

The role of within-trial location of the retention interval in rats' delayed conditional discrimination performance

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Rats were trained and tested on delayed conditional discriminations (DCDs) consisting of four possible light and tone stimulus sequences: light-light, tone-tone, light-tone, and tone-light. A lever was presented after the offset of the second or test stimulus, S_2 . Two retention intervals (RIs) were present within the DCD task, one (RI-1) between the sample or first stimulus (S_1) and S_2 , and the other (RI-2) between S_2 and presentation of the lever. Liquid reinforcement was contingent upon pressing only when S_2 matched S_1 in Experiment 1 or only when S_2 differed from S_1 in Experiment 2. RI-1 and RI-2 were separately increased to 5, 10, and 20 sec from 1-sec training conditions. Increasing RI-1 produced greater declines in performance to light S_1 than to tone S_1 in both experiments. No such stimulus modality effect occurred for increases in RI-2 in these experiments. These results indicate that retrospection of S_1 occurred during RI-1 and prospection of a response decision and reward expectancy primarily occurred during RI-2.

Honig and Thompson (1982) distinguished between retrospection (memory of a prior event) and prospection (retention of instructions for future responding and expected outcomes) in nonhuman short-term memory. Variants of Konorski's (1959) successive delayed matching-to-sample (DMTS) paradigm have been used to test this dual-process model in pigeons. Wallace, Steinert, Scobie, and Spear (1980) adapted this paradigm for rats by using changes in global visual and auditory stimulation in the operant chamber. In successive DMTS tasks, temporal sequences of two stimuli are presented in four possible combinations: A-A, B-B, A-B, and B-A. In the original paradigm, reinforcement is contingent upon responding to the second, comparison stimulus, S_2 , only when it matches the first, sample stimulus, S_1 (A-A, B-B), and not when it differs (A-B, B-A). Either true matching or symbolic matching (when comparison stimuli are different attributes of the same or of a different dimension from S_1) may be used. Also possible is a symmetrically reinforced version of this task in which responding in one way to matching pairs and in another way to mismatching pairs is rewarded (D'Amato & Worsham, 1974; White, 1974). Another variant, the delayed sequence discrimination (DSD) problem, requires the organism to respond to only one specific temporal sequence (Weisman, Wasserman,

Dodd, & Larew, 1980). In all of these forms of the delayed conditional discrimination (DCD) task, retention of S_1 is assessed by increasing the interstimulus or retention interval (RI) between S_1 and S_2 .

The basic method for investigating the dual-process model has been to vary the DMTS task so that the animal can use prospection, rather than retrospection of S_1 , for a response. One way to accomplish this end is to change the DMTS task into a simple delayed discrimination (DD) problem; another is to relocate the RI from between S_1 and S_2 to between S_2 and the opportunity to respond. In the DD problem, S_1 now provides all the information about responding for reinforcement at S_2 . When RI is shifted to follow S_2 , the subject needs to prospect its decision about responding, rather than to retrospect the nature of S_1 . As Honig and Wasserman (1981) pointed out, the successive DMTS paradigm is better suited to investigate the dual-process theory than is the simultaneous DMTS paradigm (Blough, 1959) in which the subject selects a matching test stimulus from two simultaneously presented test stimuli. Changing a successive DMTS task into a simple DD task will not alter stimulus sequences or the basic overall reinforcement schedule. Changing a simultaneous DMTS task into a DD problem, however, introduces a new reinforcement schedule if only half the trials contain the positive S_1 in the latter. Smith (1967) did maintain the same reinforcement schedule in both tasks by using a response-differentiated DD problem, but also used different sample and test stimuli in that task. It should also be noted that manipulation of RI location cannot be carried out in a simultaneous DMTS task.

The major finding with pigeons when successive DMTS tasks are changed to allow for response prospection is enhanced accuracy of performance. Honig and Wasserman (1981) found that pigeons' performance declined less on

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a DD than on a DMTS task when RI was increased. Increasing the RI following S_2 also disrupts pigeons' accuracy of performance less than does increasing the RI following S_1 in DMTS tasks (Honig & Dodd, 1983; Pontecorvo, 1985) and in the DSD problem (Weisman & DiFranco, 1981).

Unfortunately, differences in general accuracy of performance may not offer adequate evidence for dual processing in short-term memory. A unitary prospective process could account for such differences, as Honig and Wasserman (1981) suggest. Perhaps during the RI following S_1 in the DMTS task, the animal prospects an "if, then" rule (Roitblat, 1980, 1982), so that it must retain more information about the nature of the positive S_2 , the necessary response, and the outcome than it must in a DD task or during the RI following S_2 , where it need only remember how it should respond when the opportunity to do so occurs. Even if retrospection of S_1 occurs during the RI before S_2 , there is no logical reason why this type of information should be more difficult to retain than a prospected response decision generated by S_2 in a DMTS task or by S_1 in a DD task.

Differences more subtle than those in general accuracy of performance are needed to provide evidence of dual processing of information. Pontecorvo (1985), for example, also found that sample stimuli from previous trials proactively interfered with matching to S_1 in current trials only when the RI prior to S_2 was increased. This finding is consistent with the notion that retrospection of S_1 from one trial may be influenced by any persistent retention from previous S_1 stimuli. More direct evidence of S_1 retrospection could be shown, however, if delayed matching were influenced by the physical characteristics of S_1 . Any manipulation designed to promote response/reward prospection ought to attenuate such differences in S_1 matching. Urcuioli and Zentall (1986) demonstrated possible retrospection of S_1 by pigeons in simultaneous DMTS tasks. Their birds matched better to color than to line-orientation sample stimuli, regardless of the dimension of test stimuli. Evidence of S_1 retrospection in rats has been shown by better delayed matching to onset of a tone than to onset of chamber lights in a successive DMTS task (Cohen, Escott, & Ricciardi, 1984; Wallace et al., 1980, Experiment 2). In both studies, reinforcement was contingent upon leverpressing to a light or tone S_2 only when it matched a light or tone S_1 . Cohen, Galgan, and Fuerst (1986) showed that this effect was based on the modality of S_1 , not that of S_2 , and, more importantly, that the effect either disappeared or was attenuated when the DMTS problem was changed into a DD task, even though general performance did not necessarily improve in the latter.

Cohen et al. (1986) demonstrated that changing a DMTS task into a DD task changed the way rats retain information for responding to S_2 . The question posed in the present study is whether both processes, retrospection and prospection, are used in a temporally sequenced manner in the DMTS task. That is, do rats try to retain

some representation of S_1 until S_2 (retrospection) and then retain their decision about responding until they have the opportunity to exercise that decision (prospection)? Such a temporal sequence of these processes has been suggested by investigators, already cited, who varied RI location. The present study, therefore, is an extension of previous research by Cohen et al. (1986). In the present research, we observed whether changing the location of increasing RI within a successive DMTS would influence the effect of the modality of the sample stimulus on delayed matching accuracy. On some tests for delayed responding, the interval between offset of the sample stimulus and onset of the test stimulus (RI-1) was increased; on other tests, the interval between offset of the test stimulus and presentation of a lever (RI-2) was increased. We expected that the effect of S_1 modality on accuracy of responding would be restricted to increases in RI-1; that is, matching would decline more to the light S_1 than to the tone S_1 . The effect of S_1 modality was expected to disappear or diminish when only RI-2 was increased, because the rat would primarily be prospecting its decision to respond from S_2 , rather than retrospecting the nature of S_1 . Two experiments were carried out in this study. In Experiment 1, a true matching DMTS task was used. Experiment 2 was similar to Experiment 1 except that a true delayed mismatching-to-sample (DMmTS) task was used. In this task, reinforcement was contingent upon responding to S_2 only when it differed from S_1 (light-tone, tone-light sequences), rather than when S_1 and S_2 matched, as in DMTS (light-light, tone-tone). The rationale for this variation is given in the introduction to Experiment 2.

EXPERIMENT 1

Method

Subjects

Six naive male albino rats (Wistar strain) bred in our colony served as subjects when they had reached 90–150 days of age. Each rat was individually housed and was provided with free access to dry food and restricted (20–30 min) access to water, approximately 30 min following each daily experimental session. The animals experienced a 12:12-h light:dark cycle and were run during the dark cycle. Approximately every 2 weeks, the animals received free access to water for 48 h followed by restricted access to water over the next 24 h. They were not run during this period. These breaks in the running schedule were employed to maintain the health of our subjects over the lengthy duration of the experiment. The only exception to this procedure occurred when an animal was on a block of retention test sessions, in which case its free access period was delayed until after its test sessions.

Apparatus

Four commercially available operant chambers (Tech Serv), described by Cohen et al. (1984), were used. Each chamber was enclosed in a light-and-sound-attenuating isolation chamber, which contained a ventilation fan that produced a constant masking noise of 55 dB. An external speaker in the running room also emitted 62-dB white noise to further mask sounds from electromechanical programming and recording equipment in the adjacent room. Each chamber contained a retractable lever and a .05-ml water dipper on one wall and five 24-V 6-W incandescent lights and a Mallory

Sonalert 2.8-kHz tone generator in the ceiling. A 75-dB tone was produced by this generator. Two stimulus events, either an onset of the ceiling lights or a 75-dB 2.8-kHz tone, were presented in each operant chamber, which otherwise remained dark during intertrial and retention intervals. The lever could be programmed for insertion at any time from the onset of the second stimulus event onward and for retraction upon being pressed or after 5 sec had elapsed. The water dipper delivered a .05-ml droplet of sweetened water (.10% sodium cyclamate, w/v) as a reinforcement for a correct leverpress.

Procedure

Shaping and initial DMTS training, in which the lever was presented with onset of S_2 , were as described by Cohen et al. (1984). The following description focuses on final training and testing, in which the lever was presented after termination of S_2 .

Each rat first acquired the DMTS task in which the lever was presented with onset of S_2 . Four sequential pairs of 2.5-sec light and tone stimuli were presented: light-light, tone-tone, light-tone, and tone-light. Each pair appeared equally often over 100 trials in each session in a semirandom order so that matching or mismatching pairs or pairs with the same initial stimulus, S_1 , did not occur more than three times in a row. During training, RI-1 was maintained at 1 sec. Intertrial intervals between successive stimulus pairs were 24 sec from the offset of S_2 . Reinforcement was contingent upon a leverpress to S_2 only if S_2 matched S_1 . No reinforcement occurred for mismatching pairs. Thus, a maximum of 50 reinforcements, 25 to each matching pair, was possible within each session. Criterion for acquisition of this task was 30 correct presses out of 40 on each of two successive sessions. This criterion ensured that the rat could not achieve 75% correct leverpressing with a low number of presses.

Following acquisition of the initial DMTS task, each rat was trained to the same criterion with presentation of the lever delayed first 1 sec, then 2 sec, and finally 3.5 sec from S_2 onset. The final delay allowed the lever to emerge 1 sec after offset of S_2 (1 sec RI-2). Intertrial intervals were now determined from presentation of the lever and onset of the next S_1 and were kept constant at 23 sec throughout the remaining phases of the experiment.

Retention tests. Tests for S_1 retention were carried out by increasing either RI-1 or RI-2 to 5, 10, and 20 sec for each rat after it had reached criterion with both RIs at 1 sec. After reaching criterion on two successive sessions (200 trials) with 1-sec RIs, the rat received a block of two sessions (200 trials) in which one of the RIs was increased to 5 sec and the other remained at 1 sec. Three rats had RI-1 increased to 5 sec while RI-2 remained at 1 sec, and three had RI-2 increased to 5 sec while RI-1 remained at 1 sec. Following this test block, each rat was retrained to criterion with each RI at 1 sec. A second block of test trials over two sessions was then presented with the duration of the other RI increased to 5 sec and the previously increased RI now at 1 sec. The same procedure was used for testing S_1 retention at RIs of 10 and 20 sec. Each test block always followed reacquisition sessions with both RIs at 1 sec. Each rat experienced six S_1 retention test blocks following reacquisition blocks. Three animals received their six retention test blocks in the following order: 5-sec RI-1, 5-sec RI-2, 10-sec RI-2, 10-sec RI-1, 20-sec RI-1, and 20-sec RI-2. The other three rats received the opposite alternating pattern of location of increased RIs in an ascending order.

Retraining each animal to criterion with both RIs at 1 sec after each retention test block of sessions allowed it to recover from any effects of testing that might affect its responding on the next block of test sessions.

Data analysis. Each block of training or reacquisition sessions to criterion of 200 trials produced baseline performance before the next block of 200 retention test trials. Each baseline block and retention test block contained 100 matching and 100 mismatching pairs

of stimuli, half beginning with the visual S_1 and half beginning with the auditory S_1 . Proportions of leverpresses out of 50 possible presses to each stimulus pair at each baseline and retention block were calculated. Proportions of reinforced presses, or hits, and non-reinforced presses, or false alarms, were used to calculate A' , a retention index for S_1 at each criterion and test block of sessions.

A' is a nonparametric measure of signal sensitivity from signal detection theory (McNicol, 1972; Pollack, 1970) that may be used to determine retention of an event. We used this measure instead of a discrimination ratio because A' attenuates the bias to make positive responses that is inherent in successive DMTS tasks, according to Weiskrantz (1968). A more complete justification for using A' and its mathematical derivation is presented in earlier reports from this laboratory (Cohen et al., 1984; Cohen et al., 1986) and in more general treatments of signal detection theory (McNicol, 1971; Pollack, 1970). A' is calculated algebraically (Pollack, 1970) by the following formula:

$$A' = [(y-x)(1.00 + y-x)/4y(1.00-x)] + 0.5,$$

where y = proportion of hits and x = proportion of false alarms.

A' scores normally range from .50, indicating no signal sensitivity or retention because $x=y$, to 1.00, indicating perfect signal sensitivity or retention because $y=1.00$ and $x=0$. A' of less than .50 is possible when $y < x$, but such differences between hits and false alarms seldom consistently occur in our preparation.

Retention of the visual S_1 was estimated from A' scores based on proportions of hits to the light-light pairs and of false alarms to the light-tone pairs. Retention of the auditory S_1 was estimated from A' scores based on proportions of hits to tone-tone pairs and of false alarms to tone-light pairs. Two sets of A' scores were calculated, one for increases in duration of RI-1 and the other for increases in duration of RI-2. A' scores were calculated from RIs of 1 sec at each location during reacquisition blocks of sessions preceding each retention test block containing a longer RI at one of the locations.

Individual A' scores were used to calculate mean A' scores to construct figures in this study, but were not directly used for parametric statistical analysis because they are proportion measures. Therefore, individual A' scores were transformed into arcsin scores to normalize their binomial distributions and stabilize variances, as suggested by Winer (1971). Arcsin scores were subjected to a three-way analysis of variance (ANOVA) (S_1 modality [light, tone] \times RI location [RI-1, RI-2] \times RI duration [1, 5, 10, or 20 sec]) with repeated measures on all factors. Although data were gathered from training sessions with RI-1 and RI-2 both at 1 sec prior to each block of retention test sessions, only data from the training sessions before the retention test block with RI-1 at 5 sec (RI-2 at 1 sec) and before the retention test block with RI-2 at 5 sec (RI-1 at 1 sec) were used in this analysis. Subsequent baseline data were ignored to simplify the ANOVA; this was justified by the fact that baseline A' scores did not differ significantly over training blocks, as established by a separate three-way ANOVA for 1-sec RIs in each experiment. Newman-Keuls tests were used for individual comparisons.

Results and Discussion

Figure 1 shows mean A' scores for each S_1 at each RI location and duration in the first experiment. Examination of this figure reveals that a sample-stimulus modality effect was restricted to increases in RI-1. A' declined more to the light S_1 than to the tone S_1 only with increases in RI-1. Increases in RI-2 led to similar declines in A' to either S_1 . Location of increasing RI primarily affected accuracy of matching to the light S_1 . A' to the light S_1 declined more with increases in RI-1 than with increases

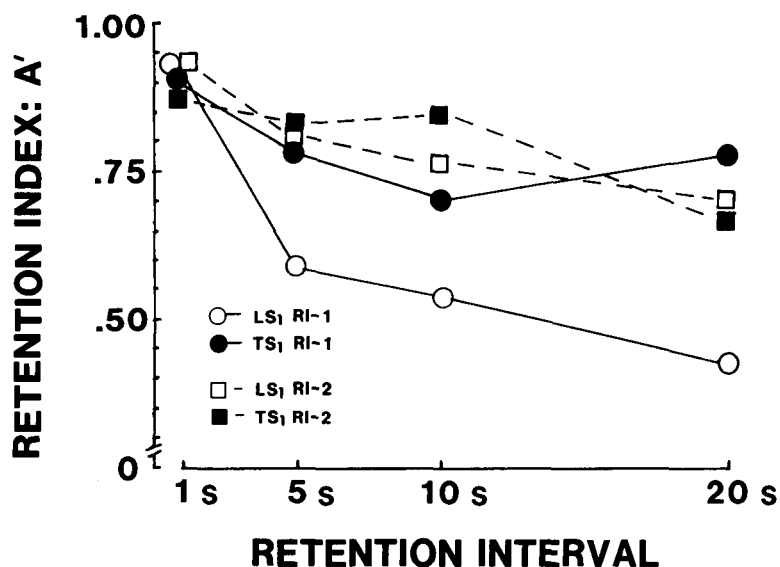


Figure 1. Mean A' retention scores for delayed matching to each sample stimulus for RI-1 and RI-2 at 1-, 5-, 10-, and 20-sec durations in Experiment 1. Only data from 1-sec RIs preceding testing with 5-sec RIs are shown. LS₁ = light sample stimulus, TS₁ = tone sample stimulus.

in RI-2. Increasing RI-1 or RI-2 to 20 sec produced greater declines in A' to the light S_1 than did increasing either RI to 5 or 10 sec. A similar retention function was also seen for declines in A' to the tone S_1 for greater increases in RI-2. A significant interaction among all three factors [$F(3,15) = 5.92, p < .01$] and individual comparisons ($p < .05$) supported these observations. A' to tone S_1 also declined more for an increase to 10 sec at RI-1 than at RI-2, but declined less for an increase to 20 sec at RI-2 than at RI-1.

The results of this experiment are consistent with a dual-process interpretation that retrospection of the nature of S_1 during RI-1 is taken over by prospection of a specific response decision during RI-2. This view is supported by the fact that modality of S_1 influenced delayed performance only for increases in RI-1. It should also be noted that possible prospection during RI-2 was not always better than possible retrospection during RI-1. Matching to the tone S_1 did not consistently decline more for increases in RI-1 than for increases in RI-2, as was found for matching to the light S_1 .

Our results, however, could be accounted for by a single prospective process similar to one proposed by Roitblat (1980, 1982). Each sample stimulus may elicit in the subject a specific "if, then" type of prospective representation, allowing it to anticipate what test stimulus requires a response for reinforcement. Perhaps the rat finds anticipating responding to a possible light S_2 more difficult to rehearse or retain than anticipating responding to a possible tone S_2 as elicited by a specific S_1 . Therefore, when S_2 is presented and the correct prospection to respond to an expected light S_2 is not well remembered, the rat may respond anyway to ensure hits, even though false alarms will also increase. If the correct prospection is to respond

to a tone S_2 that is better remembered, the rat will be better able to compare the actual S_2 with its expected S_2 , both to maintain hits and to prevent false alarms. Unfortunately, results from a DMDS task alone cannot determine whether the S_1 modality effect results from differences in retrospection of S_1 or in prospection for S_2 . Comparisons between the results of a DMDS task and a mismatching version of this task can determine which process prevails during each RI. Experiment 2 was run to answer this question.

EXPERIMENT 2

According to the prospection hypothesis of the modality effect discussed above, delayed conditional discrimination should be poorer for any sample stimulus that elicits a prospection for a possible light S_2 than for a tone S_2 . The modality of S_1 , therefore, should not matter; only the modality of the expected S_2 should account for any modality effects. To test this hypothesis, we trained rats on a DMmTS task in which reinforcement was contingent upon leverpressing only when S_2 differed from S_1 (light-tone, tone-light pairs). The prospection hypothesis would predict that now increases in RI-1 should reduce accuracy of performance more to the tone S_1 , which elicits the harder-to-remember prospection to respond if S_2 is light, than to the light S_1 , which elicits an easier-to-remember prospection to respond if S_2 is tone. According to the retrospection hypothesis, mismatching will decline more to the light S_1 than to the tone S_1 . Once the animal decides what to do at S_2 , however, prospection of this response decision that is no longer associated with modality of either S_1 or the anticipated S_2 will take over. Therefore, according to either hypothesis, increasing RI-2

with RI-1 maintained at 1 sec should result in declines in accuracy that are unaffected by stimulus modality.

Method

Subjects and Procedure

Seven experimentally naive male albino rats were trained and tested in a DMmTS task. Procedures identical to those used for training, testing, and data analysis in the first experiment were employed. Only contingencies for reinforcement differed in this experiment, in that reinforcement was contingent for leverpressing when S_2 differed from S_1 (light-tone, tone-light). No reinforcement was available for matching stimulus pairs (light-light, tone-tone). A' for the light S_1 was calculated from hits to light-tone pairs and false alarms to light-light pairs. A' for the tone S_1 was calculated from hits to tone-light pairs and false alarms to tone-tone pairs.

Results and Discussion

Figure 2 shows mean A' scores to each S_1 at each RI duration and location in Experiment 2. A comparison of Figures 1 and 2 reveals highly similar functions. Only increasing RI-1 resulted in greater reductions of A' to the light S_1 than to the tone S_1 in Experiment 2. As in the first experiment, location of increasing RI affected A' only to the light S_1 . A' to the light S_1 declined more for increases in RI-1 than in RI-2. Declines in A' were more generally directly related to RI duration in this experiment. Declines in A' to either S_1 were greater for an increase in either RI to 20 sec. Confirmation of these observations was provided by a significant interaction among all three variables [$F(3,18) = 11.95, p < .01$] and by individual comparisons ($p < .05$).

The results of Experiment 2 are also consistent with the notion that retrospection of S_1 occurs during RI-1 and prospection of a response decision occurs during RI-2. The stimulus-modality effect that occurred only for in-

creasing RI-1 was only a function of the modality of S_1 , which further supports the notion that this phenomenon indicates some form of S_1 retrospection during RI-1. The results of this experiment replicate those obtained by Cohen et al. (1986, Experiment 3) and are consistent with those reported by Urcuioli and Zentall (1986, Experiment 2). This experiment extends Cohen et al.'s (1986) findings, however, by showing that the effect of S_1 modality does not carry over to increases in post- S_2 delays. As in Experiment 1, location of RI increases affected accuracy of delayed responding to the light S_1 but not to the tone S_1 .

GENERAL DISCUSSION

Temporal sequencing of retrospective and prospective processes in the rat's working memory was shown by observing the influence of modality of a sample stimulus on delayed performance as a function of location of RI increases in two DCD tasks, successive DMmTS and DMmTS problems. Retrospection, as indicated by poorer accuracy of conditional responding to a visual than to an auditory sample stimulus, was restricted to increases in the RI between sample and test stimuli in both experiments. The notion that the stimulus-modality effect is an indicant of S_1 retrospection, rather than S_2 prospection, was supported by the fact that only the modality of the sample stimulus was responsible for differences in delayed responding. These results are consistent with Honig and Thompson's (1982) dual-process model of working memory, and extend earlier work in our laboratory (Cohen et al., 1986) that showed that the stimulus-modality effect is either eliminated or greatly attenuated by transforming a DMmTS task into a DD task.

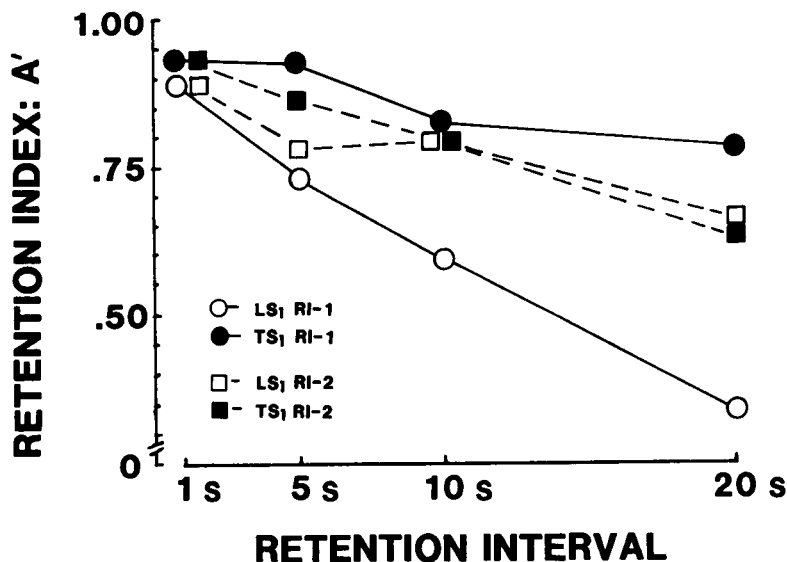


Figure 2. Mean A' retention scores for delayed mismatching to each sample stimulus for RI-1 and RI-2 at 1-, 5-, 10-, and 20-sec durations in Experiment 2. Only data from 1-sec RIs preceding testing with 5-sec RIs are shown. LS₁ = light sample stimulus, TS₁ = tone sample stimulus.

The present findings provide further and more conclusive evidence that in a DMST task the animal retrospectively the nature of S_1 until it receives S_2 , at which time it decides what to do and then prospectively its decision and expectancy for reward. That these processes need not be differentiated on the basis of general accuracy of performance was also demonstrated in this study. Our experiments provide better support for the temporal sequencing model than have previous studies in another way, as well. We demonstrated the effect of increasing RI at different locations through manipulating this variable for the same rats in the same basic DCD task in an alternating manner. Both Honig and Dodd (1983) and Pontecorvo (1983) inferred such a sequence of processes from separate groups of pigeons for whom duration of only one or the other RI was varied. Furthermore, Honig and Dodd's Conditional Delayed Discrimination (CDD) task differed from their DCD task in that the sample and task stimuli occurred simultaneously in the former but successively in the latter. Weisman and DiFranco (1981) did maintain an interstimulus interval, as distinct from the posttest stimulus RI, and did use the same pigeons in comparing the effects of increasing each RI separately. However, they trained and tested their subjects with increased RIs first at one location and then at the other, rather than alternating test locations as we did.

Sequential sharing of different ways of processing in working memory may not be restricted to DCD tasks. A similar sequencing order of retrospection and propection was proposed by Cook, Brown, and Riley (1985), who tested rats' performance in a 12-arm radial maze. They found that 15-min delays disrupted choice accuracy less when interpolated during the early or late part of the choice sequence than when interpolated midway, after the sixth correct choice. Cook et al. (1985) suggested that rats, when making a choice, initially attempt to remember which arms they have previously sampled (retrospection), but as this memory load increases, they switch to trying to determine which arms have yet to be approached (propection). In both preparations, retrospection occurs first and is supplanted by propection, but in the radial arm maze the mechanism of a fixed capacity in working memory determines when the switch is made. In our DCD tasks, information about the likelihood of reinforcement for a response signaled by a stimulus determines whether retrospection or propection is used. If S_1 offers no specific information about reinforcement until S_2 is presented, retrospection of a representation of S_1 must occur until it can be compared to S_2 , at which time a propection for a specific response and outcome expectancy can be formed.

Although temporal sequencing of dual processing was shown in this study, we cannot rule out the possibility of some form of propection during RI-1. Pontecorvo (1985) did find that earlier responding, as well as earlier sample stimuli, proactively interfered with delayed matching in subsequent trials with increased RI-1. A strict temporal separation of the processes would have produced only

proactive interference from earlier responding during RI-2 and only proactive interference from earlier sample stimuli during RI-1. The findings of Santi and Roberts (1985) also suggest that pigeons do form an "if, then" rule of prospective coding during RI-1. Santi and Roberts varied memory load on such prospective information in a simultaneous symbolic DMST task by assigning either many comparison stimuli to be correct for each sample stimulus (many to one) or only one comparison stimulus to be correct for many sample stimuli (one to many). Performance declined more for the greater load (many to one) than for the lighter load (one to many) with increased RI-1. Retrospection of S_1 , however, may have continued in either condition, since delayed matching appeared to be more accurate when sample and test stimuli were colors than when sample stimuli were line tilts or shapes. Therefore, we can conclude from our findings that retrospection of S_1 occurs during RI-1 and not during RI-2, but not that some form of propection for S_2 is absent during RI-1. We can with more certainty, however, maintain that retrospection of S_1 is absent during RI-2, during which propection of a response decision occurs.

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