

## CHOICE AND FORAGING: THE EFFECTS OF ACCESSIBILITY ON ACCEPTABILITY

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Pigeons responded in a successive-encounters choice procedure in which accessibility of the less profitable of two outcomes varied either in terms of probability of encounter or search time to encounter (keeping search time to the more profitable outcome constant). When the less profitable outcome was made more probable its acceptance became more likely. However, when search time to encounter the less profitable outcome was shortened, its acceptance became less likely. Both results are consistent with the delay-reduction hypothesis and with an optimality model developed for application to the successive-encounters choice procedure.

*Key words:* choice, foraging, delay-reduction hypothesis, optimality theory, successive-encounters procedure, probability of reinforcement, frequency of reinforcement, key peck, pigeons

The delay-reduction hypothesis states that the effectiveness of a stimulus as a conditioned reinforcer may be predicted most accurately by calculating the reduction in the length of time to primary reinforcement correlated with the onset of the stimulus in question, relative to the length of time to primary reinforcement measured from the onset of the preceding stimulus (Fantino, 1969). Expressed differently, the greater the improvement, in terms of temporal proximity or waiting time to reinforcement correlated with the onset of stimulus, the more effective that stimulus will be as a conditioned reinforcer. The hypothesis, first developed to account for choice for two variable-interval (VI) schedules of reinforcement in the concurrent-chains procedure, has been extended to such areas as observing in pigeons and human subjects (Case & Fantino, 1981; Fantino & Case, 1983), self-control (Ito & Asaki, 1982; Navarick & Fantino, 1976), elicited responding (Fantino, 1982), and three-alternative choice (Fantino & Dunn, 1983). Because foraging involves choice, the delay-reduction hypothesis may also be extended to describe aspects of foraging. Although foraging involves a range of problems from prey detection to patch depletion, the *temporal* distribution and costs associated with food acquisition

are problems common to all foraging situations. Because the delay-reduction hypothesis has been developed to account for these variables in a nonforaging context, a central question is this: Are principles that have evolved from the study of decision-making in the operant laboratory consistent with decision-making in situations sharing important properties with foraging?

The delay-reduction hypothesis has been assessed with several operant analogues to foraging using a variant of the procedure developed by Lea (1979), shown in Figure 1. For example, using this procedure both Lea (1979) and Abarca and Fantino (1982) assessed preference for 5-s versus 20-s "handling times" or times to food in the terminal links. Lea showed that acceptance of the less profitable outcome (fixed-interval 20 s or FI 20 s) increased as the duration of the FI schedule in the search state increased. However the pigeons showed a marked bias toward rejecting the less profitable outcome. That is, the less profitable outcome was rejected at FI values for which Lea noted that a version of optimal foraging theory, the optimal diet model, required acceptance. The delay-reduction hypothesis makes the same predictions as the optimal diet model (Fantino & Abarca, 1985); however, it was developed to account for choice between VI schedules. Thus, Abarca and Fantino (1982) suggested that the use of VI instead of FI schedules in the handling state might produce results more compatible with the optimal diet model and with the delay-reduction hypothesis. They re-

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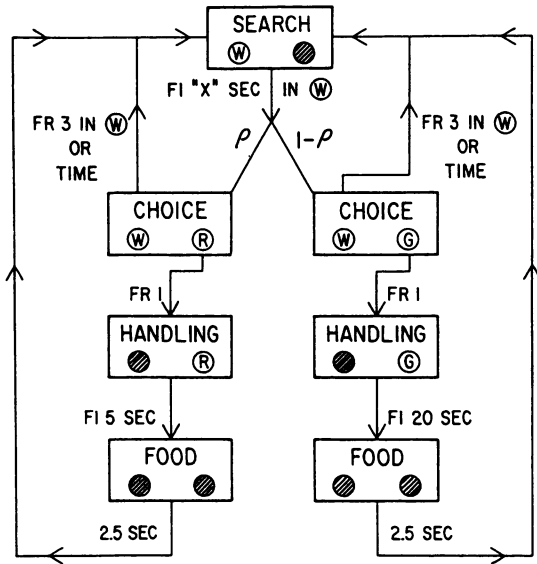


Fig. 1. Flowchart of foraging procedure used by Lea (1979). The rectangles indicate the different states of the schedule. The state-transition schedule requirements are indicated by the legends. The circles represent the response keys and the letters the corresponding colors (R: red, G: green, W: white).

peated Lea's study with several variations, most notably replacing FI with VI schedules in the handling state. Figure 2 (from Abarca & Fantino, 1982) shows that the mean data describing acceptance probabilities as a function of search time crossed the  $p = .50$  point at 7.5 s, or where predicted by the optimal diet model and by the delay-reduction hypothesis. To illustrate, at a 7.5-s search time the average overall delay to primary reinforcement from the onset of search ( $T$ ) equals 20 s ( $7.5 \text{ s} + \frac{1}{2} \cdot 20 \text{ s} + \frac{1}{2} \cdot 5 \text{ s} = 20 \text{ s}$ ), ignoring the 1 or 2 s needed to accept or reject the outcome. At this point the 20-s outcome represents neither a decrease nor an increase in mean delay to reinforcement. At search durations greater than 7.5 s,  $T$  is greater than 20 s, the 20-s outcome represents delay reduction and should be accepted; at search durations less than 7.5 s,  $T$  is less than 20 s, the 20-s outcome represents a delay increase and should be rejected. As is shown in Fantino and Abarca (1985), both the optimal diet model and the delay-reduction hypothesis require exclusive preference for the more profitable outcome (in terms of energy gain per unit time) when the following inequality is satisfied:

$$t_{1R} + t_{2R} < t_{2L} \quad (1)$$

where  $t_{1R}$  is the time to find and  $t_{2R}$  the time to handle the more profitable item and  $t_{2L}$  is the time to handle the less profitable item. In other words, given an encounter with an item of type L, the less profitable prey, that prey should be rejected if it takes longer to handle it ( $t_{2L}$ ) than it does to find ( $t_{1R}$ ) and handle ( $t_{2R}$ ) an item of type R. Note that although the models' prediction of all-or-none acceptance should be reflected by a step function in Figure 2, the function is instead continuous, a problem we discuss later.

These studies suggest that operant simulations of foraging may be useful not only in assessing the effects of variables on foraging but also, because of the large data base from prior work with comparable procedures, in permitting fair tests of theoretical predictions. It should be cautioned, however, that potential problems of external validity compromise such efforts. Certainly there are "unnatural" aspects of our simulations. Some specifics have been discussed elegantly by Baum (1983). For example, "three artificialities" of the "typical experiment in operant behavior" are that it (a) occurs inside a small box, not outdoors; (b) constitutes only a minor portion of the subject's active hours; and (c) presents food on schedules that "bear little resemblance" to the scheduling of food in nature (Baum, 1983, p. 259). Although these limitations all apply to some extent to the present work, both Baum (1983) and Fantino and Abarca (1985) have pointed out the similarities between the results obtained in relatively natural and relatively artificial environments (see Fantino & Abarca, p. 321).

Lea's successive-choice procedure permits variation in several other important variables (in addition to variation of search duration), some of which Lea (1979) reported. Thus far, researchers in our laboratory have examined the effects of providing food on only a percentage basis (i.e., a proportion of trials end with nonreinforcement replacing food delivery; Abarca, Fantino, & Ito, 1985) and of varying search and handling durations with unequal eating durations (Ito & Fantino, 1986).

Lea (1979), Collier and Rovee-Collier (1981), Abarca and Fantino (1982), and Ito and Fantino (1986) all varied the accessibility of outcomes by varying the duration of the

common search state leading to separate outcomes. As required by the optimal diet model and the delay-reduction hypothesis, as accessibility increased so did selectivity. Thus, with shorter search durations subjects were more likely to reject the less profitable outcome. It is also instructive to consider two additional ways of varying accessibility of the less profitable outcome. One involves increasing the probability of the less profitable outcome ( $1 - p$  in Figure 1); the other decreases the search time leading to it while leaving the search time to the richer outcome constant. Lea (1979) varied the search times to both outcomes and  $p$  simultaneously in order to keep the encounter rate of one outcome constant. The present experiment varies  $p$  and the search time for the less profitable outcome separately in two sets of conditions, because the two manipulations should have strikingly different effects if subjects behave optimally. In particular, for a given search time, as the less profitable outcome becomes more probable the predicted behavior eventually switches from that of a specialist (rejecting the less profitable outcome) to that of a generalist (accepting the less profitable outcome). However, for a given  $p$ , as the less profitable outcome is encountered more quickly the predicted behavior eventually switches from that of a generalist to that of a specialist (rejecting the less profitable, though increasingly accessible outcome). Both sets of predictions follow from the delay-reduction hypothesis and from an optimality model Kacelnik and Krebs (1985) developed particularly for application to Lea's successive-choice procedure. It has been shown elsewhere (Fantino & Abarca, 1985) that the model of these preeminent behavioral ecologists makes predictions comparable to that of the delay-reduction hypothesis.

For the delay-reduction hypothesis, specialization (in the sense of rejection of the less preferred outcome) should occur when the time to food from the onset of a trial,  $T$ , is less than the handling time for the less profitable (longer) outcome ( $t_L$ ) or  $T < t_L$ . Because  $T$  equals the time in the search state ( $S$ ) plus the time in the handling state [ $p \cdot t_L + (1 - p)t_s$ , where  $p$  = probability of the longer handling time, and  $1 - p$  = probability of the shorter handling time ( $t_s$ )] the subject should specialize when:

$$S + p \cdot t_L + (1 - p)t_s < t_L. \quad (2)$$

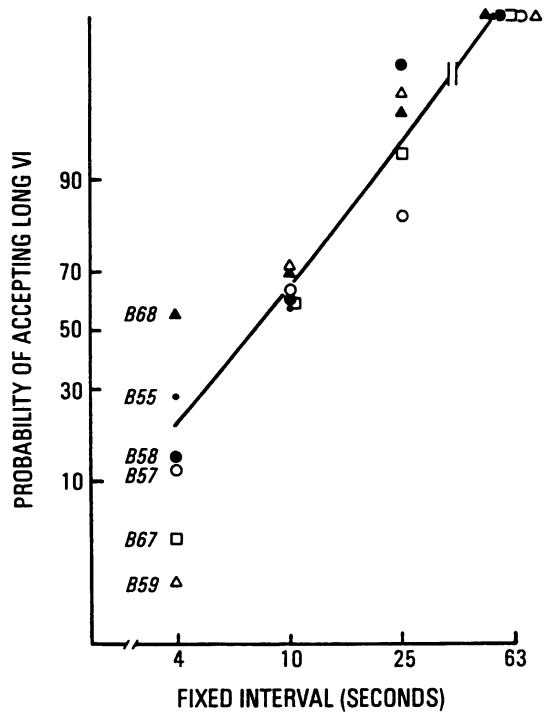


Fig. 2. Probability of accepting the longer VI (in logit scale,  $\ln p/(1 - p)$ ) for each of 6 birds as a function of the FI value used in the search state (in logarithmic scale). The solid line represents the mean (from Abarca & Fantino, 1982).

This inequality is equivalent to:

$$p < 1 - \frac{S}{t_L - t_s}. \quad (3)$$

Note first that when  $p = .5$ ,  $t_s = 5$  s and  $t_L = 20$  s, the conditions of Abarca and Fantino (1982), Inequality 3—which follows also from the Kacelnik and Krebs (1985) model—is satisfied for search time  $S < 7.5$  s. For search times less than 7.5 s the less profitable item should be rejected always (specialization) whereas for search times greater than 7.5 s both items should be accepted always. Search time of 7.5 s represents an indifference point in terms of accepting the less profitable item. Abarca and Fantino (1982) found indifference at 7.5 s (i.e., the function in Figure 2 crosses the  $p = .5$  point at 7.5).

Now consider the predictions, based on Inequality 3, as we increase  $p$ , the probability of the longer handling time ( $t_L$ ). For example, again let  $t_L = 20$  s,  $t_s = 5$  s and let  $S = 5$  s. The inequality is satisfied, and specialization

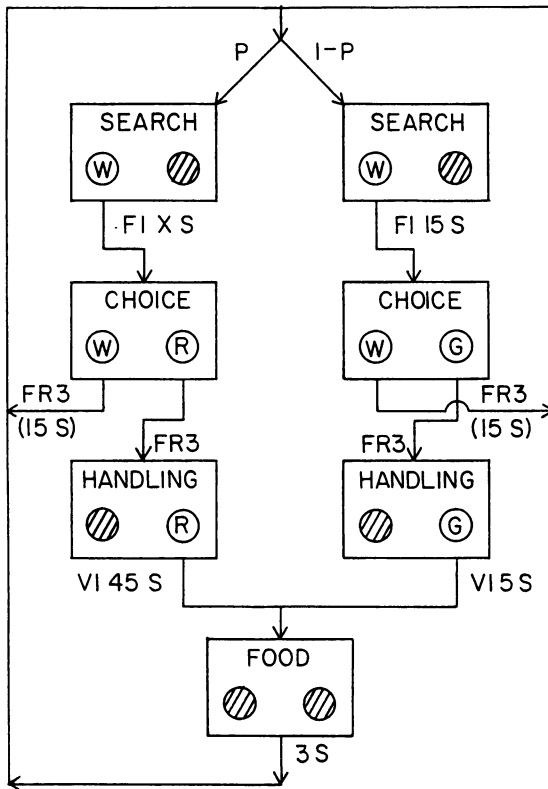


Fig. 3. The foraging procedure used in the present experiment. The rectangles indicate the different states of the schedule. The state-transition schedule requirements are indicated by the legends. The circles represent the response keys and the letters the corresponding colors (R: red, G: green, W: white).

is predicted, when  $p < \frac{2}{3}$  [because  $p < 1 - 5/(5 - 20)$  or  $p < \frac{2}{3}$ ]. In other words, for  $p < \frac{2}{3}$  the 20-s outcome should always be rejected. For  $p > \frac{2}{3}$ , however, the 20-s outcome should be accepted. But now consider what should occur—if behavior is optimal—when the longer handling time is encountered more quickly. With  $p = \frac{1}{2}$ , again let  $t_s = 5$  s and  $t_L = 20$  s. Let the search time on trials with the shorter handling time ( $t_s$ ) always be 10 s. Let search time on trials with the less profitable outcome ( $t_L$ ) be  $S_L$ . According to Inequality 2, subjects should specialize when

$$\frac{S_L + 10}{2} + \frac{1}{2}(5) + \frac{1}{2}(20) < t_L. \quad (4)$$

The left side of the inequality equals  $T$  because  $(S_L + 10)/2$  is the mean time in the search phase and  $(\frac{1}{2})5 + (\frac{1}{2})20$  is the mean time in

the handling phase as in the earlier example. For the values of this example, if  $t_L = 20$  s,  $T < t_L$  only when  $S_L < 5$  s. This means that specialization on the more profitable outcome becomes more likely as the search time to the less profitable outcome is shortened (with search time to the more profitable outcome constant). In other words, the more accessible the less profitable outcome, the less acceptable it is (and the more likely specialization on the more profitable outcome). Thus, depending upon how one arranges accessibility of the less profitable outcome one should get very different effects on its acceptability (comparison of the two sets of conditions). The present experiment assesses these predictions.

## METHOD

### Subjects

Eight experimentally experienced mixed-breed pigeons were maintained at 80% of their ad lib weights. The pigeons had experience with concurrent-chains schedules conducted in an undergraduate laboratory course. Water and grit were available constantly in the home cages and supplementary feeding maintained the prescribed weights.

### Apparatus

Sessions were conducted in eight identical experimental chambers with internal dimensions of 31 by 31 by 38 cm. The chamber was enclosed in a sealed plywood shell. Three walls of the experimental chamber were clear Plexiglas. The fourth wall was made of aluminum and contained two translucent response keys 21.5 cm above the floor and centered across the wall 11.5 cm apart. The response keys could be illuminated from behind by either red or green 6-W miniature bulbs. Illuminating the key with both red and green produced a third key color (more or less white). A solenoid-operated food hopper provided grain through a 4.5 by 5.5 cm rectangular opening located 5.5 cm above the floor centered across the wall. During reinforcement the hopper was illuminated by a 6-W bulb and all keylights and the chamber houselight (a 6-W bulb mounted on the chamber ceiling) were dark. White noise masked extraneous noise. Experimental events were controlled by a micro PDP-11® computer operating under SKED-11® software.

### Procedure

*Vary-probability conditions.* In all conditions key pecks were reinforced according to the procedure shown in Figure 3. At the start of each trial the left key was illuminated white (search state) and (with probability  $p$  and  $1 - p$ ) either 25 or 15 s later the next key peck produced the choice state. During the choice state, both keys were illuminated, the left key with white and the right key with either green or red. If the pigeon either failed to respond for 15 s or completed three responses (a fixed-ratio or FR 3) on the left key the search state was reinstated. If, instead, the pigeon completed an FR 3 on the right key the handling state was initiated. During the handling state the left key was dark and further responding on the right key produced food according to a VI schedule (either VI 5 s or VI 45 s) in which the first response after a variable delay had elapsed was reinforced with 3-s access to grain. After food, the search state was reinstated. The procedure differed from that shown in Figure 3 for these subjects in that  $S_L$  was always 25 s while the probability of obtaining the long-terminal-link chain ( $p$ ) was varied.  $S_S$  was always 15 s. The independent variable was the probability of obtaining the chain with the VI 45-s terminal link (i.e., with  $t_L = 45$  s). For Pigeons P3 and P4  $p$  was .2, .8, and again .2 in Conditions 1 through 3, respectively. For Pigeons P1 and P2  $p$  was .8, .2, and again .8. For all pigeons  $p$  was .5 in Condition 4. Terminal-link stimuli were counterbalanced across subjects. All conditions were in effect for 20 sessions.

*Vary-search conditions.* Again, in all conditions the pigeon's key pecks were reinforced according to the procedure shown in Figure 3. In these conditions the choice states were produced with equal probability (i.e.,  $p = .5$ ). The VI 5-s terminal link ( $t_S$ ) was always preceded by an FI 15-s search time (search time leading to the short terminal link,  $S_S$ ). The independent variable was the search time (search time leading to the long terminal link,  $S_L$ ) preceding each VI 45-s terminal link ( $t_L$ ). For Pigeons S3 and S4  $S_L$  was 10 s, 40 s, and again 10 s in Conditions 1 through 3, respectively. For Pigeons S1 and S2  $S_L$  was 40 s, 10 s, and again 40 s. For all pigeons  $S_L$  was 25 s in Condition 4. Terminal-link stimuli were counterbalanced across subjects. All conditions were in effect for 20 sessions.

### RESULTS

Data are not shown for acceptance of the richer outcome (i.e.,  $t_S = 5$  s) in either condition. In fact, every pigeon, in every condition, accepted the richer outcome on almost 100% of trials, as required by the delay-reduction hypothesis and the optimal diet model. The critical dependent variable in this experiment was degree of acceptance of the poorer outcome. In both sets of conditions degree of acceptance varied in the direction required by the optimality and delay-reduction models.

The results from the condition in which the probability was varied are shown in Figure 4. The probability of accepting the poorer outcome (i.e.,  $t_L = 45$  s) is shown for the last five sessions of each condition. With one exception, acceptance of the poorer outcome was always highest when its probability was .8, intermediate when  $p$  was .5, and lowest when  $p$  was .2. The exception occurred for P4 in its second exposure to  $p = .2$  (acceptance in this condition for P4 was higher than when  $p = .5$ ).

The corresponding results from the conditions in which the search time to the poorer outcome was varied are shown in Figure 5. Acceptance of the poorer outcome increased as search time to the poorer outcome increased. This was true for all pigeons at each of three search times, with one exception: For Pigeon S1, acceptance was slightly higher at the intermediate search time ( $S_L = 25$  s) than at the longest search time ( $S_L = 40$  s).

### DISCUSSION

In each set of conditions, values were studied that should have produced uniform acceptance or rejection of the poorer outcome, according to Inequality 3. In addition, in each set of conditions, an indifference point was studied for which any outcome would be consistent with Inequality 3. Consider first the conditions under which the inequality (derived from both optimality theory and the delay-reduction hypothesis) required acceptance of the poorer outcome. These conditions are those with the longest search time ( $S_L = 40$  s) and highest probability ( $p = .8$ ). Averaging over the 4 subjects in each condition, including the replications, the mean acceptance proportion was .96 when the search time was 40 s and .93 when the probability was .8. Next consider the con-

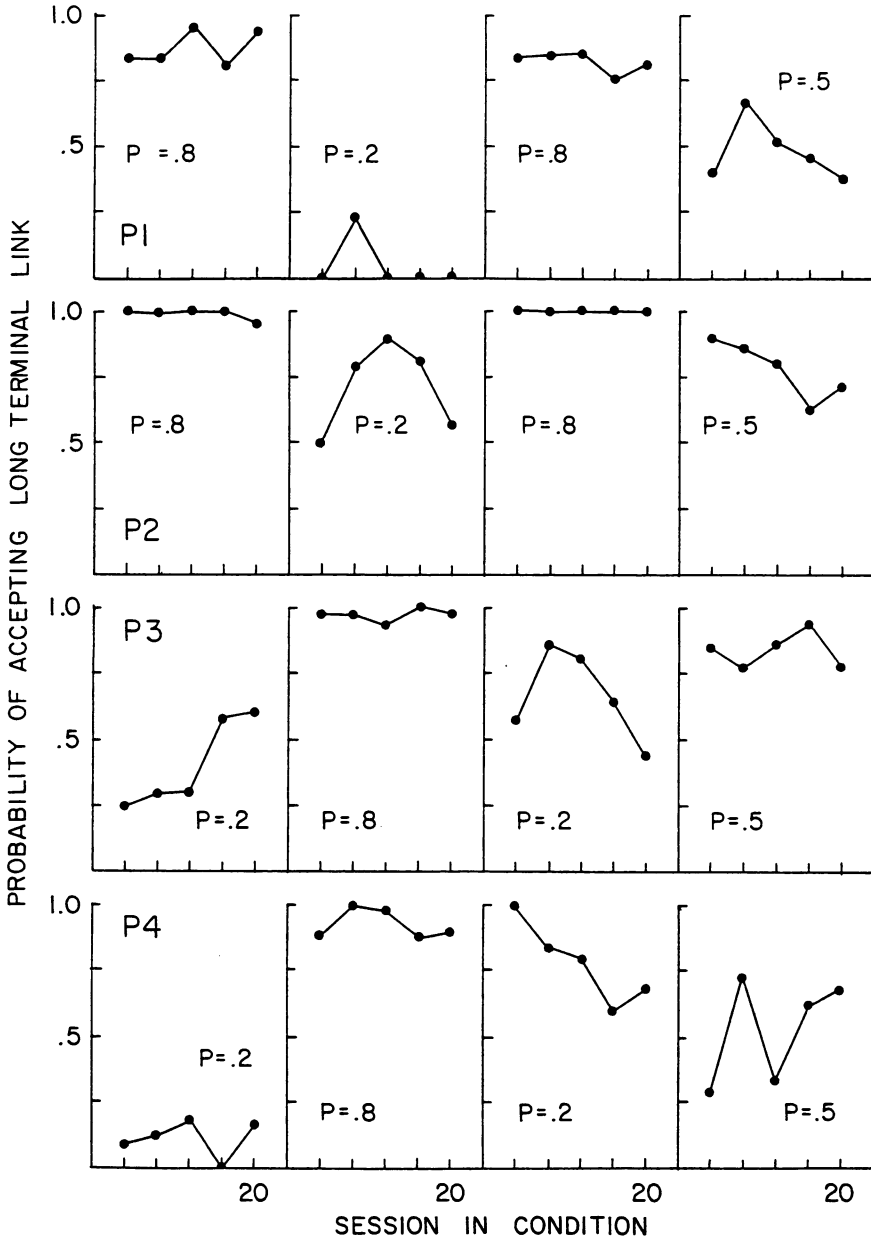


Fig. 4. Probability of remaining in the presence of the stimulus associated with the longer (VI 45 s) terminal-link schedule. Data are shown from the last five sessions of each of four conditions varying the probability of obtaining the long terminal link.

ditions under which Inequality 3 required rejection of the poorer outcome. These conditions are those with the shortest search time ( $S_L = 10$  s) and lowest probability ( $p = .2$ ). In the former condition the mean acceptance proportion was .53; in the latter condition the mean acceptance proportion was .45. The mean

acceptance proportion in the indifference condition was intermediate to those (.75). Thus the results deviated from those expected on the basis of Inequality 3 in that they were not "all-or-none." Instead, subjects accepted the poorer outcome about half the time in conditions under which the theory required rejection. This

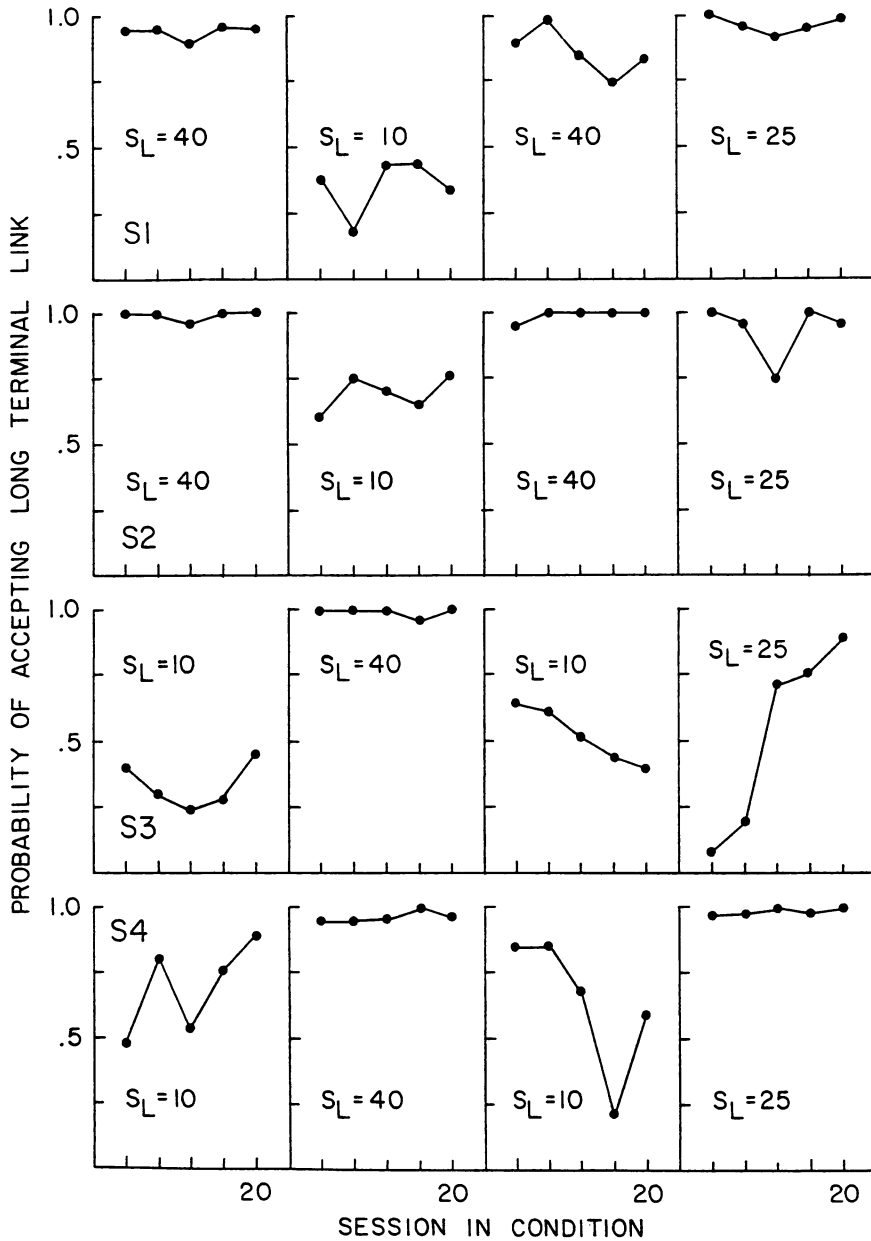


Fig. 5. Probability of remaining in the presence of the stimulus associated with the longer (VI 45 s) terminal-link schedule. Data are shown from the last five sessions of each of four conditions varying the search time leading to the long terminal link.

type of bias has been found commonly in tests of optimality (see Bovet, 1985, and Krebs, Kacelnik, & Taylor, 1978, for discussions). Although none of the explanations of this bias are entirely satisfactory, one that accords with much of the data is that advanced by Fantino, Abarca, and Dunn (1987). They note that one

should expect a bias towards acceptance. Whereas choosing to accept or reject an outcome requires a response, the stimulus cue for the proffered alternative is present and should influence acceptance, as the operant literature on both self-control and segmentation suggests. Moreover, the stimulus cue was presented on

the same key on which pecks were paired occasionally with food. Thus, elicited pecks directed at the stimulus (due to its pairing with food) might inflate the degree of acceptance found. Of course, if this account is valid and this bias were eliminated, we might also find that the more profitable outcome were not always accepted; that is, the same bias that may be inflating degree of acceptance of the less profitable outcome (and therefore disconfirming the prediction of exclusive rejection) may also be inflating degree of acceptance of the more profitable outcome (and therefore helping to confirm the prediction of exclusive acceptance of this outcome).

A second account of the lack of exclusive rejection involves economic context. Elliffe and Davison (1985) and LaFiette and Fantino (1988) have found that pigeons exposed to multiple schedules in 24-hr session procedures are much less accepting of the less preferred alternative than pigeons exposed to comparable multiple schedules with more conventional short sessions. In a sense, subjects are more "accepting" of the poorer component in short sessions than in 24-hr sessions. Perhaps we would have found stronger confirmation of our predictions had we used 24-hr sessions (a closed economy procedure of the type used by Hursh, 1984). Both of these accounts are, of course, testable.

In a qualitative sense, however, the present data are completely consistent with the predictions based on Inequality 3: Depending upon how accessibility of the less profitable outcome is arranged, very different effects on its acceptability are obtained. In the first place, as we make the poorer outcome more probable we make its acceptance more likely. In the second place, as we shorten the search time to the poorer outcome (while keeping search time to the richer outcome constant) we make its acceptance less likely. As shown in Figures 4 and 5, within each set of conditions the likelihood of accepting the poorer outcome varied directly with its probability and inversely with its encounter rate. We should repeat our caveat that the implications of our findings for naturally occurring foraging depend on the assumption that decision-making does not depend critically on the "naturalness" of the context in which it is studied. Obviously this assumption will not always be correct. Nonetheless, it appears that the present results fur-

ther extend the applicability of the delay-reduction hypothesis and the optimal diet model to operant analogues of foraging. It should also be noted that, depending on the assumptions made, other models of choice (Killeen, 1982; Mazur, Snyderman, & Coe, 1985; Vaughan, 1985) can make similar qualitative predictions. For example, according to Vaughan (1985) the distribution of responses on one of two available alternatives is determined by the local rates and values of reinforcement on each of the two alternatives. If the local rate or value of reinforcement on one alternative is higher than on the other, more time will be spent on the better alternative. As applied to the present procedure, the relevant reinforcers are those obtained in the choice phase when responses either accept or reject the lower valued outcome ( $t_L$ ). On each key the immediate consequence of responding is the termination of the stimulus on the other key and the reinforcing value of the remaining stimulus. In Vaughan's model the reinforcing value of  $t_L$  is a constant in our procedure because the rate of transition to food, given  $t_L$ , is never changed. However, as either  $p$  or  $S_L$  is varied, the reinforcing value of the search phase changes. As  $p$  or  $S_L$  decreases, Vaughan's model predicts less acceptance of  $t_L$  because the rate of transition out of the search phase is increased. Also, when  $p$  is decreased, the average value of search outcomes is increased producing less acceptance of  $t_L$ . The convergence of the several models' predictions suggests a commonality between foraging mechanisms and those studied in the operant laboratory. Thus, to respond to the central question posed earlier: Principles that have evolved from the study of decision-making in the operant laboratory continue to be consistent with decision-making in situations sharing important properties with foraging.

## REFERENCES

- Abarca, N., & Fantino, E. (1982). Choice and foraging. *Journal of the Experimental Analysis of Behavior*, **38**, 117-123.
- Abarca, N., Fantino, E., & Ito, M. (1985). Percentage reward in an operant analogue to foraging. *Animal Behavior*, **33**, 1096-1101.
- Baum, W. M. (1983). Studying foraging in the psychological laboratory. In R. L. Mellgren (Ed.), *Animal cognition and behavior* (pp. 253-283). Amsterdam: North-Holland.
- Bovet, P. (1985). The adaptive fitness of randomness in

- choice and foraging behavior. *Behavioral and Brain Sciences*, **8**, 331-332.
- Case, D. A., & Fantino, E. (1981). The delay-reduction hypothesis of conditioned reinforcement and punishment: Observing behavior. *Journal of the Experimental Analysis of Behavior*, **35**, 93-108.
- Collier, G. H., & Rovee-Collier, C. K. (1981). A comparative analysis of optimal foraging behavior: Laboratory simulations. In A. C. Kamil & T. D. Sargent (Eds.), *Foraging behavior: Ecological, ethological, and psychological approaches* (pp. 39-76). New York: Garland STPM Press.
- Elliffe, D., & Davison, M. (1985). Performance in continuously available multiple schedules. *Journal of the Experimental Analysis of Behavior*, **44**, 343-353.
- Fantino, E. (1969). Choice and rate of reinforcement. *Journal of the Experimental Analysis of Behavior*, **12**, 723-730.
- Fantino, E. (1982). Effect of initial-link length on responding in terminal link. *Behaviour Analysis Letters*, **2**, 65-70.
- Fantino, E., & Abarca, N. (1985). Choice, optimal foraging, and the delay-reduction hypothesis. *Behavioral and Brain Sciences*, **8**, 315-362. (Includes Commentary)
- Fantino, E., Abarca, N., & Dunn, R. (1987). The delay-reduction hypothesis: Extensions to foraging and three-alternative choice. In M. L. Commons, J. E. Mazur, J. A. Nevin, & H. Rachlin (Eds.), *Quantitative analyses of behavior, Vol. 5: The effect of delay and of intervening events on reinforcement value* (pp. 309-327). Hillsdale, NJ: Erlbaum.
- Fantino, E., & Case, D. A. (1983). Human observing: Maintained by stimuli correlated with reinforcement but not extinction. *Journal of the Experimental Analysis of Behavior*, **40**, 193-210.
- Fantino, E., & Dunn, R. (1983). The delay-reduction hypothesis: Extension to three-alternative choice. *Journal of Experimental Psychology: Animal Behavior Processes*, **9**, 132-146.
- Hursh, S. R. (1984). Behavioral economics. *Journal of the Experimental Analysis of Behavior*, **42**, 435-452.
- Ito, M., & Asaki, K. (1982). Choice behavior of rats in a concurrent-chains schedule: Amount and delay of reinforcement. *Journal of the Experimental Analysis of Behavior*, **37**, 383-392.
- Ito, M., & Fantino, E. (1986). Choice, foraging, and reinforcer duration. *Journal of the Experimental Analysis of Behavior*, **46**, 93-103.
- Kacelnik, A., & Krebs, J. R. (1985). Rate of reinforcement matters in optimal foraging theory. *Behavioral and Brain Sciences*, **8**, 340-341.
- Killeen, P. R. (1982). Incentive theory: II. Models for choice. *Journal of the Experimental Analysis of Behavior*, **38**, 217-232.
- Krebs, J. R., Kacelnik, A., & Taylor, P. (1978). Test of optimal sampling by foraging great tits. *Nature*, **275**, 27-31.
- La Fiette, M. H., & Fantino, E. (1988). The effects of component duration on multiple-schedule performance in closed and open economies. *Journal of the Experimental Analysis of Behavior*, **50**, 457-468.
- Lea, S. E. G. (1979). Foraging and reinforcement schedules in the pigeon: Optimal and non-optimal aspects of choice. *Animal Behaviour*, **27**, 875-886.
- Mazur, J. E., Snyderman, M., & Coe, D. (1985). Influences of delay and rate of reinforcement on discrete-trial choice. *Journal of Experimental Psychology: Animal Behavior Processes*, **11**, 565-575.
- Navarick, D. J., & Fantino, E. (1976). Self-control and general models of choice. *Journal of Experimental Psychology: Animal Behavior Processes*, **2**, 75-87.
- Vaughan, W., Jr. (1985). Choice: A local analysis. *Journal of the Experimental Analysis of Behavior*, **43**, 383-405.

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