RESPONSE-DEPENDENT PRECHOICE EFFECTS ON FORAGING-RELATED CHOICE

WENDY A. WILLIAMS AND EDMUND FANTINO

UNIVERSITY OF CALIFORNIA, SAN DIEGO

Three experiments explored the influence of prechoice events on pigeons' preference. In two of three studies, a fixed-interval 200-second prechoice period preceded the initial links of a concurrent chain in which outcomes differed either (a) in terms of the delay to food or (b) in terms of amount of food and delay to food. In Experiment 3, the prechoice period preceded the initial links that provided a choice between a small single food presentation and two identical, more delayed food presentations. In all three cases, obtained choice proportions did not vary as a function of prechoice duration. These results suggest that a local-contextual view adequately describes the foraging context; they also have implications for the appropriate formulation of the delay-reduction theory of conditioned reinforcement and rate-maximizing views of optimal foraging theory.

Key words: delay-reduction theory, rate maximization, optimal foraging theory, contextual choice, concurrent chains, key peck, pigeons

The delay-reduction theory (DRT) states that the ability of a stimulus to serve as a conditioned reinforcer can be determined by comparing the reduction in the delay to primary reinforcement signaled by that stimulus relative to the average overall delay to reinforcement as measured from the onset of the preceding stimulus (Fantino, 1969, 1977; Squires & Fantino, 1971). Originally, DRT was formulated to account for choice in the concurrent-chains procedure (Autor, 1960; Herrnstein, 1964), described in Figure 1. In this procedure, the dependent variable (preference) is defined as the distribution of choice responses to the concurrently available white (initial-link) keylights. The original equation (Fantino, 1969) described initial-link choice within the concurrent-chains paradigm:

$$\frac{R_{1L}}{R_{1L} + R_{1R}} = \frac{T - t_{2L}}{(T - t_{2L}) + (T - t_{2R})}, \quad (1)$$

where R_{1L} and R_{1R} represent responses on

each of the two initial links, and where t_{2L} and t_{2R} stand for the schedule values (i.e., average time to reinforcement) associated with the left and right terminal links, respectively. T represents the average overall time to primary reinforcement from the onset of the initial-link stimuli. Put simply, T consists of the average time spent in the initial links on any given trial plus the average amount of time spent in either of the two (mutually exclusive) terminal links. Therefore, $T = 0.50(t_L) + \Sigma[0.50(t_i)]$, where t_L represents the schedule value correlated with equal initial links and t_i represents the schedule values correlated with each of the two terminal links. Note that the calculations for the average time spent in the initial links is different from that for the terminal links because only the initial-link schedules are available concurrently. For example, if the initial links were both 60 s, then the average time spent in the initial links on any given trial would be 30 s. Terminal links do not run concurrently, so the average time spent would be the sum of the terminal-link schedules divided by two. T is equal to the sum of these two values.

Equation 1 requires exclusive preference for the left initial-link alternative when $T < t_{2R}$; the same is true for the right initial-link alternative when $T < t_{2L}$. Squires and Fantino (1971) expanded the basic DRT formulation into a more general model of choice by including a parameter for the rate of primary reinforcement ($1/\tau$):

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Reprints may be obtained from W. A. Williams, who is now affiliated with the Department of Psychology, Central Washington University, Ellensburg, Washington 98926-7575.

Fig. 1. Traditional concurrent-chains procedure. Panel A shows the sequence of events leading to reinforcement on the left key; Panel B shows the analogous sequence for the right key. Two concurrently available initial links consist of equal VI schedules presented on identical white side keys. Following completion of the VI requirement on one alternative, the other key becomes dark and inoperative. Terminal links consist of mutually exclusive VI schedules. Subjects must complete the terminal-link VI and earn the reinforcer before the initial links are reinstated.

$$\frac{R_{IL}}{R_{IL} + R_{IR}} = \frac{(1/r_L)(T - t_{2L})}{(1/r_L)(T - t_{2L}) + (1/r_R)(T - t_{2R})} \quad (2)$$

An example from Iwata and Michael (1994) illustrates the rationale of DRT. With terminal-link durations of 10 s (yellow) and 20 s (green), one might assume that the yellow key would be preferred 2 to 1 (i.e., matching). Using the DRT model, however, it becomes clear that relative preference depends on the duration associated with the initial links (white keys). When the initial-link delays are very long, the white keylights are much less favorable with respect to food if compared with the shorter duration terminal-link keylights. The difference in the time to food between getting the yellow or the green

key is small relative to the difference associated with remaining in versus moving out of the white initial links and into either terminal link. With initial-link delays of 970 s, one would expect an average of one terminal-link entry every 485 s and an average terminal-link delay of 15 s. Thus T (the average overall delay to food) would equal 500 s. Therefore, the delay-reduction value associated with the yellow stimulus would be $(500 - 10)/500$ or .98. Similarly, the delay-reduction value associated with the green stimulus would be $(500 - 20)/500$ or .96. A subject choosing between these two terminal-link alternatives would, therefore, be relatively indifferent. On the other hand, when the initial-link delays are short (e.g., 50 s), white is not nearly as unfavorable with respect to the time to food, and the change from white to either yellow or green represents only a slight improve-

ment (continuing the Iwata & Michael example: $T = 40$ s, and the resulting values for yellow and green are .75 and .50, respectively). Now, the difference between the same two terminal-link stimuli (10 s vs. 20 s) appears greater, making yellow a more highly preferred alternative.

DRT and the Foraging Context

The ability of DRT to predict foraging-related choice was compared with the classical optimal diet model (Charnov, 1976) and other rate-maximizing versions of optimal foraging theory (OFT) by Fantino and Abarca (1985) and others (Fantino & Preston, 1988; Ito & Fantino, 1986). Fantino and Abarca demonstrated that DRT and Charnov's (1976) optimal diet model are mathematically equivalent and functionally complementary. However, DRT and rate maximization can be differentiated, as Williams and Fantino (1994) have shown. In their study, environmental cues that signaled large reductions in the delay to food affected ordinal preferences in ways that were better predicted by DRT than by OFT. Their data suggested that sensitivity to conditioned reinforcers may be one mechanism that foragers use to optimize reinforcement under more general circumstances.

Traditionally, the foraging context (or cycle) is defined as the time it takes to find, handle, and consume a prey item (Emlen, 1966; MacArthur & Pianka, 1966). However, foraging bouts may be interspersed with other kinds of behavior, such as travel to an appropriate search location. Because these prechoice periods may also alter the interreinforcement interval (IRI), they could exert some effect on subsequent choice. The primary purpose of the present work was to investigate whether adopting a larger, global-contextual view that incorporates prechoice events into the conditioning and foraging contexts would improve the predictive accuracy of both DRT and rate-maximization models.

If subjects' choice behavior is sensitive to changes in prechoice periods, DRT would require modification to accommodate this sensitivity. As such, Equation 2 would require the incorporation of prechoice delays in both the rate parameter ($1/r$) and in the calculation of the average overall delay to reinforcement,

such that T would represent the average, overall delay to primary reinforcement within the larger conditioning context:

$$T = P + 0.50t_i + \Sigma(0.50t_i), \quad (2a)$$

where P is the delay associated with the prechoice period. The overall delay to reinforcement (T) in Equation 2a differs from the overall delay to reinforcement (T) in Equation 2 only in the inclusion of the prechoice period. It is important to note that Equation 2a does not represent a change in the logic of the DRT model. Traditionally, T (Equation 2) has been interpreted as including only the terminal-link stimuli and those stimulus events which immediately precede them. For our purposes here, Equation 2a merely provides an alternative interpretation of T that includes the prechoice period.

OFT and the Foraging Context

Behavioral ecologists have adopted a relatively molar perspective regarding the relevant window of time for diet selection and foraging-related choice. Although there is some controversy within the optimal foraging literature about the appropriate interval to be used when referring to the time spent foraging (for a review, see Stephens & Krebs, 1986), the generally accepted view is one of long-term maximization. Traditionally, the tendency to choose one prey item over another is viewed as a function of total energy gained relative to the total time spent foraging for the various options. Typically, the profitability ratio associated with each prey item is calculated as follows:

$$\text{profitability of prey item (i)} = E(G)_i / E(T)_i, \quad (3)$$

where $E(G)_i$ is the estimated energy gained from a particular prey item and $E(T)_i$ is the estimated time associated with the search for and the handling of that item. (It is important to note that overall average time to food, T , in the DRT model is not equivalent to the time spent foraging, $E(T)$ in the OFT model.) This relatively local-contextual version of OFT predicts exclusive preference (1.0) for the prey item correlated with the greater profitability ratio. For example, if $E(G)_1 / E(T)_1 > E(G)_2 / E(T)_2$, the traditional rate-maximizing view of OFT would predict that Item 1 would be reliably selected over Item 2.

These predictions are not based on considering the possible relevance of prechoice events to foraging-related choice, but it is possible to do so by incorporating the time associated with prechoice events into the foraging cycle and hence into the profitability ratio. Consistent with the modifications of T in DRT (Equation 2a), the formal description of the profitability ratio would not necessarily require modification; however, the definition of the time parameter (T) associated with each prey item would change as follows:

$$E(T) = \text{prechoice time} + \text{search time} + \text{handling time.} \quad (3a)$$

Experimental Evidence

Although the role of prechoice events in either DRT or OFT has yet to be addressed, investigations within the classical conditioning literature have focused on a similar question regarding intertrial interval (ITI) effects on performance in conditioning experiments. Perhaps the most thorough investigations of ITI effects on performance have focused on the respondent conditioning paradigm of autoshaping (Gibbon, Baldock, Locurto, Gold, & Terrace, 1977; Gibbon & Balsam, 1981; Reilly & Schactman, 1987). During an autoshaping trial, food is immediately preceded by the presentation of a stimulus (usually an illuminated key) for some fixed duration. The temporal context is manipulated by increasing or decreasing the ITI, the period between the trials during which the stimulus is not presented. Acquisition of the autoshaped key-pecking response is usually facilitated with longer ITI periods (for a review, see Cooper, 1991). This relatively molar account of respondent conditioning is expressed in several formalized models, such as scalar expectancy theory (Gibbon & Balsam, 1981) and other comparator models (Miller & Schactman, 1985; Reilly & Schactman, 1987).

Similarly, ITI effects have been well documented within the animal memory literature (Roberts & Kraemer, 1982; White, 1985). During a standard delayed matching-to-sample procedure, a subject is presented with a sample stimulus. Following a brief retention interval, the subject is then presented with two comparison stimuli, one that matches the previous sample and one that does not. A re-

sponse to the matching stimulus produces food; responses to the nonmatching stimulus do not. Typically, each consecutive trial is separated by an ITI, and improvements in matching accuracy are correlated with increases in ITI duration. Here too, the efficacy of training is altered as a function of the larger temporal context within which the conditioning trial occurs.

Analogous results have been obtained with operant choice procedures. For example, Rachlin, Logue, Gibbon, and Frankel (1986) found greater preference for probabilistic reinforcers when an ITI was included. Using an adjusting-delay procedure, Mazur, Snyderman, and Coe (1985) found that subjects demonstrated less preference for one of two alternatives when that alternative was differentially associated with an ITI. In a brief review of the autoshaping literature relevant to DRT, Preston and Fantino (1991) showed a mathematically equivalent relationship between DRT and the ratio effect in autoshaping. They suggested that stimulus conditioning appears to be dependent on the overall conditioning context, indicating a potential role for the ITI in the DRT. Few studies have been conducted, however, on the role of ITI on choice. The majority of DRT investigations have been limited to cases in which reinforcement is followed by immediate reentry into the initial links.¹ Although the evidence regarding ITI effects on choice appears to be less than conclusive, it does seem that increasing the salience of the ITI may contribute to its efficacy in influencing choice (Mazur, 1991).

None of the aforementioned studies manipulated response requirements during the periods between trials. The results from a number of foraging studies show that as the effort involved in switching from one patch to another increases (i.e., as the changeover requirement increases), preference shifts to-

¹ Recently, Goldshmidt and Lattal directly manipulated the delays and stimulus configurations during the ITI in a standard concurrent-chains procedure. Their preliminary data suggested no systematic effect of ITI duration on initial-link choice proportions. Goldshmidt, J., & Lattal, M. (1994, May). Contextual effect on choice behavior. In E. Fantino (Chair), *Experimental analysis of decision making in humans and pigeons*. Symposium conducted at the annual meeting of the Association for Behavior Analysis, Atlanta, GA.

ward indifference (Fantino & Abarca, 1985). This finding is consistent with the effects of increasing search (initial-link) duration (Abarca & Fantino, 1982; Collier & Rovee-Collier, 1981; Lea, 1979). Others (Baum, 1982; Dunn, 1982) have found increased selectivity as a function of increased travel requirements between patches. It should be noted, however, that these latter studies were limited to simple concurrent schedules, and they were not designed to simulate searching, traveling, and handling states independently. The present experiments investigated the effect of response-dependent prechoice events on the development of search-related choice in an attempt to identify empirically the appropriate temporal framework for both the conditioning and foraging contexts.

EXPERIMENT 1

According to DRT, the degree to which a stimulus can serve as a conditioned reinforcer can be determined by comparing the reduction in waiting time to food correlated with that stimulus relative to the overall delay to primary reinforcement from the onset of the preceding stimulus. The statement "relative to the onset of the preceding stimulus" is an important one. Increases in initial-link duration typically produce less extreme preference, perhaps due to the increase in the interreinforcement interval (IRI). However, the IRI can also be increased by including an ITI. An ITI may be analogous to the time and events that intervene between food and the subsequent search in a naturalistic foraging situation. Experiment 1 was designed to test whether the original DRT model (Equation 2) or a more global-contextual version of DRT with modifications implied by Equation 2a would provide the better quantitative prediction of choice in a concurrent-chains procedure involving equal reinforcer magnitudes and a response-dependent prechoice period.

Rate-maximizing models imply that the size of the two prey items must differ in order for temporal increases to be accompanied by a change in ordinal preference. When prey items are equivalent, ordinal preference will not shift as a function of search-related delays. A graphical representation of this implication is displayed in Figure 2. For any given delay prior to the handling phase, a line can be pro-

jected to both prey items. Ordinal preference is predicted for the item producing the steeper slope. As can be seen in the figure, the slope associated with the food that is delayed by 30 s in the handling phase will always be steeper, regardless of the delay prior to the handling phase. Therefore, it always pays to select the more immediate prey item, whether the delays prior to the handling phase are relatively short (Panel A) or relatively long (Panel B). As such, rate maximization does not distinguish between the prechoice-present and prechoice-absent conditions in Experiment 1 in terms of ordinal preference.

Unlike rate-maximizing versions of the OFT, DRT was originally formulated for use with equal reinforcer magnitudes. Therefore, a series of independent experiments was required. In Experiment 1, we attempted to determine the appropriate form of DRT. In Experiments 2 and 3, we addressed the issue of empirically defining the foraging context.

Method

Subjects. Four female White Carneau pigeons (*Columba livia*) were matched for experimental histories. The birds were experienced with two-alternative choice procedures, including simple schedules and standard concurrent-chains schedules. None of the birds had experience with aversive stimuli or with extinction. (Subjects in all three experiments had the same experimental histories.) No preliminary training was required. Subjects were housed individually in a large colony room and were maintained at 80% of their free-feeding weights. Following experimental sessions, subjects were weighed and fed accordingly. Vitamin-enriched water and oyster-shell grit were available continuously in the home cages.

Apparatus. Subjects were randomly assigned to one of four standard operant conditioning chambers (32 cm high, 35 cm wide, and 36 cm deep). Chambers were housed in wooden enclosures with ventilation fans to regulate temperature and provide background masking noise. Three response keys (2.5 cm diameter) were located 23 cm above a mesh floor and 7.25 cm apart, center to center. Each key could be transilluminated from behind with a variety of shapes, colors, and line orientations by IEE 12-stimulus in-line projectors. A force of approximately 0.15 N was re-

PANEL A

PANEL B

Fig. 2. A graphical representation of the predictions made by a rate-maximizing version of optimal foraging theory for Experiment 1. The two axes are the classic OFT axes: reinforcer duration (RFT) on the y axis and time on the x axis. The black circle represents the more immediate prey item correlated with the 30-s delay; the open circle represents the more delayed item correlated with the 60-s delay. In Panel A, a locally defined context (beginning with the search phase only) produces a prediction of preference for the more immediate outcome represented by the filled circle. In Panel B, a more globally defined context (beginning with the prechoice phase) does not alter that original prediction. As such, rate maximization does not distinguish between the prechoice-present and prechoice-absent conditions in Experiment 1 in terms of ordinal preference.

Fig. 3. Procedural schematic for Experiment 1. Panel A shows the sequence of events leading to reinforcement on the left key; Panel B shows the analogous sequence for the right key. In the prechoice-present condition, an FI 200-s schedule preceded two equal concurrent VI 60-s schedules in the initial links (search phase). In the prechoice-absent condition, the prechoice period was eliminated.

quired to operate the response keys, and each response produced an audible feedback click. A white houselight (1 W) was located 5 cm above the center key and was illuminated except during reinforcer presentations. Reinforcement was delivered via a solenoid-operated food hopper and consisted of a predetermined period of time during which the subject had direct access to milo grain. The food hopper opening (5 cm high and 6 cm wide) was located 9.5 cm below the center key and provided its own illumination (1 W) during operation. Scheduling of experimental

events and data collection were maintained by an IBM®-compatible personal computer.

Procedure. All subjects' responses were reinforced according to the modified concurrent-schedule procedure diagrammed in Figure 3. The critical manipulation across conditions consisted of either the presence or absence of a prechoice period. During the prechoice-present (P-P) condition, the center key was illuminated red. The first response following a fixed-interval (FI) 200-s schedule produced the search-choice phase. During the search-choice phase, two white side key-

lights (initial links) were presented simultaneously on equal, but independent, concurrently available variable-interval (VI) 60-s schedules of reinforcement. During the prechoice-absent (P-A) condition, nothing preceded the onset of the search phase; subjects moved directly from reinforcement to the subsequent search. A 2-s changeover delay was imposed between the concurrent VI schedules to discourage rapid alternations.

Fulfillment of either VI requirement resulted in the presentation of the terminal-link stimulus (handling phase) on the same key. Terminal-link key colors (yellow and green) were consistently correlated with one particular initial link and side key and were counterbalanced across subjects. Terminal-link responses were reinforced according to the VI schedule correlated with each handling phase, either a single VI 30-s schedule or a VI 60-s schedule, each followed by 6 s of access to grain. Upon entry into one terminal link, the other key became dark and inoperative. In both the P-P and P-A conditions, a subject was required to complete the terminal link that it had entered and earn the reinforcer before the next component (either prechoice or initial links) was presented. Upon entry into each subsequent search phase, the recently completed VI was reset with a new value and the other VI continued from its previous position.

Order of presentation for the P-P and P-A conditions was counterbalanced across subjects. To ensure sampling of both alternatives, a forced-choice procedure was implemented during the first 4 days of the first condition presented, with equal presentations of both outcomes across each of the four sessions. Following the fourth session of forced choice, the free-operant choice procedure was introduced for the remainder of the condition. Free-operant sessions allowed preference to vary from 0 to 1.0 for either alternative. Data from forced-choice sessions were not included in the final analyses. Each session lasted for a maximum of 120 min or until the subject had earned 25 reinforcers. Conditions continued for a minimum of 15 sessions, and until one of the two following stability criterion had been satisfied. Following the 15th session and daily thereafter, the choice proportions based on the initial-link responses during the last nine sessions were divided

into blocks of three consecutive sessions. Preference was considered stable when the mean choice proportions in each of the three blocks differed by no more than .05 and exhibited no directional trend (neither $M_1 > M_2 > M_3$ nor $M_1 < M_2 < M_3$). Alternatively, preference was also considered stable if the daily choice proportion remained above .90 for three consecutive days following session 15. This upper limit was instituted to prevent the development of exclusive preference, which could have led to difficulty during reversal training. Each subject received an average choice-proportion score based on the relative distribution of initial-link (search) responses (left responses divided by the sum of left responses and right responses). The obtained choice-proportion scores represented preference for the short-chain alternative across the final nine sessions.

Following stable performance in both the P-P and P-A conditions, the VI values in the terminal links were reversed to assess side or color bias and to confirm stimulus control. Once two replications of the P-P and P-A conditions were completed, a control condition was instituted. In the control condition, the prechoice period was eliminated and the initial-link durations were increased to concurrent VI 460-s schedules. These VI values were selected because they maintained the same average delay prior to the terminal link (i.e., handling phase) as had occurred in the P-P condition.

Predictions. The predictions for Equations 2 and 2a for each of the conditions are shown in Appendix A. The traditional version of DRT (Equation 2) predicted a choice proportion of .80, favoring the shorter chain alternative, irrespective of prechoice duration. Although a more global-contextual version of DRT (with T defined by Equation 2a) predicted the same .80 preference in the absence of a prechoice period (P-A), it also predicted that preference for the short chain would decline to .56 when a prechoice period was presented (P-P condition). Moreover, both the global- and local-contextual views of DRT predicted a choice proportion of .55 in the control condition.

Results and Discussion

Table 1 presents the obtained choice proportions for each of the 4 subjects. Obtained

Table 1

Obtained choice proportions (favoring the initial link leading to the short terminal link) for each of the 4 subjects across prechoice-absent (P-A), prechoice-present (P-P), and control conditions for Experiment 1. Each score represents the average obtained choice proportion derived from the last nine sessions for each experimental condition. The numbers of sessions to criterion per condition are included in parentheses.

Subject	Prechoice condition		Replication prechoice condition		Mean obtained choice proportions		Control (initial link: VI 460 s)
	P-A	P-P	P-A	P-P	P-A	P-P	
R7	.82 (15)	.78 (20)	.66 (20)	.69 (15)	.74	.74	.55 (21)
R33	.83 (17)	.86 (15)	.58 (16)	.67 (17)	.71	.77	.55 (17)
R41	.95 (19)	.82 (15)	.77 (16)	.79 (24)	.86	.81	.58 (17)
R57	.98 (17)	.95 (15)	.94 (16)	.61* (26)	.96	.78	.59 (16)

* Obtained choice proportion of .61 was derived from two independent replications (.51 and .71). Sessions to criterion for this condition were 36 and 16, respectively.

choice proportions for individual subjects were slightly lower in the reversal condition, suggesting order effects across the initial experimental conditions and reversal. Mean choice proportions were calculated across replications and are presented in Figure 4. The first pair of P-A and P-P conditions produced overall average choice proportions of .89 and .85, respectively. The P-A and P-P replications produced somewhat lower mean

choice proportions of .74 and .69, suggesting the development of a side or color bias. (The average decline in preference as a function of prechoice duration in the averaged data was not representative of directional changes for individual subjects.)

A within-subject repeated measures analysis of variance (ANOVA) showed that choice proportions in the presence of a prechoice period did not differ from those obtained in

Fig. 4. Mean obtained choice proportions and standard error bars for each of the 4 subjects in Experiment 1. Data are plotted in terms of preference for the shorter chain alternative (VI 60-s initial link leading to VI 30-s terminal link). Data are averaged across reversals for each subject.

the absence of a prechoice period for either the initial conditions or for the reversals. However, the initial conditions produced significantly higher choice proportions than did the reversals when no prechoice period was included, $F(1, 3) = 11.4$, $p < .05$. Because this difference indicated nothing more than the development of a color or side bias, it was deemed acceptable to average across reversals. Although the mean choice proportions for the P-P and P-A conditions did not differ from each other, they did differ statistically from the control condition, $F(2, 3) = 10.52$, $p < .05$.

As can be seen in Figure 4, there was no systematic decline in preference during the search-choice phase as a function of prechoice duration, consistent with the predictions of the traditional DRT. Furthermore, when collapsed across subjects, the overall mean choice proportions for the P-A and P-P conditions were .82 and .77, respectively, notably close to the .80 predicted by the traditional DRT formulation. Similarly, the overall average obtained choice proportion for the control condition was .57, only .02 higher than the .55 predicted by both versions of DRT. This decline in preference in the control condition suggests that the failure to find a prechoice effect was not simply due to limits in the subjects' temporal sensitivity.

Because there was no apparent effect of prechoice duration on the dependent measure of choice, response rates during the prechoice period (and during the search-choice phase) were calculated. The pattern of responding typically associated with FI schedules is characterized by a low overall response rate and an absence of responding early in the interval. The overall average response rate during the prechoice period was 15 responses per minute, ranging from 7 to 29 responses per minute across replications for the 4 subjects. Although within-trial response allocation was not explicitly measured, direct observation of subjects' patterns of responding suggested the typical FI scallop. Furthermore, although the obtained choice proportions did not vary as a function of prechoice duration, response rates during the search-choice phase (initial links) did demonstrate sensitivity to the presence of the prechoice period. In general, the introduction of the 200-s prechoice period resulted in an average

increase of .38 in initial-link responding on the alternative leading to the shorter terminal link and an average increase of .46 on the alternative leading to the longer terminal link. Put simply, although the rate with which the subjects responded increased considerably, the relative distribution of choice-related responses did not change. These results are not surprising, however, because the delay-reduction value associated with the initial links increases with the introduction of the prechoice period.

Unusually extreme choice proportions for the P-P condition were limited to Subject R57 only. The initial P-P condition for this subject produced a choice proportion of .95 favoring the shorter chain, comparable to the .98 preference in the subsequent P-A condition. However, upon reversing the terminal-link contingencies, the subject failed to demonstrate the same high degree of preference for the shorter outcome. The choice proportion of .51 suggested that the subject may have developed a strong side or color bias in the previous condition. Upon the elimination of the 200-s prechoice delay, the subject's preference continued to climb until it became stable at .94. For this reason, R57 completed a second replication of the P-P condition following the completion of both the P-P and P-A reversals. The reintroduction of the 200-s prechoice delay produced a choice proportion of .71, much closer to the predicted choice proportion (.80). Therefore, we concluded that the obtained choice proportion (.51) for R57 in the original reversal was the result of ending the condition prematurely rather than due to changes in prechoice duration. We averaged the choice proportions from the two reversal conditions (.61) to represent the obtained choice proportion for the P-P reversal condition in all statistical analyses.

Delay-reduction theory's quantitative predictions were most accurate when a parameter for the prechoice period was not included in the model. Subjects' preference for the shorter chain alternative did not vary as a function of prechoice duration, nor did they vary systematically from the prediction of .80. Only in the control condition did choice proportions reliably decrease as predicted by Equation 2. Therefore, the data from Experiment 1 suggest that the effectiveness of a

stimulus as a conditioned reinforcer is best described relative to the preceding stimulus only, and not relative to the average time spent in the conditioning context as measured by the interreinforcement interval.

EXPERIMENT 2

Whereas Experiment 1 allowed a quantitative analysis of the traditional formulation of the DRT model, the global- or local-contextual versions of rate maximization did not provide distinct predictions for conditions in which a prechoice period is present or absent. In short, the optimal response (in global- or local-contextual terms) would be to sample both alternatives, independent of prechoice duration. Only when absolute prey sizes or magnitudes differ between the two alternatives do equal increases in delay have a differential effect on profitability ratios. By increasing the reinforcer magnitude on the longer alternative, it becomes possible to determine whether a global- or local-contextual view of the foraging cycle is the more appropriate because each produces ordinally distinct predictions. This relation can be expressed graphically, as in Figure 5. Again, a line can be projected to both prey items from different delay points prior to the handling phase (either including prechoice or not); and at each point, ordinal preference is predicted for the item with the steeper slope. Unlike the situation in Experiment 1, the unequal reinforcer magnitudes in Experiment 2 produce profitability ratios that shift as a function of the delay prior to the handling phase. Panel A illustrates the prediction for intermediate delays prior to handling. Within this range of delays, the lines that intersect the two items have nearly the same slope, which implies indifference (or else an undefined response-sampling pattern) between the two alternatives. Actually, there might be strict indifference because of the unequal immediacies; other things being equal, the more immediate reinforcer might be preferred over the less immediate one. The lines drawn in Panel B illustrate the effect of increasing the prehandling delay by introducing a prechoice phase. These predictions are based on the assumption that prechoice time should be included in the determination of foraging time (i.e., based on the assumption

of the global-contextual view as represented by Equation 3a). In this case, the line intersecting the larger, more delayed reinforcer is more steeply sloped than is the line intersecting the smaller, more immediate reinforcer. This difference in slope implies that choice should favor the alternative correlated with the larger, more delayed reinforcer. Thus, if prechoice time should be included in calculating foraging time (global-contextual model), then adding or removing the ITI should cause preference to change in a way implied by shifting from Panel A to Panel B. If, however, foraging time should include only search and handling time (local-contextual model), then adding or removing the ITI should not affect preference. The question of interest is whether the foraging cycle is best described by the parameters defined in Panel A (searching and handling delays only) or Panel B (searching and handling delays plus the time associated with any prechoice event).

Although the optimal diet model and DRT have been shown to be complementary under certain circumstances, the basic principles underlying them are not identical. Optimality theories lack a parameter for conditioned reinforcement, and DRT lacks a parameter for unequal reinforcer magnitude (Fantino, 1969; Moore, 1979, 1982; Squires & Fantino, 1971), making it difficult for DRT to address situations involving unequal reinforcer amounts. Navarick and Fantino (1976) proposed a computational method for transforming reinforcer magnitude into a rate parameter in order to equate reinforcer magnitudes across choice alternatives. Once transformed and equalized across the two chains, DRT becomes capable of predicting choice proportions under conditions of unequal reinforcer magnitude. Although the Navarick and Fantino transformation, by their own admission, is inappropriate for deriving accurate quantitative predictions, the method is a useful computational tool for making adequate qualitative predictions. (This limitation of the model under conditions of unequal reinforcer magnitude has been previously noted to be problematic, and continued investigations into a parameter for reinforcer magnitude might enhance the quantitative generality of DRT.) However, because most rate-maximizing versions of OFT

Fig. 5. A graphical representation of the predictions made by a rate-maximizing version of optimal foraging theory for Experiment 2. The black circle represents the smaller, more immediate prey item (6-s food) correlated with the 30-s delay; the open circle represents the larger, more delayed item (12-s food) correlated with the 120-s delay. In Panel A, a locally defined context (beginning with the search phase only) produces a prediction of relative indifference, perhaps influenced by the relative immediacy of the smaller, more immediate item. In Panel B, a more globally defined context (beginning with the prechoice phase) produces a clear predicted preference for the larger, more delayed outcome.

are limited to ordinal predictions, the use of the Navarick and Fantino transformation was deemed sufficient for the present investigations. For the schedule values used in Experiment 2, all four equations predict preference for the smaller, more immediate alternative (VI 30 s) in the absence of a prechoice delay. Upon presentation of the 200-s prechoice period, the predictions based on the global and local views of both rate maximization and DRT diverge. The local-contextual models (Equations 2 and 3) predict no ordinal effect of prechoice duration on choice, whereas the more global-contextual views (including the terms defined in Equations 2a and 3a) predict a reversal of preference toward the larger, more delayed alternative (VI 120 s).

Method

Subjects. Four female (3 White Carneau and 1 Indian Mondian) pigeons (*Columba livia*) were matched for experimental histories with standard concurrent-chains schedules. No preliminary training was required. Subjects were housed and maintained as in Experiment 1.

Apparatus. Subjects were randomly assigned to one of two types of operant conditioning chambers. Two chambers were standard rectangular chambers, identical to those used in Experiment 1 (32 cm high, 35 cm wide, and 36 cm deep). The other two chambers were opaque black PVC cylinders (36 cm high and 33 cm in diameter) with a black plastic ceiling. Three response keys (2.5 cm diameter) were located 24 cm above the mesh floor and 7.25 cm apart along the circumference of the interior wall. The white houselight (1 W) was located 8.75 cm above each key. The food hopper opening (5.75 cm by 5 cm) was located below the center key, 9.5 cm above the floor. All other features of the apparatus were identical to those in Experiment 1. Scheduling of experimental events and data collection for both sets of chambers were maintained by an IBM®-compatible personal computer.

Procedure. Subjects' responses were reinforced according to the modified concurrent-schedule procedure diagrammed in Figure 6. As in Experiment 1, the critical manipulation across conditions consisted of either the presence or absence of an FI 200-s prechoice period. Both the prechoice and initial-link

(search-phase) keylights and schedule values were identical to those in Experiment 1; the keylight colors and configurations in the terminal links also matched those in Experiment 1. However, terminal-link schedule values differed. Terminal-link responses were reinforced according to either a single VI 30-s schedule followed by 6 s of access to grain or a VI 120-s schedule followed by 12 s of access to grain. All other procedural aspects of Experiment 2 matched those of Experiment 1, including the counterbalancing of schedule values and condition order and the initial use of a forced-choice procedure. Each subject received an average choice proportion score representing preference for the short-chain alternative across the final nine sessions. Once stable responding was achieved in both the P-P and P-A conditions, the VI values in the terminal links were reversed to assess side or color bias and to confirm stimulus control. Again, a control condition was conducted to demonstrate temporal sensitivity, during which the prechoice period was eliminated and the initial-link (search-phase) durations were increased to concurrent VI 460-s schedules.

Predictions. The predictions made by the two versions of DRT for each of the conditions in Experiment 2 are shown in Appendix B. The two versions differ depending on whether the total time to reinforcement (T) is calculated by either including (Equation 2) or not including (Equation 2a) prechoice time. Due to the required transformation of unequal reinforcement magnitudes, DRT predictions for Experiment 2 were viewed qualitatively, as recommended by Navarick and Fantino (1976). As such, both versions of the DRT equation predicted preference for the shorter chain in the absence of a prechoice delay. According to Equation 2, no systematic change in preference was predicted as a result of introducing the prechoice period. However, Equation 2a predicted an ordinal reversal of preference to the larger, more delayed outcome when the prechoice period was added. Similarly, both views of rate maximization—based on either including (Equation 3a) or not including (Equation 3) prechoice time—predicted a distribution of responses across both alternatives in the P-A condition (i.e., relative indifference). Consistent with the local-contextual view of DRT,

Fig. 6. Procedural schematic for Experiment 2. Panel A shows the sequence of events leading to reinforcement on the left key; Panel B shows the analogous sequence for the right key. In the prechoice-present condition, an FI 200-s schedule preceded equal concurrent VI 60-s schedules in the initial links (search phase). In the prechoice-absent condition, the prechoice period was eliminated.

Equation 3 predicted that preference would not change as a function of the prechoice duration. However, Equation 3a predicted that a 200-s increase in prechoice duration would result in ordinal preference for the larger, more delayed alternative, consistent with the prediction of Equation 2a. All models predicted a reversal of preference favoring the larger, more delayed outcome in the control condition.

Results and Discussion

Table 2 presents the obtained choice proportions for each of the 4 subjects in each condition. Obtained choice proportions were averaged across reversals for the P-P and P-A conditions for each subject, and are presented in Figure 7. Although the mean choice proportions for the P-A and P-P conditions did not differ from each other, both differed

Table 2

Obtained choice proportions (favoring the initial link leading to the short terminal link) for each of the 4 subjects across prechoice-absent (P-A), prechoice-present (P-P), and control conditions for Experiment 2. Each score represents the average obtained choice proportion derived from the last nine sessions for each experimental condition. The numbers of sessions to criterion per condition are included in parentheses.

Subject	Prechoice duration		Replication prechoice duration		Mean obtained choice proportions		Control (initial link: VI 460 s)
	P-A	P-P	P-A	P-P	P-A	P-P	
R20	.97 (24)	.98 (15)	.94 (19)	.98 (15)	.96	.98	.80 (25)
R2	.95 (24)	.96 (15)	.76 ^a (16)	.92 (16)	.86	.94	.56 (15)
R26	1.0 (15)	1.0 (15)	.99 (15)	.92 (17)	1.00	.96	.82 (18)
R65	.99 (15)	.97 (15)	.99 (15)	.99 (19)	.99	.78	.77 (27)

^a Obtained choice proportion of .76 was derived from two independent replications (.58 and .95). Sessions to criterion for this condition were 16 and 16, respectively.

statistically from those obtained in the control condition, $F(2, 3) = 22.28$, $p < .05$. Again, there was no systematic decline in preference during the search-choice phase (initial links) as a function of the prechoice period duration, consistent with the predictions of the local-contextual views of both DRT and rate maximization. As in Experiment 1, response rates to the prechoice FI

again remained low ($M = 19$ responses per minute), ranging from 8 to 34 responses per minute across subjects.

In general, subjects' ordinal preference for the shorter chain alternative did not vary as a function of prechoice duration, consistent with predictions of the local-contextual views of both DRT and rate maximization, as well as with the findings from Experiment 1. The

Fig. 7. Mean obtained choice proportions for each of 4 subjects in Experiment 2. Data are plotted in terms of preference for the shorter chain alternative (VI 60-s initial link leading to VI 30-s terminal link). Data are averaged across reversals for each subject.

global-contextual views, which predicted a reversal of preference toward the longer, more delayed alternative, were not supported by the data (predicted choice proportion for the short alternative was less than .50; average obtained choice proportion was .97). Instead, only the local-contextual versions of the equations accurately predicted the observed insensitivity to prechoice manipulations.

On the average, choice proportions dropped more than .20 when initial-link (search-choice) delays were increased to VI 460-s schedules. Although all of the models predicted a reversal of preference for this control condition, obtained choice proportions merely declined. The shift in preference was in the correct direction and was significant, but the predicted reversal of preference was not observed for any of the 4 subjects. We suspected that the absolute difference in terminal-link delays (VI 30 s vs. VI 120 s) may have been responsible for the apparent resistance to reverse; this result led to the development of Experiment 3.

EXPERIMENT 3

Experiment 3 assessed the generality of the findings from the first two experiments. In particular, it was designed to reduce the influence of the absolute difference between the terminal-link delays while holding reinforcer magnitude and total handling delays on the longer chain constant relative to Experiment 2 by employing terminal-link delays that are more commonly used. The longer chain that provided the larger amount of food in Experiment 2 (VI 120 s producing 12 s of grain) was split into a clustered encounter (two independent VI 60-s schedules each correlated with 6 s of grain), similar to that used by Williams and Fantino (1994). By doing so, the absolute difference in relative immediacy of reward on the two alternatives became similar to the difference in Experiment 1, while the total terminal-link duration and prey density on the longer chain were held constant relative to what they were in Experiment 2.

Figure 8 provides a graphical representation of Experiment 3 in rate-maximizing terms. As in Experiment 2, intermediate search-related delays diagrammed in Panel A produced slopes that pass through both sets

of prey items, suggesting relative indifference. Again, any bias favoring reward immediacy could influence preference in this case. However, it is important to note that in a clustered encounter, one of the items is obtained and consumed early in the interval. Therefore, although ordinal preference may favor the shorter delay alternative (6 s of food following a 30-s delay), one might expect the relative degree of preference to be less extreme when compared to Experiment 2. On the other hand, if subjects' choice behavior is sensitive to prechoice delays, then the clustered items should be preferred, as seen in Panel B. Because the use of a clustered encounter should reduce the influence of the highly discrepant delays that were used in Experiment 2, the subjects might now be sensitive to prechoice manipulations, suggesting a more global context for foraging. Furthermore, the control condition might be more likely to produce the anticipated reversal of preference predicted by all of the models.

The use of a clustered encounter was introduced originally by Williams and Fantino (1994) as a method of simulating multiple prey items that, although encountered together, require independent handling. It does, however, involve presenting multiple reinforcers in the terminal link. Because DRT does not have a parameter for multiple reinforcers, its predictions are based entirely on the delay reduction signaled by the onset of the first item encountered in each cluster only. Although this neglect of additional reinforcers may be viewed as a potential shortcoming for DRT's quantitative accuracy, the clustered encounters paradigm provides a way to arrange unequal reinforcer magnitudes that may be treated by DRT without the computational transformation required in Experiment 2. The DRT predictions for Experiment 3 were viewed only qualitatively, as in Experiment 2.

Method

Subjects. Four female White Carneau pigeons (*Columba livia*) were matched for experimental histories with standard concurrent-chains schedules. No preliminary training was required. Subjects were housed and maintained as in Experiments 1 and 2.

Apparatus. Subjects were randomly assigned to one of four cylindrical chambers, identical

PANEL A

PANEL B

Fig. 8. A graphical representation of the predictions made by a rate-maximizing version of optimal foraging theory for Experiment 3. The small black circle represents the smaller, more immediate prey item (6-s food) correlated with the 30-s delay; the open circles (arranged as a step function) represent the clustered items (6-s food) each correlated with a 60-s delay. Note that the locally defined context (beginning with the search phase only) produces a prediction of relative indifference, perhaps influenced by the relative immediacy of the smaller, more immediate item (Panel A). In Panel B, a more globally defined context (beginning with the prechoice phase) produces a clear prediction of preference for the clustered encounter.

Fig. 9. Procedural schematic for Experiment 3. Panel A shows the sequence of events leading to reinforcement on the left key; Panel B shows the analogous sequence for the right key. In the prechoice-present condition, an FI 200-s schedule preceded equal concurrent VI 60-s schedules in the initial links (search phase). In the prechoice-absent condition, the prechoice period was eliminated.

to those used in Experiment 2. Scheduling of experimental events and data collection were maintained by an IBM®-compatible personal computer.

Procedure. All subjects' responses were reinforced according to the clustered encounter procedure diagrammed in Figure 9. As in the two previous experiments, the critical manipulation across conditions consisted of either the presence or absence of an FI 200-s prechoice

period. Prechoice and initial-link (search-phase) keylights and schedule values were identical to those in Experiments 1 and 2; terminal-link (handling-phase) keylight colors and configurations also matched those in Experiments 1 and 2. Terminal-link responses were reinforced according to either a single VI 30-s schedule followed by 6 s of access to grain or a pair of VI 60-s schedules in sequence, each correlated with 6 s of grain access. All other

Fig. 10. Mean obtained choice proportions and standard error bars for each of 4 subjects in Experiment 3. Data are plotted in terms of preference for the shorter chain alternative (VI 60-s initial link leading to VI 30-s terminal link). Data were averaged across reversals.

aspects of Experiment 3 matched those of the previous two experiments. Again, following the two required replications, the prechoice period was eliminated and the initial-link (search-phase) durations were increased to concurrent VI 460-s schedules.

Predictions. The ordinal predictions for the P-P, P-A, and control conditions in Experiment 3 did not differ from those in Experi-

ment 2, despite the procedural differences (again, see Appendix B).

Results and Discussion

Choice proportions were averaged across reversals for the P-P and P-A conditions for each subject and are presented in Figure 10. Individual-subject data are presented in Table 3. The initial tests produced overall average

Table 3

Obtained choice proportions (favoring the initial link leading to the short terminal link) for each of the 4 subjects across prechoice-absent (P-A), prechoice-present (P-P), and control conditions for Experiment 3. Each score represents the average obtained choice proportion derived from the last nine sessions for each experimental condition. The numbers of sessions to criterion are included in parentheses.

Subject	Prechoice duration		Replication prechoice duration		Mean obtained choice proportions		Control (initial link: VI 460 s)
	P-A	P-P	P-A	P-P	P-A	P-P	
G8	.92 (18)	.95 (15)	.62 (20)	.67 (21)	.77	.81	.50 ^a (16)
R156	.80 (16)	.78 (19)	.56 (17)	.58 (15)	.68	.68	.51 (25)
R5	.67 (15)	.77 (19)	.86 (15)	.66 (16)	.77	.72	.52 (20)
G6	.94 (15)	.96 (15)	.72 (15)	.72 (22)	.83	.78	.52 (16)

^a Obtained choice proportion of .50 was derived from two independent replications (.32 and .68). Sessions to criterion for this condition were 14 and 18, respectively.

choice proportions of .83 and .87 for the P-A and P-P conditions, respectively. The replications, on the other hand, produced mean choice proportions of .69 and .66, again suggesting the development of a side or color bias. Independent within-subject repeated measures ANOVAs comparing the P-P and P-A conditions for both the initial set of experimental conditions and for the reversals showed no significant differences between the experimental conditions in either case. Therefore, it was again deemed appropriate to average across reversals. Although the mean choice proportions for the P-P and P-A conditions did not differ from each other, both conditions differed statistically from the control condition, $F(2, 3) = 46.87$, $p < .05$. Consistent with the results for Experiments 1 and 2, there was no systematic decline in preference during the initial links (search phase) as a function of prechoice duration. The global-contextual views of both DRT and rate maximization were not supported by the data (predicted choice proportion for the short delay was less than .50, the overall average obtained choice proportion was .76). Choice proportions dropped an average of .25 when initial-link delays were increased to VI 460-s schedules but, again, did not reverse, suggesting that the reinforcer magnitude differences might not have been sufficiently large to produce a complete reversal. However as noted in the discussion of Experiment 2, the preference was significantly lower under the control condition than under the experimental conditions, and this trend was in the appropriate direction toward reversal. Moreover, the overall average choice proportion obtained in the control condition in Experiment 3 ($M = .51$) was much lower than that obtained in Experiment 2 ($M = .74$), supporting the possibility that the absolute delay differences might have been a contributing factor. Response rates to the prechoice FI were again relatively low ($M = 35$ responses per minute), ranging from 6 to 58 responses per minute across subjects.

Once again, subjects' ordinal preference for the shorter chain alternative did not vary as a function of prechoice duration, consistent with predictions of the local-contextual views of both DRT and rate maximization; these findings were consistent with both of the previous investigations. The global-contextual

views that predicted a reversal of preference toward the longer, more delayed alternative were not supported by the data; only the local-contextual versions of DRT and rate maximization accurately predicted the observed insensitivity to prechoice manipulations.

GENERAL DISCUSSION

Over the last 30 years, a number of qualitative and quantitative models have been proposed that attempt to describe a forager's choice for one prey item over another. The goal of these models of choice has been to provide an increasingly clearer picture of the mechanisms, or rules of thumb, that allow organisms to choose optimally within the foraging context. Early views of the foraging context (Emlen, 1966; MacArthur & Pianka, 1966) reflected a relatively local-contextual perspective that included only the time spent searching, handling, and consuming a prey item. Since that time, the majority of foraging-related research has not investigated the potential effect of events that precede choice on the development of preference and the possibility of an even larger temporal foraging window. Whereas most proponents of rate maximization have promoted a molar view, the role of response-dependent prechoice events within the foraging cycle has not been directly tested previously.

Given the success of DRT in predicting choice behavior in operant simulations of foraging, a parallel issue regarding the temporal context for determining conditioned reinforcement efficacy arises. The question of whether the ability of a stimulus to serve as a conditioned reinforcer is best determined by comparing the reduction in waiting time to food signaled by that stimulus relative to the preceding stimulus or relative to the overall time in the conditioning context (including prechoice periods) has also been neglected. Given their complementary nature, it is important to note that present comparisons between DRT and a rate-maximizing version of OFT were made in an attempt to highlight parallel difficulties that both approaches face in attempting to define the foraging context. When viewed together, the present experiments begin to address these issues.

In general, the results of the present investigation showed no systematic decline in pref-

erence during the search-choice phase (initial links) as a function of the duration of the pre-choice period, consistent with local-contextual views of both DRT and rate maximization. Although evidence from the autoshaping and delayed matching-to-sample literature (Gibbon & Balsam, 1981; Miller & Schactman, 1985; Reilly & Schactman, 1987) suggests that the duration of a response-independent ITI may serve as an important variable that influences both the rate and probability of conditioning, the present results indicate that pre-choice delays may not influence choice. In short, a local-contextual view of rate maximization, which defines the foraging cycle as beginning with the search state and proceeding through the states of handling and consumption, appears to be adequate. Similarly, the results of all three studies suggest that the establishment of conditioned reinforcement strength is best described by a relatively local-contextual version of DRT, one that compares improvements in waiting time to food to the overall time to food, as measured from the onset of the preceding stimulus only.

The present investigation also provided a unique opportunity to compare the effect of three distinct modifications of the concurrent-chains procedure for which the traditional DRT formulation provides identical ordinal predictions. Furthermore, the scheduled (or transformed) values used to make predictions for Experiments 2 and 3 were identical. Yet the results indicate that the procedure in Experiment 2 produced greatly inflated choice proportions, probably due to the absolute terminal-link differences. The clustered encounter procedure in Experiment 3, in contrast, produced mean choice proportions that more closely approximated the quantitative predictions than did those obtained in Experiment 2. These findings are consistent with those from previous studies suggesting that subsequent reinforcers exert only a small effect on concurrent-chains choice (Kendall, 1967; Shull, Spear, & Bryson, 1981; Squires & Fantino, 1971).

The present experiments represent a first investigation of response-dependent pre-choice effects on foraging-related choice. Traditionally, operant analogues of foraging have focused on a more narrow view of the foraging context (searching, handling, and consumption). Intervening events were not treat-

ed as part of the foraging context. Within the psychological choice literature, the ITI has typically lasted for a fixed period of time and usually has been unsignaled. Within constraints designed to remain close to these traditions, the present investigation provides insights into the definitions of both the foraging and conditioning contexts. Given the present findings, there appears to be no immediate need to modify the traditional views of either DRT or rate maximization with respect to the prechoice events tested here and the development of initial-link preference. Moreover, the results also emphasize the complementary nature of these two views of choice and their ability to identify important variables that influence foraging-related preferences. Perhaps, as we systematically reintroduce increasingly complex aspects of the forager's world into our operant simulations, we may begin to identify increasingly molar contingencies that may influence the decision-making strategies used by the optimal forager. Until then, a local-contextual view of foraging and conditioning appears to be sufficient.

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APPENDIX A

Below are the calculations for predicting preference for the short terminal-link alternative (VI 30 s) for Experiment 1, according to the local-contextual version of DRT (Equation 2) and the global-contextual version of DRT (based on Equation 2a).

Prediction A1. These are calculations for predicting preference for the prechoice-absent (P-A) condition by both DRT equations. The same method is used for the prechoice-present (P-P) condition according to Equation 2, because the local-contextual view of

DRT does not require a parameter for the prechoice period. For $T = 30 + [(30 + 60)/2] = 75$:

$$\begin{aligned}
 & \frac{R_1}{R_1 + R_2} \\
 &= \frac{(1/90)(75 - 30)}{(1/90)(75 - 30) + (1/120)(75 - 60)} \\
 &= \frac{0.50}{0.50 + 0.125} = .80.
 \end{aligned}$$

Prediction 2. These are calculations for predicting preference for the short terminal-link alternative for the P-P condition by DRT Equation 2a. For $T = 200 + 30 + [(30 + 60)/2] = 275$:

$$\begin{aligned} & \frac{R_1}{R_1 + R_2} \\ &= \frac{(1/290)(275 - 30)}{(1/290)(275 - 30) + (1/320)(275 - 60)} \\ &= \frac{0.84}{0.84 + 0.67} = .56. \end{aligned}$$

Prediction 3. These are calculations for predicting preference for the short terminal-link alternative in the control equation by both DRT equations. For $T = 230 + [(30 + 60)/2] = 275$:

$$\begin{aligned} & \frac{R_1}{R_1 + R_2} \\ &= \frac{(1/490)(275 - 30)}{(1/490)(275 - 30) + (1/520)(275 - 60)} \\ &= \frac{0.50}{0.50 + 0.41} = .55. \end{aligned}$$

APPENDIX B

Below are the calculations for predicting preference for the short terminal-link alternative (VI 30 s) for Experiments 2 and 3, according to the local-contextual version of DRT (Equation 2) and the global-contextual version of DRT (based on Equation 2a).

Prediction B1. These are calculations for predicting preference for the prechoice-absent (P-A) condition by both DRT Equations 2 and 2a. The same method is used for the prechoice-present (P-P) condition according to Equation 2, because the local-contextual view of DRT does not require a parameter for the prechoice period. For $T = 30 + [(30 + 60)/2] = 75$:

$$\begin{aligned} & \frac{R_1}{R_1 + R_2} \\ &= \frac{(1/90)(75 - 30)}{(1/90)(75 - 30) + (2/180)(75 - 60)} \\ &= \frac{0.50}{0.50 + 0.17} = .75. \end{aligned}$$

Prediction B2. These are calculations for predicting preference for the short terminal-

link alternative for the P-P condition by DRT Equation 2a. For $T = 200 + 30 + [(30 + 60)/2] = 275$:

$$\begin{aligned} & \frac{R_1}{R_1 + R_2} \\ &= \frac{(1/290)(275 - 30)}{(1/290)(275 - 30) + (2/380)(275 - 60)} \\ &= \frac{0.84}{0.84 + 1.13} = .43. \end{aligned}$$

(preference reversal)

Prediction B3. These are calculations for predicting preference for the VI 30-s alternative in the control condition by both DRT equations. For $T = 230 + [(30 + 60)/2] = 275$:

$$\begin{aligned} & \frac{R_1}{R_1 + R_2} \\ &= \frac{(1/490)(275 - 30)}{(1/490)(275 - 30) + (2/580)(275 - 60)} \\ &= \frac{0.50}{0.50 + 0.74} = .40. \end{aligned}$$

(preference reversal)