**PIGEONS' SPATIAL MEMORY: III.
EFFECT OF DISTRACTORS ON
DELAYED MATCHING OF KEY LOCATION**

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The effect of distractors on pigeons' delayed matching of key location was investigated. Baseline trials began with a "ready" stimulus (brief operation of the grain feeder). Then one (randomly chosen) key from a three-by-three matrix was lit briefly as the sample. After a short delay (retention interval) the sample key was lit again along with one of the other eight keys. A peck at the key that had served as the sample (correct comparison) produced grain reinforcement, whereas a peck to the other key (incorrect comparison) produced only the intertrial interval. In Experiment 1, a houselight distractor, presented during either the sample, retention interval, or choice phases of the trial, had little if any effect on accuracy of matching key location. In Experiment 2, one of three types of spatial stimuli was interpolated during the retention interval, or the interval was blank as during baseline trials. The three stimuli were: the sample (correct comparison) location for that trial, the incorrect comparison location for that trial, or one of the seven unused locations for that trial. Relative to blank trials, accuracy improved slightly on sample-interpolated trials, decreased slightly on unused location-interpolated trials, and decreased considerably on incorrect comparison-interpolated trials. In Experiment 3, retention intervals were blank or had one of six types of interpolation: the sample, the incorrect comparison, two presentations of the sample, two presentations of the incorrect comparison, the sample followed by the incorrect comparison, or the incorrect comparison followed by the sample. Matching accuracy remained high when one or two sample presentations occurred during the retention interval and when the incorrect comparison was followed by the sample. Matching accuracy decreased when one or two incorrect comparison presentations occurred during the retention interval or when the sample was followed by the incorrect comparison. Implications of these findings for hypotheses about how pigeons remember spatial information are discussed.

Key words: delayed matching to sample, spatial cues, distractors, selective interference, order of presentation, working memory, pigeons

In delayed matching to sample (DMTS), a sample stimulus is presented and then terminated, after which choice or comparison stimuli (one of which is identical to the sample) are presented. Choice of the comparison that matches the sample is reinforced, whereas choice of a nonmatching comparison is not. The subject must remember the sample to choose the matching comparison; however, it is advantageous for it to forget the sample once the trial is over. For this reason, DMTS performance often is characterized as "working memory" (Honig, 1978).

Interpolation of certain types of stimuli during the delay or retention interval separating

sample and comparison presentation adversely affects matching accuracy. For example, illumination of a houselight (D'Amato & O'Neill, 1971), but not presentation of white noise (Worsham & D'Amato, 1973), disrupts monkeys' delayed matching of geometric forms in a dark chamber. And pigeons' delayed matching is affected adversely by houselight illumination but not by auditory or vibratory stimuli (Wilkie, Summers, & Spetch, 1981).

Discovery of which interpolated stimuli do, and which do not, adversely affect DMTS performance is an important first step in discovering the mechanism(s) of such interference. The goal of the present research was to provide some information about which interpolated stimuli affect pigeons' delayed matching of spatial cues (Wilkie, 1983; Wilkie & Summers, 1982; see also Smith, Attwood, & Niedorowski, 1982). Delayed matching of spatial cues for pigeons was implemented in a chamber contain-

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ing a three-by-three matrix of pecking keys. One key (randomly selected) was lit briefly as a sample at the start of a trial. After a delay, the previously lit key and one of the remaining keys were lit. A peck to the key that had been lit as the sample was reinforced, whereas a peck to the other key produced only the intertrial interval.

EXPERIMENT 1

This experiment measured the effect of a change in ambient illumination upon pigeons' delayed matching of key location. Such a manipulation has been found previously to affect adversely DMTS accuracy in a wide variety of situations and in several species (e.g., Cook, 1980; D'Amato & O'Neill, 1971; Maki, Moe, & Bierley, 1977; Wilkie et al., 1981). In addition to interpolating houselight illumination during the delay interval, we, like Wright, Urcioli, Sands, and Santiago (1981), also assessed the effects of illuminating the houselight during sample presentation and choice phases of the matching trials.

METHOD

Subjects

Three experimentally naive Silver King pigeons were reduced to about 85% of their free-feeding weights prior to the experiment.

Apparatus

Nine clear Plexiglas pecking keys (3.25 cm in diameter) were mounted (5 cm apart, center to center) on one wall of each of three ventilated, light proof, sound-attenuating chambers. The center key of the matrix was about 20 cm above the floor. Behind each key was a micro-switch, which sensed key pecks having a force greater than about 15 g (.15 N), and a Fairchild FLV117 red light-emitting diode (approximately 1.7 cd/m²). Each chamber contained a houselight mounted on one wall (Box 1—wall opposite matrix; Box 2—on wall adjacent to wall containing matrix; Box 3—on wall containing matrix), near the ceiling. In two chambers (1 and 3) the houselights were shielded behind translucent material; in the other it was not. The houselight brightness was approximately 10, 125, and 112 cd/m² in Chambers 1, 2, and 3, respectively. A BRS/LVE grain feeder was mounted on either the same

wall as the key matrix (Chamber 1) or on a wall at right angles to the wall on which the keys were mounted (Chambers 2 and 3).

Data collection and experimental control were carried out by a Data General NOVA 3 computer, BRS/LVE interface, and the MANX language (Gilbert & Rice, 1979).

Procedure

Testing schedule. Seven days per week between about 730 and 1730 hr the birds were housed in large individual cages in a sunlit colony room with free access to health grit and water. Each bird spent the night in a test chamber during which time three sessions were arranged, at 1800, 0, and 0600 hr. Birds 1, 2, and 3 were tested in Chambers 1, 2, and 3, respectively.

Preliminary training. Details of this phase are similar to those previously reported (Wilkie, 1983; Wilkie & Summers, 1982). Briefly, the birds were trained to eat from the grain feeder, autoshaped to peck illuminated keys, and finally, trained to peck each of the nine keys for response-contingent grain reinforcers.

Acquisition phase. Sessions had 24 trials, each of which began, after a 20-sec intertrial interval (ITI), with a 1-sec operation of the feeder as a "ready" stimulus. One-half sec later, one (randomly chosen, without replacement) of the nine key locations was lit for 2 sec as a sample. After a 1-sec delay the sample key and one (randomly selected) of the other eight keys were illuminated as comparisons. Choice of the key location that matched the sample produced 5-sec access to the grain feeder and the 20-sec ITI, whereas choice of the incorrect comparison led to a 25-sec ITI.

This phase lasted for 12 days (36 sessions). During this phase the houselight was never turned on.

Houselight interpolation phases. Following the acquisition phase, which constituted the first baseline phase, the houselight was turned on for the full duration of either the sample presentation period, the delay interval, or the comparison period (i.e., the time between the presentation of the two comparison stimuli and the choice response). The houselight was illuminated during each trial in a session. Phases lasted between 15 and 42 sessions and were replicated (see Table 1 for details). During the last four phases the delay interval was increased from 1 to 3 sec.

Table 1

Summary of procedures in Experiment 1. During baseline sessions the houselight was always off. Abbreviations used: HL—houselight, S—sample period, D—delay period, C—comparison period.

Phase	Condition	Sessions	Phase	Condition	Sessions
1	Baseline	36	9	Baseline	27
2	HL-S	21	10	HL-C	27
3	Baseline	18	11	Baseline	30
4	HL-S	21	12	HL-C	30
5	Baseline	15	13	Baseline*	36
6	HL-D	18	14	HL-D*	21
7	Baseline	15	15	Baseline*	42
8	HL-D	24	16	HL-D*	30

*Delay interval increased from 1 to 3 sec.

RESULTS

Acquisition of delayed matching of key location is shown in Figure 1. As in previous studies (Wilkie, 1983; Wilkie & Summers, 1982) matching accuracy rose quickly to asymptotic levels of near 90% correct.

Fig. 1. Matching accuracy (percentages correct) during training phase of Experiment 1.

Figure 2 shows a summary (averaged over subjects and replications) of the effect of illuminating the houselight during sample, delay, and choice periods. Relative to baseline (no houselight) trials, illumination of the houselight in no part of the trial sequence had much of a deleterious effect on matching accuracy. Details are shown in Table 2 for the sample and comparison portions of the trial.

The general ineffectiveness of presenting a houselight distractor during sample and comparison phases of the trial replicated results reported previously by Wright et al. (1981) and was not unexpected. However, the finding that the delay-interval houselight presentation did not generally affect delayed-matching accuracy was apparently unique in the literature and accordingly was subjected to a more detailed analysis. Figure 3 shows, for each sub-

Fig. 2. Matching accuracy (percentage correct) during baseline phases (B) of Experiment 1 and when the houselight was illuminated during the sample (S), delay interval (D), or comparison (C) components of the trials. The delay was 3 sec during the B and D phases shown on the right-hand side. Data are averages of all sessions in all phases, except the first baseline phase in which case only the last six sessions were used.

Table 2

Matching accuracy (percentage correct) during phase of Experiment 1 when the houselight was illuminated during sample and comparison periods. Data are averages of all sessions in a phase (except Phase 1 in which the last six sessions were used). Performance during the first session of all conditions in which the houselight was illuminated is shown in brackets. Abbreviations are the same as those in Table 1.

Phase	Condition	Bird 1	Bird 2	Bird 3	Phase	Condition	Bird 1	Bird 2	Bird 3
1	Baseline	85.7	91.8	91.8	9	Baseline	96.1	82.4	86.4
2	HL-S	88.3(87.5)	83.7(95.8)	85.8(70.8)	10	HL-C	97.5(91.7)	81.2(79.1)	86 (91.7)
3	Baseline	94.2	86.4	93.4	11	Baseline	93.2	85	80.1
4	HL-S	92.7(79.2)	83.5(95.8)	81.6(91.7)	12	HL-C	98.1(100)	85.5(95.8)	85.4(95.8)

Fig. 3. Matching accuracy (percentage correct) during last four baseline (B) days (blocks of three sessions) and all days of phases in which the houselight was illuminated during the delay (HL-D), during the first exposure and subsequent replication for each bird.

ject, day to day (blocks of three sessions) matching accuracy during baseline and houselight in delay conditions. Birds 1 and 2 showed slight disruptions in matching accuracy during certain of the initial days of exposure to houselight in the delay. For the other bird, and for all birds during the second exposures, the houselight had no discernible deleterious effect.

EXPERIMENT 2

In this experiment spatial cues were used as distractors during the delay interval. During baseline trials the delay was blank. On other trials, the delay interval contained either a presentation of the sample location for that particular trial, the incorrect comparison location for that trial, or one of the key locations unused on that trial.

METHOD

Subjects

Three pigeons experienced at delayed matching of key location, but naive to any distractor manipulations, served.

Apparatus

Same as in Experiment 1. Birds 4, 5, and 6 were tested in Chambers 1, 2, and 3, respectively.

Procedure

Sessions consisting of 36 trials were scheduled at about 1000 hr five to seven days per week. Because the birds had been trained previously to match key locations, no preliminary training was required. Rather, the birds received baseline training immediately.

Baseline training was identical to that in Experiment 1 except that the delay between sample presentation and choice was 2.5 sec. After 48 baseline sessions the subjects received 11 consecutive test sessions. During test sessions, one of four types of trial occurred with the same probability (random selection, with replacement). One type of trial was the same as baseline trials (i.e., the 2.5-sec delay was spent in darkness). On the second type of trial the sample key location was lit for 1 sec, .75 sec after the end of the sample presentation. A period of .75 sec of darkness followed the second sample presentation, prior to the choice period. The third type of trial was identical to the second except that the key location chosen to be the incorrect comparison on that trial appeared during the delay. On the fourth type of trial, one of the seven key locations not used on a trial was randomly selected and presented during the delay interval. Choice of the correct comparison continued to be rewarded on all test trials.

Test sessions were followed by 25 additional baseline sessions. Then 12 more test sessions, identical to the first test sessions, were arranged.

RESULTS

Averaged over subjects and replications (Figure 4), matching accuracy was highest on trials on which the sample was interpolated in the delay, second highest on blank trials, third highest on irrelevant key trials, and poorest when the incorrect comparison appeared during the delay. Only the deleterious effect of comparison-interpolation was large.

This pattern of results was typical for most of the pigeons during most parts of the test series (Table 3). Table 3 shows matching accuracy for each bird during the first and second

Fig. 4. Matching accuracy (percentage correct) during test phases of Experiment 2 when the delay interval was blank (N), or contained the sample (S), comparison (C), or irrelevant (I) key location.

halves of both the original and replication test series. Matching accuracy for each of the 12 separate opportunities (3 birds times 4 blocks) was ranked from lowest to highest and is shown in the top panel of Table 4. On each of 12 opportunities, the interpolated comparison produced the poorest matching (average rank = 1.00, Table 4). On 50% of these cases, matching accuracy was below chance (Table 3). Matching accuracy was highest 10 of 12 times when the sample appeared in the delay (average rank = 3.75). Interpolated irrelevant key

Table 4
Rankings from low to high of matching accuracy during each opportunity during Experiments 2 and 3. Abbreviations as in Table 3.

Experiment 2						
Trial Type	1 (Lowest)	Rank			Average Rank	
		2	3	4		
N	0	2	9	1	2.92	
S	0	1	1	10	3.75	
C	12	0	0	0	1.00	
I	0	9	2	1	2.08	

Experiment 3								
Trial Type	1 (Lowest)	Rank						Average Rank
		2	3	4	5	6	7	
N	0	0	0	0	2	4	1*	5.86
S	0	0	0	0	3	1	2	3.72
C	3	3	0	0	0	0	0	1.5
S-S	0	0	0	4	0	1	2*	5.14
S-C	0	0	5	1	0	0	0	3.17
C-C	3	3	0	0	0	0	0	1.5
C-S	0	0	1	1	1	1	2	5.33

*Ties given one of each rank.

trials (average rank = 2.08) produced slightly poorer performance than blank trials (average rank = 2.92).

Presentation of the irrelevant key location during the retention interval in all cases produced less interference with matching accuracy than did presentation of the incorrect comparison. In all cases matching accuracy over the test series on the irrelevant key trials was above chance and in several cases comparable to that on blank trials.

Table 3

Matching accuracy (percentage correct) during various phases of Experiment 2. Abbreviations: N—blank delay; S—sample key in delay; C—comparison key in delay; I—irrelevant key in delay.

Phase	Conditions	Bird 4	Bird 5	Bird 6	Phase	Conditions	Bird 4	Bird 5	Bird 6
1	Baseline (last 7 sessions)	93.4	93.4	82.3	3	Baseline	84.0	95.6	78.2
2	Test—Days 1-6 Stimulus in delay				4	Test—Days 1-6 Stimulus in delay			
	N	83.6	94.5	84.1		N	86.5	87.9	78.0
	S	95.1	97.9	81.8		S	90.0	96.0	76.6
	C	51.5	31.8	39.6		C	63.8	42.6	61.7
	I	78.3	65.4	70.0		I	88.0	73.8	80.0
	Test—Days 7-11 Stimulus in delay					Test—Days 7-12 Stimulus in delay			
	N	82.5	76.0	69.9		N	87.3	81.3	75.6
	S	100	93.8	86.8		S	87.8	95.0	80.9
	C	80	43.2	47.4		C	68.2	44.7	52.8
	I	88.9	65.3	60.0		I	74.1	78.2	68.6

A two-factor repeated measures analysis of variance of percentage correct scores (trial type and replications being the factors) revealed a significant trial-type effect [$F(3,6) = 13.32$, $p < .006$] and the Newman-Keuls post hoc test revealed two homogeneous subsets of trial types: first set—comparison-interpolated trials; second set—irrelevant-interpolated trials, sample-interpolated trials, and blank trials. The replication factor [$F(1,2) = 4.0$, $p > .05$] and replication by trial type interaction [$F(3,6) = .91$, $p > .05$] were not significant.

EXPERIMENT 3

The major purpose of this experiment was to examine the effects of presenting two spatial distractors during the delay period. In addition to single presentations of the sample and incorrect-comparison stimuli during the delay, four types of two-distractor trials were arranged. In one, two sample presentations occurred, whereas in another the incorrect comparison was presented twice. In two others, the sample was followed by the incorrect comparison, or vice versa.

METHOD

Subjects and Apparatus

Same as in Experiment 2.

Procedure

The general design and procedural details were the same as in Experiment 2. Twenty-one baseline sessions were followed by three test sessions which in turn were followed by another 12 baseline sessions. Three additional test sessions completed the experiment.

During baseline and test sessions the delay interval was 3 sec. The delay interval was always blank in baseline sessions as were 40% (randomly determined) of test session trials. During the remaining 60% of test trials, six types of trial occurred equally often (randomly selected with replacement). For two of these the delay interval was subdivided into three parts: a .5-sec blank period, a 2-sec period during which the sample for that trial or the incorrect comparison for that trial was presented, and a final .5-sec blank period. For the remaining four types of test trial, the delay interval was subdivided into five periods: a .5-sec period followed by a .75-sec period followed by a .5-sec period, another .75-sec period, and

a final .5-sec period. The .5-sec periods were always blank (i.e., spent in darkness). During the .75-sec periods, one of two stimuli—the sample-key location for that trial or the incorrect-comparison location for that trial—appeared. On one type of trial two sample presentations occurred; on another, two incorrect-comparison presentations occurred. On another, the sample was followed by the comparison, whereas on the remaining trial type the order was reversed.

RESULTS

Figure 5 shows a summary (averaged over subjects and replications) of matching accuracy during the seven types of trial arranged during test sessions. Details are shown in Table 5 and rankings of accuracy on trial types are shown in Table 4.

The effect of interpolating the key location serving as the incorrect comparison during the delay interval was essentially the same as that found in Experiment 2. Comparison-interpolation always produced the lowest or second lowest accuracy scores (average rank = 1.5, Table 4). Performance was typically below chance when the incorrect comparison occurred during the delay (Table 5). The facilitative effect of sample interpolation observed in Experiment 2 occurred less frequently in this experiment. Sample-interpolated trials produced better matching than blank trials during three of the 18 sessions during the two series (Table 5). Part of the reason for this discrepancy may have been a ceiling effect: During 6 sessions in this experiment matching was perfect on both types of trial.

Matching accuracy varied between the various types of two-distractor trial. Matching accuracy remained good when two sample pre-

Fig. 5. Matching accuracy (percentage correct) during test phases of Experiment 3 when the delay interval was blank (N) or contained one of six events: the sample (S), the incorrect choice (C), S followed by S, S followed by C, C followed by C, or C followed by S.

Table 5

Matching accuracy (percentage correct) during two test series of Experiment 3. Data are shown for each of the three sessions in each phase. Abbreviations used: S-C—sample key followed by comparison key; C-S—comparison key followed by sample key; others as in Table 3.

			Trial Type						
			N	S	C	S-S	S-C	C-C	C-S
<hr/>									
<i>Series 1</i>									
Bird 4	Session 1		100	85.7	33	100	60	33.3	50
		2	100	75	50	100	66.7	0	100
		3	100	100	0	100	100	100	100
		$\bar{x}$	100	86.8	27.7	100	75.6	44.4	83.3
5		1	83.3	80	33	60	50	28.6	100
		2	85.7	75	0	67.7	50	0	80
		3	100	80	0	75	50	50	100
		$\bar{x}$	89.7	78.3	11	67.5	50	26.2	93.3
6		1	100	100	0	67.7	25	0	100
		2	100	100	20	100	75	50	100
		3	83.3	100	100	67.7	66.7	40	75
		$\bar{x}$	94.3	100	40	78.4	55.6	30	91.7
<i>Series 2</i>									
Bird 4	Session 1		91.7	100	42.9	100	0	20	75
		2	100	100	33.3	50	80	0	100
		3	70	100	0	75	0	0	100
		$\bar{x}$	87.2	100	25.4	75	26.7	6.7	91.7
Bird 5		1	84.2	50	33.3	0	33.3	0	85.7
		2	100	100	0	33.3	25	0	100
		3	94.1	75	25	100	25	0	100
		$\bar{x}$	92.7	75	19.4	44.4	27.8	0	95.2
Bird 6		1	100	100	67.7	100	85.7	80	75
		2	92.3	85.7	0	100	75	40	33.3
		3	85.7	100	50	100	100	80	100
		$\bar{x}$	92.6	95.2	39.2	100	86.9	66.7	69.4

sentations occurred or when the incorrect comparisons was followed by the sample. Two presentations of the incorrect comparison produced as poor accuracy as single-comparison interpolated trials (average rank = 1.5, Table 4) and generally below-chance performance (Table 5). The sample followed by incorrect comparison consistently produced the third lowest accuracy (average rank = 3.17, Table 4). Accuracy on sample-then-incorrect-comparison trials (average rank = 3.17, Table 4) clearly differed from that on incorrect-comparison-then-sample trials (average rank = 5.33, Table 4).

A two-factor repeated measures analysis of variance of percentage correct scores (trial type and replications being the factors) revealed a significant trial-type effect [$F(6,12) = 24.18$, $p < .001$] and the Newman-Keuls post hoc test revealed the following three homogeneous subsets of trial types: first set—single-comparison and dual-comparison trials, second set—sample-then-comparison trials; third set—dual-sample, comparison-then-sample, single-sample, and

blank trials. The replication factor [$F(1,2) = .53$, $p > .05$] and replication by trial-type interaction [$F(6,12) = .17$, $p > .05$] effects were not significant.

GENERAL DISCUSSION

The major findings were as follows. First, a change in ambient illumination during either presentations of the sample or during the choice period had no effect on the accuracy of pigeons' matching of key locations. Wright et al. (1981) also found little effect of visual distractors presented during sample and choice periods.

The second finding, that delay-interval houselight presentation did not affect delayed matching, beyond a few days during initial exposure in some pigeons, was unexpected. Although other delay-interval stimuli have been found not to affect delayed matching (e.g., Wilkie et al., 1981; Worsham & D'Amato, 1973), I know of no cases where delay-interval

housetlight illumination has failed to affect delayed-matching accuracy.

Third, presentations of the key that had served as the sample during the delay interval in general did not adversely affect matching accuracy and in some cases appeared to aid matching. The same was true when the sample was presented twice during the delay.

Fourth, presentation of the incorrect comparison once or twice during the delay generally resulted in below-chance matching accuracy.

The third and fourth findings resemble those reported by Medin, Reynolds, and Parkinson (1980) and suggest that the pigeons may have been simply matching the comparisons to whatever stimulus was most recently seen. However, two other results show that this was not the only strategy employed by the birds.

The fifth finding, and the first that shows that the birds were not simply matching most recently seen stimuli, was that interpolation during the delay interval of a key location that was irrelevant for a particular trial (i.e., a key that was neither the correct nor the incorrect comparison) did not seriously interfere with matching accuracy (cf. Medin, 1980). Had the birds been remembering only the most recently presented stimulus, matching accuracy after an irrelevant location interpolation should have been only at chance levels. The fact that it was not shows that the birds were capable of remembering the original sample after presentations of a nonsample key location during the delay interval. The stimuli presented during the choice period obviously are important. If a key location that has recently appeared (either as a sample in regular trials or as a correct or incorrect comparison location during the delay) appears again as one of the choices, this stimulus is chosen. However, if neither of the choice stimuli was the most recently presented, as is the case when an irrelevant key intervenes, the second-most recent stimulus is chosen. This analysis obviously is consistent with D'Amato's (1973) temporal discrimination account of animals' short-term memory. According to the temporal discrimination hypothesis, an animal remembers several recent samples. Errors arise from "confusion" as to what was seen most recently, not from forgetting of the sample per se.

The sixth finding, and the second showing that the birds were doing more than simply

remembering and choosing the most recently seen stimulus, concerns performance on certain trials in which two stimuli appeared during the delay interval. The birds performed better, but still not much above chance (cf. Reynolds & Medin, 1979), on sample-then-incorrect comparison than on incorrect-comparison-then-incorrect comparison (or just one incorrect comparison) trials. If the most recent stimulus were the only controlling factor, there should have been no difference on sample-then-incorrect comparison and incorrect-comparison-then-incorrect-comparison trials. Again, the second-most recently presented stimulus seems to be important.

The present findings in general parallel those reported for tests of interference with rats' spatial memory measured in the radial-arm maze procedure developed by Olton (e.g., Olton, 1979). Maki, Brokofsky, and Berg (1979) gave rats four forced choices on an eight-arm maze and then subjected them to potentially interfering events prior to replacing them in the maze for a retention test (free choice of all arms, only the nonvisited arms baited with food). The interpolated events included lights, sounds, a distinctive odor, feeding on the maze, and a test on a four-arm radial maze in a different place. None of these interpolated events interfered. Roberts (1981) gave rats four forced choices on an eight-arm maze, then interpolated maze experiences, and finally a free choice retention test on the first maze. Interpolated maze experiences consisted of forced choices made on one, two, or three other mazes, each placed in a different room, forced choices on a maze located beside or on top of the original maze, or direct placements in one of the previously visited or unvisited arms of the original mazes. Interference with correct choice of baited arms was found only with the three interpolated mazes experience and when the animals were placed directly in one of the arms not visited during the original forced choices. Thus, rats' memory for spatial information, like the pigeon's, is not affected by general illumination and is only affected by "relevant" spatial cues.

The present results also bear on the broader issue of interference with remembering. When extraneous stimuli are interpolated during retention intervals and performance suffers, it is common practice to assume that the interpolated event interfered with remembering of the

sample. Further, it is often assumed that such effects mirror what happens during regular, uninterrupted trials (cf. Wright et al., 1981). Accordingly, when an animal makes an error on a baseline trial, it is assumed that some uncontrolled stimulus appeared during the delay interval and disrupted remembering. There are several difficulties associated with such a treatment of natural forgetting. The first obviously is that such interpolated events actually are never identified. The second is that no rules exist for predicting which of the steady stream of intruding stimuli will interfere and which will not. Third, whether a particular stimulus such as houselight illumination will interfere seems to depend upon the task: Houselight interpolation affects remembering of stimuli such as colors or forms but not key location. Last, even when certain types of stimulation do affect performance, there may be major differences in the effects of different members of that set. Spatial cues obviously affect delayed key-location matching but not all cues do so equally.

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