, each stimulus item was presented singly for 4 seconds. During this time, the S had to type the appropriate response (a five-letter word) on his keyboard which was on-line to a CDC* 1604 computer. Pairs for which S's response was not correct were presented again in another order and then the stimuli for these pairs were again presented for another recall test. This procedure was repeated until all the items were correctly recalled, thus ending a trial. Then another trial was started by presenting and testing the entire list. Learning ended when the S attained a criterion of 10 out of 12 items correct on the initial test sequence of a trial. All key press responses made by the S were recorded and judged by the program in order to control the progress of each S independently of the other Ss.

Immediately after attaining criterion, Ss were asked to respond in writing to a questionnaire. Only the stimulus members of each pair were shown on the display, one at a time. The S was asked to write on a data

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*Control Data Corporation

sheet both the response (if he recalled it) and the learning method in detail that he had used in learning the pair. Progress through the items on the questionnaire was self-paced.

Results and Discussion

The mean number of errors to criterion for each pair is shown in Table 1. Although the association value of the stimuli and the familiarity (frequency, as measured by Thorndike and Lorge, 1944) of the responses was high and homogeneous, the lists differed in difficulty, i.e., number of errors made to criterion ($p < .05$). The reason for this difference is discussed in Experiment 2, described below.

The data of main importance are those related to the evaluation of responses obtained on the post-criterion questionnaire. The reports were categorized for each list according to the scheme developed by Martin et al (1965). Two judges independently assigned each report to a category. The reliability of these ratings was high, with fewer than 3% being the subject of disagreement. Figure 1 shows the rank order of complexity and the mean number of errors made on pairs falling in each category.

These results are in agreement with those of Martin et al (1965), in that ease of learning is a function of the complexity of the associative strategy used in learning. The decrease in errors over categories is highly significant, the value of the chi-square obtained from the Errors X Categories contingency table being significant at the 0.1%

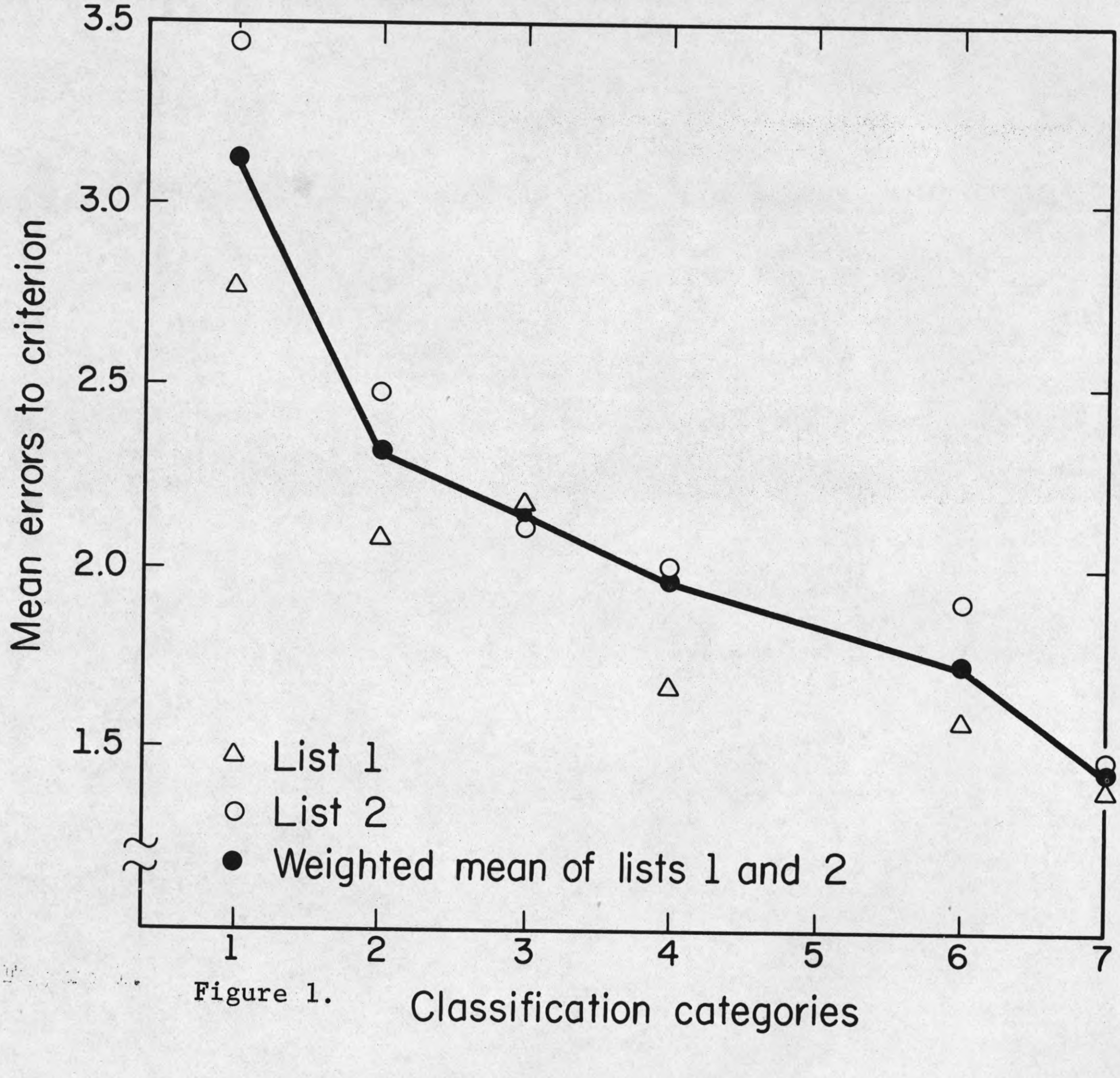
3.5
3.0
2.5
2.0
1.5
Mean errors to criterion
△ List 1
○ List 2
● Weighted mean of lists 1 and 2
1
2
3
4
5
6
7
Classification categories

Figure 1.

level. However, examination of the number of items falling into the various categories calls in question the advisability of the necessity for using all seven categories in the judging process.

Table 2

Mean Number of Errors During Acquisition and the Percentage of Responses Falling into Each Category for Both Lists

		List 1 (Group 1)		List 2 (Group 2)	
Category	Description*	Mean Errors	Percent Responses	Mean Errors	Percent Responses
1	No Report	2.77	3.7	3.44	2.8
2	Rote or repetition	2.08	33.0	2.48	32.7
3	Single letter cues	2.17	2.4	2.11	9.4
4	Multiple letter cues	1.67	0.2	2.00	3.6
5	Word formation	---	0.0	---	0.0
6	Superordinate	1.58	20.2	1.92	11.4
7	Syntactical	1.40	40.5	1.48	40.1

*See Martin, Boersma and Cox (1965) for a more detailed explanation of the meaning of these terms.

From Table 2 it can be seen that categories 2 (simple, rote or repetition learning), 6 and 7 (transformation of items and the use of syntactical relationships) contain almost 90% of the 1980 responses recorded. For this material, few reports fall into categories 3, 4 and 5 which involve NLMs using letter associations or the like. This fact suggests that if an S uses a NLM at all, it is a complex one.

Therefore, the dichotomous classification system used by Montague et al (i.e., NLM or rote) may offer a simpler, but by no means less useful means of tabulating the data. The failure to replicate the kind of distribution obtained by Martin et al (1965) is probably due to differences in the materials used in the two studies, although their procedure differed somewhat also. They used a recognition rather than a recall procedure on test trials and low association value paralogs for their pairs. With such materials it seems intuitively likely that the physical structure of the stimuli would be used more often in NLM formation than with more meaningful materials such as those used in this study. Boersma, Conklin and Carlson (1966) found a similar shift away from these intermediate categories when they used meaningful materials. However, although in the present study these categories contain only a few instances, the mean error scores conform to the general expectation of Martin et al (1965) in that the complexity of the associative strategy is a correlate of PA performance.

Experiment 2

The significant difference between the lists with respect to learning difficulty (errors to criterion) presents a problem in interpretation to which the second experiment was addressed. As can be seen upon inspection of Table 1, the stimuli and responses for both lists are approximately equivalent in association value and frequency, yet significantly more errors were made on List 2. Was the difference produced by the fact that the groups were not equivalent or were the lists not equivalent? In this experiment evidence will be presented supporting the latter hypothesis.

The importance of NLMs and their complexity for paired-associate learning has been demonstrated in several experiments. If Ss can devise associative aids for pairs, the pairs are learned faster. A single word may be used to link the two items or a phrase may be generated which includes the item. Our knowledge of these devices is obtained by means of a questionnaire administered upon the completion of the experiment. The procedure, although useful in suggesting research, may be called into question. It is possible that Ss construct answers to "please" the experimenter, and the NLMs reported may not be accurate descriptions of how learning took place. In addition, the form or content of NLMs may change during several trials, or item pairs for which NLMs are not immediately available may come to yield reports of mediation during the learning sequence. It follows that some independent measure of the likelihood of NLMs being formed for pair-associates is necessary. Montague and Kiess (1966) undertook to scale CVC pairs for Associability (AS). Large groups of Ss wrote any NLMs they had for the pair. The scale value represents the proportion of Ss reporting an NLM for each pair. Associability value variations were shown to produce reliable differences between groups in learning rate (Montague and Kiess, 1966).

The evidence showing AS value to be related to learning rate suggested that the observed differences in acquisition errors between the lists in the previous experiment may have been produced by differences in AS value. Therefore, in this experiment, we undertook the task of scaling the pairs used in these lists, and then comparing the scale values with the errors made during learning.

Method

Subjects. The Ss comprised two groups each containing 25 paid undergraduates at the University of Illinois.

Procedure. A slide projector was used to present in random order the 24 pairs shown in Table 1 along with 24 additional pairs of the same type that were used in another experiment. Each pair was shown separately for a period of 15 seconds. The Ss were instructed to write down any association that they could think of between each pair as it was presented.

The associability (AS) of each pair was defined as the proportion of Ss who were able to write down an association for the pair during the 15 second presentation period.

Results

The results are straightforward. The associability of the pairs used in Experiment 1 are shown in the column labelled "AS value" in Table 1. Using a one-tailed t-test, it was found that List 2 had significantly more errors than List 1 ($p < .05$), and List 2 had also a significantly lower AS score ($p < .02$). The outcome may be expressed in correlational terms, the rank order correlation between AS value and error score being -.64 ($p < .001$).

The justification of the one-tailed test derives from our expectation about the realtionship between AS and errors, namely, that they would be negatively correlated.

Discussion

The results of Experiment 2 allow us to account for the difference between the two lists in Experiment 1 with respect to acquisition errors (see Figure 1). Although there are no significant differences between the Archer _a_ values, or the Thorndike-Lorge word frequency counts for the two lists, there is a significant difference between the two sets of AS values.

The AS values, obtained from an independent group of _S_s, correlated -.64 with acquisition error scores, indicating that individual characteristics of stimulus pairs have a considerable effect on learning, when the characteristics in question refer to their associability in terms of generation of mediators. Clearly, the difference in the acquisition errors of the two groups is due to the materials rather than the _S_s. In other words, verbal reports about NLMs from one set of _S_s, predict the verbal reports and the error scores of another set of _S_s. These results provide yet more evidence that NLMs are not epiphenomena, but are related in a functionally significant fashion to learning, particularly in view of the fact that normative NLM data were able to predict performance in a much more powerful fashion than the traditional measures.

This study set out to achieve two goals. The first was to replicate the result of Martin _et al_ (1965). The second was to investigate the relationship between errors in PA learning for individual items, and the independently determined associability of those items. Martin _et al_'s general thesis, that learning is a function of NLM complexity, was supported even though it became clear that their categories were not an entirely adequate description. Secondly, an intimate relationship was uncovered between the learning difficulty of items, and their respective AS values. Furthermore, these AS values, which were independently determined, were able to predict fine differences in error frequency that were beyond the power of both the Archer and Thorndike-Lorge indices.

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Natural language mediators (NLM) are widely used by Ss in paired-associate learning. Experiments which have documented their effect on learning have, however, largely ignored qualitative differences between them. Two large groups each learned a different CVC-word list after which they reported any NLMs they had used. Judges rated the complexity of NLMs using a scale developed by Martin, Boersma and Cox (1965) with different materials. The results agree with theirs in that complex NLMs produced fewer errors in learning. However, some categories on the sclae were used infrequently which may indicate that, at least with highly meaningful material, a simpler dichotomous categorization (NLM or Rote) may be preferable.

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