SELF-CONTROL IN MALE AND FEMALE RATS

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Eight male and 8 female Wistar rats were exposed to a discrete-trial procedure in which they chose between the presentation of a small (one pellet) or a large (three pellets) reinforcer. The delay to the small and large reinforcer was 6.0 s in the first condition of Experiment 1. Subjects consistently chose the large reinforcer. When the delay to the small reinforcer was decreased to 0.1 s in the next experimental condition, all subjects continued to choose the large 6.0-s delayed reinforcer. When the contingencies correlated with the two levers were reversed in the next experimental condition, the majority of subjects (5 males and 6 females) still chose the large delayed reinforcer over the small immediately presented reinforcer. The delay to the small reinforcer was maintained at 6.0 s, but the delay to the large reinforcer was varied among 9.0, 15.0, 24.0, and 36.0 s in Experiment 2, in which 4 males and 4 females participated. Most subjects consistently chose the large increasingly delayed reinforcer, although choice for the small 6.0-s delayed reinforcer developed in some females when the large reinforcer was delayed for 24.0 or 36.0 s. These choice patterns were not predicted from a literal application of a model that says choice should favor the alternative correlated with the higher (amount/delay) ratio.

Key words: discrete-trial procedure, amount of reinforcement, delay of reinforcement, self-control, lever press, male and female rats

When subjects choose a large delayed reinforcer over a small immediate reinforcer, they are said to exhibit self-control (e.g., Ainslie, 1974, 1975; Grosch & Neuringer, 1981; Rachlin, 1974; Rachlin & Green, 1972). Pigeons generally choose the small immediate reinforcer over a large delayed reinforcer, exhibiting what is called impulsive behavior (Logue & Peña-Correal, 1984, 1985). Pigeons only sometimes choose the large delayed reinforcer after they have been exposed to extended training procedures in which the delay to the small reinforcer is gradually decreased or in which the delay to the large reinforcer is gradually increased (Logue, Rodriguez, Peña-Correal, & Mauro, 1984; Mazur & Logue, 1978). Pigeons' behavior in choice experiments may sometimes be described adequately by an ex-

tension of the matching law in which the equation

$$B1/B2 = (A1 \times D2)/(A2 \times D1) \quad (1)$$

describes behavior as a function of the delays to two different amounts of reinforcement (Baum & Rachlin, 1969; Herrnstein, 1970). $B1$ and $B2$ represent the number of responses, $A1$ and $A2$ the size (amount) of the two reinforcers, and $D1$ and $D2$ the delay of presentation of these reinforcers (e.g., Ainslie, 1974; Navarick & Fantino, 1976; Rachlin & Green, 1972). Recent refinements of this equation also take into account individual position bias (Ainslie & Herrnstein, 1981; Navarick & Fantino, 1976) and individual sensitivity to variations in amount and delay of reinforcement (Green & Snyderman, 1980).

It has recently been reported that humans, unlike pigeons, tend to choose the large delayed reinforcer more often than the small immediate reinforcer when offered a choice between these two response alternatives (Logue, Peña-Correal, Rodriguez, & Kabela, 1986; Navarick, 1986). It has also recently been suggested that the behavior of pigeons in discrete-trial choice experiments may be controlled not by the operant consequences arranged to follow the choice response but by the Pavlovian relationship between the presentation of a stimulus

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and the presentation of food. It is well known that a close temporal contiguity between a signal and food elicits signal-directed activity in pigeons, whereas a longer delay between the presentations of these two events does so to a smaller extent (for a review see Schwartz & Gamzu, 1977). Poling, Thomas, Hall-Johnson, and Picker (1985, Experiments I and II), for instance, showed that the choice of an autoshaping stimulus correlated with a small amount of reinforcement could be increased by either increasing the duration of an autoshaping stimulus correlated with a larger amount of reinforcement or by imposing a delay between the offset of that stimulus and the presentation of response-independent food. Lopatto and Lewis (1985) used a discrete-trial single-key choice procedure in which a pigeon's not pecking or pecking the key constituted choice between a large delayed reinforcer and a small immediate reinforcer (self-control procedure) or between a delayed reinforcer and no reinforcer (omission procedure). Lopatto and Lewis showed that pigeons contacted the choice key on more than 95% of the trials in the self-control and on more than 75% in the omission procedure. Differences in amount of reinforcement may play a role in choice when both amounts of reinforcement are presented temporally distant from a choice response but not when presentation of one amount immediately follows the stimulus complex in which a choice response occurs. Evidence for this notion may also be found in other experiments in which it was shown that pigeons will sometimes choose the large delayed reinforcer when the choice response is allowed to occur temporally distant from the actual presentation of the reinforcer (precommitment procedure, Ainslie, 1974; Rachlin & Green, 1972), or in experiments in which the duration of the stimuli associated with the delivery of food was relatively long (Poling *et al.*, 1985, Experiment III). Still other experiments, in which key pecks during the different delay intervals were measured, have provided evidence to suggest that Pavlovian parameters may be responsible for the occurrence of these ineffective responses during discrete-trial choice procedures (Logue & Peña-Correal, 1984, 1985). In view of the fact that recent experiments have suggested that the pigeon model of self-control may not adequately describe the parameters which govern self-control in other species and

because of the fact that some experiments have suggested that Pavlovian, more than operant, parameters may govern the choice of pigeons in these procedures, the present experiments employed Wistar rats to investigate the generality of Equation 1 in describing the behavior of a different species.

Male and female Wistar rats were exposed to a discrete-trial choice procedure similar to the one used by Logue and coworkers (1984, 1985, 1986). Male and female rats participated because of recent findings of behavioral differences between genders in some experimental procedures (Beatty, 1979; Heinsbroek, van Haaren, Zantvoord, & van de Poll, 1987; van Haaren & van de Poll, 1984a, 1984b, 1986; van Haaren, van Hest, & van de Poll, 1987; van Haaren, Wouters, & van de Poll, 1987; van Hest, van Haaren, & van de Poll, 1987a, 1987b).

EXPERIMENT 1

Subjects were first exposed to a discrete-trial choice procedure in which a press on the right lever produced access to a large reinforcer (three pellets, presented at 1-s intervals) delayed for 6.0 s and a press on the left lever produced a small reinforcer (1 pellet) also delayed for 6.0 s. The intent was to evaluate the adequacy of Equation 1 to predict the direction of preference. (Because the procedure used concurrent chains with fixed-ratio 1 schedules in the initial links, choice ratios were expected to be more extreme than implied by Equation 1.) More formally:

$$B1/B2 > 1,$$

when

$$A1 \times D2/A2 \times D1 > 1. \quad (2)$$

According to Equation 2, the experimental parameters manipulated in the first experimental condition should produce choice of the large delayed reinforcer (self-control). Subsequently the delay to the small reinforcer was reduced from 6.0 to 0.1 s while other experimental parameters remained the same. Also according to Equation 2, a choice reversal should be observed (impulsive behavior). In the next experimental condition, the contingencies associated with the two levers were reversed to assess the possible influence of extraneous variables (position bias). The two original choice alternatives (one pellet, 6.0-s delay; three

pellets, 6.0-s delay) were reinstated in the final condition of Experiment 1.

METHOD

Subjects

Eight male and eight female Wistar rats, who had previously participated in an auto-shaping experiment, served as subjects (van Haaren, van Hest, & van de Poll, 1987). They were 20 weeks old and weighed an average of 406 g (males) and 278 g (females) at the start of the present experiment. Subjects were housed in same-sex groups of four and maintained on a reversed light-dark cycle (lights on 3:30 p.m. to 3:30 a.m.). A 23-hour food deprivation schedule was in effect for the duration of the experiment (Hurwitz & Davis, 1983). Tap water was always available in the home cages.

Apparatus

Eight locally constructed modular rat chambers were used (34 cm wide, 33 cm long, and 37 cm high). The side walls and intelligence panel were made of black Perspex, and the front door was made of translucent Plexiglas. The floor of the chamber consisted of 26 grids, spaced 1.3 cm apart. Two retractable rodent levers (2.5 cm long, 2.8 cm wide, and 0.75 cm thick, when extended) were located symmetrically next to the pellet retrieval unit, 5.5 cm from the side walls of the chamber and 5 cm above the grids. The levers were spaced 23 cm apart (center to center) and required a force in excess of 0.20 N to be operated. The pellet retrieval unit could be illuminated by a white light. A stimulus light (green on the left and red on the right side of the intelligence panel) was located 9 cm directly above each lever. A houselight was mounted in the middle of the intelligence panel 3 cm from the ceiling of the chamber. Each experimental chamber was enclosed in a sound-attenuated, ventilated cabinet. The front door of this cabinet was also made of translucent Plexiglas. The chambers were connected to a PDP® 11-73 microcomputer (Digital Equipment Corporation) located in an adjacent room. Experimental contingencies and data acquisition procedures were programmed using SKED-11 (Snapper & Inglis, 1985), obtained from State Systems, Inc.

Procedure

Preliminary training. Lever-press training was not necessary because subjects had pre-

viously been exposed to different autoshaping procedures. They were, however, trained on a fixed-ratio 2 (FR 2) and FR 5 schedule (two sessions each) on the left and right levers before the start of the present experiment to ensure consistent responding on both levers.

Condition A. The houselight was illuminated at the start of the session. The first choice trial was initiated after 60 s; the levers were extended and the stimulus light above each lever was illuminated. A press on the left lever retracted the levers from the chamber and darkened the stimulus light above the right lever, while the delay (6.0 s) to the presentation of the small reinforcer (one pellet) was initiated. The stimulus light above the left lever remained illuminated until the delay interval had timed out. Presentation of the pellet associated with a press on the left lever was accompanied by the illumination of the tray light for 1.0 s. A press on the right lever also retracted both levers from the chamber, darkened the stimulus light above the left lever, and initiated the delay (6.0 s) to the presentation of the large reinforcer (three pellets). The light above the right lever remained illuminated during the delay interval. Presentation of each of the three pellets (at 1.0-s intervals) associated with a press on the right lever was accompanied by the illumination of the traylight for 1.0 s. Trials were presented every 60 s, unless the subjects failed to complete the preceding trial within 60 s. If that happened, the next trial was presented after an additional 60 s had elapsed. To ensure exposure to both response alternatives, forced trials (three to each alternative per session) were intermixed with choice trials. On a forced trial only one of the two levers was extended and its stimulus light illuminated. A press on the extended lever retracted the lever and initiated the same set of events that were associated with this lever during choice trials. Initially, 28 choice and six forced-choice trials were presented in each session. However, because some of the female rats failed to complete the 34 trials within the 45 min allowed, the number of trials per session was reduced to 27 (21 choice and six forced-choice trials) after 12 sessions. Forced-choice trials were then presented on Trials 4, 12, and 20 on the left lever (small reinforcer, 6.0-s delay) and on Trials 8, 16, and 24 on the right lever (large reinforcer, 6.0-s delay). Sessions were conducted

Table 1
Sequence of conditions in Experiment 1 and the number of sessions devoted to each.

Condition	Left lever		Right lever		Trials per session	Number of sessions
	Duration delay (s)	Pellets	Duration delay (s)	Pellets		
A	6.0	1	6.0	3	34	12
	6.0	1	6.0	3	27	20
B	0.1	1	6.0	3	27	16
C	6.0	3	0.1	1	27	28
D	6.0	3	6.0	1	27	16

from Monday through Friday and lasted until 27 trials had been presented or until 35 min had elapsed, whichever came first. Experimental conditions were changed whenever subjects had been exposed to an experimental condition for at least 10 sessions and when the group-averaged choice during the last four sessions in each condition did not differ by more than 10% from the averaged behavior observed during the preceding four sessions.

Condition B. This condition was identical to Condition A except that the delay associated with the presentation of the small reinforcer was reduced from 6.0 to 0.1 s, whereas the delay to the large reinforcer remained at 6.0 s.

Condition C. The contingencies associated with the two levers were reversed. Presentation of the small immediate reinforcer (one pellet, 0.1-s delay) was associated with a press on the right lever, whereas the large delayed reinforcer (three pellets, 6.0-s delay) was presented following a press on the left lever. All other experimental parameters were identical to those of the preceding experimental conditions.

Condition D. This condition was identical to Condition A except that presentation of the small or large reinforcers was associated with a press on the right and left levers, respectively. Both reinforcers were delayed for 6.0 s. Table 1 presents an overview of the sequence of conditions in Experiment 1 and the number of sessions devoted to each.

RESULTS AND DISCUSSION

Figures 1 and 2 show the percentage of large reinforcer choices (averaged over four sessions) during the different experimental conditions for individual male (Figure 1) and female rats (Figure 2). Male and female rats chose the large reinforcer when both reinforcers were delayed for 6.0 s (Condition A, second panel

from the left in Figures 1 and 2). When the delay to the small reinforcer was decreased to 0.1 s in the next experimental condition, males and females chose the large delayed reinforcer over the small immediately presented reinforcer. Choice of males was not influenced, but females tended to choose the large delayed reinforcer less frequently compared to the first experimental condition. However, individual subjects in both groups (except for Female 83) chose the large delayed reinforcer during more than 80% of the choice trials in the final four sessions of this experimental condition. Both males and females initially chose the small immediately presented reinforcer over the large delayed reinforcer when the contingencies associated with the two levers were reversed in the third condition. However, 5 males (60, 62, 70, 71, and 73) and 6 females (41, 42, 80, 81, 82, and 83) consistently chose the large delayed reinforcer over the small immediate reinforcer at the end of training in this experimental condition. Three males (61, 63, and 72) and 1 female (43) chose the small immediate reinforcer, whereas 1 female (40) chose both reinforcers about equally often. Given the fact that subjects 61, 63, 72, and 43 chose the large delayed over the small immediate reinforcer before the contingencies associated with the two levers were reversed, it may have been the case that the assessment of preference in these subjects was biased by a strong position preference. All males and females chose the large delayed reinforcer over the small immediately presented reinforcer when both the small and the large reinforcers were again delayed for 6.0 s in the final experimental condition.

The results of this experiment thus show that male and female Wistar rats, when given the choice between a small immediately presented reinforcer and a large delayed reinforc-

Fig. 1. Percentage choice of the large reinforcer during the different experimental conditions of Experiment 1 for male subjects. The leftmost panel shows choice data during the very first experimental condition in which subjects were exposed to a total of 34 trials (28 choice and 6 forced-choice trials). Subsequent experimental conditions consisted of 27 trials (21 choice and 6 forced-choice trials). Condition A: small (one pellet) reinforcer delayed for 6.0 s; large (three pellets) reinforcer delayed for 6.0 s. Condition B: small reinforcer delayed for 0.1 s; large reinforcer delayed for 6.0 s. Condition C: reversal of the experimental contingencies of Condition B. Condition D: large and small reinforcers delayed for 6.0 s.

er, choose the large delayed reinforcer within a relatively small number of training sessions, showing ample evidence of self-control and maximization of the total amount of reinforcement obtained per unit time. These observations are in contrast with those observed in other experiments. It has been frequently reported that pigeons will choose a small immediate reinforcer over a large delayed reinforcer when exposed to discrete-trial choice procedures in which these variables are manipulated (e.g., Fantino, 1966; Logue & Peña-

Correal, 1984, 1985; Logue et al., 1984; Mazur & Logue, 1978) even when such behavior produces less than the maximum amount of food available.

EXPERIMENT 2

Experiment 1 investigated the behavior of male and female rats when different amounts of reinforcement were delayed for either 6.0 or 0.1 s in a discrete-trial choice procedure. It could be argued that the scheduled delay of

Fig. 2. Percentage choice of the large reinforcer during the different experimental conditions of Experiment 1 for female subjects. The leftmost panel shows choice data during the very first experimental condition in which subjects were exposed to a total of 34 trials (28 choice and 6 forced-choice trials). Subsequent experimental conditions consisted of 27 trials (21 choice and 6 forced-choice trials). Condition A: small (one pellet) reinforcer delayed for 6.0 s; large (three pellets) reinforcer delayed for 6.0 s. Condition B: small reinforcer delayed for 0.1 s; large reinforcer delayed for 6.0 s. Condition C: reversal of the experimental contingencies of Condition B. Condition D: large and small reinforcers delayed for 6.0 s.

0.1 s was actually longer, due to, for instance, the time it takes the rat to travel from the lever to the pellet retrieval unit. If the experienced delay were longer than 2.0 s, a modification of Equation 2, in which such travel time can be taken into account, would adequately predict choice of the large delayed reinforcer (see Mazur, 1986a, 1986b; Mazur, Snyderman, & Coe, 1985). Experiment 2 was thus designed to investigate the effects of different delay parameters on behavior of male and female rats in the same discrete-trial choice procedure. Four male and 4 female rats, who had participated in Experiment 1, were exposed to different

experimental conditions in which the delay to the large reinforcer was either 9.0, 15.0, 24.0, or 36.0 s, and the delay to the small reinforcer remained fixed at 6.0 s. Equation 2 suggests that subjects will choose the large reinforcer when its delay does not exceed 18.0 s, whereas the small reinforcer should be chosen when the delay to the large reinforcer exceeds 18.0 s.

METHOD

Subjects, Apparatus, and Procedure

Four male (60, 61, 62, and 63) and 4 female rats (40, 41, 42, and 43) from Experiment 1

Table 2

Experimental conditions in Experiment 2 and the sequence in which they were presented.

Left lever		Right lever		Sequence of conditions			
Duration delay (s)	Pellets	Duration delay (s)	Pellets	60, 43	61, 42	62, 41	63, 40 ^a
6.0	1	9.0	3	1	2	4	3
15.0	3	6.0	1	2	1	3	4
6.0	1	24.0	3	3	4	1	2
36.0	3	6.0	1	4	3	2	1

^a Subject identification.

participated. The apparatus was the same as used in Experiment 1.

The experimental procedure was basically identical to the one used in Experiment 1. The delay to the large reinforcer was manipulated in different experimental conditions and was either 9.0, 15.0, 24.0, or 36.0 s. Subjects were exposed to each of the different large reinforcer delays for 20 sessions. The sequence in which these conditions were presented differed for each subject. When experimental conditions were changed, the correlation between lever position and reinforcer amount was reversed. For instance, if presentation of the large reinforcer had been associated with a response on the left lever in the first experimental condition, presentation of the large reinforcer followed a response on the right lever in the second experimental condition, and so on. This manipulation was introduced to prevent position preferences from biasing the behavioral effects of manipulations of other experimental variables. Table 2 presents an overview of the different experimental conditions and the sequence in which they were presented.

RESULTS AND DISCUSSION

Figure 3 shows the percentage of large reinforcer choices (averaged over four sessions) for males (top panel) and females (bottom panel) during the different experimental conditions. Delay durations to the large reinforcer are shown in increasing order from left to right. Note, however, that the sequence in which they were presented differed for individual subjects.

When given the opportunity to choose between a small reinforcer delayed for 6.0 s or a larger reinforcer delayed for 9.0, 15.0, 24.0, or 36.0 s, males consistently chose the large reinforcer in more than 90% of the choice trials during the final four sessions of each experimental condition. Females 41 and 42 also chose the large delayed reinforcer (except Female 41

during the 24.0-s condition). Female 40 chose the large reinforcer over the small reinforcer when the delay to the large reinforcer was 9.0, 15.0, or 24.0 s, but chose the small 6.0-s delayed reinforcer when the large reinforcer was delayed for 36.0 s. The behavior of Female 43 was completely unlike that observed in other subjects. Her choice was systematically affected by the manipulation in the delay to the large reinforcer. She chose the large reinforcer over the small reinforcer when the delay to the large reinforcer was 9.0 s, was indifferent at the 15.0-s delay duration, and chose the small 6.0-s delayed reinforcer when the delay to the large reinforcer was 24.0 or 36.0 s. Figure 4 shows the averaged percentage of large delayed reinforcer choices for male and female rats in the different conditions of this experiment.

Analysis of variance in which the factors Gender, Delay (duration to large reinforcer), and Sessions (five blocks of four) were analyzed, the latter two repeated measures, showed that males were more likely than females to choose the large delayed reinforcer [Gender: $F(1, 6) = 8.84, p < 0.025$]. Choice for the large delayed reinforcer developed faster for males than for females within experimental conditions [Gender $\times$ Sessions: $F(4, 24) = 4.79, p < 0.005$]. Although the results presented in Figure 4 suggest the existence of a Gender $\times$ Delay interaction (a decrease in the percentage of large delayed reinforcer choices as a function of an increase in delay duration for females, but not for males), this effect failed to reach statistical significance [Gender $\times$ Delay: $F(3, 18) = 1.08, n.s.$].

In summary, the behavior of male and female rats in discrete-trial choice procedures in which amount and delay of reinforcement are systematically manipulated is not adequately predicted by Equation 2. Males consistently chose the large 9.0, 15.0, 24.0, or 36.0-s delayed reinforcer over the small 6.0-s delayed

Fig. 3. Percentage choice of the large reinforcer during the different experimental conditions in Experiment 2. The small (one pellet) reinforcer was always delayed for 6.0 s, whereas the delay to the large reinforcer was either 9.0, 15.0, 24.0, or 36.0 s. Large reinforcer delay conditions are shown from left to right for all subjects, but individual subjects were exposed to the delay conditions in different orders. Choice percentages in the top and bottom panels of the figure refer to those observed in males and females, respectively.

reinforcer. The choice of female rats suggested that they may have been more sensitive than males to manipulations in the delay to the large reinforcer.

GENERAL DISCUSSION

The present experiments were designed to investigate whether or not the pigeon model of self-control (Logue & Peña-Correal, 1984, 1985; Mazur & Logue, 1978) adequately describes self-control or impulsive behavior in another species (the albino rat). The choice of male rats resulted in maximizing the amount of food in the discrete-trial choice procedures intended to be similar to those in which pi-

geons' choices usually do not maximize food. Female rats tended to choose similarly to males, but chose the large delayed reinforcer less frequently than males did at longer delay-interval durations. The results of these experiments thus are not identical to those obtained with pigeons but rather resemble the recent observations with human subjects in similar experimental procedures (Logue *et al.*, 1986; Navarick, 1986). It should be noted, however, that the results of the present experiments are also at odds with the results of T-maze experiments with rats, in which it was shown that delay and amount of reinforcement systematically affected the choice behavior of rats (e.g., Eisenberger, Masterson, & Lowman, 1982; Lo-

Fig. 4. Averaged percentage choice for the large delayed reinforcer for males and females during the different conditions of Experiment 2. The small reinforcer (one pellet) was always delayed for 6.0 s, whereas the delay to the large reinforcer (three pellets) was varied among 9.0, 15.0, 24.0, and 36.0 s.

gan, 1965). A further analysis of procedural differences reveals the basis of these different results.

Pigeons' behavior has been investigated in different discrete-trial choice procedures in which response opportunities are not continuously available but are scheduled to occur once every T seconds. In one variant of this procedure, responses on different choice alternatives initiate the delay period to and the presentation of one of the two available reinforcers (Logue & Peña-Correal, 1984, 1985; Logue et al., 1986; Mazur & Logue, 1978). In another variant of this procedure, signal periods are presented on one response manipulandum, which result in the presentation of a large reinforcer when responses do not occur and the presentation of a small reinforcer immediately upon the occurrence of a response during the signal period (go/no-go discrimination, Ainslie, 1974; Grosch & Neuringer, 1981; Lopatto & Lewis, 1985). In both discrete-trial procedures, reinforcement frequency is independent of the subjects' behavior but is determined by the frequency with which the trials are presented. Despite the differences in experimental procedures, some variation of Equation 1 usually describes the choice of pigeons (see Logue & Peña-Correal, 1984, 1985), but may not always describe the choice of humans (Logue et al., 1986; Navarick, 1986) or rats.

A number of variables may be responsible for the behavioral differences between pigeons and rats in discrete-trial choice procedures. It could be argued, for instance, that between-individual, within-individual, and perhaps between-species differences in discrete-trial choice performance can be interpreted to reflect different sensitivity exponents for the amount and delay dimensions manipulated in these experiments (Logue et al., 1984). By this line of reasoning, the performance of the rats in this experiment might indicate a reduced sensitivity of choice for the delay dimension, relative to that found for pigeons, rather than a different kind of control. However, whether or not between-species differences in sensitivity are species related or are a function of procedural parameters remains to be investigated in future experiments. It could also be argued that the relation between the number of pellets and the theoretical quantity A might not be the same as that between feeder duration and A . Perhaps the amount of preparatory consummatory behavior influences the reinforcing effectiveness of a given amount of food (Shettleworth, 1985). Finally, it has been argued that discrete-trial choice in pigeons may be influenced more by the Pavlovian relationship between the presentation of a stimulus (key-light) and the delay to the presentation of food than by the operant consequences which follow the choice. If short delays between stimulus

presentations and the presentation of food are more likely to generate stimulus-directed behavior than longer delays, one would expect choice of pigeons to be more susceptible to Pavlovian interference than that of rats exposed to a similar procedure. The pairing of a keylight with food usually generates higher stimulus-directed activity than do similar pairings of lever presentations and food (see Schwartz & Gamzu, 1977).

In summary, the present experiments provide evidence that the pigeon model of self-control does not contain the information necessary to predict the direction of choice in another species. Logue *et al.* (1986, p. 160) suggested that it is important "to begin to explore why it has been difficult to demonstrate impulsive behavior in the laboratory using positive reinforcement in adult humans." The results of their and other experiments, however, suggest that it might be profitable to explore further the variables that influence impulsive behavior in other species as well.

Males were more likely than females to show exclusive preference for the large delayed reinforcer in Experiment 2. Behavioral differences between the genders have, until recently, been explored only in relatively simple operant procedures. For instance, males have been shown to be more efficient than females in lever-hold experiments (van Hest *et al.*, 1987a), whereas females were more likely than males to behave efficiently when exposed to procedures in which low rates of lever pressing were reinforced (van Hest *et al.*, 1987b). Males have been shown to respond at higher rates than females during random-ratio acquisition (Heinsbroek *et al.*, 1987) and autoshaping experiments (van Haaren, van Hest, & van de Poll, 1987). Although these data and those of the present experiment suggest that manipulations of environmental variables may differentially affect an organism's behavior dependent upon its prevailing hormonal condition (see also Beatty, 1979), it is premature to determine whether these effects are quantitatively or qualitatively different.

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