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Is memory for spatial location automatically encoded?

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Naveh-Benjamin (1987, 1988) has shown that memory for spatial location does not meet the criteria for automatic encoding as claimed by Hasher and Zacks (1979). Age, intention, concurrent processing demands, practice, strategies, and individual differences affected memory for location. These variables should have affected effortful but not automatic processing. The experiments reported in the present paper, in which a different task was used, showed that intention, practice, and concurrent processing demands did not affect memory for location. I concluded that (1) the location task used by Naveh-Benjamin included effortful subtasks and also incidental cover or concurrent processing tasks that interfered directly with performance, and (2) the variables that he manipulated may not have affected the encoding of location. The need to differentiate processes from task performance in analyzing the automaticity issue is discussed. The dominant mode for remembering location is automatic, but such information may also be remembered voluntarily.

Some theorists view information processing as being dependent upon a limited attentional capacity system. Performance is determined by the attention demanded by a task as well as the available attentional resources (e.g., see Kahneman, 1973). Tasks are described as lying on a continuum from those that are performed automatically, requiring little or no attentional allocation, to those that make heavy attentional demands. Processing on some tasks becomes automatic through extended practice (see, e.g., Ackerman & Schneider, 1985; Logan, 1979; Posner & Snyder, 1975; Shiffrin & Schneider, 1977), thus freeing resources for other concurrent processing. Hasher and Zacks (1979) hypothesized that some automatic processes are inborn or prewired, and therefore require no attentional resources. They believe that frequency of occurrence, spatial location, and the order of events are automatically encoded into long-term memory.

It seems apparent that cognitive processes do become automatic through practice, but the evidence for inborn automatic processes is less compelling and has been open to much debate. Whether or not processes are automatized, either as a result of practice or inheritance, is an issue of fundamental importance to an understanding of cognition. More intelligent organisms may prove to be those more capable of automatizing processes, and, therefore, of possessing a greater attentional capacity for coping with novel problems. The present experiments were carried out to reexamine whether the encoding of spatial location into long-term memory is automatic or effortful.

In two recent papers, Naveh-Benjamin (1987, 1988) presented evidence that memory for spatial location is not automatically encoded as Hasher and Zacks (1979) claim. Using a paradigm designed by Mandler, Seegmiller, and Day (1977), he found effects due to age of subjects, competing concurrent task load, practice, intention, strategy manipulations, and individual differences. According to the Hasher and Zacks' criteria for defining automaticity, none of these effects should have occurred if the task involved only automatic processing. Our research on this issue (Ellis, Katz, & Williams, 1987; Ellis & Rickard, 1989; Ellis, Woodley-Zanthos, & Dulaney, 1989) leads me to believe that the task developed by Mandler et al. (1987), and used by Naveh-Benjamin (1987, 1988), may include both effortfully and automatically processed subtasks. Thus, the manipulated variables may have affected effortful components of the task. It is also possible that the cover tasks used by Naveh-Benjamin to manipulate intention and the secondary task used to study concurrent processing effects directly affected the perception of stimuli rather than the encoding of location into long-term memory.

In the Mandler et al. (1977) task, college students studied a 36-location matrix with 16 randomly placed familiar objects and then attempted to recall the objects and replace them in their original positions. There were three types of instructions: intentional (remember the objects and their locations), incidental (remember the objects), and true incidental (price the objects and estimate the total cost). More objects were located by the intentional and incidental groups than by the true incidental groups. The intentional and incidental instruction groups

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did not differ significantly. Mandler et al. replicated the experiment with kindergarten, 3rd and 6th graders, and college students. Age and instructions affected both recall and relocation. Intentional and incidental instructions did not result in differences, but both were better than the true incidental condition.

Naveh-Benjamin (1987) compared college students and elderly persons, using a 36-position matrix and 20 drawings of common objects. In Experiment 1, subjects rated the usefulness of the objects (incidental instructions), or they rated the objects and were told that a location test would follow (intentional instructions). The ratings (1-5) were written near the positions of the objects. Memory for location was better following intentional instructions, and college students remembered more locations than did older persons (65 years and older). Dual tasks were used in Experiment 2; subjects counted backward by 1 (light load) or 13 (heavy load) while studying the matrix. Memory for location was better under the light load condition (24.7% vs. 8.3%). In Experiment 3, practice and training effects on the location task were assessed. Two sets of objects were presented in order to assess practice effects, and a strategy training group was taught to organize objects into four groups in accordance with their location in quadrants. Both practice and strategy training effects were found. In Experiment 4, Ben-Gurion University students from two departments with different admission standards were compared. Students from the department with higher admission standards, and presumably higher intelligence, relocated significantly more pictures. On the surface, these findings suggest, as Naveh-Benjamin (1987) concluded, that memory for spatial location is not automatically encoded. However, this may be more apparent than real. The relocation task was complex and may have required effortful processing. The study phase, during which the matrix was scanned, required the discrimination of complex spatial relationships among items, and the processes that ensure the minimal attention needed to perceive stimuli may involve effortful and strategic processing.

In previous studies, we (Ellis et al., 1987; Ellis & Rickard, 1989; Ellis et al., 1989) devised a task in which effortful processing seemed minimally involved. In a study phase, subjects looked through a picture-book; then they were tested for location of the pictures. The opened book presented four large photographs of common objects, one in each quadrant of the two-page area. Location cues for each object were immediately apparent, and the discrimination of the location of objects was easy. The pictures were salient, and attention to each picture was ensured by requiring a naming response. The picture book contained 40 or 60 pictures, and strategic processing did not appear to be feasible. We found no age effects among groups ranging from kindergarten to old age. There were no effects due to level of intelligence; mentally retarded persons remembered location as well as college students. Subjects instructed to say what items "were used for" remembered significantly more locations than did those who merely named objects. These findings of age and intelligence invariance do not agree with those of Naveh-Benjamin (1987). Although we did find instructional effects, this does not mean that the encoding of location is effortful or strategic. In fact, we found better location memory following incidental instructions.

EXPERIMENT 1

The purpose in this experiment was to assess practice and instructional effects. Subjects practiced on three 100-picture books in one session following intentional, incidental, or true incidental instructions.

Method

Subjects. The 72 college students from introductory psychology courses volunteered to participate for extra course credit. They were randomly and equally assigned to three instructional groups. (New subjects were recruited for each of the seven experiments in this paper. They were all drawn from introductory psychology classes, and they received course credit for participation. In each experiment, they were assigned equally and without bias to the various conditions.)

Materials. The picture books were similar to those used by Ellis et al. (1987). There were three books with 100 unique pictures in each. The pictures (17 × 22 cm) were photographs of objects (e.g., a bed, a wallet, an auto) in their natural settings or against pastel backgrounds. The picture books were fashioned from heavy poster paper and a spiral binder. When open, the two pages provided an area of 43.5 × 57 cm, divided into quadrants by a white horizontal line and vertically by the spiral binder. Four pictures were mounted in the two-page area, one in each quadrant. The last two pages in the book were blank and used for the location test. The pictures were randomly arranged in the book, except that the four pictures in a viewing area each came from a different conceptual category. Also, obvious associations among the pictures within a set were eliminated.

Procedure. In the intentional instruction condition, the subjects were fully informed about the relocation test. Those in the incidental condition were told to remember the pictures. In the true incidental condition, the subjects were told that this was a study in advertising and that we were interested in pictures used in the media. For each four-picture set, they were to select the one picture most likely to be used and the one least likely to be used in television commercials and in other advertising. The subjects looked through the picture books at a self-paced rate. After looking through a book, the experimenter engaged the subject in light conversation for 3 min, and then the relocation test was given. Each of the 100 pictures was shown to the subjects in a random order, and they attempted to indicate the original location of each. The order of the three books was counterbalanced so that each book was used equally often in each practice session. Following the first practice session, the subjects in the incidental and true incidental groups were asked if they anticipated a location memory test; none did. Study time for each book was recorded. The subjects were tested individually in this and all subsequent experiments.

Results and Discussion

Preliminary analyses revealed no effects due to the three different books, nor to order. Table 1 presents the means and *SD*s for instructional condition and practice session. Since instructional effects can only be evaluated for the first practice session, a separate analysis of variance

Table 1
Mean Percent of Pictures Located as a Function of Instructions and Practice Session in Experiment 1

Practice Session	True Incidental *M*	True Incidental *SD*	Incidental *M*	Incidental *SD*	Intentional *M*	Intentional *SD*
First	88.96	6.75	79.83	13.60	83.33	12.98
Second	86.67	6.61	79.58	12.57	85.17	11.75
Third	85.92	5.81	81.96	13.28	85.33	10.50

(ANOVA) was performed on these data. All findings reported as reliable throughout the paper meet the .05 alpha level or better. The reliable instructional effect [$F(2,69) = 3.82$] was due to the difference between the incidental (79.8%) and the true incidental (89.0%) groups [$t(46) = 2.74$]. The intentional group relocated 83.3% of the pictures, which is not different from the other groups. A 3 (instructions) × 3 (practice sessions) repeated measures ANOVA revealed no significant effects due to practice ($F < 1$).

The correlations between study time and accuracy were .13, .37, and .30 in the true incidental group for the first, second, and third practice sessions, respectively. Those for the incidental and intentional groups were .56, .50, and .50, and .58, .57, and .54, respectively. These correlations are across subjects and not items, and they may reflect individual differences. An ANOVA of the study time yielded significant main effects for instruction [$F(2,138) = 4.30$]. The means for the true incidental, incidental, and intentional groups were 5.09, 6.09, and 8.61, respectively. The instruction × practice interaction was also significant [$F(4,138) = 3.11$]. The interaction is due to a small decrease in study time with practice in the true incidental group and the absence of change in the other groups.

Memory for location was best under true incidental conditions. Deeper encoding in this condition was expected to produce more memorable traces of stimuli and, therefore, more accurate memory for location. Instructions to remember location and instructions to remember pictures did not produce differences in relocation accuracy. Moreover, subjects in the incidental group did not improve in location accuracy in the second session when they knew they would be tested for location. Relocation accuracy did not improve with practice. Within the intentional and incidental groups, there was a positive relationship between study time and relocation accuracy. This suggests that the memory-instructed groups attempted to use strategies; but overall, this was less effective than the incidental encoding of location. (Since the intentional group did not receive the deep encoding instruction, it is possible that intention might have had some facilitatory effect above that of deep encoding. However, this is contraindicated by the results of Experiments 3, 4, and 5.)

EXPERIMENT 2

The purpose in this experiment was to test the effect of simultaneous processing demands on memory for location in a dual-task situation. The subjects attempted to retain sets of digits while studying picture sets in the picture book following intentional or true incidental instructions.

Method

Materials and Design. One of the 100-picture books from Experiment 1 was used. An 8-picture practice set was added and blank pages were inserted between pages containing pictures. Sixteen subjects were assigned to each of the cells in a 2 (instruction) × 2 (memory load) factorial design.

Procedure. The digit span for each subject was determined prior to the location memory task, and subjects were assigned randomly to light and heavy memory-load conditions. In the light-load condition, the subjects attempted to retain sets of digits equal in length to one half their digit span (rounded upward) while viewing four-picture sets. In the heavy-load condition, they were given sets one digit less than their digit span. The experimenter turned the page to a four-picture set immediately after reading the last digit of a set. The pictures were exposed for 20 sec; then the experimenter turned to a blank page, and the subject attempted to recall the digits. The intentional and the true incidental instructions were the same as in Experiment 1. Only 50 pictures were used in the location test, two randomly selected from each four-picture set.

Results and Discussion

An ANOVA of digit set recall found both an instructional effect [$F(1,60) = 6.36$] and a memory-load effect [$F(1,60) = 18.58$]. The subjects in the intentional instruction condition recalled more digit sets (25 possible) accurately than did those in the incidental condition (22.6 vs. 20.1). Those in the light memory-load condition recalled more digit sets than did those in the heavy memory-load condition (23.5 vs. 19.3). The means and *SD*s for digit sets recalled are shown in Table 2.

An ANOVA for relocation accuracy revealed a significant instructional effect only [$F(1,60) = 19.04$]. Memory for location was superior in the true incidental group (86.8% vs. 73.8%). This confirms the finding in Experiment 1, which suggests that memory for location is facilitated by deeper processing of the stimuli. There were no significant effects due to concurrent memory load (81.0% for light load, 79.5% for heavy), no interaction of memory load and instruction, and no tradeoffs between digit recall and relocation accuracy. The Pearson correlations between number of digit sets recalled and pictures relocated for the true incidental conditions was .39 and .84 for the

Table 2
Mean Percent of Digit Sets Recalled and Pictures Relocated as a Function of Concurrent Memory Load and Instructions in Experiment 2

Memory Load	True Incidental *M*	True Incidental *SD*	Intentional *M*	Intentional *SD*
	Digit Recall			
Half	92.50	8.75	95.25	5.10
Whole	68.50	21.01	85.50	20.91
	Location			
Half	85.50	9.48	76.50	14.04
Whole	88.00	9.71	71.00	13.66

light and heavy loads, respectively. These correlations for the intentional instructions were .17 and .44 for the light and heavy loads. A tradeoff would have been reflected by negative correlations. I have no explanation for the positive relationship between digit retention and relocation accuracy, other than that both probably relate to an organismic variable.

EXPERIMENT 3

In this experiment, line drawings such as those used by Naveh-Benjamin were compared with the photographs used in our studies. Spatial separation of the stimuli was also varied. The incidental group was given the media advertising instructions to rate the usefulness of objects pictured. The intentional group received the media advertising instructions and was told to remember the location of the pictures.

Method

Materials. Instead of the picture book format, four pictures were mounted on each of 25 posters. Three types of posters were used. In one condition, the photographs were similar to those used in Experiments 1 and 2. The posters were 41 × 54 cm, approximately the size of the two-page areas of the picture books. For another condition, the posters were the same size but the stimuli were colored line drawings (6.5 × 9 cm). Since the line drawings were much smaller than the photographs, the spatial cues were somewhat exaggerated in this condition. In a third condition, the line drawings were mounted on smaller (17.5 × 23 cm) posters, and the spatial cues were much less salient.

Procedure. Three of the 12-subject groups were given true incidental instructions. They were told that we were interested in media advertising, and that they were to look at each four-item set and select the pictured object judged most useful in their daily lives. The other three 12-subject groups were given intentional instructions, which included the true incidental instructions, along with instructions to expect a location memory test, and its nature was described.

Results

Table 3 shows that study time was longer following intentional instructions [$F(1,66) = 11.41$], and there was a main effect for stimulus/poster type [$F(2,66) = 3.34$]. The subjects studied the line drawings on the large posters longer than they did the other two types.

Table 3 also presents the means and *SD*s of the proportions of correct relocations. A 2 × 3 ANOVA yielded a significant main effect for stimulus/poster type [$F(2,66) = 4.44$]. A one-way ANOVA showed that the main effect was due primarily to a difference between the photographs and the large poster line drawings [$F(2,69) = 4.50$]. No other differences were statistically significant.

Intentional instructions led subjects to study the posters longer, but this did not improve their memory for location. They also studied the larger posters with the line drawings longer, but they were least accurate in relocating these pictures. If study time reflects the use of strategies, then such strategies are ineffective under these conditions in improving memory for location beyond that resulting from automatic encoding.

Table 3
Study Time(s) for All 25 Posters along with Proportions of Correct Relocations in Experiment 3

Stimulus and Poster Type	Instructions: Intentional *M*	Intentional *SD*	Incidental *M*	Incidental *SD*
		Study Time		
Photos				
Large	375	67	306	56
Line drawings				
Large	416	113	368	88
Small	379	103	276	106
		Relocations		
Photos				
Large	.89	.08	.90	.09
Line drawings				
Large	.83	.12	.79	.11
Small	.85	.07	.80	.12

EXPERIMENT 4

This experiment was an attempt to replicate Naveh-Benjamin's (1987) finding that intentional instructions facilitate memory for location. The cover task he used to create incidental instructions required subjects to rate the usefulness of each of the 20 items. They wrote the ratings (1-5) in the areas of the matrix between items. It is possible that the rating task was differentially affected by the intentional and incidental instructions, thus directly affecting the accuracy of location memory. In this study, instead of writing the ratings, the subjects called out their ratings, and the experimenter recorded them. The time required to complete the ratings within the 90-sec interval was also recorded. The subjects in the intentional group were told that the rating task and the memory tasks were equally important.

Method

Materials. The matrix of pictures was similar to that used by Naveh-Benjamin (1987, 1988). The pictures were 100 colored drawings of common objects, primarily designed for use in children's language instruction. Six different 36-location (6 × 6) matrices were made with heavy black poster board and white tape. Overall, the posters were 51 × 66 cm. Horizontal and vertical strips of 5-mm white tape defined the locations. The picture cards were randomly and equally assigned to each poster. The placement of pictures on posters was similar to that used by Naveh-Benjamin; there were 5 pictures in each quadrant and 4 or less in each row and each column.

Procedure. Twenty-five subjects were told that the study was about media advertising, and that they were to rate each of the 20 items pictured in terms of usefulness in their daily lives by saying aloud the ratings (1-5) as they looked at each picture. The 25 intentional subjects were also told to remember the locations of the pictures for a memory test. The experimenter presented the matrix for 90 sec. A 3-min interval followed the matrix presentation, during which the experimenter engaged the subject in light conversation. Then a blank matrix was presented, and the subject was given the set of 20 pictures to replace in their original locations. The subjects were allowed to rearrange the pictures as they wished. Five subjects within each of the conditions were assigned to each of the five different matrices.

Table 4
Percentage Correct Relocations, Displacements, and Time(s) to Complete the Rating Task for the Intentional and Incidental Instruction Groups in Experiment 4

	% Correct		Displacement		Time	
Group	*M*	*SD*	*M*	*SD*	*M*	*SD*
Incidental	43.60	21.34	3.70	1.92	57.84	17.41
Intentional	50.40	20.66	3.10	1.65	56.04	16.58

Results

A preliminary analysis revealed no differences among the five matrices. Two measures of relocation accuracy were used: percentage correct relocations, and the distance a picture was displaced from the correct location. The experimenter recorded item placements on a data sheet spatially similar, and proportional in size, to the matrix with item names written in the locations. The displacement score was the distance in centimeters between the correct location of an item and where it was actually placed, as measured on the data sheet. These displacements were averaged for each subject. Table 4 presents the means and *SD*s for percentage correct, the displacement scores, and the time to complete the ratings. None of the *t* tests comparing instruction groups on the three measures was significant, nor did any values approach significance. Three subjects in the intentional condition and 1 in the incidental condition failed to complete the rating tasks within the 90-sec interval, and these subjects had location scores less accurate than the average of their groups. Correlation coefficients between time to rate the items and accuracy and displacement scores did not differ significantly from zero.

The trends in our data are similar to those reported by Naveh-Benjamin (1987); but he found a significant instruction effect, and we did not. He reports mean percent correct relocations of 45 (SD = 14.0) and 38 (SD = 18.0) for the intentional and incidental college groups, respectively. This compares with means of 50.4 (SD = 20.66) and 43.6 (SD = 21.34) for our intentional and incidental groups, respectively. Even though an ANOVA of his percent correct results, including the college and elderly groups, revealed a significant difference, *t* tests of his college data alone were not significant, nor was a test of the displacement scores. The mean difference between his college groups (7.0) is comparable to the difference we found (6.80). Thus, it would appear that the intentionality effect is weak even in this task, which seems to involve effortful processes. Nevertheless, these results essentially confirm his findings, and they provide no hard evidence that his rating task directly interfered with the perception of the stimuli.

EXPERIMENT 5

In view of the equivocal outcome of Experiment 4, it seemed appropriate to attempt an exact replication of Naveh-Benjamin's (1987) Experiment 1, in which he showed an instructional effect on memory for location.

Method

The procedure was the same as that in Experiment 4, except that subjects wrote their ratings beside the pictures in the matrix as in the Naveh-Benjamin (1987) experiment. White tape (2 cm) was used to outline the positions of the matrix, and subjects wrote their ratings on the tape. There were 25 subjects in an intentional group and 25 in a true incidental group.

Results

Four subjects in the intentional condition, but none in the incidental condition, failed to complete the rating task within 90 sec. These 4 subjects had lower relocation accuracy scores than did those who completed the task (33.75% vs. 51.43%). Overall, the mean percent correct relocations for the intentional group was 48.6 (SD = 21.43), and that for the true incidental group was 43.2 (SD = 20.46) ($t < 1$). The mean displacement score for the intentional group was 3.13 (SD = 1.68) and that for the incidental group was 3.41 (SD = 1.66) ($t < 1$).

In absolute terms, these results are quite similar to those of Naveh-Benjamin's (1987) Experiment 1, and to our Experiment 4. Intentionality did not significantly affect memory for location in the present study, but the effect was significant in Naveh-Benjamin's study. To be sure, the difference between intentional encoding and encoding under incidental conditions is only 7.0% in Naveh-Benjamin's study and 6.8% and 5.4% in our Experiments 4 and 5, respectively. Any effortful aspects of this task could well account for these small differences.

EXPERIMENT 6

To assess the effects of concurrent processing on the encoding of location, Naveh-Benjamin (1987, Experiment 2) had subjects count backwards by 1 or 13 during a 2-min period in which they studied the location of 20 pictures in the 36-position matrix. They began with a four-digit number, subtracted 1 or 13, and wrote the new numbers by each of the 20 pictures. It is possible that this task interfered directly with the perception of pictures rather than by reducing central attentional resources. We replicated Naveh-Benjamin's study but with a different secondary task. The subjects remembered half or all of their digit span over the 2 min during which they studied the pictures in the matrix.

Method

The task was the same as that used in Experiments 4 and 5. The subjects were told that the study was about how well they could do two things at once. They were to study the pictures for 2 min, and then they would be given a relocation test. Also, they were to remember a set of digits while studying the location of the pictures. Digit spans had been determined for each subject, and they knew the nature of this task. The experimenter orally presented a set of digits equal to either the half (light load) for 25 subjects or the whole digit (heavy load) span for 25 subjects; then the matrix was immediately exposed for 2 min; the matrix was covered at the end of the 2-min interval, and the subjects attempted to recall the digits. Then the relocation test was given.

Results

The mean percent correct relocations for the half memory-load condition was 73.20% (*SD* = 24.95) and that for the whole-load condition was 72.00% (*SD* = 23.58) ($t < 1$). The mean displacement for the half memory-load condition was 1.85 cm (*SD* = 1.93) and that for the whole load was 1.88 cm (*SD* = 1.64) ($t < 1$). Only 3 of the subjects failed to recall half of their digit span; 17 failed to recall their full digit span.

It is clear that the memory loads were of unequal difficulty. It is also clear that these memory-load conditions did not differentially affect the encoding of the locations of the pictures.

EXPERIMENT 7

In view of the outcome of Experiment 6, we attempted an exact replication of Naveh-Benjamin's (1987) Experiment 2, in which simultaneous processing demands were varied. We also assessed the extent to which subjects were able to complete the concurrent counting task during the 2-min picture-study interval.

Method

The pictures and the matrix were the same as those used in Experiments 4, 5, and 6. The 17 subjects in a light memory-load condition were instructed to count backwards by 1 from the number 1,423. The 17 subjects in the heavy-load condition counted backwards by 13s from the number 1,548. They wrote each new number by one of the 20 pictures in the matrix. The experimenter recorded the number of counts in each condition—that is, the number of pictures with numbers written by them.

Results

The mean percent correct relocations in the light-load condition was 48.23 (*SD* = 22.63), and that for the heavy-load condition was 17.06 (*SD* = 12.25) [$t(32) = 4.99$]. The mean of the displacements for the light-load condition was 4.05 (*SD* = 2.42) and that for the heavy-load condition was 7.89 (*SD* = 2.79) [$t(32) = 4.99$]. The mean of the displacements for the light-load condition was 4.05 (*SD* = 2.42) and that for the heavy-load condition was 7.89 (*SD* = 2.79) [$t(32) = 4.29$]. In the light-load condition, only 1 subject failed to make 20 backward counts by 1. This subject wrote numbers by 18 pictures. In the heavy-load condition, none of the subjects made 20 backward counts by 13. The mean number of counts was 12.29 (*SD* = 3.68). Within the heavy-load condition, the relocation accuracy of pictures with numbers by them was 25.44% (17.75%) and the accuracy for those without a number by them was 14.19% (25.86%). A sign test showed this difference to be statistically significant.

These results show that the concurrent counting task had a robust effect on the encoding of memory for location, and this finding agrees with that of Naveh-Benjamin (1987). However, the subjects were not able to complete the concurrent counting task within the 2-min interval, as his subjects had reported, and it seems evident that the subjects did not look at all the pictures in the matrix. Indeed, many commented that they did not see the pictures because they were "too busy counting." Apparently, the cover task directly affected perception of items, the light-load task more than the heavy-load task. Therefore, it is not clear whether subjects are less accurate on the memory task because they are distracted by the counting task and do not attend minimally to all the pictures, or whether the counting task requires the use of central attentional resources that would, otherwise, be devoted to encoding the location of pictures. Our results favor the former hypothesis.

GENERAL DISCUSSION

The task for studying location memory used by Mandler et al. (1977) and Naveh-Benjamin (1987, 1988) and the task used in Experiments 1 and 2 in this paper are qualitatively different, and they cannot be systematically and fully decomposed in order to contrast components of the two tasks. The task developed by Mandler et al. (1977) involves a single exposure to a complex matrix of stimuli, followed by a test trial on 20 stimuli. The task used in the present studies involves multiple exposures of sets of four stimuli, followed by a test trial on some or all of the stimuli. The single 20-stimulus matrix may be retained in working memory, through imagery, or some other strategy. Only one stimulus appears in a location and interference effects would be minimal. On the surface, scanning the matrix would seem necessary to identify locations of the stimuli, since they are defined by their relationship to other locations. Thus, whether subjects use imagery, verbal, or some other mnemonics, effortful processing is likely to facilitate memory for location in this paradigm.

On the other hand, in the four-position task, the use of an imagery mnemonic or any other strategy is not likely. New stimuli continue to appear in the four positions over multiple trials. If imagery were used, 25 separate and potentially interfering images would be required. Memorizing the positions of objects in a paired-associate fashion would be a formidable task. Subjectively, the identity and location of the four pictures is immediately perceived, and this aspect of the task does not seem to involve conscious processing.

In Experiments 1 and 2, subjects remembered the location of about 84% of 100 pictures, and this was unaffected by intent to remember or other concurrent processing demands. Instructions that led to semantic or deep encoding of the pictures slightly improved memory for location, but this occurred in the true incidental conditions in which a memory test was not expected. Therefore, it is unlikely that more effort was associated with the semantic encoding instructions. (Craik & Tulving, 1975, showed that encoding time does not always predict the depth of processing effect.) In any case, since subjects did not expect a test for locations, there is no basis for assuming that difference in effort associated with the semantic instructions would have been allocated to encoding locations. More salient stimuli, photographs, also resulted in better memory for location than line drawings. Thus, it would appear that the location of a more memorable stimulus is remembered better than that of a less memorable one; and, variables that affect the perception of a stimulus—that is, its memorability—may also affect memory for the location attribute. In other studies with this task, we have found neither age (kindergarten to elderly) nor intelligence level (college students vs. mentally retarded persons) effects (Ellis et al. 1987; Ellis et al., 1989). (Some, but not all, mentally retarded persons with severe organic pathology do have deficits in memory for location [Ellis et al., 1989].) In three experiments (Ellis et al., 1987; Ellis & Rickard, 1989; Ellis et al., 1989), we saw no differences between intentional and incidental instructions when depth of processing was controlled. There is one exception. Ellis et al. (1987) found that 3- and 4-year-old children performed slightly, but significantly, better following intentional instructions. However, I am reluctant to attribute this to intent, for it appeared that these children had a better understanding of the task with intentional instructions. There were no instructional effects in children 5 and 6 years old through the 6th grade. Contrary to Hasher and Zacks's position (1979), we have found marked individual differences in memory for location, though we have been unable to relate these differences to intelligence, age, or other organismic variables. (Hunt, 1978, hypothesizes that there are large individual differences in automatic processing.) In the study of retarded persons with severe organic pathology, we retested 36 of these subjects 3 months later and found a test-retest correlation coefficient of .35 for the recall of pictures, but a correlation of .75 for relocation accuracy (Ellis et al., 1989). Memory for location on this task is also fairly durable. Ellis and Rickard (1989) found a loss in accuracy from 78.5% to 50.4% over a 24-h period.

Why do these results differ from those of Naveh-Benjamin (1987, 1988)? First, his results, taken on their face, do not disconfirm the hypothesis that automatic encoding may be involved in memory for location. Regardless of the experimental condition in his experiments, location is remembered at better than a chance level, even when subjects do not expect a memory test. Also, for the most part, the variables manipulated have small effects, and to the extent that strategic processing is involved in his task, these variables should affect performance. Naveh-Benjamin recognized that strategic behavior may be involved, but he equates performance on his task with encoding into long-term memory. This leads him to reject the Hasher and Zacks (1979) criteria. If it could be assumed that his task measured only the encoding of location, then he is correct in rejecting their criteria. But, it is apparent that other processes are reflected in the dependent variables. Therefore, changes in memory for location cannot be attributed to any one of the hypothetical events. I attempted to avoid this problem by selecting a task that minimized the influence of processes other than encoding on the dependent measure.

The cover task used by Naveh-Benjamin (1987) and the secondary task used in the assessment of concurrent processing effects seem problematic. Not all subjects completed the usefulness ratings designed to create incidental conditions in Experiments 4 and 5; they did in his Experiment 1. Even though I could not relate performance on the cover task to the accuracy of location memory, subjects who did not complete the rating task were not as accurate in locating pictures as those who completed the task. (The mean accuracy for the 8 subjects in the two experiments who did not complete the rating task was 38.75%, as compared with 47.86% for those who did.) As for the counting task used as a secondary task in Naveh-Benjamin's Experiment 2 and in my Experiments 6 and 7, it seems likely that this task distracts the subject from attending to the stimuli, and as a result, some of the stimuli are not perceived. I believe that this is a factor even in Naveh-Benjamin's study, in which subjects did complete the counting tasks. The effects of this task on memory for location do not seem to be due only to dividing a central attentional resource. Of course, there is the possibility that the counting backwards task affected memory for location by both interfering directly with the perception of stimuli and dividing attentional resources. We have no means to determine whether this occurred. Perhaps, our secondary tasks (remember half or the whole digit span) did not result in memory-load differences that were substantial enough to affect memory for location. Possibly, some degree of concurrent processing might be tolerated without any effects in a primary task, but heavier demands would have effects.

No doubt, performance on most tasks reflects the operation of both automatic and effortful processes. Some tasks may involve one type of process to a greater extent than the other. Therefore, performance on few tasks is likely to fully meet criteria for automaticity such as those adopted by Hasher and Zacks (1979). Of course, there may be subcomponents of tasks that do meet such criteria. It also seems apparent that there are situations in which strategies or effortful processing can improve upon automatic encoding. Consider telling the subject to remember only the location of the yellow school bus in our task. With this in mind, I completed another experiment (unpublished) following the present series of experiments.

Five groups of 24 subjects each were tested on the 120-picture task following different instruction. All groups received the media advertising instructions to rate the usefulness of the objects pictured. One group was also told to remember the location of 1 of the photographs. Another group was told to remember 6 targeted pictures, and still another group, 12. The targeted photographs were identified with small stick-on labels. A fourth group was to remember all of the locations (no labels), and a fifth, true incidental group, was not given memory instructions. The proportions of correct relocations for these groups were .950, .847, .760, .788, and .783. Only 1 subject missed the single target, and he claimed not to have seen the label. A statistical analysis showed the proportions correct for the 1- and 6-target conditions to differ from each other and from the other three conditions. There were no differences among the other three conditions. Clearly, instructions to remember location improved performance when there were only a small number of locations to remember. The subjects did no better on 12 than they did when they attempted to remember all or none of the locations. I anticipated some slight improvement with 12 targeted items, but this did not occur. Intention improved memory for location over that attributed to automatic processing. But these results showed that the effectiveness of strategic processing is quite limited in this task and will facilitate performance for only a few circumscribed items.

What are the implications of these findings, as well as those of Naveh-Benjamin (1987, 1988), for the concept of automatic encoding and the Hasher and Zacks (1979) theory? First, it seems apparent that people do, in fact, remember the location of objects on an automatic basis. Even in the Naveh-Benjamin task, locations are remembered at better than a chance level regardless of the experimental condition. In our task, in which effortful subtasks seem minimally involved, 80% of 100 or more locations are remembered, and this is unaffected by intention, concurrent processing demands, practice, intelligence level, or age of subjects. Intention can facilitate the strategic processing of a few items, raising the accuracy level above that resulting from automatic processing alone. Also, the accuracy of location memory is improved by deeper encoding and by better quality stimuli (photographs versus line drawings). The Hasher and Zacks (1979) criteria for defining automaticity are not met, and if all of the criteria must be met, then the strong form of their position must be rejected. But the main thrust of their position seems valid, and the criteria for defining automaticity advanced by most theorists (e.g., Logan, 1979; Posner & Snyder, 1975; Shiffrin & Schneider, 1977) are met by performance on our task. Memory for location is primarily an automatic process, but it may also be remembered voluntarily.

The most murky theoretical issue in this research is defining the boundary conditions for the perception of an item and distinguishing this event from further effortful processing. (See Johnson, Peterson, Yap, & Rose, 1989; Mitchell & Hunt, 1989; and Zacks, Hasher, & Hock, 1986, for discussions of this issue.) Obviously, an item must be perceived if it is to be encoded into memory. According to the Hasher and Zacks (1979) position, perception of a stimulus is a necessary and sufficient condition for encoding location, frequency, and order attributes. Their theory might accommodate the depth of processing and the stimulus quality effects by assuming that these variables affect item perception.

Still another problem is the failure to differentiate task performance and underlying cognitive processes. Hasher and Zacks (1979) describe processes as lying on a continuum of mental effort. Some processes require little or none, others make heavy attentional demands. On the other hand, they describe automatic processes as occurring optimally, and once started, they will run their course to completion and cannot be inhibited. This seems more descriptive of all-or-none processes, but, no doubt, their theory is about processes, not task performance. Naveh-Benjamin (1988) recognizes that task performance is determined by both effortful and automatic processes. But neither Hasher and Zacks (1979) nor Naveh-Benjamin (1988) explicitly recognizes that a test of the Hasher and Zacks' theory requires a task paradigm in which the processes determining performance be distinguished. This may prove to be a formidable problem, even rendering their theory somewhat untestable.

Taken together, these findings suggest that the processing of memory for location may occur in one of two ways. Locations of objects will be remembered automatically, provided that the objects are clearly perceived, and this is the dominant mode of processing location. But this automatic system does not function perfectly, and memory for location can be encoded strategically, provided that the situation is such that strategy use is feasible. The importance of this lies in the fact that one must continuously process the location of objects in the environment, and if this had to be done voluntarily, or strategically, then mental resources for processing other information would be seriously compromised. Moreover, because of capacity limitations on strategic processing, this would be an inadequate system for processing location. There may well be many aspects of experience that are remembered automatically (e.g., frequency of occurrence and other stimulus attributes such as the color or gender of a speaker). Perhaps the greater docility of human beings may be due, in part, to the capacity to automatize many cognitive functions through experience, or to enjoy this capacity as a result of inheritance.

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