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RECOGNITION AND IDENTIFICATION OF COMPLEX VISUAL FORMS AS A FUNCTION OF THE LABELING SYSTEM EMPLOYED

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FOREWORD

This report is the result of experiments performed by Harold W. Hake and Charles W. Eriksen under Contract No. AF 33(038)-22642 at the Institute for Cooperative Research, The Johns Hopkins University. The contract is carried under Research and Development Project No. 7192, "Human Engineering Analysis of Weapon Systems," and Task No. 71598. It was administered by the Psychology Branch of the Aero Medical Laboratory, Directorate of Research, Wright Air Development Center, with Julien M. Christensen acting as Task Scientist.

ABSTRACT

This report describes two experiments conducted to explore variables affecting the ability of human observers to learn to recognize and identify previously unfamiliar complex visual forms. In both experiments the effect upon subsequent recognition skill of giving subjects practice in the use of irrelevant labels as discriminating responses before they learned to associate them with a set of unfamiliar stimulus forms was systematically studied. The results suggested that labeling practice can have a double function. It can have the function first of forcing subjects to differentiate a set of stimulus forms, and can provide also a denotative process whereby subjects organize and identify the stimulus aspects differentiated by practice. This latter process occurs only with the use of larger sets of labels following practice in their use as identifying responses. The denotative use of labels appeared to have one possible concomitant deleterious effect. Subjects who had learned to associate practiced labels with a set of nonsense forms were significantly more willing, following such practice, to accept as familiar new forms of similar construction. That is, they showed significantly less accuracy in rejecting forms which were similar to those labeled in practice but not identical to any of them.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:

JACK BOLIERUD
Colonel, USAF
Chief, Aero Medical Laboratory
Directorate of Research

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I. INTRODUCTION

This report describes two experiments in a series conducted at this laboratory to explore variables affecting the ability of human observers to learn to recognize and identify previously unfamiliar complex visual forms. The perceptual problem of practical interest is that of the airborne radar observer who must separately identify and recognize two-dimensional forms as they appear on a PPI display. The configurations appearing on the display are complex usually and have little resemblance to forms with which the observer has had experience previous to his experience with radar displays.

To be successful at his task the observer must develop familiarity with certain of these forms before being called upon to recognize them under a variety of viewing conditions. Our interest is in those variables which affect the development of visual familiarity, that is, in the set of variables which operate before the observer is faced with the actual configurations which he sees on the radar display.

One set of variables of potential importance in the development of familiarity is the set related to the particular identifying responses which observers use in first learning to separately recognize and identify the previously unfamiliar forms. Ability to discriminate among a set of forms and to separately identify them at some future time can be increased, for example, by practice in learning to associate a verbal response with each form in the set. The use of a set of verbal labels in this way can force the observer to respond to those aspects of complex visual forms by which the forms can be discriminated one from another. Verbal labelling practice can increase skill in differentiating complex visual patterns and make their recognition and identification under less optimal viewing conditions more probable at some subsequent critical time.

It has been suggested that practice in associating a set of verbal responses with each of a set of stimulus forms has a significance beyond the mere fact that it constitutes practice in discriminating among the set of forms (7). The labels once learned could provide a symbolic means for retaining knowledge of the discriminable aspects of the forms. This is an important possibility because our primary interest is not in ability to learn to differentiate a set of forms, but rather in the ability to retain what is learned about the forms such that subsequently the forms can be separately recognized and responded to in an appropriate manner. The possibility exists that the learning and retention of a set of verbal identifying responses for the forms may enhance this ability. We should expect this to be true especially where verbal responses describe some critical aspect of stimulus form, but it could hold true also where the verbal responses were not related to the stimuli in obvious ways.

Although there has been much evidence to indicate that verbal labeling practice does increase the ability of subjects to recognize separately complex visual patterns subsequently (1, 4, 5, 8, 9), there has been no clear indication that the nature of the verbal labels used may be critical (6, 8).

An experiment completed prior to our first experiment in this series indicated that one controllable aspect of verbal labels, the number of different labels used in learning to identify a set of complex visual forms, was not a critical variable. Subjects who used just two verbal responses to label a set of 16 forms were not handicapped as a result of this practice in their ability subsequently to learn new verbal responses for the same forms. Although it was reasonable to expect that just two labels would be of considerably less use in retaining information about the discriminable aspects of 16 forms than would the use of eight labels, for example, there was no indication that the subsequent performance of subjects using the smaller number of responses originally with the forms was impaired in any way.

Furthermore, although the subjects in the study learned to differentiate the stimulus forms during the original labeling practice there appeared to be no special significance related to the act of successfully associating a verbal response with a stimulus form. Those forms which were labeled most successfully with the first set of verbal responses used by each subject were not necessarily those which he labeled most successfully while using a second set of responses. These results appeared to minimize the importance of factors related to the particular labels used in labeling practice. That is, although there is little doubt but that a perceptual gain results from the labeling process, there existed little reason to suppose that the gain resulted from the successful association of the verbal responses with the stimuli. It appeared instead that the gain resulted from the need to discriminate among the forms, where this need could arise from the use of as few as two irrelevant responses.

The experiments reported here were undertaken because of the possibility that these essentially negative results could be related to the fact that the verbal responses studied were "irrelevant" responses. That is, they were chosen to have a minimum of relevance to the stimulus forms and to have few private and uncontrolled associations and significances for the subjects prior to the experiment. Letters of the alphabet were considered suitable because they are familiar to subjects but are not used habitually as identifying responses. The subjects, consequently, were not using verbal responses which they were accustomed to use in labeling or naming objects.

In the two experiments reported here, we systematically studied the effect of giving subjects practice in the use of irrelevant labels as discriminating responses before learning to associate them with a set of unfamiliar stimulus forms. In both experiments the effect of this previous familiarity with the response set was measured in terms of the ability of subjects to learn to associate the responses with a standard set of forms and in another subsequent situation in which they were required merely to recognize the labeled forms, without naming them, as they appeared with other similarly constructed new forms. This provided two measures of ability to demonstrate knowledge of the forms, one of which depended upon ability to use the verbal labels efficiently and one of which was independent of this ability.

II. EXPERIMENT I

In the first experiment reported here the effects of two response variables were studied. The first was the number of different verbal labels which the subjects were permitted to use in first learning to differentiate a set of previously unfamiliar complex visual forms. This is the same response variable which was described in a previous report (6). Here, however, we have combined it with another variable--the type of previous experience which the subjects had with these response categories before learning to associate them with the set of unfamiliar forms.

Subjects were given initial experience in associating a set of verbal responses with a set of stimulus forms having some degree of pre-experimental familiarity prior to learning to associate these same responses with a standard set of previously unfamiliar forms. For example, one-third of our subjects were required first to learn to associate the responses with a set of very familiar geometric forms. A second third of the subjects were required to learn to associate the responses with a set of fragments of an air photograph of the City of Baltimore which we had found subjects could learn to discriminate among in relatively few trials. This provided initial labeling experience which varied in pre-experimental familiarity but was constant in terms of the actual number of labeling trials experienced. The effects of this initial experience in the use of the verbal response categories upon subsequent performance was compared with that of the remainder of the subjects who were given no experience with the verbal responses prior to associating them with the standard set of unfamiliar forms.

Method

Procedure. Except for subjects in the control groups who were given no initial experience in the use of the standard sets of labels, the procedure consisted of three tasks. In Task I subjects in the experimental groups were given initial experience in applying the standard sets of labels to either a set of 12 familiar geometric forms or else a set of 12 air photographs of the City of Baltimore, Maryland. In Task II all subjects labeled a standard set of unfamiliar complex visual forms. All subjects in the experimental groups used the same labels in the first and second tasks. Four sets of labels were used containing, respectively, two, four, six, or twelve labels. In Task III all subjects saw the forms which they had labeled in Task II presented together with 12 other forms of the same type. Subjects were required merely to indicate those forms which they thought they had labeled in Task II.

Eight experimental groups of subjects were used, representing the eight combinations of the four sizes of label sets with the two types of experience given in Task I. Four control groups, one for each of the four label sets, experienced only the procedures of Task II and Task III.

Each of the learning tasks, Task I and Task II, consisted of 120 trials in which each subject saw each of the 12 forms ten times. The forms appeared in a partially restricted random order which provided for the appearance of all twelve patterns in the first 12 trials, in the second 12 trials, etc. Successive appearances of the forms were spaced 10 sec. apart and each form was presented for 2 sec.

At the beginning of each trial, a form was placed in view of subject. Immediately following this subject was required to assign one of the verbal labels to the form. Each subject had a card in front of him on which was

printed a list of labels which he could use. These consisted of letters of the alphabet chosen to have as little sequential connection as possible. After subject on each trial had identified the form, experimenter then pronounced the arbitrarily predetermined correct label for that form. The task of subject in the first two tasks, then, was to learn which of the labels from his list could be correctly applied to each of the patterns.

In each of the 12 groups one-half of the subjects were required to learn an arbitrary set of label-form assignments which was different from that required of the remaining subjects. This variation in the nature of the label-form assignments produced no significant effects in any of the three tasks; and, for this reason, will not be discussed again.

There were six trials in Task III, the recognition task. On each trial subject was given an 8-1/2 x 11 in. sheet on which appeared the 12 standard complex forms he had labeled in Task II together with 12 other similar forms that he had not seen previously. On each of the first two trials the familiar forms were rotated 90° to the left or right. On the third and fourth trials the forms were rotated 180°. On the fifth and sixth trials all of the familiar forms appeared in the positions in which they had appeared when subject labeled them in Task II. The systematic rotation of the familiar forms was designed both to make the task of recognition somewhat more difficult and to require subject to generalize information which he had gained about the forms during the second task. The 12 new unfamiliar forms introduced in this third task were also rotated systematically from trial to trial in an attempt to prevent subject's learning about the characteristics of these new forms. Each of the 12 familiar and 12 unfamiliar forms occupied one of the 24 cells, 1 in. square, formed by the intersection of four vertical columns and six horizontal rows. Except for being rotated on some of the sheets, each familiar form appeared in the same size and color in Task II and Task III.

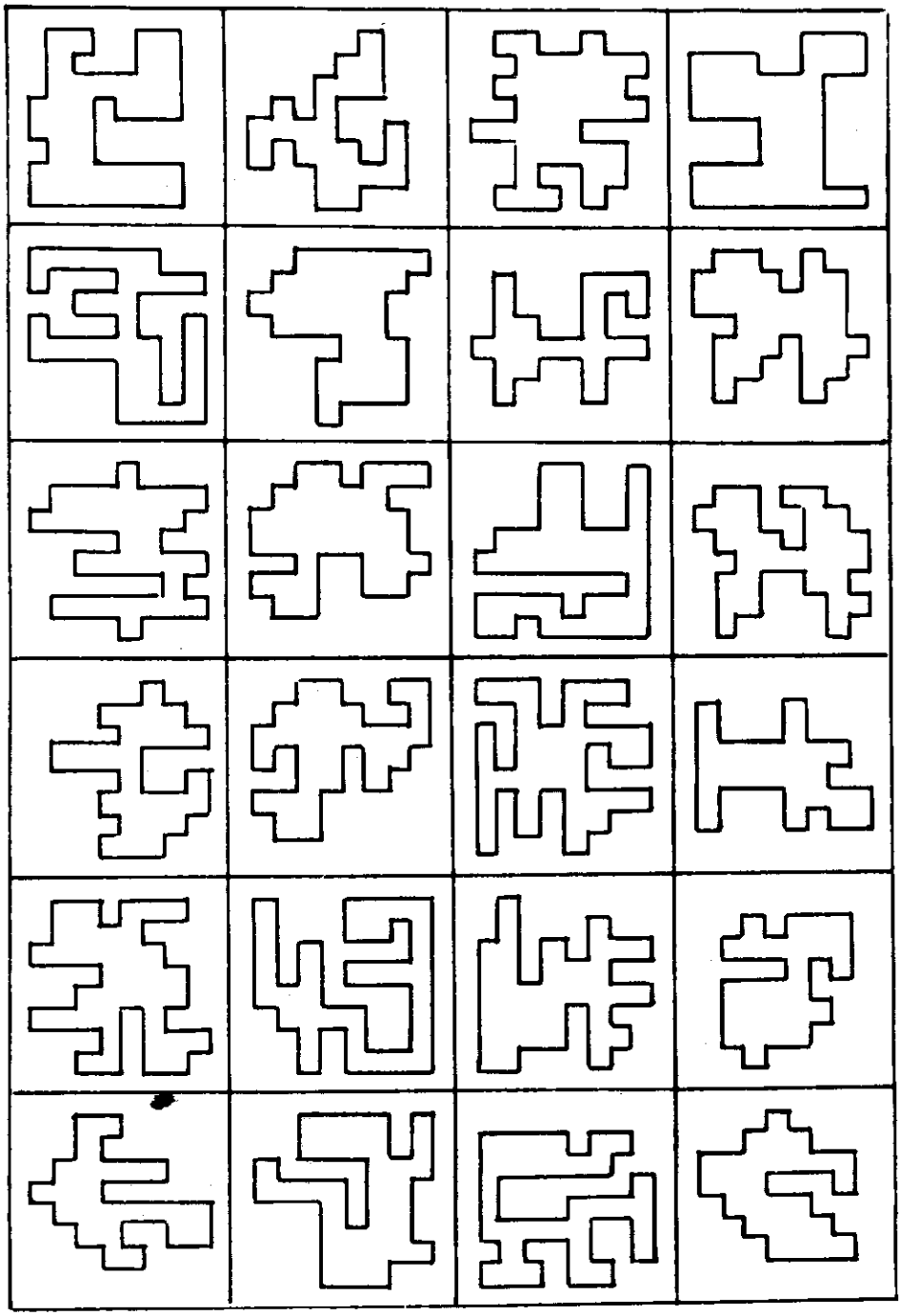
Each sheet was presented to subject for one minute, and during this time he was required to check those forms that he thought were the ones he had labeled in Task II. He was told in advance of each trial that the forms could appear in rotated positions and that each sheet contained 12 familiar forms and 12 unfamiliar.

Apparatus. Each of the forms used in the first two tasks was mounted within a 1 in. square area in the center of a 3 x 5 in. index card. The overall dimensions of the forms varied somewhat; the smallest dimension was about 3/4 in., the largest almost 1 in.

The 12 familiar and the 12 unfamiliar nonsense forms which subjects saw in Task II and Task III were "nonsense" closed line drawings constructed by following certain rules chosen by a partially restricted chance selection. These forms are shown in Figure 1 which represents one of the sheets shown to subjects in Task III. The Air Photo forms were small segments, about 1 in. square, of a series of large air photographs of the City of Baltimore

FIGURE 1

The Nonsense forms used in the experiment in Task II and Task III. This matrix of forms is identical, except for scale, to one of the sheets presented to subjects in Task III.



published by the Baltimore Sun over a period of several months in 1954. The segments chosen were mainly top views of the geometrical configurations formed by typical blocks of Baltimore "row" houses. The geometric forms included a square, circle, triangle, cross, diamond, a rectangle with a long vertical dimension, two horizontal bars, a parallelogram inclined to the right, an ellipse with a long vertical dimension, an ellipse with a long horizontal dimension, a six-pointed star, and a semi-circle.

Subjects. A total of 120 subjects was used, 10 in each of the 12 groups. They were male undergraduate students at The Johns Hopkins University who were run through the experimental procedures one at a time.

Results

The data considered first are the proportion of correct labeling responses achieved in the first two tasks. These require correction for chance effects in both tasks. Subjects were using different numbers of labels in identifying the 12 forms and thus could achieve correct labeling responses by means of the chance expectancies associated with the number of labels used. Consequently, the performance of each subject was corrected for chance by the formula used by Bricker in a situation similar to ours (3).[1]/

Task I. In the left half of Table I we present the average proportions of correct labeling responses achieved by the 10 subjects in each of the eight experimental groups during the 120 trials of labeling practice. The proportion of correct responses was computed for each subject individually using the correction formula described by Bricker (3). The groups are arranged in columns according to the number of labels used in Task I and in rows according to the forms being labeled.

An analysis of variance of the results of Task I indicated significant effects attributable to the number of labels being used and the type of

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1/ The proportion correct was computed from a number correct score which had been corrected for chance by the use of:

$$R_c = R - W(p_r/p_w),$$

where R_c is the corrected number right, R is the raw number right, W is the number wrong, p_r is the probability that a correct response will occur by chance, and p_w is the probability that a wrong response could occur by chance.

TABLE 1

Proportion of Correct Labeling Responses Achieved in Task I and Task II. Row designation refers to Task I Experience of Subjects. In Task II all Subjects Labeled the Standard Set of Nonsense Forms.

Task I Experience		Task I					Task II				
		Number of Labels Used					Number of Labels Used				
		2	4	6	12	Means	2	4	6	12	Means
None							.330	.411	.358	.247	.337
							.620	.651	.602	.396	
Labeled Air Photos	M. =	.593	.602	.500	.507	.551	.383	.387	.438	.389	.399
	S.D.=	.598	.542	.522	.675		.809	.599	.551	.809	
Labeled Geometric Forms		.860	.678	.850	.689	.769	.387	.431	.690	.553	.515
		.558	.764	.333	.916		1.034	.665	.568	.806	
Means		.727	.640	.675	.598		.367	.410	.495	.396	

stimulus materials labeled.[2] Subjects labeling the Geometric forms had more success in learning to associate the labels with the forms, independent of the number of labels used, than did subjects learning to associate the labels with the Air Photo forms ($P < .001$).

The decreasing accuracy of labeling, corrected for chance, with increasing number of response categories was an unexpected result ($P < .05$). We had not found this result in a previous study (6); nor had Bricker (3). The analysis of variance term for the interaction of number of labels used and type of stimulus material being labeled was not significant, indicating that the relation between accuracy and number of labels used was not affected significantly by the type of material being labeled.

Task II. Average performance of subjects in each of the 12 groups in Task II is presented in the right half of Table I. In the first row are the four control groups of subjects who did not participate in Task I. In the second row are the four groups of subjects who labeled the Air Photo forms in Task I, and in the third row are the four groups of subjects who labeled the Geometric forms in the first task. In Task II all subjects labeled the standard set of Nonsense forms.

An analysis of variance of the data of Task II indicated that the effect of the Task I treatment was significantly large ($P < .05$). Subjects who had labeled the Air Photo forms in the first task did significantly less well than did subjects who had labeled the Geometric forms prior to Task II. Subjects in both of these groups did better in the second task than subjects who had not used their labels previously. Although consideration of the group mean scores in the cells of the table indicates that the effect of the Task I procedures was less noticeable in the case of subjects using the smaller numbers of labels, there was no evidence of a significant interaction between the number of labels used in Task II and the type of Task I experience. The effect of previous experience with the labels held for all of the label sets used in the experiment. On the other hand, the effect of the number of labels used in the tasks, independent of the type of stimulus forms labeled in the first task, was not significantly large. This latter finding suggests that the effect of practice in the use of labels was most pronounced for subjects using large numbers of labels. These subjects had achieved significantly fewer labeling responses in Task I than did subjects using smaller numbers of labels.

Task III. In the third task, subjects were required merely to recognize the forms labeled in Task II. The data averaged over the six trials of this task are presented in two forms. We present first in the left half of Table 2

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[2] The group variances in this analysis and those in all subsequent analyses can be assumed homogeneous. Prior to the analysis of variance in each case group variances were tested for heterogeneity by Bartlett's test (2).

TABLE 2

Number of Recognition Responses given in Task III and the Proportion of these Responses which were Correctly given to Familiar Forms

Task I Experience		Number of Recognition Responses					Proportion Correct Recognition Responses				
		Number of Labels used Previously					Number of Labels used Previously				
		2	4	6	12	Means	2	4	6	12	Means
None	M. =	64.4	63.8	46.5	63.7	59.6	.641	.647	.738	.665	.673
	S.D.=	31.08	17.09	42.90	32.40		.210	.265	.358	.207	
Labeled Air Photos		53.8	64.8	58.4	61.6	59.6	.765	.693	.668	.677	.701
		46.08	26.94	31.11	36.22		.401	.370	.348	.402	
Labeled Geometric Forms		67.3	62.7	60.7	52.4	60.8	.645	.654	.777	.719	.699
		20.93	23.24	27.24	48.58		.385	.377	.251	.359	
Means		61.8	63.8	55.2	59.2		.684	.665	.728	.687	

the average number of forms identified as familiar. The right half of the table shows the relative accuracy with which the forms were identified as familiar. The latter score was computed by dividing the number of familiar forms which were called familiar by the total number of all forms which subjects thought they recognized. Each value in the table represents the average performance of the 10 subjects in each group.

An analysis of variance performed upon each half of Table 2 separately revealed no clear-cut effects of either the number of labels used or the kind of experience which subjects had with their labels prior to Task III. The effect of the number of labels used in Task II upon the number of forms recognized in Task III, without regard to the accuracy of such recognitions, was significant ($P < .05$). This result is ambiguous, however, because the interaction of this variable with the type of experience which subjects had prior to Task II was highly significant ($P < .025$). This tendency for subjects in some of the groups to make significantly more recognition responses does not appear related in a simple way to the main variables of the experiment.

The only significant effect shown by the analysis of the data in the right half of Table 2 was also due to the interaction effect ($P < .05$). This significant interaction term could be identified with unusually high relative accuracy on the part of subjects in four of the groups. This result again does not appear to be related in any systematic way to the group results of Task I or Task II. In general, the performances on Task III do not appear to reflect in any simple way the effects of variables introduced in the first two tasks.[3/]

Within-subject correlations. Another possible effect of the main variables of this experiment was upon the degree to which performance within subjects during Task II was related to performance during the recognition task. If the act of learning to associate labels with each form affected the degree to which subject learned about the discriminable aspects of these forms, we could expect that subject would most reliably recognize in the third task those forms that he had labeled most successfully in the second task. On the other hand, if the degree to which subject learned about the forms was independent of the success with which he labeled each form we could expect insignificant within-subject

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3/ The results were analyzed separately for Trials 1 and 2, Trials 3 and 4, and for Trials 5 and 6. In general, this further breakdown provided results similar to those reported for all trials taken together. The only additional information added was that recognition of familiar figures in the upright position on Trials 5 and 6 was significantly better than in any of the other orientations of Trials 1 through 4.

correlations between performances of each subject on the two tasks. Our previous experiment indicated that this relationship accounted for a significant, but minor, part of the variance within subjects in learning new labels for a set of stimulus forms with which they had previously learned to associate another set of labels (6).

Average within-subject correlations for each of the present groups are shown in Table 3 where the groups are ordered by rows and columns as before. These coefficients are based upon the number of times that a given stimulus was labeled correctly in Task II and recognized correctly in Task III by each subject. The coefficients were computed from pooled variates from the 10 subjects in each group, each deviation involved being measured from its own subject mean (10).

Table 3

Within-Subject Correlation Coefficients Computed from Number of Times Each Form was Correctly Labeled in Task II and Correctly Recognized in Task III

Task I Experience	Number of Labels Used 2	4	6	12	Mean Correlation
None	.218*	.213	.206	.141	.193**
Labeled Air Photos	.017	.233	.402	.350	.265
Labeled Geometric Forms	-.007	.207	.399	.422	.251

* Computed from pooled variates from 10 subjects in each group, each deviation involved being measured from its own subject mean.

** Computed from pooled variates from 30 subjects who had same Task I experience.

Within-subject correlations are significantly affected by practice in the use of sets of labels, and the specific effect found is significantly related to the number of labels in the set being used. Within those subjects who labeled the Air Photo forms or the Geometric forms in Task I there is a statistically significant increasing degree of correlation between performance in Task II and Task III with increasing number of verbal responses ($P < .05$).[4] This is not true of subjects who had no prior experience with their labels before using them to identify the familiar Nonsense forms in Task II. Within these subjects the correlations are of the same order of magnitude consistently found within the subjects of the previous study (6).

This interesting result will be discussed in some detail in a later section. We wish here to mention only its role in generating the second experiment to be reported next. The second experiment was designed to answer the question of whether the critical aspect of the experience which subjects had with the labels prior to their use in identifying the Nonsense forms was experience with the particular labels used or simply experience with a label set of the same size. That is, are the effects of practice in the use of labels as identifying responses specific to those particular responses alone or are they attributable instead to mere practice in responding discriminantly, independent of the particular labels used in practice?

The second experiment bears upon this question. We compared the performance of subjects on the learning task of Task II and then on the recognition task of Task III when the previous labeling experience which they had prior to Task II was with the same identical labels used in Task II or with some other label set of the same size.

III. EXPERIMENT II

The methods and procedures of the second experiment are essentially similar to those of the first.

Method

Procedure. The procedures consisted of three tasks for all subjects. In Task I all subjects learned to associate a set of 6 verbal responses (letters of the alphabet) with 12 stimulus patterns which were one of three types. One-third of the subjects learned to associate their six labels with the Air

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[4] These significant changes in the magnitude of correlations are not due simply to systematic changes in the magnitude of the variances of the predictor or predicted variates. The within-subject variances were homogeneous among all groups of subjects who experienced the same labeling practice in Task I.

Photo forms of Experiment I. One-third learned to associate their six labels with the set of Geometric forms, and the last third learned to associate their labels with a set of 12 Nonsense forms similar to those used in the second and third tasks of the first experiment but not identical with any of them.

One-half of the subjects labeling each of the three types of stimulus forms in the first task used the same six verbal responses in Task I and Task II. The other half of our subjects used one set of six verbal responses in the first task and then changed to another set for the second task. The combination of the three types of stimulus materials used in Task I with the variable of whether or not the subjects used the same labels in Task I and Task II produced the six groups of the experiment. In all other respects this experiment was the same as that reported in the previous section, the procedures of Task II and Task III being identical to those described there with the exception that all subjects used just six labels in Task II.

Subjects. A total of 60 new subjects was used, ten in each of the six experimental groups. They were men undergraduate students who did not participate in the first experiment and who were run through the procedures one at a time.

Results

Since all subjects used the same number of labels in identifying the visual patterns in the first and second tasks there was no need to correct their performances for the effects of chance. All data for the first two tasks are reported in terms of the average number of correct labeling responses achieved in the 120 trials of each task.

Task I. Table 4 contains the average number of correct labeling responses made by the 60 subjects of our experiment during Task I and Task II. The groups are ordered in columns according to the type of stimulus forms labeled in Task I and in rows according to the label set used in Task I.

The particular alphabet letters making up the six verbal labels of Set "A" are not those used in Set "B", but there was no reason to suspect that the use of these two different sets should produce differences in ability to associate the letters in each set with the visual forms. This is supported by the results of Task I reported in the left half of Table 4. An analysis of variance of these data indicated that the only significant effect in this first task was related to the type of forms being labeled ($P < .05$). Subjects labeling the Geometric forms had most success, those labeling the Air Photo forms did somewhat less well, and the subjects labeling the Nonsense figures had the least success. There was no evidence of a significant effect due to the label set being used or of a significant interaction effect.

TABLE 4

Average Number of Correct Labeling Responses Achieved in Task I and Task II. Row designation refers to Label Set used in Task I. In Task II all subjects used Label Set "A" to Label a Standard Set of Nonsense Forms

Labels used in Task I	Task I				Task II			
	Forms Labeled in Task I				Forms Labeled in Task I			
	Geometric	Air Photo	Nonsense	Means	Geometric	Air Photo	Nonsense	Means
Set "A"	M. = 48.6	42.2	25.0	38.6	M. = 27.3	38.7	37.1	34.4
	S.D. = 53.48	38.35	28.88		S.D.= 21.21	30.63	35.76	
Set "B"	50.0	45.5	22.8	39.4	33.5	37.1	43.3	38.0
	60.65	54.00	25.50		40.08	45.92	48.68	
Means	49.3	43.8	23.9		30.4	37.9	40.2	

Task II. The data of the second task are summarized in the right half of Table 4. All groups in this task used a set of six verbal labels to identify the standard set of Nonsense figures which did not include any of those used in the first task. All used the verbal responses of Set "A". Thus, all subjects in the first row of the table used the same responses which they had used in the first task, while subjects in the second row had shifted from Set "B" used in Task I to Set "A" which were used in Task II.

An analysis of variance of the data of Task II indicate no significant effect due to shift in label set from the first to the second task. Subjects who were using the labels of Set "A" for the first time in Task II did as well as subjects who had previous practice in the use of those particular labels in Task I. In spite of the unimportance of the variable of whether or not the subjects used the same labels in the two sessions, however, the effects of the type of forms which were labeled in Task I are highly significant ($P < .025$). Subjects who had labeled the Nonsense forms in Task I did best in Task II, subjects who had labeled the Air Photo forms did somewhat less well, and subjects who labeled the Geometric forms in Task I did least well in Task II. Since the order of accuracy of performance in Task I was just the reverse of this, it would appear that the ability to learn to label the Nonsense forms in Task II was related more to the type of forms labeled in the first task than to the number of correct labeling responses achieved there. Again, no significant effect related to the interaction of the two variables of the experiment was found.

Task III. Once again the data of Task III are presented in two forms. We present first in the left half of Table 5 the average number of forms in the recognition task which the subjects in each group identified as familiar. In the right half of this table we present the proportion of those forms identified in Task III as being familiar which actually were forms labeled in Task II.

An analysis of variance performed upon each set of data separately produced only one significant effect. This was the effect of the set of labels used in Task I upon the number of forms which were called familiar in Task III, independent of the accuracy of these identifications. Subjects in the first row of the table, those who used the same set of labels in the two sessions, identified significantly more forms as being familiar. The data in the right half of Table 5 indicate, however, that proportionally these subjects did not recognize the forms of Task II with any greater accuracy than did the subjects of the second row who used a set of labels in Task I which was different from the set used in Task II. Once again, a separate consideration of trials 1 and 2, 3 and 4, and 5 and 6 corresponds to the analysis based upon all six trials considered together, although recognition of familiar forms in the up-right position on trials 5 and 6 was again significantly better than when they were in one of the rotated positions of trials 1 through 4.

TABLE 5

Average Number of Recognition Responses given in Task III and the Proportion of these Responses which were Correctly given to Familiar Forms.

Labels used in Task I	Number of Recognition Responses — Forms Labeled in Task I				Proportion Correct Recognition Responses — Forms Labeled in Task I			
	Geometric	Air Photo	Nonsense	Means	Geometric	Air Photo	Nonsense	Means
Set "A"	M. = 69.8	60.3	64.1	64.7	M. = .691	.692	.679	.687
	S.D. = 27.78	32.25	32.25		S.D. = .760	1.087	1.120	
Set "B"	54.8	61.8	54.1	56.9	.746	.695	.706	.716
	40.16	37.16	44.10		.957	1.276	1.300	
Means	62.3	61.0	59.1		.718	.694	.692	

The correlations within subjects between the number of times each form was correctly labeled in Task II and the number of times it was recognized in Task III also reflect the relative unimportance of the response variables studied in this experiment. The average within-subject correlation for all of the 60 subjects of the study was .375. This, again, was computed by pooling values from all subjects, each deviation involved being computed from its own subject mean (10). No significant deviation from this average within-subject correlation was produced by any of the experimental variables. The correlation within all subjects who used the same set of labels in the first two tasks was .370. Within-subjects who used a different set of labels in the two tasks, the correlation was .378. Correlations within subjects who labeled the three types of forms in Task I, independent of the set of labels used, were respectively .396 for subjects who labeled the Nonsense forms, .332 for subjects who labeled the Geometric forms, and .394 for subjects who labeled the Air Photo forms.

IV. DISCUSSION

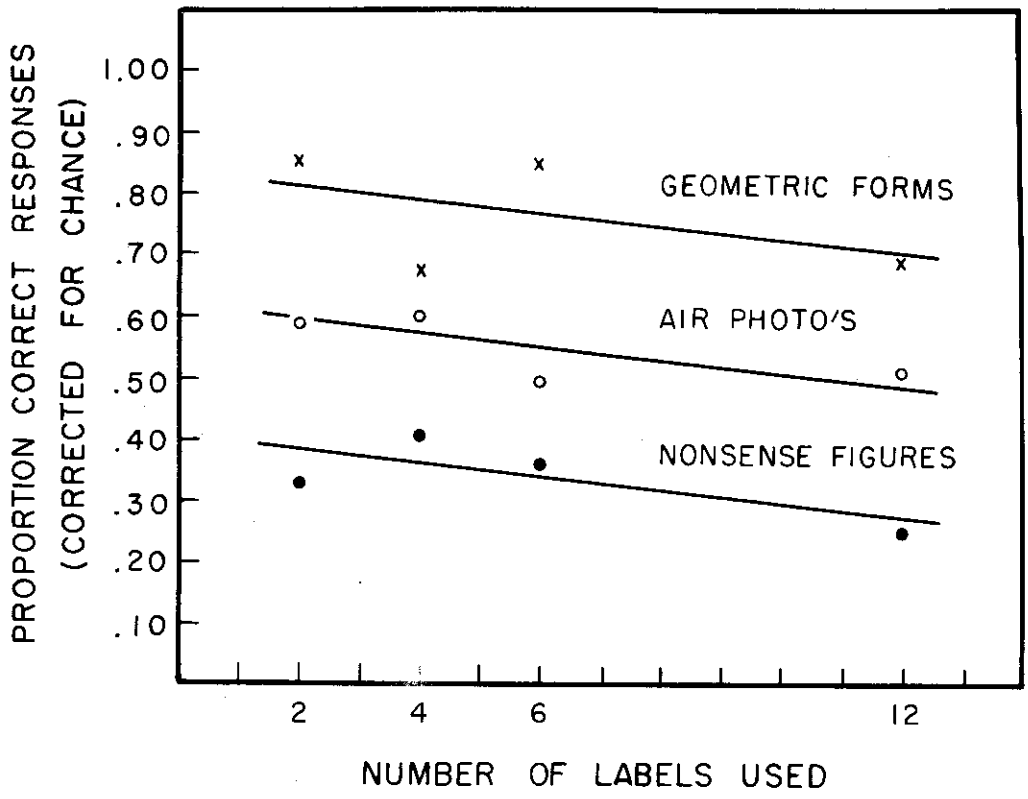
There appear to be four outstanding results of the experiments reported here. The first emphasizes aspects of verbal labeling performance which previously have been neglected. These are aspects of verbal labeling skill which are specific to the responses used rather than to the stimulus forms being labeled. We should expect, for example, that the perceptual changes which occur while subjects use verbal labels for the first time in attempting to label a set of forms should include progressive differentiation of the responses as well as of the forms. Subjects during such practice must learn to discriminate among their responses, as well as among the stimulus forms and acquire other skills which may be specific to the responses used. Since we can reasonably expect response sets to differ in the extent to which the responses in each set are easily differentiable, there should exist aspects of verbal labeling performance which are characteristic of the use of particular sets of responses, independent of the type of stimulus materials being labeled.

Evidence supporting this suggestion is supplied by Figure 2 where we have plotted the proportion of correct labeling responses achieved by subjects using sets of labels for the first time to label forms differing in initial familiarity. The plotted points are from Experiment I and are the Task I performances of subjects who labeled the Air Photo and Geometric forms in that task and the Task II performances of subjects who had no Task I experience.

An analysis of the relationship between the proportion of correct labeling responses and the number of labels used indicated that this is a significant linear trend decreasing as the number of labels used increases ($P < .05$). More importantly, this trend can be assumed the same for all sets of stimulus forms, indicating that an aspect of labeling skill can be independent of the stimulus sets being labeled and specific to the

FIGURE 2

Proportions of correct labeling responses achieved plotted as a function of the number of different labeling responses being used. The lines fitted to the data represent a least-squares fit to all the points adjusted for the mean labeling proficiency achieved in the case of each type of stimulus form.



number of labels being used. When larger and larger response sets are used, subjects have increasing difficulty in learning to associate the responses with the stimulus forms; and this same relationship holds for sets of stimulus forms differing in initial familiarity. The lines fitted to the data represent a least-squares fit to all the points adjusted for the mean labeling proficiency achieved in the case of each type of stimulus forms (10).

A second result of these experiments is the demonstration that increased skill in the use of verbal responses need not be accompanied by increases in discriminative skill specific to the stimulus forms labeled. That is, increases in response differentiation need not be accompanied by increased stimulus differentiation. The effects of practice in the use of sets of labels previous to Task II in both experiments did significantly increase skill in labeling the Nonsense forms in Task II. This enhanced ability to correctly associate the labels with the forms, however, did not increase the ability of subjects, considered in groups, to recognize these forms when presented with others in Task III. Thus, it is evident that variables exist which can affect the efficiency of labeling practice without significantly affecting at least one type of perceptual discriminative skill which can result from that practice.

This negative result contrasts interestingly with the third result considered here. This is the evidence produced in the first experiment to indicate that within-subjects previous practice in the use of labels prior to Task II could affect the success with which each form was recognized in the third task. Provided subjects are given previous practice in the use of labels, the degree of success achieved in subsequently using these labels to identify a new set of forms can become a good indicator of the degree to which they learn about an aspect of the forms while making these verbal identifications. That is, the perceptual gain, of the sort tested by Task III, can become more reliably tied to a measure of labeling performance.

This suggests that when unfamiliar labels are used without prior opportunity to acquire skills specific to the labels, correct labeling responses have little significance. Subjects learn about the forms whether or not correct labeling responses are achieved. With previous practice in the use of the labels, however, it appears that what subjects learn about the forms becomes more dependent upon the correctness of labeling responses.

Since the effect of practice upon the within-subject correlations in the first experiment was significantly related to the number of labels being used in the labeling tasks, it appears reasonable to suppose that familiar labeling responses may have a denotative function for subjects. They may be useful to subjects in retaining from trial to trial the identity of some of the forms and certain information associated with them such as which forms had been correctly labeled on a previous trial, which critical differentia appear in which forms, which forms have certain differentiable features in common, etc. If the labels had such a denotative function, we should expect

that subjects using the smaller numbers of labels would find them less useful in this way. This appears to be the case. The effect of previous experience in the use of just two labels upon the within-subject correlations, for example, is to reduce them to zero.

These results taken together suggest two possible perceptual effects which can be produced by verbal labeling practice. One of these is a differentiation process involving both the set of stimulus forms and the set of labels used. The other process, the appearance of which depends upon the use of larger sets of well differentiated responses, may be the denotative use of labels to organize and identify the discriminable aspects of stimulation which are differentiated by practice.

We cannot assume, however, that this denotative function of labeling results from practice in using a particular set of labels. The results of the second experiment indicate that practice with a label set of the same size may be sufficient. Thus, practice in using a particular set of labels is not a critical factor. Practice in using labels of a particular kind and number, on the other hand, does appear important in permitting what we have called the denotative use of labels.

The fourth outstanding result of these experiments, indeed, suggests that practice in the use of a particular set of labels may interfere with precise subsequent recognition of forms which subjects had learned to identify using the labels. In the second experiment subjects who used the same set of labels in Task I and in Task II were willing to accept as being familiar many more of the unfamiliar forms which were shown to them for the first time in Task III. This suggests that these subjects generalized to a significantly greater degree in the third task what they had learned about the forms in Task II. We could reasonably expect such a stimulus generalization effect to occur in the third task because the new forms introduced there were similar in construction to those labeled in the second task.

If stimulus generalization occurred in the third task, it should occur to a greater extent for those subjects who appeared to learn the least about the forms in Task II. These subjects would have learned fewer of the construction details unique to each form and could be expected to accept as familiar new forms which contained some familiar details. This appears to be the case. Those subjects who achieved fewest correct labeling responses in the second task accepted more of the new forms of Task III as being familiar. That is, a significant inverse correlation exists within-groups between the number of correct labeling responses achieved in Task II and the number of new forms accepted as familiar in Task III ($r = -.207$).

This correlation cannot account entirely for the greater number of new forms accepted as familiar by subjects who used the same labels in the first two tasks, however. An analysis of covariance indicated that even after scores were adjusted for this inverse correlation the number of such incorrect recognitions in Task III was still significantly greater for subjects who used the same labels in Task I and Task II ($P < .05$). We must conclude that the use of practiced labels can lead to greater generalization of form concepts learned while using the labels to identify a set of previously unfamiliar forms. This, of course, is an extremely undesirable result in the case where the objective of such labeling practice is not only to enable observers to recognize particular forms as they appear but also to reject with high accuracy all forms similar to but not identical with these particular ones.

These remarks apply rigorously only to the use of irrelevant labels of the kind which were used in these experiments. We believe, however, that the use of other verbal units, including words which have some meaning relevant to the discriminable aspects of the forms, can be understood to some degree within the framework of the results and concepts presented here. For example, many of the words used could be expected to be adjectives or nouns which subjects use with high frequency as identifying or categorizing responses. In this respect they are similar to the practiced labels of these experiments. To the extent that the comparison is valid we should expect them to have the useful function which we have described as denotative. That is, the success with which they were used in learning to separately identify a set of new unfamiliar forms should provide a reliable indication of the proficiency which observers could show subsequently in recognizing each form under new and perhaps deteriorated viewing conditions. On the other hand, the use of such well-practiced labels may lead to the same kind of error shown by the subjects of our second experiment who tended to over-generalize the form concepts which they had achieved during labeling practice.

V. SUMMARY

Two experiments were reported in which subjects were given prior practice in the use of sets of irrelevant labeling responses before learning to associate them with a set of unfamiliar Nonsense forms. Although previous practice in the use of the labels did significantly increase the number of correct labeling responses achieved by subjects in labeling the new forms, it did not increase their ability to recognize the forms later when seen together with new forms of similar construction.

Previous practice did affect the size of within-subject correlations. With larger sets of practiced labels, the number of times each form was correctly labeled in labeling practice became an important indicator of the number of times it would be recognized in the recognition task. When only two labels were used the effect of the previous practice in the use of the

labels was to reduce the within-subject correlations to zero.

It was suggested that verbal labeling practice can have a double function. It has the function first of forcing subjects to differentiate the stimulus set, as well as the responses used, and can provide also a denotative process whereby subjects organize and identify the stimulus aspects differentiated by practice. This latter process occurs only with the use of larger sets of labels following practice in the use of labels as identifying responses.

The use of well-practiced labels in learning to identify a new set of forms produced one deleterious effect. Subjects who had learned to associate practiced labels with a set of Nonsense forms were significantly more willing, following such practice, to accept as familiar new forms of similar construction. That is, they showed significantly less accuracy in rejecting forms which were similar to those labeled in practice but not identical with any of them.

VI. REFERENCES

1. Arnoult, M.D. Transfer of pre-differentiation training in simple and multiple shape discrimination. J. exp. Psychol., 1953, 45, 401-409.

2. Bartlett, M. S. Some examples of statistical methods of research in agriculture and applied biology. Suppl. J. Roy. Statis. Soc., 1937, 4, 137-183.

3. Bricker, P. D. The identification of redundant stimulus patterns. J. exp. Psychol., 1955, 49, 73-81.

4. Gagné, R. M. & Baker, K. E. Stimulus pre-differentiation as a factor in transfer of training. J. exp. Psychol., 1950, 40, 439-451.

5. Goss, A. E. Transfer as a function of type and amount of preliminary experience with task stimuli. J. exp. Psychol., 1953, 46, 419-428.

6. Hake, H. W. and Eriksen, C. W. Effect of number of permissible response categories on learning of a constant number of visual stimuli. J. exp. Psychol. (In press).

7. Miller, N. E. Theory and experiment relating psychoanalytic displacement to stimulus-response generalization. J. abnorm. soc. Psychol., 1948, 43, 155-178.

8. Robinson, J. S. The effect of learning verbal labels for stimuli on their later discrimination. J. exp. Psychol., 1955, 49, 112-115.

9. Rossman, I. L. & Goss, A. E. The acquired distinctiveness of cues: The role of discriminative verbal responses facilitating the acquisition of discriminative motor responses. J. exp. Psychol., 1951, 42, 173-182.

10. Snedecor, G. W. Statistical Methods. (3rd Ed.) Ames, Iowa: Collegiate Press, 1940.