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EFFECTS OF CONTIGUITY AND MEANINGFULNESS OF RELEVANT AND IRRELEVANT ATTRIBUTES ON CONCEPT FORMATION[1]

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Meaningfulness of the relevant (MR) and irrelevant (MI) syllables and contiguity of the relevant syllables were manipulated in a task analogous to concept formation. Stimuli consisted of two nonsense syllables with one being relevant, in that it was consistently paired with a number response, and the other being irrelevant, in that it appeared equally often with each number response. MR was varied within *S*s, while MI and contiguity were varied between *S*s. Learning was by the study-test method, with *S*s required to identify the relevant syllables and give the associated number response on test trials. Contiguity facilitated identification of the relevant syllable. There was an MR × MI interaction such that identification was dependent upon the differences between MR and MI, with greater differences producing earlier identification. There also appeared to be a positive relationship between MR and identification. Since a conditional probability analysis indicated that there may have been differential associative learning prior to the completion of identification learning, the effects of meaningfulness and contiguity on the associative stage could not be unambiguously determined.

Cue selection has recently been investigated in both paired-associate and concept formation tasks. The similarity of the variables affecting cue selection in these tasks suggests that a common process might be operative in both situations. The present study investigated cue selection in a task which involved components of both paired-associate learning and concept formation.

Cohen and Musgrave (1964) reported an effect of meaningfulness (M) on cue selection in a compound-stimulus paired-associate task, finding the high-M component syllables of the compound stimuli more strongly associated with the response than the low-M syllables. There was also some association of low-M syllables with the response. Thus, when syllables differed in M, component M appears to have had its effect on degree of association between the response and each component.

If there were differential attention to the components of compound stimuli depending on their level of M, one might expect a stronger association of the response to a high-M syllable when it was presented with a low-M syllable than when it was presented with another high-M syllable. Similarly, there would be a stronger association of the response to a low-M syllable when that syllable was presented with another low-M syllable rather than with a high-M syllable. That is, it would seem reasonable that the degree of association of the response with one syllable of a given M level would be inversely related to the M of the other syllable of the compound. The results of Cohen and Musgrave (1964), however, do not fully support this position.

Recent studies of concept formation (Suchman & Trabasso, 1966; Wallace, 1964) have also been concerned with the effect of cue selection. Wallace presented data suggesting that when *S* encounters a multidimensional stimulus, he responds (attends) differentially to the stimulus attributes. Attribute dominance was scaled in a classification task, with the most dominant attribute defined as the one that most *S*s used as a basis for classifying the stimuli. Using these scaled stimuli in a concept formation task with different *S*s, learning was found to be faster when the relevant attribute

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was the most dominant one. However, the dominance of the relevant and irrelevant attributes was confounded; when relevant attributes were of high dominance, irrelevant attributes were of low dominance, and vice versa.

In a concept formation task, *S* is presented with a multidimensional stimulus as a concept instance with which he is to associate a response that serves as the concept indicator. Some of the variables affecting cue selection in compound-stimulus paired-associate learning may also be effective in concept formation. Thus, with the single presentation of a concept instance and the appropriate response, there should be a stronger association of the response with the more dominant attribute than with the less dominant attributes of the concept instance. Furthermore, the degree of association of the response with an attribute of the concept instance should be inversely related to the dominance of the other attributes of the concept instance. Thus, both dominance of the relevant and irrelevant attributes may have an effect on concept formation.

The task employed in the present study involved aspects of both paired-associate learning and concept formation. Compound stimuli, consisting of two nonsense syllables, were paired with single-digit responses. The relevant syllable in each compound stimulus was always paired with the same digit, while the irrelevant syllable was paired equally often with each digit, and, thus, with each relevant syllable. The *S* had to learn to identify the relevant syllables and to associate them with the appropriate digits. The M of the relevant and irrelevant syllables and the contiguity of the relevant syllables were varied.

This task differs from compound-stimulus paired-associate learning and bears a resemblance to concept formation because *S* must discover the relevant syllable, that portion of the compound stimulus which is consistently paired with the same response. However, in most concept formation tasks, a particular dimension, such as color or form, is relevant and different values on this dimension are associated with different responses. The concept of dimensionality is inapplicable to the present task since there was not, across all concept instances, a dimension that was relevant.

Several studies have demonstrated that contiguity of instances of the same concept is directly related to the ease of concept attainment (Dominowski, 1965). The M of the relevant and irrelevant syllables, which should affect the association of the relevant syllable with the response, is less likely to affect ease of identification of the relevant syllable when instances of the same concept are presented contiguously. If concept instances are presented contiguously, association of the relevant syllable with the concept indicator is not necessary for identification since *S* can identify the relevant syllable merely by determining the syllable common to contiguous concept instances. In a low-contiguity condition, where instances of the same concept are not presented contiguously, *S* can identify the relevant syllable only on the basis of the association of the relevant syllable with the concept indicator. Thus, the associative effects of the M manipulations should exert a greater influence on identification of the relevant syllable under low-contiguity than under high-contiguity conditions.

METHOD

Subjects and design.—The design was a $3 \times 3 \times 2$ factorial with three levels of M of the relevant syllable (MR), three levels of M of the irrelevant syllable (MI), and two levels of contiguity. MR was manipulated within *S*s and MI and contiguity were manipulated between *S*s. One hundred and one introductory psychology students served as *S*s in partial fulfillment of a course requirement. Five *S*s were eliminated from the study, 4 for failure to understand the instructions, and 1 for failure to show any evidence of learning in 12 trials. With the restriction that the $N+1$ *S* was not assigned to a group until N *S*s had been assigned to the other groups, the remaining 96 *S*s were randomly assigned in their order of appearance to the six groups dictated by the design.

Lists.—The relevant and irrelevant syllables were high (95%), medium (50%), and low (5%) meaningful CVCs selected from Archer (1960). Care was taken to minimize formal similarity of the syllables comprising a list. The eight high-, medium-, and low-M CVCs were made up of 16, 17, and 12 different letters, respectively. There was

no great difference in similarity among the CVCs as a function of M. No bigrams comprising the CVCs were repeated within a list, and no more than one syllable began with the same letter as another syllable within a list.

Each list contained six relevant syllables paired equally often with six irrelevant syllables, producing 36 pairs. A single-digit number from 1 to 6 was randomly assigned to each of the relevant syllables. Thus, each list consisted of six instances of six concepts, two at each level of MR. MI was varied between lists. The position of a syllable within a pair was randomly determined for each instance.

Contiguity was defined in terms of the number of instances of other concepts intervening between presentations of the instances of a given concept. For high contiguity, all instances of a concept were presented successively, while for low contiguity, no two instances of a concept appeared successively, being separated by at least two instances of other concepts. There was a mean separation of 4.06 instances in the low-contiguity condition.

There were two replications of the basic design using different CVCs. Within the limits imposed by the contiguity manipulation, there were three random orders of each list.

Procedure.—The lists were presented on a memory drum using an alternating study- and test-trial procedure. On study trials each syllable pair was presented with a number, while on test trials the syllable pairs appeared without the numbers. Contiguity was manipulated only on study trials; on test trials, the order of presentation was completely random. There was a 2-sec. presentation rate on study trials and a 4-sec. rate on test trials. A 6-sec. interval separated successive study and test trials, with the word "study" or "test" presented for 4 sec. before each type of trial.

The *S*s were told that one syllable of each pair was relevant in that it was consistently associated with the same number, while the other was irrelevant since it appeared equally often with each number. On study trials, *S* was instructed to attempt to discover the relevant syllable and to associate the relevant syllable with the number. On test trials, he was to indicate the relevant syllable, by spelling it aloud, and the number with which that syllable was associated on study trials.

A learning criterion of two consecutive errorless trials was employed, with each *S* receiving a minimum of 8 trials. If the criterion was not reached in 12 trials, the session was ended and *S* was assigned an arbitrary score as specified subsequently.

Results

The number of trials to criterion for each relevant syllable was computed independently for identification and association responses. The criteria were two successive perfect identification and association trials. If *S* had not reached the identification criterion for a relevant syllable by the twelfth trial, he was assigned a score dependent on his identification performance on the twelfth trial. If his identification of that syllable was errorless, he was assigned an identification score of 12 for that syllable; otherwise a score of 14 was assigned. An identical procedure was employed for *S*s failing to reach the association criterion. There were only 8 subject-concepts, of a possible 576, that failed to attain either one or both of the criteria and these were well distributed across experimental conditions.

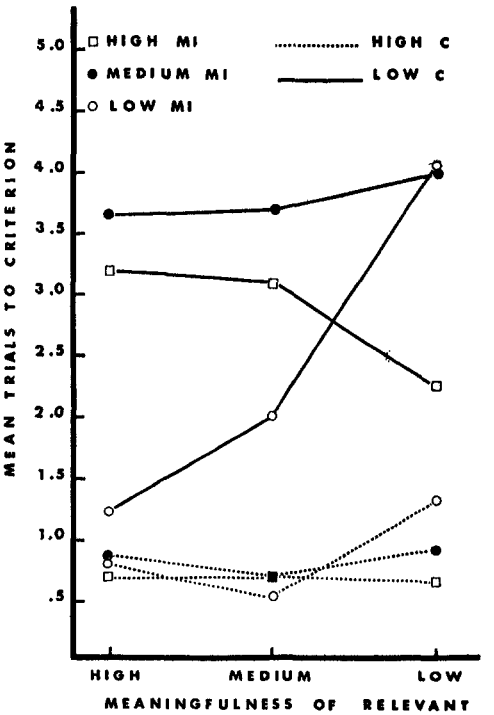

FIG. 1. Mean trials to identification criterion as a function of meaningfulness of relevant syllables, meaningfulness of irrelevant syllables (MI), and contiguity (C).

Identification.—The trials to identification criterion data are presented in Fig. 1. As can be seen, there is a strong contiguity effect, F (1, 84) = 31.29, $p < .001$, with identification occurring earlier with high contiguity, as expected. The main effect of MR, F (2, 168) = 4.37, $p < .025$; the MR × MI interaction, F (4, 168) = 8.47, $p < .001$; and the MR × MI × Contiguity interaction, F (4, 168) = 3.75, $p < .01$, were

all significant. Tests of the simple MR × MI interactions revealed a significant interaction in low contiguity, F (4, 84) = 48.15, $p < .001$, but not in high contiguity, $F < 1$. Neither MR nor MI appeared to have much of an effect in high contiguity. Within low contiguity the identification of the relevant syllable was dependent on the difference in M of the relevant and irrelevant syllables. Regardless of the level of MR, when MR differed from MI, identification was better than when MR and MI were of the same level. However, it should be noted that the effect of MR was much less pronounced with high MI than with low MI. If, in addition to the difference in M, identification of the relevant syllable was dependent on MR, we would expect the obtained results of a steeper MR curve under low MI, and a shallower curve in the opposite direction under high MI.

No other effects were significant except for the MR × Replications interaction, F (2, 168) = 3.39, $p < .05$, which was apparently generated by medium MR producing performance similar to low MR in one replication and similar to high MR in the other replication.

Association.—The results of the analysis of number of trials to association criterion paralleled the results of the trials to identification criterion analysis. However, since trials to attain the identification and association criteria are not independent, the results of trials to association criterion are not presented.

It was suggested previously that under low contiguity, identification of the relevant syllable is dependent on the formation of associations between the syllables and the responses, while under high-contiguity conditions, *S* need not form such associations to identify the relevant syllable. To assess the extent of preidentification-criterion associative learning, a conditional probability analysis was performed. Prior to the identification criterion, the conditional probability of a correct association response given a correct identification response, $P(C|C)$, was computed by dividing the number of correct associations following correct identifications by the total correct identifications for each level of MR for each *S*. The preidentification-criterion conditional probability of a correct association response following an incorrect identification response, $P(C|I)$, was similarly determined. Since both of these conditional probabilities would be equally affected by nonassociative factors such as response elimination, which would increase the probability of a correct associative response, the difference between the two conditional probabilities can be considered to reflect preidentification-criterion associative learning.

Since a number of *S*s exhibited perfect identification performance from the first trial on some concepts, it was impossible to obtain conditional probability measures at all levels of MR for all *S*s. These *S*s were eliminated from the analysis, with a larger number of *S*s being eliminated from the high-contiguity condition than from the low-contiguity condition. Thus, it was not feasible to directly compare the two contiguity conditions, and the arc-sine transformed data were analyzed separately for each level of contiguity.

The high-contiguity analysis, performed with 18 *S*s, 6 per cell, revealed no significant main effects or interactions. Collapsed across levels of MR and MI, the conditional probabilities for the high-contiguity condition were .238 for $P(C|C)$ and .091 for $P(C|I)$, F (1, 15) = 2.98, $p > .10$.

In the low-contiguity condition, the analysis was performed with 39 *S*s, 13 per cell, and revealed significant effects for MI, F (2, 36) = 4.02, $p < .05$, and type of conditional probability, F (1, 36) = 81.10, $p < .001$. No other effects were significant. The conditional probabilities for the low-contiguity conditions are presented in Table 1. As is evident, $P(C|C)$ was consistently greater than $P(C|I)$ over all levels of MR and MI. The significant MI effect was the result of decreasing conditional probabilities of correct association responses from medium to high to low MI.

Another associative measure, designed to assess association formation after identification learning had taken place, was the number of trials intervening between attainment of the identification and association cri-

TABLE 1

MEAN CONDITIONAL PROBABILITIES OF CORRECT ASSOCIATION RESPONSES GIVEN CORRECT $P(C|C)$ OR INCORRECT $P(C|I)$ IDENTIFICATION RESPONSES PRIOR TO THE IDENTIFICATION CRITERION FOR THE LOW-CONTIGUITY CONDITIONS

Meaningfulness of irrelevant syllables	Meaningfulness of relevant syllables			
	High	Medium	Low	Mean totals
High				
$P(C\|C)$	.475	.432	.382	.429
$P(C\|I)$	.190	.100	.155	.149
Medium				
$P(C\|C)$	.545	.485	.545	.525
$P(C\|I)$	.307	.033	.155	.165
Low				
$P(C\|C)$	.386	.231	.359	.325
$P(C\|I)$	.026	.089	.137	.084
Mean totals				
$P(C\|C)$	.469	.383	.429	.423
$P(C\|I)$	.174	.074	.149	.132

teria computed for each relevant syllable for each S. It should be noted that this measure, to be referred to as trials between, was also influenced by preidentification association formation; the more association formation occurred prior to identification, the less had to occur after identification.

The eight subject-concepts in which either the identification or the association criterion were not attained were assigned a trials-between score equal to the mean of the condition to which the concept belonged. The only significant effects in the analysis of the trials-between data were contiguity, $F(1, 84) = 18.26$, $p < .001$, and MR, $F(2, 168) = 5.66$, $p < .005$. High contiguity had a larger number of trials between than low contiguity, and medium MR took a larger number of trials between than either high or low MR.

DISCUSSION

The effect of contiguity on identification of the relevant syllable and the results of the conditional probability analyses suggest that identification of the relevant syllable was accomplished differently in the high- and low-contiguity conditions. The conditional probability analyses revealed preidentification-criterion associative learning in the low-contiguity condition with $P(C|C)$ significantly greater than $P(C|I)$, while failing to provide reliable evidence for such associative learning in the high-contiguity condition. Thus, the results are consistent with the supposition that some associative learning is necessary for S to identify the relevant syllable in the low-contiguity condition. In the high-contiguity condition, it would appear that Ss were able to identify the relevant syllable with the aid of very little, if any, associative learning. Such identification could be accomplished with relative ease by directly comparing successive instances of the same concept to determine which syllable was relevant. Therefore, it would appear that the later identification of the relevant syllables in the low-contiguity condition relative to the high-contiguity condition was due to a differential necessity for associative learning.

Within the low-contiguity condition, the analysis of conditional probabilities revealed an effect of MI on the probability of a correct response. The conditional probabilities for the levels of MI correspond with the MI differences in the trials to identification criterion data. Although MI was not significant in trials to identification, the longer it took to reach the identification criterion, the higher the probability of a correct response prior to the identification criterion. However, this does not necessarily reflect differences in preidentification-criterion associative learning since the correspondence with trials to identification seems to hold equally well for $P(C|C)$ and $P(C|I)$.

It was expected that trials between would reflect the effect of the M and contiguity variables on associative learning after identification learning was completed. However, as noted, the analysis of such effects was confounded with the amount of preidentification associative learning. Thus, although the detrimental effect of high contiguity on association formation has been noted elsewhere (Greeno, 1964), in the present study this effect may well have been a function of the relatively large amount of preidentification associative learning in the low-contiguity condition. Due to the confounding of trials between with preidentification associative learning, the significant MR effect in trials between is also difficult to interpret.

If it is assumed that identification of the relevant syllable in the high-contiguity conditions is independent of association, the high-contiguity conditions might be regarded as control conditions reflecting the nonassociative effects of MR and MI on identification. The lack of any significant differences within the high-

contiguity condition suggests that such nonassociative effects of MR and MI were not great. However, the lack of significant MR and MI effects may have been due to the very rapid identification in the high-contiguity conditions.

Considering the effects of MR and MI on identification of the relevant syllable in the low-contiguity conditions, it was suggested earlier that M should affect identification through preidentification associative learning. The higher the M value of a given syllable, the greater this accrual of association between the syllable and the response on a given trial (Cohen & Musgrave, 1964). Thus, it was anticipated that the higher values of MR would produce faster identification of the relevant syllable. In addition, it was suggested that the degree of association of the response with a relevant syllable would be inversely related to the M value of the other syllable of the concept instance, i.e., inversely related to MI.

Identification of the relevant syllable was found to be primarily a function of differences in M of the relevant and irrelevant syllables. Regardless of the level of MR, when MR differed from MI, performance was better than when MR and MI were of the same level. Such "relational responding" makes it difficult to draw conclusions concerning the effects of either MR or MI. However, MR appeared to have had an independent effect in that there was a significant MR effect, with the higher M relevant syllables more readily identified. In addition, the effect of MR was much more pronounced with low than with high MI. If MR had an independent effect, this result would be expected since the effects of MR and "relational responding" were acting in opposition in the high-MI condition, while acting in the same direction in the low-MI condition. From this analysis, one would expect a positive relationship between MR and ease of identification in the medium-MI condition since "relational responding" should be at a minimum in this condition. A weak relationship was observed, with high-MR syllables identified earlier. The MI effect was not significant, and there was no good evidence for any independent MI effect.

The effects of M on preidentification associative learning were not reflected in the conditional probability analysis. This would be expected if a minimal amount of association were necessary to identify the relevant syllable in the low-contiguity condition. The M of the syllables would then not affect the amount of associative learning prior to identification, but the rapidity of attainment of a minimal amount of association.

Since MI and MR were between- and within-*S* manipulations, respectively, for any *S*, MI was the most frequently represented M level. Differences between MR and MI may have increased the salience of the relevant syllable and had a resultant effect on cue selection. The more apparent the difference in M level of a given syllable with respect to other syllables within the list, the more likely that that syllable would serve as a cue in associative learning. The identification of the relevant syllables of the infrequently represented M level should, then, be facilitated due to a larger amount of associative learning on a given trial. Thus, "relational responding" may have had its effect on identification in the same way that was suggested for the effect of MR.

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