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EFFECTS OF STIMULUS RELEVANCE ON MEMORY IN THE PIGEON

By

Rodney Charles Howard

# A DISSERTATION

Submitted to Michigan State University in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Department of Psychology

#### ABSTRACT

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The effect of stimulus relevance on retention in the pigeon was investigated in three experiments. In the basic procedure, the occurrence of a 3 sec pre-stimulus indicated that a forthcoming 15 sec white stimulus would be reinforced on a variable interval schedule. The absence of a prestimulus indicated that extinction was in effect during white. In testing, retention functions were obtained by manipulating the interval between the pre-stimulus and a 15 sec white test stimulus. In Experiment 1, the effect of direct relevance on retention was investigated by comparing the pigeon's retention for a food pre-stimulus with that of a keylight pre-stimulus. Results showed food retention to be superior to keylight retention. In Experiment 2, the effect of associative relevance was investigated by comparing the pigeon's retention for two keylights after one received direct food pairing. Results showed that retention for the keylight paired with food was superior to the keylight lacking such pairing. In Experiment 3, discriminative relevance was investigated by manipulating the probability with which a

keylight pre-stimulus predicted a white stimulus. Results showed that retention was a direct function of the probability with which the keylight predicted the white stimulus.

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To my wife, Sharleen,

for her valuable advice and consistent support

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#### INTRODUCTION

In the recent surge of research on animal memory, attempts have been made to characterize the structure of memory in animals (Honig, 1978; Lett, 1975; Olton, 1978; Revusky, 1971; Spear, 1973; Wagner, 1978). Most researchers have generally assumed that animal memory consists of a long term retention structure, a short term retention structure and specific mechanisms for interaction between the two. Evidence that animals can store information over extended periods of time and then retrieve that information to facilitate learning has come from delayed alternation (Capaldi, 1971) and delayed reinforcement (Lett, 1973) studies. There is also support for the view that information can be actively maintained over short periods of time (Grant & Roberts, 1976; Maki, Moe & Bierley, 1977) and that this process, called rehearsal, may be necessary for the formation of associations (Terry & Wagner, 1975; Wagner, Rudy & Whitlow, 1973). Finally, the term "working memory" has been coined to describe retention when information is available in memory during a discriminative trial and then is terminated (Honig, 1978).

While research abounds on memory mechanisms, little attention has been directed toward the nature of information stored in memory. There is some evidence, for example, that

a memory for food is important for learning. In runway studies, rats have been able to learn that only alternate trials are reinforced (Capaldi, 1967; Cogan & Capaldi, 1961) or that magnitude of reinforcement changes across trials (Capaldi & Cogan, 1967; Crespi, 1942). With the exception of a few studies (Honig, 1978; Maki, Moe & Burley, 1977), there is a paucity of research directly investigating memory for stimuli. It seems likely that retention of a stimulus would be affected by: (a) how directly relevant the stimulus is to the animal (e.g., food to a hungry pigeon); (b) whether the stimulus has relevant associations for the animal (e.g., a CS which predicts food); and (c) to what extent the stimulus provides information about behavior associated with an upcoming event (i.e., that future keypecking will be reinforced). The purpose of the present research was to investigate memory for a stimulus as a function of the type of relevance it has for the animal.

#### EXPERIMENT 1

The Pigeon's Memory for Food Versus Wavelength

One aspect which may affect retention is the amount of direct relevance the stimulus has for the animal. Probably the most relevant stimulus used in animal research is food. Staddon (1974) has suggested that a pigeon's memory for food is superior to its memory for other events. While some evidence exists that animals show better retention for preferred reinforcers (Cowles & Nissen, 1937) and that the occurrence of reinforcement contributes to the retention of a pre-stimulus in a conditional discrimination task (Honig, 1978), direct evidence for better retention of food is sparse.

In the present study, retention of food was directly compared with the retention of a keylight. If, as has been suggested, food is a better remembered stimulus, its retention by the pigeon should be superior to the keylight. In the procedure used (Reynolds & Catania, 1962; Weisman, 1976) keypecking during a white keylight was differentially reinforced depending upon a discriminative pre-stimulus. If either access to grain or illumination of the keylight with a wavelength occurred, keypecking during white was reinforced. In the absence of either event, extinction was in effect. After the pigeon developed a discrimination between reinforced (S+) and non-reinforced (S-) trials, retention

functions were obtained by varying the delay between the discriminative stimuli and the trial onset. If access to food is retained in memory better than the presentation of a keylight, responding should occur during white after longer retention intervals when the discriminative stimulus was food than when it was the keylight.

#### METHOD

## Subjects

Four naive White Carneaux pigeons maintained at 80% of their free-feeding weights were used. The pigeons were provided free access to grit and water.

#### Apparatus

A three key Lehigh Valley pigeon chamber was used. The center key could be illuminated with either a green, red, yellow or white stimulus using an Industrial Electronics Engineers inline projector (Model #10-0W78-1820L). A houselight consisting of a GE #1820 lamp remained on during the session. A GE #1820 lamp illuminated the food hopper during reinforcement. A fan which provided masking noise and ventilation remained on during the session.

# Procedure

Pigeons were initially magazine trained and auto-shaped to peck the center key. An autoshaping trial, presented a variable interval 30 sec (VI 30 sec) schedule, consisted of the illumination of the key with a white stimulus for 8 sec followed by access to a grain filled hopper for 3.5 sec.

Following autoshaping, pigeons received discrimination training in the following manner. The center key was illuminated with the white light for both reinforced (S+) and non-reinforced (S-) trials. A reinforced trial began with a pre-stimulus of either a dark keylight and 3 sec access to grain or 3 sec keylight illumination with the green stimulus. Following either event, the key was illuminated with the white light (S+) and keypecking was reinforced on a VI schedule. Only one reinforcement was collected per S+ and the trial ended with reinforcement. The average duration of the variable interval schedule was 15 sec (VI 15 sec). For an extinction trial, no stimulus preceded the illumination of the key with the white stimulus (S-). Keypecking during S- was not reinforced and the duration of the trial was 15 sec. Trials were presented in a mixed order with all trials separated by a 30 sec intertrial interval (ITI). A session consisted of 40 S+ and 40 S- trials with S+ trials equally divided between those beginning with the food pre-stimulus and those beginning with the keylight prestimulus. Training was completed when a discrimination index of .90 was reached for two consecutive sessions. The  $\frac{S+}{S++S-}$  where S+ is the total number of formula is: responses to the white (S+) stimulus, and S- is the total number of responses to the white (S-) stimulus in a session. Figure 1 shows a diagram of the training procedure.

Figure 1. A diagram of the procedure used during training. For an S+ trial either food or green keylight preceded white. For an S- trial no stimulus preceded white.



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Testing consisted of presenting probe delay trials intermixed with normal training trials. In a testing trial, either food or the keylight was followed by a delay interval of 0 sec, 2 sec, 4 sec, 8 sec or 12 sec. During these probe trials, keypecking to the white stimulus was not reinforced and the stimulus remained on for 15 sec. Both pre-stimuli were tested at each delay interval per session. A testing session consisted of the 40 S+ and 40 S- trials, as in training, with the 14 probe trials inserted between training trials in a mixed order. All trials were separated by a 30 sec ITI. Each pigeon received seven sessions of testing with the order of delay intervals counterbalanced across sessions and pigeons.

# RESULTS AND DISCUSSION

The left panel of Figure 2 shows the average rate of responding for S+ when preceded by food (filled circles) or green (open circles) and for S- (filled triangles) when averaged over the last three days of acquisition training. The rate of responding did not differ significantly as a function of the discriminative stimulus used over this period, t (3) = .60, p < .10.

The right panel of Figure 2 shows that rate of responding during a white keylight preceded by either food or green as a function of the interpolated retention interval. The figure shows that responding during white dropped off at a shorter delay interval with the green keylight than with food.

Figure 2. The average rate of responding for the food prestimulus and the green keylight pre-stimulus for the last three days of training (X) and across retention intervals during testing.



A within-subject analysis of variance performed on the data showed that pre-stimulus and retention interval significantly interacted to affect responding during white,  $\underline{F}$  (6,8) = 18,  $\underline{p} < .001$ . A test for simple main effects showed that responding differed significantly at 2 sec,  $\underline{F}$  (1,18) = 6.8,  $\underline{p} < .025$ , 4 sec,  $\underline{F}$  (1,18) = 12,  $\underline{p} < .005$ , 6 sec,  $\underline{F}$  (1,18) = 7.98,  $\underline{p} < .01$ , and 8 sec,  $\underline{F}$  (1,18) = 6.95,  $\underline{p} < .025$ . Responding did not differ significantly at 0 sec,  $\underline{F}$  (1,18) = .16,  $\underline{p} > .10$ , 10 sec,  $\underline{F}$  (1,18) = .55,  $\underline{p} > .10$  and 12 sec,  $\underline{F}$  (1,18) = .51,  $\underline{p} > .10$ .

The results indicate that pigeons were able to show discriminative behavior over greater retention intervals when food was the pre-stimulus. The differences in retention were obtained following training to near asymptotic performance levels for both the food and keylight stimuli. In testing, similar performance was obtained for both stimuli at the 0 sec retention interval. It is unlikely, therefore, that differences in responding observed at later retention intervals resulted from inequities between stimuli in the level of original learning. If the association between the green keylight and white (S+) was not well formed, some error in discriminative behavior would be expected at the 0 retention interval resulting in an average response rate for green below that obtained with food. In general, the results support the notion that food produces a more lasting memory than a keylight. Other interpretations, however, are also possible. First, stimulus aftereffects may result from food ingestion. These aftereffects may

persist long enough to effectively mediate the retention interval through, perhaps, lengthening a peripheral sensory trace (Sperling, 1963) for food and thereby retarding trace decay. Roberts and Grant (1974) have shown that retention in matching to sample is improved following increases in sample stimulus duration. Another possibility is that separate sensory traces were found for each aspect of food presentation. Assuming variance in the rate of trace decay for any one stimulus, the probability of a stimulus trace at the end of the retention interval would be greater for the food prestimulus, consisting of an auditory solenoid click, a hopper light and grain presentation than the green pre-stimulus consisting merely of keylight illumination. Therefore, although retention of food was superior to a keylight, it is equivocal whether this reflects differences in memory for the events or some other factor.

#### EXPERIMENT 2

Retention of a CS

In Experiment 1, the superior retention of food over the keylight supported the view that direct relevance affects memory. A second factor which may affect memory is the associative relevance of a stimulus. The most obvious member of this category of stimuli is a CS. Although it is well known that a CS comes to control the behavior of an animal. it is not known if an animal's memory for a stimulus changes when it becomes a CS. Support has been gathered (reviewed by Rescorla, 1978) for cued retrieval of an internal representation of a US. It seems likely that if a stimulus such as food forms a powerful memory as Experiment 1 suggests, a stimulus which retrieves that memory should show some gain in retention. To test this, a keylight pre-stimulus in the present procedure was paired with food while another was not. If associative relevance facilitates memory, the CS keylight should show superior retention over the other keylights. Also, while Experiment 1 was confounded because of problems with the stimulus complexity of food presentation, this is avoided when stimulus associations are manipulated because physical properties can be held constant.

Some additional changes were made in the basic procedure. To decrease the possibility that pigeons would discriminate the varying duration S+ from the fixed duration testing trial, the S+ trial was set at 15 sec during which a VI 15 sec schedule of reinforcement was in effect. Although it is possible that the pigeon could adopt a strategy in which a slow rate of responding was maintained during any trial until reinforcement indicated that the trial was an S+, pilot work indicated that such a strategy was not adopted. Also, to decrease the difference between a testing trial in which a delay was interpolated between the discriminative stimulus and the test trial and an S+ trial in which no delay occurred, a 2 sec delay was interpolated between the discriminative stimulus and the S+ during acquisition.

#### METHOD

#### Subjects and Apparatus

Eight naive, White Carneaux pigeons, maintained at 80% of their free-feeding weights were used. The apparatus was the same as described in Experiment 1.

## Procedure

The procedure followed the basic pattern described in Experiment 1 with some important exceptions. An S+ trial began with the presentation of a discriminative pre-stimulus on the key for 3 sec. After a 2 sec delay, the white stimulus indicating an S+ trial was presented. The duration

of the white (S+) stimulus was set at 15 sec, matching the duration of the white (S-) stimulus. Keypecking was reinforced on a VI 15 sec schedule with the number of reinforcements per trial ranging from 0 to 2. Two discriminative prestimuli, red and green keylights, were used. One keylight (DS) was never directly paired with food but consistently predicted the white (S+) stimulus. The other keylight (CS) also consistently predicted the S+ but was additionally followed by a 3 sec access to grain on 75% of the trials. Figure 3 shows a diagram of the procedure used. A session consisted of 40 S+ and 40 S- trials. For half of the pigeons, 20 S+ trials began with green, 15 began with red followed by food and 5 began with red alone. For the remaining pigeons green was paired with food. Presentations of the CS followed by food insured conditioning, while presentation of the CS alone was intended to reduce the possibility of a generalized decrement problem during testing. All other aspects of training were the same as in Experiment 1. Training ended when a pigeon obtained a .90 discrimination index for two consecutive sessions.

Testing was basically the same as in Experiment 1. Retention functions were obtained for the DS, the CS alone, and the CS followed by food. Each stimulus was tested at 2 sec, 4 sec, 6 sec, 8 sec, 12 sec, and 16 sec retention intervals per session. The intervals were selected based on pilot research. Testing ended when a pigeon received 6 sessions. Order of testing was controlled as in Experiment 1.

Figure 3. A diagram of the procedure used during Experiment 2. The CS pre-stimulus predicted the occurrence of S+ and was additionally followed by food on 75% of the trials. The DS prestimulus only predicted S+ and was never directly followed by food.

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S+ TRIAL

# DISCRIMINATIVE STIMULUS (DS)



# CONDITIONED STIMULUS (CS)



Figure 4. The average rate of responding for the DS, the CS alone, and the CS followed by food for the last three days of training (X) and across retention intervals during testing.

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## **RESULTS AND DISCUSSION**

The left panel of Figure 4 shows the average rate of responding for S+ over the last 3 days of training when S+ was signalled by the DS keylight (filled squares) and by the CS keylight alone (filled circles) or followed by food (open circles). Responding during the S- is also shown (filled triangles). An analysis of variance performed on the acquisition data shows that the rate of responding among the stimuli did not differ significantly over the last 3 days of training, Fs < 1.0.

The right panel of Figure 4 shows the rate of responding during a white keylight preceded by either the DS keylight, the CS keylight alone, or the CS keylight followed by food as a function of the interpolated retention interval. The figure shows that responding to the DS keylight decreased at a faster rate than responding to either the CS keylight alone or followed by food.

A within-subjects analysis of variance, performed on the data, shows responding to differ significantly as a function of the pre-stimulus used,  $\underline{F}(2,14) = 9.12$ ,  $\underline{p} < .005$ , and as a function of the retention interval tested,  $\underline{F}(3,35) = 39.2$ ,  $\underline{p} < .001$ . A Duncan's multiple range test showed that the CS keylight did not differ as a function of whether or not it was followed by food, but did differ significantly from the DS keylight,  $\underline{F}(2,14) = 9.12$ ,  $\underline{p} < .005$ . A test for simple main effects comparing the CS and DS keylights showed that responding differed significantly at 4 sec,  $\underline{F}(1,40) =$ 

10.6, p < .005; 6 sec, F = (1,40) = 17.6, p < .001; 8 sec, F = (1,40) = 15.8, p < .001; and 12 sec, F = (1,40) = 7.4, p < .01. Responding did not differ significantly at 0 sec and 16 sec, Fs < 1.0.

The results of this experiment show that retention of a stimulus can be improved by its direct association with food. There can be little doubt that good associations were formed for both stimuli because discriminative behavior for each keylight was excellent. The keylight associated with food, however, showed better retention. In Experiment 1 a nonmemory hypothesis, involving sensory traces, was capable of accounting for differences in retention. This was possible because access to food and the illumination of a response key differed along a number of physical dimensions. In the present experiment, physical aspects of the discriminative stimuli, both keylights of approximately equal intensity, were controlled. The superior retention for the keylight associated with food, therefore, implicates memory processes. Perhaps the superior retention for directly relevant and associately relevant stimuli results from the same factor, superior retention for memories of directly relevant stimuli. Considerable evidence has been accrued for internal representation of USs (Konorski, 1948; Rescorla & Heth, 1975) and for CS retrieval of these representations (Rescorla & Cunningham, 1977; Terry & Wagner, 1975). In the present experiment, the CS pre-stimulus could retrieve an internal representation of food which then mediates the retention interval.

#### EXPERIMENT 3

Retention of Discriminative Stimuli

The results of the previous two experiments indicate that the direct and associative relevance of a stimulus affects its retention. In each study, retention was compared against a stimulus which consistently predicted an upcoming S+. This stimulus is considered to have discriminative relevance. This occurs when a stimulus indicates that a designated response will lead to a specified outcome. The present procedure is ideal for investigating a pigeon's memory for a stimulus with discriminative relevance for it temporally separates the pre-stimulus from the required response. To investigate discriminative relevance in Experiment 3, the probability with which a stimulus predicted S+ was manipulated. One stimulus (S1) predicted S+ 90% of the time, a second stimulus (S2) 50% of the time, and a third stimulus (S3) 10% of the time. For the remaining trials, the stimuli were followed by an ITI. Previous research has demonstrated that the amount of associative strength which accrues to a stimulus is affected by the probability with which it predicts reinforcement relative to other stimuli (Wagner, 1969). While each pre-stimulus in the present study is the best predictor of the S+ on its

given trial, and discriminative performance is near asymptote, the stimuli differ as to the consistency with which they predict reinforcement. If this affects retention of a stimulus, then the pre-stimulus which always leads to S+ (S1) should be superior to the stimulus which leads to S+ 50% of the time (S2) which, in turn, should be superior to the poorest predictor of S+ (S3).

#### METHOD

# Subjects and Apparatus

Six naive White Carneaux pigeons maintained at 80% of their free-feeding weights were used. The apparatus was the same as described in Experiment 1.

# Procedure

The pigeons were initially trained to peck the key using autoshaping as described in Experiment 1.

Discrimination training utilized the same basic procedure as used in Experiment 2. The center key was illuminated with the white light for both reinforced and nonreinforced trials. Both S+ and S- trials were 15 sec in duration and responding during the S+ trial was reinforced on a VI 15 sec schedule.

Three discriminative pre-stimuli, varying in the probability with which they predicted S+ were used. Pre-stimulus S1 was followed, after a 2 sec delay, by white (S+) 90% of the time, pre-stimulus S2 by white 50% of the time, and Figure 5. The average rate of responding for the S1 prestimulus, the S2 pre-stimulus, and the S3 prestimulus for the last three days of training (X) and across retention intervals during testing.

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pre-stimulus S3 by white 10% of the time. When a pre-stimulus was not followed by the white (S+) it was followed by the standard 30 sec ITI. Keylight colors (red, green, yellow) were counterbalanced across pigeons. A session consisted of 20 presentations of each discriminative stimulus for a total of 60 trials. The S- was also presented 60 times. Training ended when a pigeon obtained a .90 discrimination index for 2 consecutive sessions.

Testing was basically the same as in Experiments 1 and 2. All three discriminative stimuli were tested at each retention interval per session. The retention intervals were 2 sec, 4 sec, 6 sec, 8 sec, 10 sec, and 12 sec. Testing ended when a pigeon had received 6 sessions. Order of testing was controlled as described in Experiment 1.

#### RESULTS AND DISCUSSION

The left panel of Figure 5 shows the average rate of responding for S+ over the last three days of training when S+ was signalled by S1 (filled circles), S2 (open circles), or S3 (filled squares). Responding to S- is also presented (filled triangles). An analysis of variance, performed on the acquisition data shows that the rate of responding among the three stimuli did not differ significantly over the last 3 days of training, Fs < 1.0.

The right panel of Figure 5 shows the rate of responding during a white keylight preceded by either S1, S2 or S3 as a function of the interpolated retention interval. The

figure shows that S1 (90%) was superior to S2 (50%) and that S2 was superior to S3 (10%).

A within-subject analysis of variance performed on the data showed that pre-stimulus and retention interval significantly interacted to affect responding during white,  $\underline{F}$  (10,40) = 6.09,  $\underline{p} < .001$ . A test of simple main effects showed that S1 differed from S2 and S3,  $\underline{F}$  (5,40) = 2.94,  $\underline{p} < .025$  and  $\underline{F}$  (5,40) = 11.10,  $\underline{p} < .001$  respectively; and S2 differed from S3,  $\underline{F}$  (5,40) = 4.06,  $\underline{p} < .005$ . Furthermore, a Tukey test with criterion set at  $\underline{p} < .05$  showed all pre-stimulus to differ at 4 sec and 6 sec, and for S1 and S2 to differ from S3 but not each other at 8 sec. The pre-stimuli did not differ significantly at 2 sec, 10 sec, and 12 sec.

The results clearly demonstrate that the consistency with which a stimulus predicts S+ affects its retention. Furthermore, the poorest predictor of S+ shows the least retention, the intermediate predictor intermediate levels of retention and the best predictor the strongest retention. The differences in retention implicate memory processes in the present experiment for the same reasons given in Experiment 2.

# GENERAL DISCUSSION

The purpose of the present research was to determine if the relevance of a stimulus affects its retention. The results of Experiment 1 showed that food, a stimulus with direct relevance, was retained for a longer interval than a stimulus lacking direct relevance. Experiment 2 expanded this finding to stimuli associated with food. In Experiment 3, the probability with which a discriminative stimulus predicted S+ directly affected its retention. Taken as a whole, these results demonstrate that stimuli differ in their retention as a function of their relevance to the pigeon. This study is an initial attempt to determine the relationship between external stimuli and the animal's memory for these stimuli. Such an endeavor is potentially useful in furthering our understanding of both memory and learning processes. For example, it seems likely that the superior retention found with food and stimuli associated with food would have some direct effect on what is learned in an environment when they are present. In particular, while learning without reinforcement can occur, superior learning with it may be more the result of memory factors than motivational factors.

The improved retention observed in these experiments also raises questions about underlying mechanisms. In general, the results are consistent with the view that internal

representations can be achieved by associative stimuli. Early work by Pavlov (1927) and Konorski (1948) and recent work by Rescorla and Heth (1975) showed that a substantial portion of the response to an extinguished CS can be "reinstated" following separate presentations of the US. Rescorla and Heth have argued convincingly that modification of the memory of the US account of these findings. Rescorla and Cunningham (1977) have further demonstrated that reinstatement can be "erased" following isolated CS presentation supporting the view of CS cued retrieval of US memories. An alternative view holds that a direct sensory trace of the stimulus is formed which then passively decays in a linear fashion (Roberts & Grant, 1976). This view has difficulty accounting for the differential retention found in the last two experiments where all discriminative stimuli were of equal duration and approximately equal intensity. This is because the trace decay model assumed that the internal trace is a direct representation of physical properties of the external stimulus.

While the present data are consistent with the view that internal representations are formed, such a concept does not, in itself, account for the improved retention. An additional mechanism must be postulated to explain how the pigeon mediates the retention interval. One popular view is that stimuli must be actively rehearsed or they will quickly fade (Grant & Roberts, 1976; Maki, Moe & Bierley, 1977). This may be viewed as maintenance rehearsal (Atkinson & Shiffrin,

1968) which actively maintains information in an accessible, short term store. The problem with such a model is that it does not easily account for differences in retention. If rehearsal is necessary to bridge the retention interval, all pre-stimuli would have required rehearsal. Therefore, it is not clear what would lead to differences in retention between the stimuli. One possibility is that a retrieved representation of food which is likely to have occurred in Experiments 1 and 2 facilitated the rehearsal process. This view, however, would be contrary to the research (Terry & Wagner, 1975) which suggests that CS and US cued retrievals result in a suppression in rehearsal. Furthermore, differences in retention were observed in Experiment 3 in which retrieval of an internal representation of food was unlikely.

Another hypothesis has been forwarded by Honig (1978) to explain performance in which a "working memory" is necessary. Such a memory is required in paradigms such as the one used in the experiments presented here, in which discriminative cues terminate before the animal has the opportunity to make the correct response. In such cases, Honig has suggested that the discriminative stimulus establishes an "instruction" about the criterion response. This "instruction" is a memory of what is to be done; i.e., to peck or not to peck a key. Such an instruction does not decay over time but is terminated following the opportunity to execute the criterion response. In the present experiment, the discriminative stimulus gives the instruction to peck the key when it is illuminated with the white stimulus. Without

the discriminative pre-stimulus the instruction is: don't peck. One problem with this model is the assumption that the instruction is either formed at full strength or it isn't formed. Again, all stimuli were discriminated and therefore, the pigeon would be expected to form the instruction to peck for each stimulus.

In the above models, it has been assumed that information either passively decays from a sensory store or is actively maintained in a short term store. An alternative view is that information is accessible in memory but need not be rehearsed. This would be similar to the notion of "working memory" in humans proposed by Baddeley and Hitch (1974) and require only some modification in Honig's (1978) or Olton's (1978) "working memory" models. A trial begins with retrieval of information about the pre-stimulus, its associations and the to be executed response. The extent of information retrieved depends on interference factors at retrieval and the elaborateness of initial encoding. The elaborateness of encoding, in part, is a function of the relevance of the stimulus to the organism. Stimuli with direct relevance elicit maximum encoding, possibly as a natural consequence of their importance to the organism. Encoding of stimuli with associative relevance is also elaborate and includes the internal representation of a directly relevant stimulus. Finally, the encoding of stimuli with discriminative relevance is limited to the "to be executed" response. It has been demonstrated in human memory studies that the elaborateness of encoding affects

retention of words. Craik and Lockhart (1972) found that requiring subjects to encode words semantically led to greater retention than encoding phonemically which, in turn, was superior to encoding orthographically. A simple explanation of the present findings is that all stimuli were encoded for an "instruction" which was sensitive to interference from alternative behaviors during the retention interval. In Experiment 3, interference was greatest for S3 (10%) because the majority of trials during training ended in non-reinforcement. Behaviors engaged in by the pigeon on these non-reinforced trials might produce maximum interference because they involve behaviors directed away from the task designated by the instruction. Similarly S2 (50%) produced intermediate interference, while S1 (90%) showed the least interference. In addition to an encoded "instruction", the food and CS pre-stimuli included internal representations of food. Such memories are less sensitive to interference from behaviors because they are memories of stimulus events, not memories of responses. If at the end of a trial, the pigeon is unable to retrieve the instruction, retrieval of the internal representation of food can either aid retrieval of the instructions or re-instruct the pigeon.

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