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RETENTION OF ABSTRACT IDEAS [1]

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Previous work has shown that after memorizing a set of distortions, *S*s are able to recognize the central tendency of that set better than other patterns within the category. If abstraction of information concerning the central tendency occurs during learning, a time delay could lead to less forgetting of the schema than of the patterns which *S* memorized. Two experiments suggested that the schema pattern is less subject to loss over time than the learned instances. The results are consistent with the idea that information concerning the central tendency is abstracted during learning.

In a previous experiment, *S*s learned to classify dot patterns which were distortions of a nonsense prototype (Posner & Keele, 1968). After learning to classify four severely distorted patterns of each of three prototypes, *S*s were transferred immediately to a pattern-recognition task. The results showed that *S*s classified the prototypes, which they had never seen before, and the memorized distortions with almost equal speed and accuracy. Both of these classes of patterns were recognized better than other new distortions of the prototype which served as controls.

Information concerning the prototype had to be abstracted from the individual distortions, but the abstraction process could have taken place either during learning or during pattern recogniton. The first notion suggests that *S*s build up a representation of the prototype as they learn to classify the distortions (Podell, 1958; Woodworth, 1938). According to the second notion, *S* would have stored only information concerning the individual exemplars during learning; during later testing, the prototype would be recognized based on the stored information and then remembered as a particularly good instance of the concept. This latter possibility had some support from the data, since reaction time (RT) to the prototype on the first trial of pattern recognition was longer than to already learned patterns, and this difference disappeared after the first presentation of the prototype.

Bartlett (1932) suggested that forgetting tends to affect the peripheral information more than the abstracted central information. Thus, if information is abstracted during the learning phase, a time delay should lead to more forgetting of the individual distortions than of the stored information concerning the schema. The following two experiments were designed in order to determine how well the individual exemplars, schema, and control patterns would be recognized after a delay interval.

EXPERIMENT I

In contrast to Exp. III of the earlier paper by Posner and Keele (1968), half of the *S*s in the present experiment performed the pattern recognition immediately after learning and half waited a period of 1 wk. Four concepts were sorted rather than three as in the previous study so that the overall error rates would be raised and differences between retention conditions could be detected more easily. In an attempt to facilitate learning, a study–test method was employed.

Method

Subjects.—The *S*s were 50 students recruited from the University of Oregon Employment Service and paid $1.50/hr for their services. Half of the *S*s ran in one session of about 2 hr. and the other half ran in two 1-hr. sessions separated by 1 wk.

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Materials.—The original learning materials consisted of 16 patterns. The patterns were four distortions of each of four different prototypes (three from List A and one from List B of the previous experiment). The prototypes were constructed by randomly positioning nine dots in a 30 × 30 matrix. The four distortions were constructed from a prototype by using four random samples of a 7.7-bit distortion rule. Since the distortion samples were the same for the four prototypes, the distances from a prototype to corresponding dots in its four distortions were equal for all protoypes. Table 4 of the previous study (Posner & Keele, 1968) gives the distance from the four memorized distortions of each prototype to the respective transfer patterns.

The transfer (pattern recognition) materials consisted of 28 patterns. Four of the patterns were the prototypes of the distortions in the learning list. Eight patterns, two from each prototype, were distortions memorized during original learning. Eight patterns, again two from each prototype, were new 7.7-bit distortions, and eight were new 5-bit distortions.

Procedure.—The four distortions of each prototype were placed in random order on separate file folders. The *S*s were given an unlimited exposure time to view the patterns. When *S*s were ready, the folders were turned over and *S*s sorted, without feedback, a deck of the 16 patterns into four boxes in front of the folder. The file folders were then turned over and *S*s were given another study trial. Study and test trials alternated until *S*s obtained two completely correct sorts in a row. It is important to note that the prototypes themselves were not included in the study–test trials. At this point, half of the *S*s performed the pattern-recognition task and the other half left and returned 1 wk. later.

For the pattern-recognition task, *S*s were shown slides of the 28 transfer patterns and were told to classify each pattern as rapidly as possible, based on their previous learning. Their response stopped a clock and began a 4-sec. interstimulus interval. No feedback was given during this part of the experiment. The recognition list was presented four times.

Results

Errors to criterion in original learning were 18.7 for the immediate group and 15 for the 1-wk. delay group. This difference did not approach significance.

Table 1 shows the overall percentage errors and RTs during pattern recognition for the four pattern types. The old distortions and schema patterns are significantly better recognized, both immediately and after a delay, than the other patterns ($p < .01$, by sign test), with the old distortions being better recognized than the schema pattern. An analysis of variance of the error scores for the old distortion and schema patterns shows a significant difference between the two, F (1, 48) = 10.4. There is, however, no significant effect of delay and no significant interaction. Thus, the overall pattern-recognition data provided no evidence of significant forgetting during the delay interval.

An examination of errors for each of the four successive runs through the recognition list (see Table 2) showed substantial improvement over trials for the old distortions at the 1-wk. retention condition. All other conditions showed a slight deterioration over trials. We are interested primarily in the initial recognition of the patterns, since we are attempting to determine whether recognition of schemata on *first* exposure is based on remembering the old distortions. Changes over trials were of secondary interest. Consequently, an analysis was run on the first trial only. The results of the analysis show a highly significant effect of delay, F (1, 48) = 6.13. Thus, for the first trial there is evi-

TABLE 1

PERCENTAGE ERROR AND REACTION TIME (RT) IN PATTERN RECOGNITION IMMEDIATELY AND AFTER A 1-WK. DELAY—EXP. I

Score	Pattern type							
	Immediate				1 wk.			
	Old distortion	Schema	5 bit	7.7 bit	Old distortion	Schema	5 bit	7.7 bit
% error	20	32	44	56	29	34	46	58
RT	2.88	2.93	3.62	3.75	2.76	2.92	3.20	3.52

Note.—RTs are given in seconds.

TABLE 2

Percentage Error and Reaction Time (RT) for Each Trial of Pattern Recognition Immediately and after a 1-Wk. Delay—Exp. I

Trial	Pattern type							
	Immediate				1 wk.			
	Old distortion		Schema		Old distortion		Schema	
	Error	RT	Error	RT	Error	RT	Error	RT
1	17.5	3.48	28	3.75	37	3.44	34	3.72
2	17.5	2.91	35	2.92	24	2.89	30	3.12
3	22.5	2.76	31	2.81	28.5	2.37	33	2.21
4	21.5	2.42	36	2.41	27	2.38	40	2.50

Note.—A trial is one complete exposure to the list of 28 pattern recognition slides. RTs are given in seconds.

dence of forgetting. Moreover, there is no significant difference between old distortion and schema, F (1, 48) = 1.0. This is due primarily to the tendency for the schema to show less forgetting over the interval than the old distortion. The Pattern Type × Delay Interval interaction approaches but does not reach significance, F (1, 48) = 3.4. The RTs for the first trial show virtually no change over the interval, and sign tests reveal no significant differences between schema and old distortion patterns either immediately or after a 1-wk. delay.

Experiment II

The results of Exp. I showed a greater loss over a 1-wk. retention period for old distortions than for schema patterns, particularly on the first recognition trial. However, the interaction was not significant at the .05 level of confidence. Consequently, a second experiment was conducted in an attempt to replicate the results. Because the study–test method of Exp. I resulted in a considerably higher error rate for schemata than for old distortions, the paradigm used in the earlier study by Posner and Keele (1968) was used in the present experiment. In this paradigm, patterns are individually presented and feedback is given after each one is classified.

Method

Subjects.—Forty *S*s from the University of Oregon Employment Service were paid $1.50 per experimental session. Half of the *S*s were run in one session of approximately 1 hr. and the others in two sessions separated by 1 wk.

Materials.—The materials were again dot patterns, but in this case the patterns were determined by a PDP-9 computer and displayed on an oscilloscope. Three prototype patterns were determined for each *S*, with no two *S*s having the same prototypes. For each prototype, six large distortions and two small distortions were constructed. Each distortion was a new sampling using a statistical rule. Thus, unlike Exp. I, in Exp. II the actual distances of distortions from their corresponding prototype were not measured. To facilitate computer programming, some changes were made in method of constructing prototypes and distortions (see Posner, Goldsmith, & Welton, 1967, for a description of the earlier method). The prototypes were constructed by randomly positioning nine dots in a 20 × 20 matrix. To obtain the disorted patterns, each dot in the prototype was moved to one of five circular areas surrounding the original position of the dot. Area 1 was the original position. Area 2 had a radius of 1.7 units; Area 3, surrounding Area 2, had an outer radius of 2.8 units; Area 4, a radius of 5.6 units; and Area 5, a radius of 11.3 units. For small distortions, the probability that a dot was moved to Areas 1–5 was .20, .30, .40, .05, and .05, respectively. For large distortions, the probabilities were .00, .24, .16, .30, and .30. Within an area, the dot was randomly positioned with respect to direction from the original position (0–360°) and distance from inner and outer radius. The large and small distortions were designed to approximate 7.7- and 5-bit distortions of the earlier study, but would tend to be slightly larger due to modifications of the distortion rule.

The original learning material consisted of four large distortions of each of three prototypes presented one at a time on the oscilloscope. The transfer (pattern recognition) patterns were: six old distortions from the original learning material (two from each prototype); the three prototypes; two new, large distortions from each prototype; and two new, small distortions from each.

Procedure.—For original learning, *S*s were shown one of the learning patterns on the oscilloscope and

TABLE 3

Percentage Error and Reaction Time (RT) of the Correct Classifications in Pattern Recognition Immediately and after a 1-wk. Delay—Exp. II

Score	Pattern type							
	Immediate				1 wk.			
	Old distortion	Schema	New small	New large	Old distortion	Schema	New small	New large
% error	18	35	39	49	31	40	43	54
RT	2.39	3.05	3.00	3.20	2.68	3.26	3.10	3.25

Note.—RTs are given in seconds.

they pressed one of the three keys indicating their classification. Feedback indicating the correct classification was then given on the oscilloscope and, a short interval later, another of the 12 learning patterns was presented. Different orders of the 12 patterns were presented until all 12 had been correctly classified twice in succession. At that time, half of the *S*s were tested for pattern recognition and the other half were dismissed to return in 1 wk. for the transfer task.

During pattern recognition, *S*s were told to classify the patterns as rapidly as possible and the RT for each classification was taken. No feedback was given. The recognition list was presented four times, each time in a different order.

Results

The mean number of trials in learning to classify the original lists was 17.9 for the immediate recognition group and 15.6 for the delay group. The difference is not significant.

The percentage of errors and RTs over all pattern-recognition trials are shown in Table 3. Sign tests on the errors showed the old distortions to be better recognized than any of the other classes ($p < .01$); schemata were better recognized than new, large distortions ($p < .01$); and new, small distortions were better recognized than new, large distortions ($p < .05$). For all pattern types, there was greater error after a 1-wk. delay than for immediate recognition, with the loss being greater for the old distortions. However, an analysis of variance of the errors for old distortions and schemata showed only the pattern type to be significant at the .05 level of confidence. Neither delay nor the interaction with prototype was significant.

When a breakdown of the data was made for individual trials (a trial being one exposure to each of the 21 transfer patterns), a pattern of errors remarkably similar to that of Exp. I emerged. Looking at Trial 1, it can be seen that the old distortions showed a large increase in error from immediate to delayed recognition. The schemata, on the

TABLE 4

Percentage Error and Reaction Time (RT) of the Correct Classifications for Each Trial of Pattern Recognition Immediately and after 1-wk. Delay—Exp. II

Trial	Pattern type							
	Immediate				1 wk.			
	Old distortion		Schema		Old distortion		Schema	
	Error	RT	Error	RT	Error	RT	Error	RT
1	.14	2.69	.35	3.87	.39	3.11	.38	4.21
2	.19	2.31	.35	3.31	.30	2.58	.40	2.74
3	.20	2.16	.35	2.58	.29	2.61	.35	2.97
4	.19	2.39	.33	2.46	.28	2.49	.45	3.11

Note.—A trial is one complete exposure to the list of 21 recognition patterns. RTs are given in seconds.

other hand, showed little loss. On subsequent trials, the old distortions showed some loss for the immediate group and some improvement in the delayed group, resulting in a smaller difference between the two groups. Again, since we are interested primarily in initial recogniton, an analysis was performed on the first trial only. The effects of delay, F (1, 38) = 6.71, old distortion vs. schema, F (1, 38) = 5.54, and their interaction, F (1, 38) = 6.50, were all significant.

Conclusions

The results of these two experiments are consistent with the idea that abstraction of information concerning the schema occurs during learning rather than at the time of recognition. If abstraction occurred at the time of recognition and was based on memory for previously learned patterns (old distortions), then one would expect large losses in memory for old distortions to result in large increases in failure to recognize the schemata. Exp. I and II show, on initial exposure, large losses in recognition of the old distortions over 1 wk., but little change in schema recognition. Strange, Keeney, Kessel, and Jenkins (in press) have also reported significantly less loss of schema information than of old distortions over a retention interval. It should be noted that retention loss of the schemata is not limited by a ceiling effect. At the 1-wk. retention interval, performance is considerably above that for new, large distortions and even further above a chance level of performance. Thus, it would appear that schema information is not only abstracted at the time of learning, but is also more stable over time.

A finding of secondary interest was that on first exposure, the old distortions showed a large deficit in retention over a week, but appeared to recover some with subsequent exposures, even in the absence of feedback. The lack of any improvement in schema recognition accompanying the improvement over trials for the old distortions is further evidence that schema recognition is based on information abstracted at the time of learning and not on recognition of previous exemplars.

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