INFLUENCE OF TEMPORAL CONTEXT ON VALUE IN THE MULTIPLE-CHAINS AND SUCCESSIVE-ENCOUNTERS PROCEDURES

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This set of studies explored the influence of temporal context across multiple-chain and multiple-successive-encounters procedures. Following training with different temporal contexts, the value of stimuli sharing similar reinforcement schedules was assessed by presenting these stimuli in concurrent probes. The results for the multiple-chain schedule indicate that temporal context does impact the value of a conditioned reinforcer consistent with delay-reduction theory, such that a stimulus signaling a greater reduction in delay until reinforcement has greater value. Further, nonreinforced stimuli that are concurrently presented with the preferred terminal link also have greater value, consistent with value transfer. The effects of context on value for conditions with the multiple-successive-encounters procedure, however, appear to depend on whether the search schedule or alternate handling schedule was manipulated, as well as on whether the tested stimuli were the rich or lean schedules in their components. Overall, the results help delineate the conditions under which temporal context affects conditioned-reinforcement value (acting as a learning variable) and the conditions under which it does not (acting as a performance variable), an issue of relevance to theories of choice.

Key words: choice, delay reduction theory, stimulus value, context of reinforcement, chain schedule, key peck, pigeons

An area of research that has important implications for theories of choice is how temporal context influences conditioned reinforcement value. It is well known that a stimulus associated with a smaller average interval until reinforcement should have greater conditioned reinforcing strength than a stimulus associated with a larger average interval until reinforcement (Fantino, 1977). Therefore, a stimulus associated with a variable-interval (VI) 10-s schedule should have more value as a conditioned reinforcer than a stimulus associated with a VI 20-s schedule. Another well-documented finding is that the temporal context in which a stimulus appears exerts an influence on choice (see Fantino, 2001, for review). The effect of temporal context can be seen in the concurrent-chains procedure, where responding to concurrent initial-link schedules (the choice portion of the trial) is reinforced by the presentation of two mutually exclusive terminal-link schedules (the outcome portion of the trial), completion of which leads to primary reinforcement. In

this procedure, if two different terminal-link schedules are held constant while the duration of the initial-link schedules is varied, choice will be closer to indifference with larger initial links than with shorter initial links. When the initial links are both long, either outcome represents a large reduction in time to reward ("large delay reduction") and the difference between them is therefore relatively modest. But when the initial-links are both short, the shorter outcome represents a relatively larger delay reduction than the longer outcome and the difference between them is therefore relatively robust. More recent models developed to account for choice in the concurrent-chains procedure also account for this effect (e.g., Grace, 1994; Mazur, 1995).

A more difficult question to answer at the moment is whether temporal context influences the conditioned reinforcement value of stimuli. In the situation just described, choice was assessed within that temporal context, and therefore one does not know if the influence of temporal context was on performance alone or also was affecting learning. If context affects behavior only when that context is present, then it is best considered to be a performance variable. In contrast, if behavior also is affected, at least for a time, once the context has been removed, then it is best considered a learning variable. The value of a conditioned

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reinforcer, because this is assessed outside of the training context, is representative of this learning.

According to delay-reduction theory (DRT), the conditioned reinforcing strength of a stimulus may be predicted by calculating the reduction in the duration of time to primary reinforcement signaled by that stimulus (Fantino, 1969, 1981; Squires & Fantino, 1971). The simplest form of DRT (from Fantino, 1981) states that:

Conditioned reinforcement strength of stimulus

$$X = f\left(\frac{T - t_x}{T}\right) \quad (1)$$

in which t_x is the time between the appearance of stimulus X and primary reinforcement, and T is the overall time between reinforcer presentations. As can be seen in Equation 1 and as DRT has been interpreted (Fantino, 2000; Grace & Savastano, 2000), the value of a conditioned reinforcer is influenced by its context, such that a stimulus that signals a greater percentage improvement to reinforcement should be a more valuable conditioned reinforcer than a stimulus that signals a smaller percentage improvement to reinforcement. Stated another way, the larger the difference between T and t_x , the greater the improvement in time to reinforcement that is correlated with the onset of the stimulus associated with t_x , which should make that stimulus a more effective conditioned reinforcer. Therefore, if a stimulus associated with a VI 30-s schedule is preceded by a 90-s period of nonreinforcement, it should be a more valuable conditioned reinforcer than if preceded by a 10-s period of nonreinforcement. When preceded by 90 s of nonreinforcement, the stimulus associated with the VI 30-s schedule signals a three-fourths reduction in delay to reinforcement; however, when preceded by 10 s of nonreinforcement the stimulus signals only a one-fourth reduction in delay to reinforcement.

DRT has been extended, with some success, to such areas as self-control (Ito & Asaki, 1982; Navarick & Fantino, 1976), elicited responding (Fantino, 1982), three-alternative choice (Fantino & Dunn, 1983), observing (Case & Fantino, 1981, 1989; Fantino & Case, 1983), operant analogues to foraging (Abarca &

Fantino, 1982; Fantino & Arbaca, 1985), percent reinforcement (Spetch & Dunn, 1987), and the serial-position effect in short-term memory (Wixted, 1989). However, despite the extensive assessment of choice predictions derived from DRT, very few investigations of the influence of temporal context on conditioned reinforcement value have been carried out.

Grace (1994) and Grace and Savastano (2000) have interpreted the contextual-choice model (CCM) as predicting that although context may influence performance, the value of a conditioned reinforcer depends solely on its own relation to reinforcement, independent of temporal context. This can be observed in the CCM equation:

$$\frac{B_L}{B_R} = b\left(\frac{R_L}{R_R}\right)^{a_1} \left[\left(\frac{1/D_L}{1/D_R}\right)^{a_2} \left(\frac{X_L}{X_R}\right)^{a_x}\right]^{[Ti/Ti]} \quad (2)$$

in which B_L and B_R are the initial-link response rates and R_L and R_R are the reinforcement rates obtained by these schedules, with terms for bias (b) and a sensitivity exponent (a_1). Terminal-link value is determined by the ratios inside the brackets, with the delays associated with the terminal links represented as D_L and D_R , and a potential second variable that may differentiate the terminal links (X_L , X_R), such as reinforcement magnitude. Sensitivity to these terminal-link variables are represented in a_2 and a_x . To determine the influence of the terminal links on performance, terminal-link value is raised to an additional exponent (Ti/Ti), the ratio of the average times spent in the terminal and initial links, respectively. Therefore, according to CCM, the value of the terminal links, occurring inside the brackets, is separate from the influence of temporal context on performance (Ti/Ti).

Fantino (2000) pointed out that CCM could be interpreted equally well as asserting that "context directly affects value" if the exponent representing the temporal context was retained during testing of conditioned reinforcement value, and that such a version of CCM made correct ordinal predictions for data Grace and Savastano (2000) had interpreted as implicating a limited role of temporal context (Fantino, 2000, p. 445). In the same vein, DRT need not predict that context directly affects value. Instead, DRT could be interpreted as applying only when the organ-

ism remains in the relevant context. However, Grace and Savastano's (2000) interpretation of DRT, with which Fantino (2000) agreed, was that context does affect value. The present experiments, therefore, are no doubt less important for their potential to discriminate between DRT and CCM as they are for their potential to illuminate the conditions under which context directly affects reinforcer value.

A similar prediction of temporal context not influencing value is made by the scalar expectancy theory (SET), according to which the organism forms memory representations of the encountered delays associated with each alternative (Gibbon, 1977, 1995). When presented with a choice, the organism is hypothesized to recall a memory representation of each and select the alternative with the lower recalled sample. Therefore, this account implies that the value of a stimulus as a conditioned reinforcer should be dependent on the delays associated with that stimulus, independent of the temporal context that is created by schedules not presented concurrently with the stimulus of interest.

One of the earliest attempts to assess whether context influences conditioned reinforcement value was performed by Belke (1992), who trained pigeons on a multiple concurrent VI schedule with VI 20-s and VI 40-s schedules available in one component, and VI 40-s and VI 80-s schedules available in the other. He then tested the conditioned reinforcing value of the stimuli associated with the two VI 40-s schedules by presenting them concurrently. The results were that pigeons strongly preferred the stimulus that had been presented along with the VI 80-s schedule. Although at first glance the results appear to support DRT's prediction that context can impart differential value to stimuli, debate continues as to whether the pigeons' choices in testing reflect the conditioned reinforcement value of the stimuli or different learned patterns of responding during training that may have transferred to testing (Gibbon, 1995; Williams & Bell, 1996, 1999).

Support for a more limited view of temporal context was found in studies performed by Grace and Savastano (1997, 2000), who trained pigeons with multiple-concurrent chains. In this procedure two concurrent-chains components were alternated, with initial-link schedules and/or terminal-link

schedules differing between components. Once performance became stable in training, the conditioned reinforcement value of the terminal-link stimuli was tested with two different testing procedures. In one test the terminal-link stimuli from training, one from each component, were presented following novel initial-link stimuli, thus forming a new concurrent chain. In the other test the terminal link stimuli were presented concurrently. The results showed that overall, pigeons responded to the stimuli in testing according to their current relation to reinforcement and independent of the context from training. Thus, Grace and Savastano failed to find an effect of temporal context on conditioned reinforcement value. However, these results are not conclusive (see Fantino, 2000). In one experiment, Grace and Savastano (1997) found evidence in favor of DRT when terminal-link stimuli were presented concurrently in testing. Further, failing to find an influence from temporal context may not mean that temporal context has no effect on conditioned reinforcement value, but rather may reflect the failure of conditioned reinforcement value transferring from training to testing.

O'Daly, Meyer, and Fantino (2005) demonstrated that temporal context affects the value of a conditioned reinforcer within a multiple-chain schedule. In two experiments, pigeons were trained on a multiple-chain schedule in which the initial link for one chain was a VI 100-s schedule and for the other chain a VI 10-s schedule. The terminal links were both fixed-time (FT) 30-s schedules signaled by differently colored stimuli. Following training, choosing the terminal-link stimuli was tested either by presenting these stimuli in concurrent probes or by presenting these stimuli as reinforcers for completing novel initial links (either in novel concurrent chains or as concurrent-chain probes). In three of the five conditions of Experiment 1, consistent with DRT, pigeons chose the terminal-link stimulus that followed the long initial link significantly more often. This pattern of choices was observed across all three testing procedures. Experiment 2 repeated the experiment with one of the conditions from Experiment 1 and replicated the results.

Clement, Feltus, Kaiser, and Zentall (2000) and Clement and Zentall (2002) not only found similar evidence of temporal context

influencing the conditioned reinforcement value of stimuli, but also observed that the value of these stimuli transferred to nonreinforced stimuli that had been associated with them in training. In the Clement *et al.* study, pigeons were trained on a multiple schedule. In one component a single peck was followed by a simple simultaneous discrimination; a single response to one stimulus led to reinforcement, whereas a response to the other led to a timeout. The second component was similar to the first except that an FR 20 requirement preceded the simple simultaneous discrimination. In a test between the two stimuli previously pecked to obtain a reinforcer (one from each component), pigeons more often chose the stimulus that had followed the FR 20. Clement and Zentall replicated the experiment but altered training such that in one component, an FR 1 alternated (with 50% probability) with a simple simultaneous discrimination, whereas in a second component a FR 30 alternated (again with 50% probability) with a different simple simultaneous discrimination. In a test between the two reinforced stimuli from the simultaneous discrimination, the pigeons more often chose the stimulus that had alternated with the FR 30 schedule. The results from both studies are consistent with the predictions of DRT.

Similar findings were reported when Clement *et al.* (2000) tested the unreinforced stimuli from the two components (*i.e.*, pigeons more often chose the unreinforced stimulus that was in the same component as the preferred reinforced stimulus). The authors attributed these results to a value-transfer effect, whereby a stimulus acquires value not only directly, through its own association with reinforcement, but also indirectly, through the transfer of value from stimuli with which it is paired. According to this interpretation, the reinforced stimulus having greater conditioned reinforcement value should transfer greater value to its paired unreinforced stimulus.

The present studies further assess the role of temporal context in determining the value of a stimulus, using both multiple-chain schedules and multiple successive-encounters procedures. The results should permit assessment of predictions made by three major theories (CCM, DRT, and SET) as well as considerations of value transfer.

EXPERIMENT 1

The present experiment investigated the issue of value transfer with a training procedure similar to that used by O'Daly *et al.* (2005). Training consisted of a two-component multiple-chains schedule, with identical terminal-link schedules (FR 30), but different initial-link schedules (either VI 100 s or VI 10 s) and corresponding stimuli. During the terminal link for each component a second stimulus was presented on another key and responding on this key was not reinforced. Following training, the conditioned reinforcement value of both terminal-link FR 30 stimuli and both non-reinforced stimuli were tested in transfer tests between training components by presenting these stimuli in concurrent probes. According to DRT, the stimulus associated with the FR 30 outcome that follows the VI 100 s, should be a more potent conditioned reinforcer than the stimulus associated with the FR 30 that follows the VI 10 s (since the former is associated with greater delay reduction). But according to CCM and SET, both FR 30 outcomes should have equivalent value in transfer tests (CCM and SET predict indifference across all five experiments in the present study). Testing the value of the non-reinforced stimuli assesses a possible influence of value transfer.

METHOD

Subjects

The subjects were 8 White Carneau pigeons (*Columba livia*). All 8 were experienced in a variety of experimental procedures, including chain schedules. The pigeons had free access to water and grit in their home cage. Food was obtained during experimental sessions with additional food given, if necessary, in their home cage to maintain them at their 80% mean ad libitum body weight. Pigeon 299, from the terminal-link-stimuli test group, and pigeon 475, from the nonreinforced-stimuli test group, stopped responding during their first exposure to training due to an equipment malfunction and were subsequently dropped from the experiment.

Apparatus

The pigeons were tested in four operant conditioning chambers, measuring approximately 32 cm high and 36 cm long and wide.

The floors of the chambers were made of steel rods suspended above newspaper. The ceiling of the chambers and three walls, one of which was the door wall, were made of black plastic. The remaining wall of each chamber was made of aluminum. Three plastic, circular response keys, 2.5 cm in diameter, were placed horizontally on the aluminum wall, 24 cm from the floor of the chamber. The keys required a force of approximately 0.10 N to register a response and to produce an auditory feedback. The keys were translucent and could be illuminated from the rear by 12-stimulus IEEE® projectors. Stimuli used in the present experiment were blue, yellow, red, green, a white vertical line, and a white horizontal line. A grain magazine was located below the center response key, and when activated provided access to milo seed by means of a solenoid and the turning on of a 6-W light, which illuminated a 6 cm wide by 5 cm high opening to the food (located 13 cm below the center key). A 6-W houselight was located 7 cm above the center response key. The chambers were enclosed in plywood boxes to reduce external illumination. A fan provided ventilation and provided a masking noise for external sounds. A Turbo Pascal ® program on an IBM® compatible computer, located in an adjacent room, controlled the stimulus events and response contingencies, as well as collection of the data.

Procedure

Pigeons were given initial training on a concurrent-choice procedure, in which two alternatives were presented concurrently, with different VI schedules between them ranging between 15 and 60 s. The stimuli used during this preliminary training were various white symbols not used during the experiment. This training was conducted to ensure that the pigeons had prior experience discriminating between different schedule values. Once pigeons' relative rate of responding matched the relative rate of reinforcement between the choice alternatives for each concurrent pair, the schedule values were changed and they experienced another concurrent pair. Each pigeon experienced 12 sessions of this training (approximately three different concurrent pairs). Following preliminary training, pigeons immediately began the experimental training procedure.

The experimental training procedure consisted of a multiple schedule with two chain components. As shown in Figure 1 the initial-link schedule for one chain was a VI 100 s (Component A), and the other was a VI 10 s (Component B). Table 1 shows how the location and color of the initial- and terminal-link stimuli were counterbalanced across pigeons. Responding to the initial-link schedule was reinforced by entry into the terminal link, which was signaled by two changes in stimuli: 1) the initial-link stimulus was replaced by either a white horizontal line (following the VI 10) or a white X (following the VI 100), depending on the component; and 2) the presentation of a stimulus associated with a FR-30 schedule. Responding on the non-FR-30 key had no programmed consequence, whereas completion of the FR 30 resulted in 4 s of magazine access to milo seed.

The first multiple-schedule component (A or B) was randomly chosen ($p = 0.5$) by the computer and was composed of 10 trials. Subsequent components were also 10 trials and were separated by a 30-s blackout in which all stimuli and the houselight were turned off. Components then strictly alternated between A and B until the pigeons had completed 20 trials in each component, 40 trials total (four components) for the session.

Following the 20th training session, pigeons continued to receive training as usual, but following each of the three blackout periods they completed a single concurrent probe testing trial. Pigeons were randomly assigned to two testing groups to lessen the probability that they would learn that the probe context featured stimuli with identical outcomes. For 3 pigeons (see Table 1), the two FR-30 terminal-link stimuli were concurrently presented on the left and right keys (terminal-link test). For the other 3 pigeons, the two non-reinforced stimuli that were previously presented on the key opposite the terminal-link stimuli were presented (nonreinforced test). The stimuli appeared on the same key throughout testing. A single response to either stimulus started the timer for a fixed-interval (FI) 20-s schedule, in which the first response on either key after 20 s resulted in another 30-s blackout followed by the next multiple-schedule component. This test measured the relative ability of the stimuli to evoke responding, which has been shown to reflect the conditioned reinforce-

Multiple-Chains Procedure

Fig. 1. Diagram of the multiple-chains schedule. The left and right panels illustrate the sequence of events for multiple-schedule Components A and B, respectively. Circles represent the response keys with the schedule requirement indicated inside, except for the nonreinforced stimuli, in which the stimulus projected onto the key is presented (either an X or a horizontal line). Shaded keys were not lit and were not operational.

ment value of the stimuli (O'Daly *et al.*, 2005). Because the only schedule difference between components was the initial links (either VI 100 s or VI 10 s), choosing one stimulus over the other should be a result of differences in the temporal context (the initial links). Pigeons received three testing trials per session over five sessions for a total of 15 test trials. The proportion of choice responses for both

the FR 30 stimulus following the longer initial link (FR 30 [VI 100 s]) and the nonreinforced stimulus following the longer initial link (EXT [VI 100 s]) was calculated by dividing the number of responses in testing to this stimulus by the total number of testing responses.

Following testing, pigeons repeated the preliminary training condition for 10 sessions. The concurrent schedule values and stimuli

Table 1
Summary of Experiment 1.

Pigeon	Color of A ^a	Side of A ^b	Testing stimuli ^c	Choice proportion ^d	
				Initial	Reversal
276	Red, Blue	Left	FR 30	.64 (.05)	.81 (.21)
298	Red, Blue	Right	FR 30	.60 (.35)	.95 (.04)
280	Green, Yellow	Left	FR 30	.62 (.01)	.52 (.38)
453	Green, Yellow	Right	Nonreinforced	.78 (.21)	.68 (.24)
458	Green, Yellow	Left	Nonreinforced	.82 (.07)	.78 (.03)
483	Red, Blue	Right	Nonreinforced	.98 (.04)	.79 (.07)

^a The first color represents the initial link and the second is the color of the terminal link for Component A for the initial condition.
^b Side on which the terminal link of component A was presented in training.
^c Stimuli presented during testing.
^d For the FR 30 test, proportions represent the choice responses to the FR 30 (VI 100 s) stimulus. For the Nonreinforced test, proportions represent the choice responses to the nonreinforced stimulus (VI 100 s). Proportions were averaged over the first two sessions of testing for both the initial condition and the reversal. The number in parentheses represents the standard deviation.

were the same as those used in the original preliminary training condition. This was done to ensure that the pigeons had continued experience discriminating between different schedule values. Following this training, pigeons immediately began in a reversal of the multiple concurrent-chains condition. In this condition, training and testing were the same as before, with the exception that the initial-link VI schedules were switched between components. Because none of the schedule-correlated colors were switched, demonstration of an effect of temporal context during testing would require that the pigeons more often choose the opposite side and opposing stimulus color from their initial testing condition.

RESULTS AND DISCUSSION

The purpose of the present experiment was to assess whether temporal context (initial-link VI-schedule value) would influence the conditioned reinforcement value of stimuli presented in the terminal link (both stimuli for which responding had been reinforced and those for which responding had not been reinforced). According to DRT the FR 30 (VI 100 s) stimulus should have greater conditioned reinforcement value because it signals a greater reduction in delay to obtaining a reinforcer. With respect to the non-reinforced stimuli, according to the value transfer theory, if one terminal-link stimulus has greater value then its associated nonreinforced stimulus (EXT [VI 100 s]) also should have greater value.

Following the first two sessions of testing, for both groups, mean responding gradually approached indifference. The shift toward indifference was expected because the consequence of pecking either stimulus was a blackout. Therefore, only the first two sessions of testing (six test trials) are reported.

The results for the test of the reinforced stimuli are presented in the top of Figure 2 (see also Table 1). Mean proportion choice responses made on the FR 30 (VI 100 s) stimulus was .62 ($SE = .01$) in the initial test condition and .76 ($SE = .13$) in the reversal. The results for the nonreinforced test are presented in the bottom of Figure 2 (see also Table 1). Mean proportion of choice responses allocated to the EXT (VI 100 s) stimulus was .86 ($SE = .06$) in the initial

condition and .75 ($SE = .04$) in the reversal. Thus, for each of 12 determinations (initial and reversal for each of 6 pigeons over the two tests) temporal context affected value. This finding was highly significant with a Binomial test ($p = .0002$).

The tendency to respond more on the FR 30 (VI 100 s) stimulus in both test conditions supports DRT's prediction that stimuli signaling a greater reduction in delay until reinforcement have greater conditioned reinforcement value. This finding extends those of O'Daly et al. (2005) from FT to FR terminal-link schedules. Likewise more frequent probe responding on the EXT (VI 100 s) stimulus is further evidence suggesting that the reinforced stimulus following the longer initial link had greater conditioned reinforcement value, and is consistent with the results found by Clement et al. (2000) and Clement and Zentall (2002). A likely explanation for the results of the non-reinforced test is that this stimulus, being the first one the pigeon sees when completing the initial link, also signaled the presence of the terminal-link stimulus and a greater reduction in delay until reinforcement.

Another way of stating this finding is that value transfer occurred from the FR 30 stimulus to the EXT stimulus, with the FR 30 stimulus having greater conditioned reinforcement value (FR 30 [VI 100 s]) transferring greater value to its concurrently presented nonreinforced stimulus (EXT [VI 100 s]). Because the tested stimuli had identical schedule values, CCM and SET predict that pigeons should have been indifferent between the stimuli.

O'Daly et al. (2005) and Fantino (1982) found that during training pigeons responded more to a terminal-link stimulus that followed a longer initial link. A similar result was found for the nonreinforced stimulus in the present study. Averaging across the last five sessions of training for both the pigeons' first testing sequence and the reversal, the average response rate per session to the EXT (VI 100 s) stimulus was 20.93 ($SE = 5.21$) responses per trial, whereas the average response rate to the EXT (VI 10 s) stimulus was 8.89 ($SE = 2.31$) responses per trial. This difference was significant, $t(5) = 2.634$, $p = .046$. Thus, the nonreinforced stimulus receiving a higher rate of responding in training was the stimulus pigeons chose in testing.

Fig. 2. Testing results from Experiment 1. The top panel represents results from the test of the FR 30 stimuli, and the bottom panel represents results from the test of the nonreinforced stimuli. Data for both the pigeons' first condition and reversal condition are averaged over the first two testing sessions. Error bars for individual pigeons indicate the standard deviation; error bars for the mean indicate the standard error.

EXPERIMENT 2

Experiment 1 supported DRT with the multiple-chains procedure, in which the pigeons equally experienced the two chain schedules. The present experiment again investigated the conditioned reinforcement value of stimuli, but unlike Experiment 1 the multiple-successive-encounters procedure was used in training. Under this procedure, pigeons first completed a VI 100-s or VI 20-s search schedule and then chose to either accept or reject a handling schedule that

ended with reinforcement. The handling schedules arranged in both multiple-schedule components were VI 15-s and VI 30-s schedules. Following this training, the two identically valued handling schedules arranged across training components were presented concurrently in testing. The present experiment was analogous to Experiment 1 because we assessed the conditioned reinforcement value of stimuli that in training had differed in the delay reduction signaled by their onset. The successive-encounters procedure is well suited

for testing the role of context on conditioned reinforcement value, due to the temporal separation of the choice alternatives that were never presented concurrently during training. According to DRT, the handling schedules following the VI 100-s search schedule should have greater conditioned reinforcement value because they signal a larger reduction in delay until reinforcement.

METHOD

Subjects and Apparatus

The subjects were 8 White Carneau pigeons (*Columba livia*). All pigeons were experienced in a variety of experimental procedures, but none had experience with the successive-encounters procedure. Four of the pigeons were tested in the same experimental chambers as in Experiment 1. The other four were tested in four identical chambers except that three of the chamber walls and the ceiling were made of clear Plexiglas instead of black plastic. Pigeon 524, from the lean handling test, stopped responding during its first exposure to training due to an equipment malfunction and was subsequently dropped from the experiment.

Procedure

Preliminary training was conducted under concurrent VI VI schedules, with schedule values ranging between 15 and 60 s. The stimuli used during preliminary training were various white symbols not used during the experiment. Just as with Experiment 1, the purpose of preliminary training was to ensure that pigeons had experience discriminating between different schedule values.

Following preliminary training, pigeons began training under the multiple-successive-encounters procedure. Under this procedure, subjects first complete a search schedule. Upon completion of this schedule, alternatives that differ in delay to food (prey handling times) are presented successively and subjects choose to either accept or reject the proffered handling schedule (Collier & Rovee-Collier, 1981; Lea, 1979), thereby representing a more realistic environment of prey selection (e.g., Charnov, 1976).

Figure 3 illustrates this training procedure for multiple-schedule Component A in which the search schedule was a VI 100-s schedule.

Training sessions began with the onset of the houselight and the illuminated search key. The search key was illuminated with a white X. For half of the pigeons the search key was on the right key, for the others it was on the left key. Completion of this search schedule initiated the choice portion of the trial, in which the opposite side key was illuminated either blue or red depending on which handling alternative was randomly selected by the computer ($p = .5$). During the choice portion of the trial both keys were on a FR 3 schedule. Three further responses to the search key reset the VI schedule programmed on the search key (as did a failure to respond to either key for 20 s, a rare occurrence). Such choices were recorded as rejections of the presented alternative. If three responses were made to the other key, this was recorded as an acceptance of the presented alternative. During the handling portion of the trial the search key became dark and inoperative and the schedule associated with the accepted alternative went into effect (either a VI 15 s or VI 30 s). Completion of this schedule resulted in a 4-s activation of the food hopper. Following reinforcement, a new trial began with the illumination of the search key.

Multiple-schedule component B was identical to Component A, with three exceptions. First, a VI 20-s schedule was programmed during the search portion of the trial. Second, the search and handling keys were on opposite sides to those keys from Component A (such that if the search key had been on the left key and the handling alternatives on the right in component A, the search key was on the right and the handling alternatives on the left for Component B). Finally, the search key was illuminated with a white horizontal line, and the handling alternatives were randomly illuminated either yellow or green (again, $p = .5$). Just as with Component A, the schedules associated with the handling alternatives were VI 15 s or VI 30 s.

Similar to Experiment 1, sessions began with a randomly chosen ($p = .5$), 10-trial multiple-schedule component. A 30-s blackout separated these components. At the conclusion of this interval the houselight was reinstated and the other component was presented. Components alternated in this fashion until the pigeons had received 20 trials of each component, 40 trials total (four 10-trial blocks) for the session.

Fig. 3. Diagram of the successive-encounters procedure. Rectangular boxes represent the different portions of the trial. Circles represent the response keys with the letters indicating the corresponding colors (B = blue, R = red, X = white X). Schedule requirements are located below their corresponding rectangles. A VI 100-s schedule operated during the search portion of the trial in Component A (shown in the figure) whereas a VI 20-s search schedule was programmed in Component B (not shown). The probability of encountering the rich or lean alternative during the choice portion of the trial was .50. Arrows indicate the consequences of meeting the schedule contingencies on the operative key.

There were 20 sessions of training. The stimulus arrangement and the key placement for Components A and B were counterbalanced across pigeons (see Table 2). Normally, the measure of interest in the successive-encounters procedure is the acceptance or rejection of the lean alternative, because the pigeon should always accept the rich alternative when it is presented. Pigeons' rate of accepting the lean alternative depends on the average overall delay until reinforcement

from the beginning of the search stage (Fantino & Abarca, 1985; Fantino & Goldschmidt, 2000). If the delay associated with the lean alternative is less than the delay associated with the beginning of the search stage, the pigeon will usually accept the lean alternative. However, if the delay associated with the lean alternative is greater than the overall delay, this alternative typically is rejected. In the present study, the schedule values (15 & 30 s) were less than the average delay from the

Table 2
Summary of Experiment 2.

Pigeon	Color of A ^a	Side of A ^b	Testing stimuli ^c	Choice proportion ^d	
				Initial	Reversal
521	Green, Yellow	Left	Rich	.91 (.07)	.58 (.11)
506	Green, Yellow	Right	Rich	.56 (.20)	.22 (.25)
356	Red, Blue	Left	Rich	.64 (.20)	.56 (.02)
353	Red, Blue	Right	Rich	.74 (.24)	.83 (.16)
501	Red, Blue	Left	Lean	.75 (.19)	.36 (.12)
352	Green, Yellow	Left	Lean	.57 (.18)	.83 (.05)
520	Green, Yellow	Right	Lean	.95 (.07)	1.0 (0)

^a The first color represents the rich-handling stimulus and the second is the color of the lean-handling stimulus for Component A for the initial condition.

^b Side on which the handling stimuli appeared for Component A in training.

^c Stimuli presented during testing.

^d For the Rich test, proportions represent the choice responses to the VI 15-s (VI 100 s) stimulus. For the Lean test, proportions represent the choice responses to the VI 30-s (VI 100 s) stimulus. Proportions were averaged over the first two sessions of testing for both the initial condition and the reversal. The number in parentheses represents the standard deviation.

beginning of a trial until reinforcement in Component A [$100 + 15(.5) + 30(.5) = 122.5$] and Component B [$20 + 15(.5) + 30(.5) = 42.5$]. Thus, the pigeons should always accept the lean alternative in both components.

The testing procedure was carried out in a similar manner as in Experiment 1. Four of the pigeons received concurrent probes with the stimuli that had been correlated with the two VI 15-s handling alternatives from training (rich handling test: VI 15 s [VI 100 s] vs. VI 15 s [VI 20 s]). The other 3 pigeons received concurrent probes with the stimuli previously correlated with the two VI 30-s handling alternatives (lean handling test).

Also similar to Experiment 1, following testing, pigeons completed another 10 pre-training sessions and then a reversal condition in which VI handling schedule values were switched between components.

RESULTS AND DISCUSSION

As required by DRT and optimality models, all pigeons accepted the lean alternative on over 90% of trials for both Components A and B by the 5th session of training and continued this level of acceptance throughout the remainder of training.

The purpose of the present experiment was to determine whether temporal context influences the conditioned reinforcement value of stimuli in the successive-encounters procedure. Results of the rich handling test are presented in the top of Figure 4 (see also

Table 2); as in Experiment 1, only the first two sessions of testing are reported. All pigeons more frequently chose the stimulus that normally followed the longer search schedule (VI 15 s [VI 100 s]), with a mean proportion of choice responses of .71 ($SE = .08$). During the reversal, 3 of 4 pigeons more often chose the VI 15-s (VI 100 s) stimulus, with an across-subjects mean of .55 ($SE = .13$). Results of the lean handling test are presented in the bottom of Figure 4 (see also Table 2). All 3 pigeons more often chose the VI 30-s (VI 100 s) stimulus, with an across-subjects mean of .76 ($SE = .11$). During the reversal, 2 of 3 pigeons allocated more choice responses to the new VI 30-s (VI 100 s) stimulus with an across-subjects mean of .73 ($SE = .19$). Summing over both tests and reversals the stimulus following the longer search was preferred in 12 of 14 cases ($p = .0056$, Binomial test). The results thus extend those of Experiment 1 to the successive-encounters procedure, suggesting that handling schedules following a longer search schedule have greater conditioned reinforcement value, consistent with DRT and contrary to the predictions made by CCM and SET.

EXPERIMENT 3

A question that remains is whether the critical temporal context is limited to the delay that precedes the stimuli to be tested or whether the temporal context is best represented by T , as predicted by DRT. The

Fig. 4. Testing results from Experiment 2. Data are averaged over the first two testing sessions. The top panel represents results from the rich-handling stimuli, and the bottom panel represents results from the lean-handling stimuli. Error bars for individual pigeons indicate the standard deviation; error bars for the between-subjects mean indicate the standard error.

previous experiments only manipulated the delay preceding the stimuli that were later tested. However, DRT makes the prediction that temporal context (T) is made up of the average delay until reinforcement from the beginning of the trial. Therefore, any schedules that affect the average delay until reinforcement, regardless of when they occur, should impact temporal context and hence value.

The present experiment investigated whether the conditioned reinforcement value of the

handling alternatives (VI 20 s) would be affected, not by differing search durations, but by having an alternate handling schedule that was of the same duration (another VI 20 s) or was of a longer duration (VI 40 s). The search duration for both components was VI 30-s schedules. According to DRT, the VI 20-s stimulus that had alternated with the VI 40-s schedule should have greater conditioned reinforcement value because it signals a larger reduction in delay until reinforcement.

METHOD

Subjects and Apparatus

The subjects were 4 White Carneau pigeons (*Columba livia*). All four were experienced in a variety of experimental procedures, but none had experience with the successive-encounters procedure. The same experimental chambers were used as in Experiment 1.

Procedure

The procedure was the same as that in Experiment 2 except for the schedule values used (see Table 3 for stimulus arrangements and key placements). The search schedules for both components were VI 30 s. For Component A pigeons accepted or rejected two VI 20-s handling schedules, each with a distinct schedule-correlated color. In Component B VI 2-s and VI 40-s handling schedules (and unique stimuli) were accepted or rejected. As before, these schedule values were selected so that pigeons should always accept the leanest handling alternative (VI 40 s) because it was less than the overall delay to reinforcement ($T = 50$ s for Component A, $T = 60$ s for Component B). Testing of the VI 20-s stimulus from component A (VI 20 s [VI 20 s]) and the VI 20-s stimulus from component B (VI 20 s [VI 40 s]) was carried out as in Experiment 2.

RESULTS AND DISCUSSION

All pigeons had over 90% acceptance of the lean alternative for both Components A and B by the 5th session of training and continued this level of acceptance throughout the remainder of training. As shown in Figure 5 (and Table 3), during testing the mean proportion of choice responses made on the handling stimulus from Component B (VI 20 s [VI 40 s]) was .91 (SE = .04). During the reversal 3 of 4 pigeons more often chose the new VI 20-s (VI 40 s) stimulus, with an across-subjects mean of .59 (SE = .17). Including reversals, seven of eight determinations favored the VI 20-s (VI 40 s) stimulus ($p = .0312$, Binomial test). Thus, the results support a prediction made by DRT, namely that temporal context is not limited to the duration that precedes the stimuli to be tested, but is also impacted by other schedules influencing T .

EXPERIMENT 4

Experiment 3 tested a stimulus associated with a rich schedule for one component against a stimulus that was associated with a neutral schedule for the other component. The present experiment assessed the general-

Table 3
Summary of Experiments 3, 4, and 5.

Pigeon	Color of A ^a	Side of A ^b	Experiment ^c	Choice proportion ^d	
				Initial	Reversal
473	Green, Yellow	Left	Rich	.96 (.06)	.75 (.05)
463	Green, Yellow	Right	Rich	.81 (.24)	.09 (.09)
480	Red, Blue	Left	Rich	.87 (.18)	.80 (.10)
457	Red, Blue	Right	Rich	.99 (.02)	.71 (.31)
453	Green, Yellow	Right	Lean	.33 (.46)	.01 (0)
458	Green, Yellow	Left	Lean	.43 (.39)	.66 (.05)
475	Red, Blue	Right	Lean	.87 (.18)	.06 (.03)
483	Red, Blue	Left	Lean	.34 (.09)	.09 (.10)
504	Red, Blue	Right	Rich vs. Lean	.26 (.22)	.58 (.18)
354	Red, Blue	Left	Rich vs. Lean	.41 (.07)	.01 (0)
515	Green, Yellow	Right	Rich vs. Lean	.49 (.17)	.05 (.06)
359	Green, Yellow	Left	Rich vs. Lean	.33 (.24)	.91 (.02)

^a The first color represents the rich-handling stimulus and the second is the color of the lean-handling stimulus for Component A for the initial condition.

^b Side on which the handling stimuli appeared for Component A in training.

^c Stimuli presented during testing.

^d For the Rich experiment, proportions represent the choice responses to the VI 20-s (VI 40 s) stimulus. For the Lean experiment, proportions represent the choice responses to the VI 30-s (VI 20 s) stimulus. For the Rich vs. Lean experiment, proportions represent the choice responses to the VI 30-s (VI 60 s) stimulus. Proportions were averaged over the first two sessions of testing for both the initial condition and the reversal. The number in parentheses represents the standard deviation.

Fig. 5. Testing results from Experiment 3. Data are averaged over the first two testing sessions. Error bars for individual pigeons indicate the standard deviation; error bars for the between-subjects mean indicate the standard error.

ity of this result by testing the conditioned-reinforcement value of stimuli associated with lean schedules that alternated with different richer schedules. In particular, this study investigated whether the conditioned reinforcement value of two lean handling alternatives (VI 30 s) would be affected by having a rich schedule that was VI 5 s or was VI 20 s. The search duration for both components was a VI 40-s schedule. According to DRT, the VI 30-s stimulus that alternated with the VI 20-s schedule should have greater conditioned reinforcement value because it signals a larger reduction in delay until reinforcement.

METHOD

Subjects and Apparatus

The subjects were 4 White Carneau pigeons (*Columba livia*). Three of the pigeons had completed the terminal-link test condition of Experiment 1, and the fourth was the pigeon that had begun Experiment 1 but failed to finish. None of the pigeons had experience with the successive-encounters procedure. The same experimental chambers were used as in Experiment 1.

Procedure

The same procedure was used as in Experiment 2 (see Table 3 for stimulus arrangements and key placements). The only difference was the schedule values used. The

search schedules for both components were VI 40 s. In Component A, pigeons accepted or rejected VI 5-s and VI 30-s handling schedules, whereas in Component B they accepted or rejected VI 20-s and VI 30-s handling schedules. As before, the handling schedules should always be accepted because their duration was less than the overall delay to reinforcer delivery ($T = 57.5$ for Component A, $T = 65$ for Component B). Testing of the VI 30-s stimulus from each component was carried out in the manner described in Experiment 2.

RESULTS AND DISCUSSION

All pigeons had over 90% acceptance of the lean alternative for both Components A and B by the 5th session of training and continued this level of acceptance throughout the remainder of training. The results of testing are presented in Figure 6 (see also Table 3). The across-subjects mean proportion of choices of the VI 30-s handling stimulus from Component B (VI 30 s [VI 20 s]) was .49 (SE = .13). During the reversal, the mean proportion of choices for this stimulus was .21 (SE = .15). The results were not significant according to a Binomial test ($p = .1094$), nor did a t -test reveal a significant preference for either stimulus, $t(7) = 1.414$, $p > .05$. The results are not consistent with DRT, and instead suggest that the values of the lean-handling stimuli are not affected in a similar manner as

Fig. 6. Testing results from Experiment 4. Data are averaged over the first two testing sessions. Error bars for individual pigeons indicate the standard deviation; error bars for the between-subjects mean indicate the standard error.

the rich-handling stimuli by the temporal context. The results also do not appear to support CCM or SET. Across pigeons, choice was highly variable and there was a frequent failure of pigeons to reverse their preference. Although the mean for the first attempt was close to indifference, which was predicted by CCM and SET, the results suggest a lack of experimental control and hence cannot be viewed as support for these theories.

Given these findings, *T* is apparently not the only important variable in predicting whether temporal context impacts the value of stimuli. What is not clear is why this occurred when testing the lean schedules. One possibility is that value transfer may have presented an opposing influence that cancelled out any influence from *T*. If value transfer were occurring between handling schedules, then the VI 30-s (VI 5 s) stimulus should have greater value because of its being paired with the better handling alternative (VI 5 s). Previous findings of value transfer only occurring on the worse schedule would explain why this was not found when testing the rich-handling alternatives in Experiment 3. However, prior investigations of a possible mechanism responsible for value transfer have suggested that value transfer likely occurs from the ability of the worse stimulus to signal the presence of the better stimulus (Dorrance & Zentall, 1999; Zentall, Sherburne, Roper, & Kraemer, 1996). This explanation would not apply in the present experiment since the VI 30-s (VI 5 s)

stimulus signaled not the presence of the VI 5 s, but rather its absence.

EXPERIMENT 5

The results of Experiments 3 and 4 suggest that the ability of temporal context to affect the value of conditioned reinforcers depends on whether the tested stimuli are rich or lean alternatives in their components. To further explore this issue the present experiment tested the rich stimulus from one component against the lean of the other. This is similar to the test that Belke (1992) performed with multiple concurrent schedules, but now the successive-encounters procedure was used. The conditioned reinforcement value of the handling alternatives (VI 30 s) was investigated to see if their value would be affected by having an alternate handling schedule that was VI 5 s (Component A) or was VI 60 s (Component B). The search schedules for both components were VI 40 s. According to DRT, the VI 30-s stimulus that alternated with the VI 60-s schedule should have greater conditioned reinforcement value because it signals a larger reduction in delay until reinforcement.

METHOD

Subjects and Apparatus

The subjects were 4 White Carneau pigeons (*Columba livia*). All four were experienced in

Fig. 7. Testing results from Experiment 5. Data are averaged over the first two testing sessions. Error bars for individual pigeons indicate the standard deviation; error bars for the between-subjects mean indicate the standard error.

a variety of experimental procedures, but none had experience with the successive-encounters procedure. The same experimental chambers were used as in Experiment 1.

Procedure

The same procedure was used as in Experiment 2 (see Table 3 for stimuli arrangements and key placements). The only difference was the schedule values used. The search schedules for both components were VI 40 s. For Component A the choice was between VI 5-s and VI 30-s handling durations, whereas for Component B the choice was between VI 30-s and VI 60-s handling durations. Pigeons should accept the lean alternative for both components ($T = 57.5$ for Component A, $T = 85$ for Component B). Testing of the VI 30-s stimulus from each component was carried out in a similar manner as in Experiment 2.

RESULTS AND DISCUSSION

All pigeons had over 90% acceptance of the lean alternative for both components by the 5th session of training and continued this level of acceptance throughout the remainder of training. As shown in Figure 7 (and Table 3) the across-subjects mean proportion of choice responses for the VI 30-s handling stimulus from Component B (VI 30 s [VI 60 s]) was .37 (SE = .05). Although not reflected in the between-subject mean (.39, SE = .22), choice proportions during the reversal did not accord

with those in the initial testing. According to a Binomial test, the choice proportions did not deviate significantly from chance ($p = .1094$) nor did a t -test reveal a significant preference toward either stimulus, $t(7) = 1.163$, $p > .05$. Therefore, just as when comparing two lean-handling stimuli, when a lean-handling stimulus is compared to a rich-handling stimulus, temporal context did not affect conditioned reinforcement value. This result is inconsistent with DRT; indeed, mean choice was in the direction opposite that predicted. However, given the lack of consistent findings in the reversal, the results do not appear to support CCM or SET. The results do not appear to be due to an inadequate difference between T in the components as the difference was greater in this experiment than in Experiment 3, which did find support for DRT.

GENERAL DISCUSSION

The present experiments explored the influence of temporal context across chain schedules and the successive-encounters procedure. None of the experiments found systematic evidence supporting the predictions made by CCM or SET, according to which temporal context, although influencing performance within that context, should not influence the value of stimuli. On the contrary, a robust effect of temporal context was found in Experiments 1, 2, and 3. However, based on the inconclusive results of Experiments 4 and

5 it appears that the effect of temporal context on value differed depending on the stimuli being tested.

With the multiple-chains schedule, DRT's prediction that stimuli signaling a larger reduction in delay until reinforcement will have greater conditioned reinforcement value was supported when testing the terminal-link stimuli. When testing the nonreinforced stimuli that had been presented concurrently with the terminal links, evidence of value transfer was found.

The results with the successive-encounters procedure offer a mixed picture of how temporal context influences value, depending on whether the search schedule or alternate handling schedule was being manipulated, as well as whether the tested stimuli were the rich or lean schedules in their components. When search schedules were manipulated in a similar manner as the initial links were manipulated in Experiment 1, the predictions of DRT were supported regardless of whether the rich or lean schedules were being tested. Similarly, when a rich-handling stimulus was presented with a handling stimulus that was neither rich nor lean, temporal context again influenced value in accordance with predictions made by DRT. However, contrary to DRT, temporal context did not influence value when two stimuli correlated with lean schedules in their respective training components were tested, nor when a stimulus associated with the rich schedule in its component was tested against a stimulus associated with the lean schedule in its component.

A possible explanation for not finding an influence from temporal context in those experiments where the handling alternatives were manipulated and the lean stimulus was tested, is that value transfer may be occurring from the rich to the lean stimulus, therefore canceling out the influence predicted by DRT. However, this is only possible in the successive-encounters procedure if value transfer is not limited to second-order conditioning. Second-order conditioning cannot be simply applied to the successive-encounters procedure since the handling stimuli never occur concurrently. However, Zentall et al. (1996) found evidence that within-event learning, and not second-order conditioning, may be responsible for value transfer. Within-event learning involves learning that stimuli are associated, and

therefore the value of one reflects on the value of another. It may be that the association of being in the same component is sufficient for within-event learning to occur and hence the occurrence of value transfer in the successive-encounters procedure.

Although we were concerned primarily with the ordinal predictions made by the models it is possible to develop quantitative estimates as well. Probe predictions for DRT were obtained by calculating the relative delay reduction for each stimulus to be tested (see Equation 1). The ratio of the relative delay-reduction values was then used to predict choice in the probes. As can be seen from Figure 8, DRT was a better predictor of choice than CCM or SET for Experiments 1 and 2. For Experiment 3, although DRT correctly predicted the direction of probe choice, preference was much more extreme than predicted. None of the models being tested accurately predicted the results of Experiments 4 and 5. However, interpretation of the data in terms of the quantitative predictions is complicated by the fact that in these experiments, pigeons' choice may have been influenced by the change to the testing context, in which pigeons were confronted with a novel arrangement of stimuli with equivalent schedules.

The results from the present study remain to be reconciled with those found by Grace and Savastano (1997, 2000) with multiple-concurrent chains. As discussed earlier, they found that pigeons responded to the stimuli according to the schedules of reinforcement associated with the stimuli from training, irrespective of temporal context in training. Thus, if schedule values were identical in training then pigeons were indifferent between the two stimuli in testing. The specific arrangements of the procedure may be a contributing factor in whether the influence of temporal context is observed. Grace and Savastano differentiated the initial and terminal links with the elimination of a superimposed white X or white cross, or the changing from continuous to blinking illumination. In either case the color of the keylight remained the same for the initial and terminal link. The difficulty that this raises is in determining what was learned in training. Did the pigeons learn the conditioned reinforcement value with the stimulus associated with the terminal link, the change from the initial link to the terminal link (i.e.,

Fig. 8. Comparison of the overall accuracy of quantitative predictions derived from DRT, CCM, and SET for probe test trials. Probe preference is given in terms of preference for the stimulus associated with the larger value for T in training. For Experiment 1, the stimulus that was reinforced in training is presented as S+, and the stimulus that was on extinction is presented as S-.

the termination of the superimposed stimulus, or the blinking illumination), or perhaps both? This arrangement may have interfered with transfer and therefore may have masked any influence of temporal context. Further, the concurrent presentation of the initial links may complicate a test of value due to influences consistent with both DRT and value transfer.

The present set of experiments tested the value of stimuli by presenting them as concurrent probes. Therefore, this test was a measure of the relative ability of the stimuli to evoke responding, and not a direct test of their conditioned reinforcement value. In order to test conditioned reinforcement value directly, the stimuli could have been presented as the reinforcer for completing a concurrent schedule with novel choice stimuli. This was not done in the present study for several reasons. First, when O'Daly *et al.* (2005) compared both direct and indirect testing methods of conditioned reinforcement value, the results were the same, suggesting that the ability of stimuli to evoke responding reflected the conditioned reinforcement value of the stimuli.

A second reason for using a test of the evocative strength is that a more direct test of conditioned reinforcement value may be an overly conservative test, as it relies on the

pigeon learning which of the choice stimuli results in a particular test stimulus. This is problematic when measuring the effect of temporal context, given that the pigeon is actively learning the appropriate responses in a new procedure with a new contingency, during the time that the effects of temporal context from training are being measured. By the time the pigeon has acquired responding appropriate to the testing contingency, the effect of the temporal context from training may have diminished. Although the same may be said of the testing procedures used in the present studies, the relatively simple task may reduce this effect. This was evident in O'Daly *et al.* (2005), in which results of more direct measures of conditioned reinforcement value were more variable and less durable than the evoking power of the stimuli.

In summary, these studies address the question: Does the value of a stimulus as a conditioned reinforcer depend on the temporal context of reinforcement in which the stimulus is embedded? The results suggest that for most of the situations studied here, temporal context does affect conditioned reinforcement value. In some situations, stimuli correlated with a greater reduction in delay to reinforcement are stronger conditioned reinforcers and at least some of this strength transfers to changing contexts, consistent with

DRT. Further, stimuli that are presented concurrently with better alternatives also have greater value, consistent with value transfer. The failure to find an influence of temporal context in two experiments may be attributed to insensitive testing procedures, to the rapid degradation of preference under probe procedures, or to the opposing influences of delay reduction and value transfer. In any event, these results, together with those of O'Daly et al. (2005), suggest that there are conditions under which temporal context affects value.

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