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The retention of automatically and effortfully encoded stimulus attributes

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Current research suggests that a memory trace is a record of the mental activity associated with an event, not a literal record of the event. Thus, more elaborate and effortful encoding is associated with better memory traces. Paradoxically, Hasher and Zacks' (1979) theory holds that some information is encoded into long-term memory automatically—that is, effortlessly. However, tests of this theory have not assessed the durability of automatically encoded information for periods beyond a few minutes. We assessed memory of an effortfully encoded stimulus attribute, color, and of an automatically encoded attribute, spatial location. Intentional and incidental instructions did not differentially affect the encoding of these attributes, and both were remembered over a 24-h retention interval. It was concluded that automatically encoded information is encoded into long-term memory. The results suggest that color is also an attribute that may be encoded automatically.

A widely accepted view of memory is that the memory trace is a record of mental activities engendered by an event, rather than a literal record of the event (e.g., see Craik, 1979). According to the levels-of-processing theory, events that elicit more elaborate processing produce more distinctive memory traces; hence, greater attentional allocation at the time of encoding results in a better memory. On the other hand, the Hasher and Zacks (1979) theory holds that some information is encoded into memory automatically—that is, with little or no allocation of attentional resources. In particular, certain fundamental stimulus attributes (frequency of occurrence, spatial location, and temporal order) are assumed to be encoded automatically, provided they are given minimal attention. Also, encoding for later recognition appears to be effortless, yet recognition accuracy is typically very high. Even though obligatory encoding of certain attributes into long-term memory is required by the Hasher and Zacks (1979) theory, this theory is silent on the strength or durability of such memories. To be sure, studies of memory of frequency of occurrence and spatial location typically rely on immediate tests or on tests that are delayed a few minutes (e.g., see Ellis, Katz, & Williams, 1987; Greene, 1986; Naveh-Benjamin, 1987), and memory is never perfect under these conditions.

In view of the limited mental activity involved, memory of automatically encoded stimulus attributes is likely to be transient. On the other hand, attributes that are encoded with conscious mental effort should be more durable. Logan (1988) has adduced evidence that information encoded by acquired automatic processes is poor. Logan cites a study by Kolers (1975), which shows that memory of information read in transformed text is better than memory of information read in normal text. However, the studies Logan cites were not designed to assess long-term memory, and they are not definitive on this issue. We found no studies of the long-term durability of memory of frequency of occurrence, spatial location, or temporal order, attributes that Hasher and Zacks (1979) view as inborn and not dependent on learning or experience. In order to explore this issue, we compared the 24-h retention of an effortfully encoded stimulus attribute, color, with that of an automatically encoded attribute, spatial location. Because different scales of measurement are involved, comparisons cannot be made in absolute terms; however, rates of forgetting can be established that provide some evidence regarding the relative durability of memory of these attributes.

The encoding of color has been investigated in a series of studies by Light and colleagues. Light and Berger (1974) found better memory of the print color of words following intentional instructions as opposed to incidental instructions, and on this basis they concluded that color was not automatically encoded. In a similar study, Light, Berger, and Bardales (1975) found that memory of color (print color of words) improved with slower presentation rate, higher imagery value of the words, and intentional instructions. Light and Berger (1976) confirmed the earlier findings, which had indicated that color is effortfully encoded. Park and her colleagues (Park & James, 1983; Park & Mason, 1982; Park & Puglisi, 1985) also studied memory of color, using pictures and words as stimuli. They found instructional effects that led them to conclude that color was not automatically encoded.

Even though there is some controversy regarding the automatic encoding of spatial location, we (Ellis et al., 1987; Ellis, Woodley-Zanthos, & Dulaney, 1989) de-

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vised a task to meet the automaticity criteria proposed by Hasher and Zacks (1979). Previous studies on this issue had used tasks that may have included effortfully processed components such as scanning and difficult discriminations of spatial cues. Our task was designed to eliminate or minimize the need for effortful processing. It consists of looking through a large picture book and then relocating pictures to their original positions. Memory of location in this task was unaffected by developmental age, intelligence, instructions, practice, or concurrent processing demands.

In the present study, the subjects looked through the picture book after receiving either intentional or incidental memory instructions. Then they were given a recognition test, a test on spatial location, and a test on color. The tests were administered either immediately after the subjects had looked through the book or 24 h later.

METHOD

Subjects

The 96 college students from introductory psychology classes were assigned equally and randomly to the 2×2 factorial design. They participated for course credit.

Materials

The picture book was similar to those used by Ellis et al., (1987, in press). (In order to minimize size, there were two parts to the book. The subjects looked through one part and then immediately began looking through the second.) The picture book was made of heavy black illustrator board and a spiral binder. When open, the two-page area was 43.5×57 cm. This area was divided into quadrants by the binder and a horizontal white line. The 140 pictures were photographs of familiar objects such as an umbrella, a canoe, a bar of soap, or a jeep. The objects were photographed against their natural backgrounds or against pastel backgrounds. The 140 photographs were randomly assigned to 35 4-photograph sets. Blank pages with the quadrants outlined were included at the end of the book for the location test. A set of 25 photographs identical to 25 of those in the book served as a test set. These were randomly selected from the middle 25 sets of photographs, 1 photograph from each set. The first and last 5 sets of photographs were buffers to eliminate possible serial position effects, as well as to separate the memory test temporally from the study phase.

Procedure

The subjects were told that this was a study in advertising, and that they were to look through the picture book and select from each 4-photograph set the pictured object that would be most useful to them and the one that would be least useful to them. This defined the incidental instructions. The subjects in the intentional instructions group also selected the most and least useful objects, but they were told that they would be tested for memory of the photographs, their locations, and the colors of the objects pictured. The experimenter recorded both the total study time and the two photographs selected as most and least useful from each set.

Immediately after looking through the book, half of the subjects received a photograph-recognition test, a test on color, and then a test on spatial location. The other half of the subjects received these tests 24 h later. The recognition and color tests included a typed list of names of the 25 target objects randomly mixed with 25 distractor object names. The distractors were the names of pictures randomly drawn from the same sources as the targets. The subjects marked "yes" or "no" on the answer sheet, and for "yes" responses they indicated the color of the objects by circling one of seven color names: *white*, *red*, *yellow*, *black*, *green*, *brown*, or *blue*. For the location test, the subjects attempted to place each of the 25 target photographs in its original position on the blank test quadrant. Each photograph was removed after its placement, and the subject was then handed the next photograph.

A separate study was performed in order to determine the contribution of guessing habits to the color-memory data. Three classes of undergraduate students, totaling 61, were asked to predict the color of the 25 target objects used in the main study. They were told that we were interested in the extent to which people are aware of colors in their environment. They were given a list of the 25 items, and they circled "white," "red," "yellow," "black," "green," "brown," or "blue" on the answer sheet. The mean proportion correct was .23; $SE = .01$. Of course, a correct response consisted of identifying a color that was the same as the target color.

RESULTS AND DISCUSSION

Table 1 presents the main findings. Each of the six variables was analyzed with a 2×2 analysis of variance for a randomized factorial design. There were no significant differences in study time among the four conditions. In all other analyses, delay proved to be the only variable of significance. These effects are as follows: hits, $F(1,92) = 6.41$, $p < .05$; false alarms, $F(1,92) = 92.67$, $p < .001$; P_A, $F(1,92) = 76.12$, $p < .001$; color, $F(1,92) = 23.93$, $p < .001$; location, $F(1,92) = 70.54$, $p < .001$. All of these measures were based on proportions. P_A is a nonparametric measure of d' (McNicol, 1972). Pearson correlation coefficients were computed to assess the relationship between study time and P_A, the proportion of correct color responses, and the proportion of correct location responses. These are shown in Table 2.

Table 1
Means and Standard Deviations for Each Variable for the Four Conditions

	Instructions							
	Intentional				Incidental			
	No Delay		Delay		No Delay		Delay	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Study time*	7.95	2.26	7.93	3.31	8.11	1.67	6.83	1.75
Hits†	0.91	0.08	0.88	0.09	0.92	0.08	0.86	0.09
False alarms†	0.07	0.11	0.35	0.16	0.05	0.05	0.30	0.18
P_A	0.96	0.04	0.85	0.08	0.96	0.03	0.88	0.05
Color†	0.67	0.22	0.49	0.22	0.70	0.17	0.50	0.14
Location†	0.80	0.15	0.52	0.16	0.77	0.13	0.49	0.21

Note—No Delay = tests immediately after instructions. Delay = tests 24 h later. *Minutes. †Proportions.

Table 2
Pearson Correlation Coefficients (r) Between Study Time and P_A, Proportion Correct Color Responses, and Proportion of Correct Location Responses

	Instructions			
	Intentional		Incidental	
	No Delay	Delay	No Delay	Delay
P_A	0.45*	0.42*	−0.06	0.36
Color	0.41*	0.42*	0.00	0.31
Location	0.33	0.38	0.08	0.51†

Note—No Delay = tests immediately after instructions. Delay = tests 24 h later. $^*p < .05$. $^\dagger p < .01$.

The memory loss with respect to item information over the 24-h period is reflected mainly in an increase in false alarms. The proportion of hits changes from .915 to .870 over the retention interval. This amounts to a 5% loss in accuracy. But there is an increase in false alarms from 0.058 to 0.324, which is more than fivefold. The accuracy of color identification changes from 0.684 to 0.497; corrected for guessing, this becomes a decrease from 0.454 to 0.267, or a loss of 41%. Location identification changes from 0.785 to 0.504. Corrected for chance responding, this becomes a decrease from 0.535 to 0.254, a loss of 53%.

Even though the rates of forgetting of items, color, and location information cannot be established, except on an ad hoc basis, it is apparent that memory of items is, as expected, better than memory of attributes. The comparison of color and location memories is of the most interest. If color were effortfully encoded, it should have been remembered more accurately after the intentional instructions. Location, an automatically encoded attribute, should have been unaffected by instructions. But neither color nor location memory was affected by instructions. As for the rates of forgetting, the attributes of color and location had strikingly similar values after 24 h: 26.7% of the colors and 25.4% of the locations were retained (these results are corrected for guessing). Of course, the retention test is probably more favorable for remembering location. The retrieval cue for colors was the object name; the cue for location was the original stimulus.

These results invite a reassessment of whether or not color is an automatically encoded attribute. In the studies on this issue cited earlier, the retention of the color of naturally occurring objects was not assessed. To be sure, the print color of words and the color of line drawings of objects were assessed. In one of the studies (Park & Puglisi, 1985), the color was appropriate to the line-drawn objects, and under these conditions, color was remembered after incidental instructions. Our unpublished data suggest that the color of naturally occurring objects is remembered under incidental conditions; the print color of words is not.

The study-time results may have provided information on the nature of encoding the attributes. If the subjects had been attempting to remember an attribute strategically, study time should have been longer. But it was unaffected by instructions. The correlations between study time and the measures of item and attribute memory may reflect nothing more than individual differences, as, for example, in attention to the task. There is a significant relationship between study time and item and color memory under intentional conditions; this does not occur for location memory. This is consistent with the notion that color is strategically encoded, whereas location is not. However, the highest correlation occurs between study time and location in the 24-h data under incidental conditions. We have no explanation for this. Memory of color should receive further study in order to determine whether it meets the criteria for automaticity fully. Greene (1986) has suggested that all stimulus attributes may be automatically encoded to some extent.

Finally, we have shown that memory of location, which according to Hasher and Zacks (1979) is an automatically encoded stimulus attribute, is a durable memory. Even though their theory holds that this information is encoded into long-term memory, in previous studies retention had been measured only after a few minutes had elapsed, so the information might have been retained by working memory. In the present study, the subjects were exposed to 140 photographs of common objects over a 7.71-min interval, and 24 h later they remembered the location of a fourth of them. Therefore, it is not surprising that one remembers the location of a picture in a textbook for many years! Color may also be remembered on a similar basis; there is no firm evidence in our results to suggest otherwise.

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