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CONCEPT LEARNING WITH DIFFERING SEQUENCES OF INSTANCES

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Under conditions where several concepts are learned concurrently and concept instances are presented successively, the instances of any given concept may be presented in varying degrees of proximity to one another. At one extreme these may be presented one after the other without the interpolation of instances of any other concept, and at the other extreme two instances of a given concept may never occur in succession without the interpolation of one or more instances of other concepts. The present investigation concerns the rate of concept attainment under these two modes of presentation of concept instances.

Theoretical considerations advanced by Underwood (6) suggest that the first condition in which the instances of a given concept are presented in close proximity should produce more rapid learning. This expectation is based upon the assumption that to abstract the common property or properties of several concept instances, perceptual, ideational, or motor representations of the properties of these instances must occur contiguously. The implicit representation may be either in direct response to the presentation of a concept instance or recalled from the past presentation of an instance. When two concept instances are presented simultaneously, occurrence of perceptual representations of the relevant stimulus properties will depend primarily upon factors of set or attention; when the instances are presented successively, the additional factor of memory is introduced, so that, even though the relevant properties of a first instance are perceived at the time of presentation, they may be forgotten in the period intervening before the presentation of a second instance. The likelihood of forgetting would be expected to be a function of such factors as the complexity of the original instance, the length of the intervening period, and the nature of the activities interpolated during the period.

The conditions employed in the present experiment and those employed in a recent study reported by Hovland and Weiss (4) may be regarded as bracketing adjacent segments on a continuum of conditions facilitating to varying degrees the contiguous perceptual representation of concept instances. In the study of Hovland and Weiss, learning with *simultaneous* presentation of concept instances was compared with the theoretically less favorable condition of *successive* presentation of instances, and a significant difference was obtained in the expected direction. In the present study a condition similar to the successive condition of the Hovland and Weiss study was compared with the theoretically still less favorable condition in which concept instances were not only presented successively but were also intermixed with instances of other concepts. In this method of presentation, at the time of presentation of an instance of a given concept, retention of earlier instances of the same concept would be expected to be impaired both by

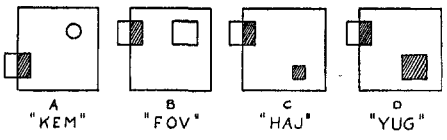

FIG. 1. Illustrative concept instances.

the longer delay intervening and by interference arising from the interpolation of instances of different concepts.[1]

PROCEDURE

The experimental problem consisted of the presentation of several instances of each of four concepts, followed by a test of mastery of these four concepts. Test performance was compared following two different methods of presentation of the concept instances. In the first method, instances of the four different concepts were intermixed so that two instances of any given concept were separated by instances of one or more of the other concepts; in the second method, all the instances of any given concept were presented in close succession without the interpolation of instances of other concepts.

The stimulus materials were simple geometric patterns which varied in four relevant dichotomous properties or dimensions (3). The dimensions of variation were shape (circle or square), size (large or small), color (black or white), and position (up or down). Each of the four concepts was defined by a combination of two properties and was designated by a distinctive nonsense-syllable name. The names and defining properties of the four concepts were (*a*) *kem*, up and circle; (*b*) *fov*, up and square; (*c*) *haj*, down and small; and (*d*) *yug*, down and large. Examination of the defining properties shows that every possible shape-color-size-position combination is an instance of one and only one of the four concepts. All the instances of a given concept were alike in the defining properties, but differed in the remaining properties. For example, all *kem*'s were circles and up, but could be large or small, black or white.

Stimulus materials.—One illustrative instance of each concept is presented in Fig. 1. Each drawing consists of three parts: a 1½-in. square frame, a smaller square overlapping this frame, and either a circle or square completely contained within the frame. The shape, size, color, and position of the inner figure determined the four concepts. The two different shapes are illustrated by drawings A and B, the sizes by C and D, the colors and positions by B and D. A fifth dimension involving the placement and shading of the overlapping square was irrelevant to the concepts.

The five dimensions, each with two possible values, yielded a total of 32 ($=2^5$) combinations of properties to be used as concept instances. The 32 instances were drawn separately on 3×5-in. index cards for presentation during the learning procedure. These were divided into eight instances of each of the four concepts as follows: they were first divided into two groups according to whether the inner figure was up or down; those on top were further divided into *kems* and *fovs* according to whether the shape was circle or square; those on the bottom were divided into *haj*'s and *yug*'s according to whether they were small or large, respectively.

Two test packs, each including two instances of each concept were also prepared. Together these two packs included all 16 instances formed by combinations of the two values of each of the four relevant dimensions. All these instances had the same value of the irrelevant dimensions. Within a given test pack the two instances of any given concept differed in both of the dimensions which were irrelevant to that particular concept. For example, if one *kem* was large and black, the other one in that test pack was small and white.

Preliminary training.—Throughout the experimental session *E* and *S* sat at a table facing one another. Prior to training and testing on the experimental problem, each *S* was given practice on a preliminary problem to familiarize him with the procedures involved. The figures employed on the preliminary problem were equilateral triangles with the following variations: number (*one vs. two* triangles), position of apex (pointed *up vs. down*), pattern (*checkered vs. striped* markings), and color of markings (*black and red vs. black and white*). The *S* was informed of the nature of these variations, and each variation was illustrated by presenting two instances differing only in the variation being demonstrated. It was explained to each *S* that learning a concept would consist in discovering the two properties in which a series of cards were all alike, i.e., that *S* was to be shown a series of four cards one at a time and would be required to find the common properties. These cards were all black and white and checkered. The series included all four combinations of two values of the two remaining dimensions (position of apex and number). The *S* was asked to report verbally what he believed to be the common properties. If his answer was correct, *E*

[1] The present problem has been independently investigated in an unpublished research by Newman (5). The two studies differ considerably in the type of materials and procedures employed and thus complement each other and serve to extend the range of conditions investigated.

indicated this to *S*; if *S*'s answer was incorrect, *E* presented the series again. The presentation of the cards and questioning of *S* was continued until *S* gave the correct answer. When the first problem had been solved, the procedure was repeated with a second series of four cards having in common the colors black and red and the inverted position.

Experimental task.—The experimental problem was given immediately following completion of the preliminary problem. First, each of the four relevant variations was described to *S* and illustrated by a pair of instances differing only in the dimension being described. It was explained to *S* that he was to learn four concepts and that all the instances of a given concept would be called by the same nonsense name. A card on which the four nonsense names were lettered was placed on the table in *S*'s view and left there throughout the remainder of the procedure. It was further explained that the instances would be shown one at a time and the name of each instance would be given by *E* as presented. The *S* was told that at the end of the learning series he would be asked to describe the properties corresponding to each of the nonsense names and would be asked to identify a series of test instances by their names.

Two different experimental conditions were determined by the method of presentation employed. In the first method, instances of all four concepts were intermixed so that two successive instances of any given concept were always separated by instances of one or more other concepts. In the second method, all the instances of a given concept were presented in immediate succession without the interpolation of instances of other concepts. The order in which the concepts were presented and the order of the instances within each concept were varied among different *S*s. Half of the *S*s were randomly assigned to each of the two methods of presentation. Each *S* was informed whether the different concepts would be presented separately or intermixed.

The cards bearing the 32 instances were presented manually by *E*. The training-testing sequence was as follows:

1. Presentation of concept instances. The *E* presented all 32 instances at the rate of 2 sec each and pronounced aloud the name of each instance as it was exposed.

2. Verbal description test. The *S* was requested to report verbally the common properties corresponding to each of the nonsense names, and his responses were recorded by *E* without any comment as to whether or not they were correct. If *S* failed to mention any of the names, *E* inquired: "Can you remember the properties of the ——'s?"

3. Identification test. The eight instances in the first test pack were presented one at a time and *S* was requested to identify each by the appropriate nonsense name. The *S* was required to guess when not certain, and each card was exposed until *S* responded with a concept name. No indication was given as to the correctness of *S*'s responses.

Upon completion of the above procedures, the entire sequence was repeated a second time. Prior to the second presentation of the concept instances, the cards were shuffled so that they were not in the same order as on the first trial, although they were in the same series. For example, if the concepts had been presented in an unmixed sequence, then on the second trial they were also presented in an unmixed sequence, but the order of the various concepts and of the instances within each concept was changed. On the second identification test, the second test pack was substituted for the first.

Subjects.—The *S*s were 26 Yale undergraduate men hired through the Student Appointment Bureau.

TABLE 1

CONCEPT ATTAINMENT WITH MIXED AND UNMIXED ORDERS OF PRESENTATION

Trial	Mixed	Unmixed	*P*
A. Mean Number of Correct Identifications			
1	3.61	4.69	.10
2	4.38	5.54	.13
B. Mean Scores on Verbal Description Test			
1	2.92	4.84	.03
2	4.08	6.46	.01

RESULTS

Table 1 shows the mean number of correct identifications on the first and second test for the two methods of presentation. It will be seen that on both tests there was a slight difference in the expected direction, i.e., more correct identifications following the unmixed order of presentation. On neither of the tests, however, was this difference statistically significant.

The verbal description test was scored in the following manner: one point was given for every property correctly ascribed to a given concept

name. For every concept an *S* could obtain a score of 0, 1, or 2. The over-all score given each *S* was the total of the scores on the four different concepts, and could vary from 0 to 8. The mean over-all scores on the first and second test under the two conditions of presentation are also presented in Table 1. On both tests the difference is in the expected direction of higher scores following the unmixed order of presentation. The one-tailed p values for the differences on the first and second tests were less than .03 and .01, respectively, as calculated by Wilcoxon's rank total test (7).

Discussion

The results obtained support the conclusion that, under the conditions studied, the learning of concepts is more rapid when positive instances of the same concept appear in close succession than when they are separated by instances of other concepts. At present, the most likely interpretation appears to be that under the latter condition, upon the appearance of a second instance of a given concept, memory of a prior instance of that same concept is subject to considerable interference resulting from the interpolation of instances of other concepts. Owing to this impairment of memory, implicit representations of two instances of a given concept do not regularly occur in close contiguity, and the difficulty of abstracting common properties of two instances is appreciably increased.[2]

The foregoing account has been simplified by involving only the factor of memory of consecutive instances of a given concept. Undoubtedly other factors are important, and under different conditions the relative efficacy of the two methods of presentation might be altered and even reversed. The results might be expected to be influenced by the type of criterion used and the degree of learning involved. Gagné's data (1) indicate that confusion errors tend to be made more frequently in the early portions of learning when similar stimuli are placed in adjacent positions but that this leads to better differentiation later and superior final performance in learning paired associate lists.

Another consideration would be the degree of discriminability between stimuli associated with different concepts. When the degree of discriminability is low, it might be expected that placing of instances from different concepts in juxtaposition would facilitate discrimination and learning, whereas with greater discriminability, like that obtaining in the present study, the reverse might obtain. This prediction might seem to be in contradiction to results in the Gagné study already mentioned, but it is to be noted that in his experiment each stimulus was to be associated with a different response, whereas in the current situation stimuli within a block all involve the same response (concept).

Finally, the effect of grouping instances may depend upon the general manner in which *S*s set about to solve the problem. Although not much is known about the conditions determining choice of approach, the present authors have observed that *S*s differ in the extent to which they make use of information conveyed by concept instances in formulating verbal hypotheses about the nature of a particular concept. At one extreme, some *S*s seem to "randomly" formulate and test various possible hypotheses, while at the other extreme,

[2] The descriptive use of the term *contiguity* in the present context must be distinguished from the use of the same term as an explanatory concept, e.g., in "contiguity" theories of learning (2). In its latter use the condition of contiguity is specified as a necessary and sufficient condition for establishing an association between a stimulus and response; in its present usage the contiguity of implicit responses (perceptual representations) is specified as a condition which facilitates the abstraction of common features of two stimulus complexes. A more elaborate conceptual and empirical analysis of the mechanisms involved in concept learning must be developed before the term contiguity in the latter sense has great theoretical power.

some *S*s carefully study the concept instances presented in an attempt to "infer" the common properties, reserving the choice of a hypothesis until sufficient data are available. In general, fewer hypotheses are considered by the latter group before arriving at the correct one. It seems likely that, among *S*s who actively attempt to abstract the common properties of several instances before formulating a hypothesis, the unmixed order of presentation would be relatively easier than the mixed order, but among *S*s choosing hypotheses by trial and error the difference might be considerably reduced. An experimental test of this prediction would be provided by studying learning under mixed and unmixed orders of presentation following two different types of instruction and pretraining designed to induce different methods of solution.

Summary

The present study was an exploratory investigation of the rate of concept attainment under two conditions of presentation of concept instances. The hypothesis studied was that learning would proceed more rapidly under a condition in which the instances of a given concept were presented one after another without interpolation of instances of other concepts as compared with a condition in which the instances of several concepts were presented in an intermixed order.

The concept materials consisted of geometrical designs varying in color, size, shape and position. Each concept was defined by a combination of two properties, e.g., *large square*, or *small black* object. The *S*s were presented one at a time with eight instances (each identified by the same distinctive nonsense name) of each of the four concepts. In Cond. I, all eight instances of a given concept were presented in succession before presenting instances of a second concept, etc. In Cond. II, instances of all four concepts were presented in an intermixed order so that no two instances of a given concept were presented in succession without the interpolation of an instance of at least one other concept. At the end of this training *S*s were asked to give a verbal description of each concept and to identify several instances of each concept by the appropriate nonsense name.

Following the unmixed order of presentation *S*s gave both more correct identifications and more correct verbal descriptions of the concepts than following the mixed order of presentation. Only the latter difference was statistically significant ($P = .03$ for Trial 1 and .01 for Trial 2, single tail).

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