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ON THE GENESIS OF ABSTRACT IDEAS[1]

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Previous work has shown that Ss can learn to classify sets of patterns which are distortions of a prototype, even when they have not seen the prototype. In this paper it is shown that after learning a set of patterns, the prototype (schema) of that set is more easily classified than control patterns which are also within the learned category. As the variability among the memorized patterns increases, so does the ability of Ss to classify highly distorted new instances. These findings argue that information about the schema is abstracted from the stored instances with very high efficiency. It is unclear whether the abstraction of information involved in classifying the schema occurs while learning the original patterns or whether the abstraction process takes place at the time of the first presentation of the schema.

When a man correctly recognizes an animal he has never seen before as a dog, he has manifested an ability to generalize from previous experience. What has he learned that allows him to make the classification successfully? This question has been discussed in various forms since Aristotle. Some philosophers suggest a process of abstraction in which *S* builds up a representation of a figure (e.g., triangle)which is different from the instances he has seen. Others have denied the reality of such composite representations or abstractions. For example, Bishop Berkeley pointed out that he could search his imagination in vain for the abstraction of a triangle which was neither equilateral nor scalene but which represented both of these and all other triangles at once. The philosophical idea of abstract representations entered modern psychology from clinical neurology through the work of Barlett (1932) on schema formation (see also Oldfield & Zangwill, 1942).

In the areas of perception and pattern recognition, psychologists have studied questions related to schema formation. Attneave (1957) demonstrated that pretraining on the schema (prototype) of a set of patterns could facilitate later paired-associate learning. Subsequently Hinsey (1963) showed that pretraining on the proto-

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type pattern is superior to pretraining on a peripheral pattern. However, these studies suggest only that knowing the schema can aid later learning and do not reflect on whether *S* in fact abstracts information concerning the schema in the course of learning.

Attneave's (1957) study, like most of the subsequent experiments, used stochastic distortion rules to obtain patterns which varied around a prototype. For rules of this type the prototype represents a kind of average or central tendency of the distortions. Following this same line, Posner, Goldsmith, and Welton (1967) showed that the rate at which *S*s learned to classify a list of patterns was a function of the amount of distortion of the instances from their respective prototypes. As the amount of distortion increased, so did the variability among instances within a category. This increase in variability served to reduce the rate at which the category was learned. Evans and Edmonds (1966) have developed much the same theme. They also showed that *S*s could learn a discrimination between patterns generated from different prototypes without having seen the prototypes. This discrimination could be obtained with or without knowledge of results. These studies indicate very little, if anything, about the use of a schema. That *S*s can learn to discriminate patterns without seeing a prototype does not indicate that abstraction is involved or that the schema is itself being learned or used.

The philosophical notion of abstract ideas is vague but it does suggest that information which is common to the individual instances is abstracted and stored in some form. In its strongest sense, this might be translated operationally into the hypothesis that the commonalities among a set of patterns are abstracted during learning and that they alone are stored. In the case of patterns obtained by statistical distortion rules, this suggests that *S* abstracts the prototype. A less extreme hypothesis suggests that *S* stores the abstracted schema in addition to the individual instances. A still weaker interpretation is that *S*s will recognize the schema better than patterns which are similar to the memorized instances but which are not their prototype. This last hypothesis would not necessarily require the abstracting process to take place during learning.

The studies reported in this paper examine various transfer tasks in an effort to understand what *S* stores during the process of learning to classify distorted patterns. The stimuli are meaningful or nonsense dot patterns which can be distorted by statistical rules. In Exp. I and II, different groups of *S*s learned to classify high and low variability distortions of the same prototype. They were then transferred to learning or recognition tasks which involved new distortions not previoulsy seen. In Exp. III all *S*s learned to classify distortions of high variability. They were then transferred to the following patterns: old distortions just memorized, the schema of the memorized instances, and control patterns at varying distances from the memorized patterns. Performance in these transfer tasks was used to infer the role of abstraction and of pattern variability in recognition.

Experiment I

The original learning in this experiment involved instances of four different prototypes. One group had small distortions of the prototypes, while for the other group the distortions were large. After reaching critieron on the original learning task, both groups were transferred to a list of patterns which were more highly distorted than those in either of the two original lists. Previous work (Posner et al., 1967) demonstrated that the transfer list patterns were equal both in physical and perceived distance from the patterns in the two original lists. Since these new patterns are equally similar to the two original lists, any differences between the groups in transfer must be due either to the distance of the memorized patterns from their prototypes or to their distance from each other (variability). If a clearly defined schema was of primary importance in transfer, the small distortion group should show better transfer. If variability is more important, the larger distortion group should show better transfer. A control group with no original learning was used to assess the direction of the transfer effects.

Method

Subjects.—The *S*s were 36 introductory psychology students at the University of Wisconsin who received course points for participating in the experiment.

Materials.—The prototype patterns consisted of a triangle, letters M and F, and a random pattern, all made from nine dots within a 30 × 30 matrix. Pictures of prototypes and some of the distortions were previously published (Posner, Goldsmith, & Welton, 1967). From each of the four originals, six distortions were constructed at each of three different levels (1, 5, and 7.7 bits/dot). The detailed statistical rules and distance data have also been published (Posner et al., 1967). The six distortions were arbitrarily divided into two lists of three distortions each. Each list, therefore, consisted of 12 patterns in total, divided into three distortions of each of the four different prototypes (triangle, M, F, and random). Patterns were placed on 2 × 2 slides and each was duplicated three times, thus providing three independent orders for each list.

Procedure.—The 36 *S*s were randomly assigned to one of three conditions and to one of the two lists within the condition. All lists consisted of 12 patterns of one particular level of distortion. The conditions were: learning of Level 1 patterns, learning of Level 5 patterns, and no original learning (control). The exact procedure was reported previously (Posner et al., 1967). Briefly, a slide was presented and remained on until *S* pressed one of four buttons which represented his choice. Then a feedback light indicating the correct button for that slide came on and remained on during the 8-sec. interstimulus interval. The *S* continued through trials until he correctly classified two complete lists in a row.

After completing the original learning, the two experimental groups were transferred to a list of 7.7-bit distortions. The control group began its session with the 7.7-bit list. The transfer list was learned by all groups in the same way as the original list except that the learning was terminated at the end of six trials.

Results

Table 1 shows the basic results of the experiment. The two subgroups

TABLE 1

MEAN ERRORS TO CRITERION FOR ORIGINAL LEARNING AND TRANSFER TASKS, EXP. I

Original Learning	Transfer						
Errors to Criterion	Trial (Mean Errors)						
	1	2	3	4	5	6	$\bar{X}$
Group 1 4.8	8.1	6.2	5.3	5.6	4.4	3.7	5.6
Group 5 12.3	6.0	5.5	4.5	3.7	3.2	3.0	4.3
Group 7 —	8.3	7.8	7.6	6.0	5.5	5.8	6.8

within each condition were combined since the sublists were arbitrary samplings of the statistical rule which governed the distortions. As expected, the group at Level 5 made more errors in original learning than did the group at Level 1. This replicated findings reported previously (Posner et al., 1967).

During the transfer task Group 1 made more errors on each of the first six trials than did Group 5. The control group showed more errors on each trial than either of the two experimental groups. Analyses of variance of both the first trial and of all six trials were run. For the first trial the overall effects of groups was significant, $F\ (2,\ 33) = 10.6,\ p < .01$. Subsequent t tests showed that on the first trial Group 1 was significantly worse than Group 5 but not did differ from the control group. The analysis of all six trials also showed a significant effect of groups, $F\ (2,\ 33) = 32,\ p < .01$. Subsequent t tests showed that Group 1 was significantly worse than Group 5 and significantly better than the control.

Conclusions

The results of this study indicate that transfer from the broader (Level 5) concept was better. This occurs despite the fact that the average distance between corresponding dots and the perceived similarity of the patterns at Levels 1 and 5 to those at Level 7.7 are the same (Posner et al., 1967). Moreover, the minimum distance from Level 5 patterns to any of the new distortions is at least as great, on the average, as the minimum distance of the Level 1 patterns from the new distortions. Thus the superior performance of the groups at Level 5 cannot be due to perceived similarities or actual physical distance between the learned patterns and the new instances. In addition, *S*s at Level 1 uniformly reported the correct names of the meaningful patterns, whereas *S*s at Level 5 rarely did. Thus having the verbal label does not appear to help as much as practice in classifying patterns which had considerable noise or variability.

The performance of the control group may have been suppressed somewhat due to lack of warm-up prior to the Level 7 list. However, it seems likely that both Level 1 and 5 are showing positive transfer due to their specific learning experience as well as generalized learning-to-learn. The unpaced nature of the learning situation would probably reduce learning-to-learn effects found in the usual anticipation methods. There are two serious objections which could be raised to the differences between groups at Levels 1 and 5. First, is the initial surprise which *S*s at Level 1 had when confronted with highly distorted patterns. This is suggested by the finding that Level 1 is not superior to the control group on the first trial. Even though Level 1 remains below Level 5 on each trial, it might be argued that a learning procedure confounds initial recognition with later performance. Second, is that Level 5 *S*s took more trials to learn and it might be argued, therefore, that they have learned methods of how to deal with the storage of information from distorted patterns. Their superior performance would then be due to the appropriateness of the strategies they had previously learned to the new material. Experiment II was designed to eliminate some of these problems.

Experiment II

In Exp. II the transfer task was pattern recognition rather than learning. It was not necessary for *S* to memorize the new material and thus storage strategies attained in original learning were not appropriate. Since 24 different patterns were shown, performance on each slide was less dependent upon recognition of previous slides than it is in a learning situation. In order to assess the relative influence of new learning during the transfer tasks, groups were run with and without feedback.

Method

Subjects.—The *S*s were 32 students in introductory psychology at the University of Oregon who received course points for their participation.

Material.—The original learning lists were identical to those used in Exp. I. The transfer material consisted of a list of 24 different slides. The 24 slides were six random samples of the 7.7-bit distortion rule for each of the four original patterns.

Procedure.—The learning procedure was the same as in Exp. I. The *S*s were divided into two groups. Sixteen *S*s learned a list at Level 1 and 16 *S*s learned a list at Level 5. Learning was continued until two successful repetitions of the list were completed. The *S*s were then given pattern recognition instructions. These instructions indicated that *S*s should classify each successive slide as rapidly as possible into one of the four categories that they had learned during the original learning task. For half the *S*s in each condition feedback was given after each classification. The other half received no feedback. The *S*s were shown the transfer list twice in different random orders. The interslide interval was 9 sec.

Results

Table 2 shows the mean errors to criterion in original learning and the average error in the pattern recognition tasks for all conditions for each block of four trials. As before, *S*s in Level 5 took longer in original learning than those in Level 1. There was no significant difference in speed of learning between feedback conditions. Analysis of variance of errors in the pattern recognition task showed that the effect of level was significant, $F(1, 28) = 9$, $p < .01$, and the effect of feedback conditions was also significant, $F(1, 28) = 4.8$, $p < .05$. There were no significant interactions between level and feedback or between either of the two main variables with successive blocks of 24 slides. Table 2 also shows the mean errors for successive blocks of four trials in the pattern recognition task. There is a nonsignificant trend for the differences between Levels 1 and 5 to be reduced with practice particularly when feedback is present.

A correlation coefficient was computed between groups at Levels 1 and 5 over the particular slides to which errors were made during pattern recognition. This correlation was .83 indicating that both groups tended to miss the same patterns. A rank order correlation of .97 between distance from the prototype and errors indicated that patterns most distant from the prototype were more difficult to recognize.

Conclusions

The results of this study confirmed those obtained in Exp. 1. Once again, *S*s who had been trained with the high variability patterns did better on transfer

TABLE 2

Mean Errors in Original Learning and Pattern Recognition, Exp. II

Condition	Original Learning	Block of Four Trials												
		1	2	3	4	5	6	7	8	9	10	11	12	$\bar{X}$
Group 1														
Feedback	3.4	22	16	17	15	13	16	13	12	11	11	11	15	10.8
No Feedback	4.1	16	19	15	14	17	21	17	16	11	10	19	13	11.9
Group 5														
Feedback	16.8	15	12	17	10	14	9	8	15	16	12	9	9	9.1
No Feedback	11.9	16	11	13	13	17	15	14	17	15	9	14	11	10.4

than those trained with the low variability patterns. Moreover, they maintained the advantage over the first 24 slides, even though each slide was different. Therefore, it is difficult to argue that the deficiency in transfer for Level 1 *S*s was due to an initial startle at seeing patterns which were more distorted than those used in original learning. Moreover the transfer task reduced or eliminated the advantage of general learning strategies attained in the original task (learning-to-learn).

However, it could still be argued that the advantage of Level 5 is primarily in the kinds of criterion which *S*s set for admission of a particular pattern into one of the meaningful categories. The use of three highly familiar categories and one nonsense pattern within the same list may have contributed to this. There is a strong tendency for *S*s at Level 1 to classify patterns about which they were unsure into the random category. The percentage of random responses made during the 48 trials of pattern recognition were 25.5, 37.5, 33.5, and 42.9 for conditions: 5 feedback, 5 nonfeedback, 1 feedback, and 1 nonfeedback, respectively.

Table 3 shows a breakdown of the proportion of correct and false alarm responses during pattern recognition for each of the prototypes. The false alarm rate is obtained by dividing the errors in a category by the number of possible errors. In the case of the three meaningful patterns, Level 5 *S*s show a higher proportion of correct responses and about equal false alarms. For these distortions, therefore, it is clear that Level 5 *S*s are showing better discrimination than those trained on Level 1. For the random patterns, Level 1 *S*s have both more correct responses and more false alarms. When these two measures are combined using a graphical method (Norman, 1964) the Level 5 *S*s are slightly superior in overall performance. Thus even though Level 1 *S*s have a higher proportion of correct responses with the random pattern, when false alarms are taken into consideration, they do not show better discriminability.

TABLE 3

PROPORTION OF CORRECT AND FALSE ALARM RESPONSES FOR EACH CATEGORY

	Category				
	Triangle	M	F	Random	$\bar{X}$
Cond. 1					
Correct	.59	.49	.50	.53	.53
False Alarm	.10	.13	.06	.33	.16
Cond. 5					
Correct	.73	.71	.60	.49	.64
False Alarm	.11	.12	.05	.26	.14

The strong tendency of *S*s in Level 1 to use the random category suggests that they were somewhat reluctant to classify distorted instances into one of the meaningful categories. While in this study the main differences between groups seem to be in the ability to discriminate the categories, it would seem reasonable to explore changes in criterion particularly in studies where a forced choice between categories is not required.

EXPERIMENT III

The previous two experiments have indicated that *S*s do learn something about the variability of instances that they have seen. In both of these experiments, *S*s in each group had the same prototypes. If *S*s had been storing only the schema, then Level 1 *S*s should have shown better performance than Level 5 since it is easier to define the prototype based on Level 1 patterns than based on Level 5 patterns. The results are in the opposite direction, indicating that *S*s are learning some information about the individual patterns which they use in their later judgment. In this experiment an effort is made to determine directly whether *S*s are also learning information about the prototype.

Method

Subjects.—The *S*s were 30 students recruited from the University of Oregon Employment Service and paid $1.50 per hour for their services.

Material.—There were two lists of original learning materials. Each list contained 12 slides. The 12 slides were four distortions of three different prototypes. A set of distortions of the same prototype is called a "concept." The prototypes were different for the two lists and were constructed by placing dots in nine randomly selected positions in a 30 × 30 matrix. The four distortions of each prototype were constructed using the same four random samples of a 7.7-bit distortion rule. Thus the distances from each of the prototypes to its four distortions were identical.

The transfer material consisted of two lists of 24 slides. Three of the slides were the prototypes of the patterns in the learning lists. These represent the schema of each concept. Six slides, two from each of the concepts, were patterns memorized during the original learning (old distortions). Six slides, two from each of the concepts, were new 7.7-bit distortions of the prototypes which had not been seen during learning. Six slides, two from each of the concepts, were new 5-bit distortions of the prototypes. Finally, three slides were new random patterns unrelated to any of the concepts which *S* had learned.

In Table 4 the distances from the four memorized patterns of each concept to the respective transfer patterns are shown. The individual patterns are identified by a number or letter. In the case of the old distortions the two transfer patterns are identical to two of the stored patterns. These distance relationships hold for all concepts in both lists, although the prototypes differ from one concept to another and between the two lists. The distances represent the sum of the vertical and horizontal distances from each dot in the stored pattern to the corresponding dot in the transfer patterns. The numbers are in units of 1/20 of an inch. Previous results have shown that, for a given grain size, the logarithm of this measure is linearly related to perceived distance (Posner et al., 1967).

Procedure.—The 30 *S*s were divided randomly into two equal groups and assigned to the original learning lists. Original learning proceeded as described in the previous experiments until completion of two correct classifications of the lists. After the original learning was complete, *S*s were given their respective transfer lists in the pattern recognition procedure described in the last experiment. On the same day as the original learning they went through the transfer patterns twice, for a total of 48 patterns. Twenty-four hours later *S*s returned to the laboratory and ran through the pattern recognition tasks four additional times. During the pattern recognition task, no feedback was provided. Both the classification chosen and the speed of classification were recorded. The *S*s were instructed to respond accurately, but to try to respond as rapidly as they could when each new pattern was presented. Concepts were randomly assigned to switches for each *S*.

Results

Original learning required an average of 41 and 34 errors to criterion, for List A and List B, respectively. This difference was not significant. The error and speed data for the pattern recognition task are shown in Table 5. Since the lists are replications of each other except for the use of different randomly selected original patterns and the results are similar for the two groups, all 30 *S*s were combined in subsequent analyses.

The analyses were performed by

TABLE 4

Distances from Stored Exemplar Pattern to Each Transfer Pattern

Stored Pattern	Schema	Old Distortion		New Level 7s		New Level 5s		
		2	4	A	B	C[a]	D	E[b]
1	36	73	66	87	89	49	48	51
2	43	0	77	104	98	65	71	59
3	65	88	65	82	60	54	51	56
4	65	77	0	83	87	51	62	55
$\bar{X}$	52	59	52	89	83	54	58	55
% Errors in Transfer	15	11.5	14.7	42	39	26	28.5	19

[a] List B only.
[b] List A only.

TABLE 5

PERCENTAGE OF ERRORS AND SPEEDS (IN SEC.) FOR CLASSIFYING TRANSFER PATTERNS FOR DAY 1 AND DAY 2

	Day 1					Day 2				
	Old	Schema	5	7	New	Old	Schema	5	7	New
List A										
% Error	10	13.3	23.3	35	—	9.7	14.4	24.1	36	—
RT	2.04	2.19	2.36	2.52	2.88	1.86	1.88	2.03	2.18	2.51
List B										
% Error	16.1	16.6	30.5	41.7	—	15.8	16.1	25.3	46.9	—
RT	1.97	2.37	2.71	3.22	2.95	1.88	2.06	2.12	2.33	2.35
Average % Error	13.0	14.9	26.9	38.3	—	12.8	15.3	24.5	41.9	—
RT	2.01	2.28	2.53	2.87	2.91	1.87	1.97	2.07	2.25	2.43

sign tests because of the high correlation between successive experiences with the same pattern. Separate analyses were run for Day 1 and Day 2. The results of the sign tests are shown in Table 6.

On Day 1, it is clear that *S*s show no significant differences in proportion of errors between the patterns which they had just finished learning and the prototypes which they had never seen. It is also clear that both the old distortion and the schema have a significantly lower error rate than any of the new distortions seen by *S*. The Level 5 distortions showed significantly better recognition than the Level 7. No error data can be given for the new random patterns since there is not any correct classification for these patterns On Day 2, there is a slightly lower mean error for the old distortions than for the schemas. However, when the data are analysed by individual *S*s, 16 show a higher proportion of error on the old distortions and only 11 have a higher proportion on the schema. This difference does not reach significance by a sign test. On Day 2, the new distortions all show significantly more error than either the old distortions or schema patterns. Overall, it is clear that the schema patterns show no greater error than the patterns

TABLE 6

NUMBER OF *S*S WITH HIGHER AVERAGE ERRORS OR LONGER AVERAGE TIMES IN SPECIFIED CONDITIONS OF TRANSFER

Day 1							Day 2						
						Sign Test[a]							Sign Test
Error													
Old Distort.	9	Schema	9	Tie	12	*ns*	Old Distort.	16	Schema	11	Tie	3	*ns*
Level 5	23	Schema	5	Tie	2	.01	Level 5	24	Schema	4	Tie	2	.01
Level 7	19	Level 5	6	Tie	5	.05	Level 7	24	Level 5	5	Tie	1	.01
Reaction Time													
Old Distort.	11	Schema	19	Tie	0	*ns*	Old Distort.	14	Schema	16	Tie	0	*ns*
Level 5	22	Schema	8	Tie	0	.05	Level 5	23	Schema	7	Tie	0	.01
Level 7	21	Level 5	8	Tie	1	.05	Level 7	22	Level 5	8	Tie	0	.05
New Randoms	17	Level 7	13	Tie	0	*ns*	New Randoms	18	Level 7	12	Tie	0	*ns*

[a] All sign test were two-tailed.

which S had actually seen and memorized.

On Day 1 the old distortions show faster classification times than the schema patterns. This approaches but does not reach significance by a sign test. In every other respect the Day 1 speeds give the same picture as the error data. On Day 2 there is no significant difference between the old distortion and the schema patterns in speed. The other differences on Day 2 are identical to those discussed previously for errors.

A trial by trial analysis of errors and speeds was performed for the schema vs. old distortions. On the very first trial, 21 *S*s have longer RTs to the schema while 8 *S*s have longer RTs to the old distortions. This is significant ($p < .01$) by sign test. By the second trial the distribution is 14 RTs longer with the old distortion and 16 with the schema, and on no subsequent trial do more *S*s show longer times to the schema. The error data are similar. On the first trial, 13 have a higher proportion of errors on the schema and 7 on the old distortion. This is not significant by sign test; however, this tendency disappears after the first trial.

The transfer lists contain five general types of patterns. These are the old distortions, schema patterns, the new distortions at Level 7, the new distortions at Level 5, and new random patterns. As described earlier, Table 4 shows a breakdown of the various patterns used in the transfer list and their distances from each of the patterns shown in the original list. The schema pattern and the 5-bit distortions have roughly the same mean distance from the four stored patterns. Nonetheless, the schema pattern always shows better performance in terms of mean errors than the 5-bit distortions. The distances from the stored patterns also differed among the three 5-bit distortion patterns used in the transfer lists. The performance on those distortions did not seem to be closely related to their mean distance from the stored patterns. Therefore, mean distance does not prove to be a particularly good predictor in the range of distances which include the schema and Level 5 patterns. However, a comparison of Level 5 patterns with the new Level 7.7 patterns shows that the patterns which have the larger mean distance are recognized more poorly. In summary, the old distortions, schema, and new Level 5 patterns have nearly identical mean distances from the memorized patterns, but the old distortions and schema are better recognized than the Level 5s and are not different from each other.

General Conclusions

Abstraction.—In the introduction some operational statements of the old notion of abstract ideas were suggested. The data of the present experiments confirm that some form of this proposition is correct. The weakest operational form of this proposition which is consistent with the present authors' findings is that the prototype (schema) of the stored patterns has a higher probability of recognition than other new patterns contained within the concept. This is confirmed both by the finding that the schema is better recognized than transfer patterns with similar distance relationships (Level 5) and by the finding that, after its first presentation, the schema is as well recognized as the patterns which have actually been memorized by *S*s. This form of the proposition is consistent with but more explicit than the idea of stimulus generalization. It singles out the prototype of the patterns as unique. In other words, it shows that the maximal generalization for multidimensional patterns of this sort occurs at the prototype even though other patterns are nearly the same average distance from the stored exemplars. Although other patterns may have nearly the same average distance from the distortions, the prototype must share the most common properties with the set of patterns generated from it. This proposition is stronger than a generalization notion because the schema pattern is, on the whole, as well recognized as the exemplars from which it is abstracted.

The first and second experiments allow the authors to reject the idea that only the abstracted prototype is stored. Clearly the information about the individual patterns must also be present in order for a loose concept (high variability) to give better transfer than a tight concept (low variability). Moreover, the variability is of sufficient importance to overcome whatever advantage the tight concept has from a more clearly defined central tendency. The beneficial effect of variability confirms results in other areas of problem solving (Morrisett & Hovland, 1959) and pattern recognition (Dukes & Bevan, 1967) which argue for the importance of variability during training. It is also consistent with Attneave's (1957) suggestion that part of the process of learning to recognize patterns involves acquaintance with the limits of variability.

Time of abstraction.—It is possible to ask when the information is abstracted which allows the efficient recognition of the central tendency. One possibility is that the abstraction of this information takes place during the learning task. This is undoubtedly the notion which philosophers have implied in discussing the genesis of abstract ideas. The present authors cannot either confirm or deny this form of the proposition from the present data. It could be that information concerning the central tendency is stored during learning, but it also could be that the abstraction takes place when the schema pattern is first shown to *S*. That is, *S* may not recognize the schema on its first presentation in the direct way in which he identifies the old distortions. Rather he may respond correctly on the basis of a calculation from stored information concerning the exemplars. The finding that RT to the schema is longer than to the old distortions on the first presentation of the transfer list may indicate that *S* is calculating on the basis of his stored information. However, it could also mean that he has stored abstracted information but that it is not as clearly or completely defined as information concerning the individual exemplars. In either case, once he has seen the schema he recognizes it with the same efficiency as the memorized patterns. If the schema information is not abstracted during learning, then upon its first presentation *S* must store it as a particularly good example of its concept and treat it on subsequent trials as equivalent to a memorized instance. One way to demonstrate that abstraction occurs during learning would be to find a situation in which the schema, when first introduced, is recognized as well as or better than the patterns memorized during the original learning.

What is abstracted.—In the present study the authors have used the word *idea* in a neutral sense. It is not at all clear what *S*s abstract in learning to recognize the transfer patterns. To say *S*s learn the central tendency and the variability of the patterns does not tell in what type of a coding system such information is stored. For example, *S*s might have an image or mental picture of the individual instances or of the abstracted central tendency. Or perhaps the material is in the form of verbal description, such as has been suggested by various theories of short-term memory (Glanzer & Clark, 1963; Sperling, 1963).

The data obtained here give only a very incomplete answer to these questions. Introspective reports were taken from 15 *S*s run in a pilot study with materials identical to one list of Exp. III. These reports suggested that some *S*s used verbal rules which related to the patterns. The rules tended to emphasize position of dots, center of gravity, overall orientation of figure, familiar subgroups, and association to familiar objects. The rules were highly idiosyncratic and some *S*s verbalized no rules at all. These verbal reports suggest that some of the storage, at least, is by way of rules which are related to the common features of the patterns within a concept. Whether these verbal codes represent all of the information storage or are used in conjunction with other storage codes cannot be determined from the present data.

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