*SELF-CONTROL IN MENTALLY RETARDED ADOLESCENTS:
CHOICE AS A FUNCTION OF AMOUNT AND DELAY OF
REINFORCEMENT*

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Three severely mentally retarded adolescents were studied under discrete-trial procedures in which a choice was arranged between edible reinforcers that differed in magnitude and, in some conditions, delay. In the absence of delays the larger reinforcer was consistently chosen. Under conditions in which the smaller reinforcer was not delayed, increasing the delay to delivery of the larger reinforcer decreased the percentage of trials in which that reinforcer was chosen. All subjects directed the majority of choice responses to the smaller reinforcer when the larger reinforcer was sufficiently delayed, although the value at which this occurred differed across subjects. Under conditions in which the larger reinforcer initially was sufficiently delayed to result in preference for the smaller one, progressively increasing in 5-s increments the delay to both reinforcers increased percentage of trials with the larger reinforcer chosen. At sufficiently long delays, 2 of the subjects consistently chose the larger, but more delayed, reinforcer, and the 3rd subject chose that reinforcer on half of the trials. These results are consistent with the findings of prior studies in which adult humans responded to terminate noise and pigeons responded to produce food.

Key words: self-control, species differences, choice, delay of reinforcement, humans

Several researchers have defined self-control as choosing the larger, but more delayed, of two alternative reinforcers (Ainslie, 1974, 1975; Green, Fisher, Perlow, & Sherman, 1981; Grosch & Neuringer, 1981; Rachlin, 1974; Rachlin & Green, 1972). Choosing the smaller reinforcer constitutes impulsiveness. Pigeons often behave impulsively in the sense of preferring smaller, less delayed, food deliveries (e.g., Fantino, 1966; Logue, Rodriguez, Peña-Correal, & Mauro, 1984; Mazur & Logue, 1978).

In contrast to findings with pigeons, Logue, Peña-Correal, Rodriguez, and Kabela (1986) reported that adult humans usually chose the larger reinforcer (points exchangeable for money) even when it was delayed. In summarizing the results of a series of five experiments employing discrete-trial and concurrent-schedule procedures, Logue et al. (1986) concluded that "the results of all the experiments suggest that the subjects followed a max-

imization strategy in choosing reinforcers. Such behavior makes it easy to observe self-control and difficult to observe impulsiveness in traditional laboratory experiments that use adult human subjects" (p. 159). This conclusion is supported to a degree by the results of a study by Millar and Navarick (1984), who found that only a minority of the adult humans they studied failed to maximize (i.e., behaved impulsively). It is not, however, supported by the results of studies in which adult humans responded to terminate white noise. When this form of negative reinforcement was employed, preference for the smaller, but less delayed, of two reinforcers was consistently observed (Navarick, 1982; Solnick, Kannenberg, Eckerman, & Waller, 1980).

It is not obvious why pigeons and people behave differently under procedures involving positive reinforcement, or why results with adult humans differ with positive and negative reinforcement. However, in the study by Logue et al. (1986), conditioned positive reinforcers were employed, whereas primary reinforcers (food deliveries) were used in the experiments with pigeons (e.g., Ainslie, 1974; Green et al., 1981; Logue et al., 1984; Mazur & Logue, 1978). It is possible that this difference contributed to the dissimilar performance of humans and nonhumans. The present study ex-

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amined the choice behavior of mentally retarded adolescents under conditions in which two food deliveries, differing in amount and delay, were available. The procedures employed were similar to those used by Green *et al.* (1981) to examine self-control in pigeons. In that study, the birds were given a choice between 2-s and 6-s food deliveries under conditions in which delay to the larger reinforcer was always 4 s longer than delay to the smaller reinforcer. The delay to each reinforcer was varied and, "as the delay between the availability of the choice and the availability of the smaller reward increased from 2 to 28 s, every pigeon reversed its preference from the smaller to the larger, more delayed reward" (Green *et al.*, 1981, p. 43). The present study determined whether a similar outcome would obtain with humans. Severely mentally retarded adolescents were studied because food served as a powerful reinforcer for them in the absence of programmed deprivation.

METHOD

Subjects

The subjects were three severely mentally retarded adolescents, ages 14 (Subject 1), 17, and 17 years, enrolled in a school program for the severely impaired. Subjects 1 and 3 were males, Subject 2 was female. They were viewed by the school staff as working well for edibles and possessing the skills necessary to complete the experimental tasks. Each subject had limited communication skills but responded to a number of simple requests. Informed consent to participate in the study was obtained from the parent(s) or guardian of each subject.

Apparatus

The study was conducted in an observation room (2m by 2m) containing a desk with attached chair, an unattached chair, and a cabinet containing electromechanical programming equipment. Subjects responded by touching a purple circle (14 cm diameter) or a yellow square (14 cm on a side). These stimuli, separated by 9 cm, were centered on a white paper card (24 cm by 40 cm). During experimental trials the card was centered on the desk 15 cm in front of the subject. A white card (14 cm by 20 cm) covered the appropriate stimulus during forced trials. Cocoa Puffs cereal (General Mills, Minneapolis) was used

as the reinforcer because it was easy to deliver and to measure and did not produce satiation at the amounts delivered.

The experimenter was provided with a small (19 cm by 10 cm by 8 cm) metal recording box on which were mounted two pushbuttons and associated stimulus lights. The experimenter pushed one of these buttons during trials when the subject selected (touched) the purple circle; he pushed the other when the yellow square was chosen. Depressing the pushbutton advanced a counter and operated a timer set for the appropriate delay of reinforcement. The stimulus light above the button that was pushed was lighted during the delay interval; the experimenter delivered the appropriate reinforcer (one or three Cocoa Puffs) when the light went out. The stimulus light and the illumination it provided were not visible to the subject; the experimenter's hands were returned to the top of the table after the button was depressed (*i.e.*, the delay was not signaled).

Procedure

All subjects were given five sessions of pretraining. Each consisted of 20 trials in which two objects familiar to the subject were placed on the desk (*e.g.*, a pencil and an apple). The subject was asked to sit with his or her hands down and to look at the experimenter (first author), then was requested to "Touch the _____." The subject was verbally praised if he or she did so. The trial was repeated if this did not occur.

Following pretraining the experiment proper was begun. The general experimental procedure was the same in all sessions, each of which consisted of 10 forced trials followed by 10 choice trials. At the beginning of the session the subject was instructed to sit at the desk in the attached seat with his or her hands down. The experimenter sat directly across the desk from the subject. A tray containing the reinforcers (placed in cups containing one or three bits of cereal) and the recording box were placed on the experimenter's lap out of sight of the subject.

Each trial began with the experimenter placing the response card on the table in front of the subject. The location of the yellow square and purple circle relative to the subject (*i.e.*, to the right or left) was determined quasi-randomly, with the provision that the card be presented in the same orientation on no more

than two consecutive trials. After the card was presented, the subject was told to "Pick one." During the first 10 trials of each session, only one stimulus was available; the other was covered. The yellow square was covered during five of these forced trials (selected at random); the purple circle was covered during the remainder. When the subject touched the stimulus, the experimenter removed the response card and began timing the delay interval. The appropriate reinforcer (one or three bits of cereal) was delivered after the scheduled delay. Subjects always consumed the cereal as soon as it was presented.

Choice trials were identical to forced trials except that both stimuli were presented. In these trials, the magnitude and delay of reinforcement depended on the stimulus that the subject touched first. In the majority of trials, only one choice response occurred. All trials were separated by an intertrial interval (ITI) in which the response card was unavailable. For all trials, a minimum ITI of 10 s was arranged. This value was used for all trials unless the larger reinforcer was delayed. If this occurred, the ITI following a trial with the larger reinforcer selected was 10 s. If, however, the smaller reinforcer was selected, the delay associated with the larger reinforcer was added to the ITI. This procedure was used to ensure that the overall rate of reinforcement was not indirectly affected by the delay value. Throughout the study, experimental conditions remained in effect until the performance of each subject stabilized. The criterion for stability was three consecutive sessions in which percentage of choices of the larger reinforcer did not vary or five consecutive sessions in which this measure varied by less than 10%. Because of the very limited verbal skills of the subjects, no formal instructions were given at any point in the study. The experimenter began each session by telling the subject "come with me" and leading him or her to the room in which the study was conducted. Other than that vocalization and the request "pick one" that prompted a response in each trial, the experimenter did not speak to the subjects during the experiment.

The experiment was conducted in two phases. During both phases, two sessions were typically conducted each weekday for all subjects (at about 9:30 a.m. and 2:00 p.m.). Phase 1 was designed to assess preference under con-

ditions in which one and three pieces of cereal were available, the smaller reinforcer was delivered immediately after a response, and the larger reinforcer was delayed by increasing amounts until preference shifted from the larger to the smaller reinforcer. Initially, each subject was given a choice between one and three Cocoa Puffs, each delivered immediately after a choice response (touching the yellow square or purple circle). The purple circle was correlated with the larger reinforcer for Subjects 1 and 2 and the yellow square was correlated with the larger reinforcer for Subject 3. After performance became stable, the outcomes associated with these stimuli were reversed (i.e., the square was correlated with the larger reinforcer for Subjects 1 and 2 and the circle was correlated with the larger reinforcer for Subject 3). When performance became stable under this condition, delivery of the larger reinforcer was delayed by 5 s. In subsequent conditions, the delay was increased in multiples of 5 s until the percentage of choice responses directed to the stimulus correlated with the larger reinforcer was 20 or below on three consecutive sessions. This occurred with the larger reinforcer delayed 10 s for Subject 1, 20 s for Subject 2, and 30 s for Subject 3. Throughout the study, each condition was in effect until performance was stable for all subjects.

Following exposure to the ascending sequence of delays to the larger reinforcer, each subject was exposed to the same delays arranged in descending order, with the exception that the maximum delay was repeated at some point in the sequence. Table 1 shows for each subject the conditions involved in Phase 1 and the number of sessions of exposure to them. Note that the delay to the smaller reinforcer was 0 s throughout this phase.

Phase 2 evaluated the effects of delaying both reinforcers. In the initial condition of this phase, the smaller reinforcer was not delayed and the larger reinforcer was delayed by the value that shifted preference from the larger to the smaller reinforcer in Phase 1 (i.e., by 10 s for Subject 1, 20 s for Subject 2, and 30 s for Subject 3). In the next condition, 5 s was added to the delay for each reinforcer. Thus, for Subject 1, the larger reinforcer was delayed by 15 s and the smaller by 5 s. Each subsequent condition added 5 s to the delay of each reinforcer. For Subjects 1 and 2, delays were in-

Table 1

Experimental conditions for each subject during Phase 1. Conditions are listed in chronological order and are labeled according to the delay and magnitude of reinforcement correlated with each response alternative. Delays are listed in seconds. The larger reinforcer consisted of three pieces of breakfast cereal (Cocoa Puffs) and the smaller reinforcer consisted of one piece of the same cereal.

Condi- tion	Ses- sions	Yellow square		Purple circle	
		S ^R	Delay (s)	S ^R	Delay (s)
Subject 1					
1	8	Smaller	0	Larger	0
2	8	Larger	0	Smaller	0
3	10	Larger	5	Smaller	0
4	5	Larger	10	Smaller	0
5	8	Larger	5	Smaller	0
6	8	Larger	10	Smaller	0
7	3	Larger	0	Smaller	0
Subject 2					
1	13	Smaller	0	Larger	0
2	12	Larger	0	Smaller	0
3	3	Larger	5	Smaller	0
4	3	Larger	10	Smaller	0
5	3	Larger	15	Smaller	0
6	5	Larger	20	Smaller	0
7	3	Larger	15	Smaller	0
8	4	Larger	10	Smaller	0
9	3	Larger	5	Smaller	0
10	5	Larger	0	Smaller	0
11	4	Larger	20	Smaller	0
Subject 3					
1	8	Larger	0	Smaller	0
2	9	Smaller	0	Larger	0
3	6	Smaller	0	Larger	5
4	8	Smaller	0	Larger	10
5	4	Smaller	0	Larger	15
6	4	Smaller	0	Larger	20
7	8	Smaller	0	Larger	25
8	6	Smaller	0	Larger	30
9	8	Smaller	0	Larger	25
10	3	Smaller	0	Larger	20
11	3	Smaller	0	Larger	15
12	3	Smaller	0	Larger	10
13	5	Smaller	0	Larger	5
14	7	Smaller	0	Larger	0
15	3	Smaller	0	Larger	30

creased until over 80% of choice responses were directed to the larger reinforcer on three consecutive sessions. This occurred for Subject 1 with the smaller reinforcer delayed 15 s and the larger reinforcer delayed 25 s and for Subject 2 with the smaller reinforcer delayed 5 s and the larger reinforcer delayed 25 s. For Subject 3, delays were increased to 30 s for the smaller reinforcer and 60 s for the larger. Be-

Table 2

Experimental conditions for each subject during Phase 2. Conditions are listed in chronological order and are labeled according to the delay and magnitude of reinforcement correlated with each response alternative. Delays are listed in seconds. The larger reinforcer consisted of three pieces of breakfast cereal (Cocoa Puffs) and the smaller reinforcer consisted of one piece of the same cereal.

Condi- tion	Ses- sions	Yellow square		Purple circle	
		S ^R	Delay (s)	S ^R	Delay (s)
Subject 1					
1	6	Larger	10	Smaller	0
2	3	Larger	15	Smaller	5
3	8	Larger	20	Smaller	10
4	9	Larger	25	Smaller	15
5	4	Larger	20	Smaller	10
6	3	Larger	15	Smaller	5
7	5	Larger	10	Smaller	0
8	4	Larger	25	Smaller	15
Subject 2					
1	4	Larger	20	Smaller	0
2	5	Larger	25	Smaller	5
3	4	Larger	20	Smaller	0
4	5	Larger	25	Smaller	5
Subject 3					
1	3	Smaller	0	Larger	30
2	4	Smaller	5	Larger	35
3	3	Smaller	10	Larger	40
4	3	Smaller	15	Larger	45
5	3	Smaller	20	Larger	50
6	3	Smaller	25	Larger	55
7	3	Smaller	30	Larger	60
8	3	Smaller	20	Larger	50
9	3	Smaller	10	Larger	40
10	5	Smaller	0	Larger	30
11	3	Smaller	30	Larger	60

cause considerable emotional responding was observed at this value and the school year was ending, no further increases were arranged although the criterion for preference had not been met. After the ascending series of delays was evaluated, the same delays were examined in a descending sequence with Subjects 1 and 2, with the exception that the largest delay was repeated at some point in the sequence. In order to complete the study during the school year, for Subject 3 delays were decreased by multiples of 10 s during the descending series. Table 2 shows for each subject the conditions involved in Phase 2 and the number of sessions of exposure to them.

During 33 randomly selected experimental sessions, an observer watched the subject

through a one-way mirror and recorded his or her choice on each trial. These values were compared to the numbers on the counters to check the accuracy of the experimenter's recording. Unlike the experimenter, the observer was not aware of the purpose of the experiment and was not informed with respect to experimental conditions.

RESULTS

In each session for which reliability data were collected, the data recorded by the observer agreed perfectly with those recorded on the counters, indicating the experimenter was accurately monitoring behavior. Figure 1 shows individual-subject data for the last three sessions of each condition of Phase 1. Although some between-subject variability was evident, each subject generated stable and similar data on both exposures to each experimental condition. All subjects strongly preferred the larger reinforcer when neither was delayed. As the delay to delivery of the larger reinforcer increased, the percentage of trials in which that reinforcer was chosen decreased. All subjects directed the majority (>80%) of choice responses to the smaller reinforcer when the larger reinforcer was sufficiently delayed. However, the value at which this occurred varied across subjects. The preference of Subject 1 changed when the larger reinforcer was delayed 10 s, that of Subject 2 changed when it was delayed 20 s, and that of Subject 3 changed when it was delayed 30 s. For Subjects 1 and 3, percentage of trials in which the larger reinforcer was chosen declined systematically as delay to the larger reinforcer increased. Subject 2 directed over 80% of all choice responses to the larger reinforcer until it was delayed by 20 s, at which point the smaller reinforcer controlled over 80% of choices.

Figure 2 presents data from the last three sessions of each experimental condition in Phase 2. This phase began with the larger reinforcer delayed by the value that shifted preference from the larger to the smaller reinforcer in Phase 1. At this value in the beginning of Phase 2, each subject directed the majority of choice responses to the smaller reinforcer. For all subjects the percentage of trials with the larger reinforcer chosen increased as delays were added to the delivery of both the smaller and the larger reinforcers. When the delays

were sufficiently long, Subjects 1 and 2 allocated the majority (>80%) of choice responses to the larger reinforcer. This occurred for Subject 1 when the delay to the smaller reinforcer was 15 s and the delay to the larger reinforcer was 25 s. For Subject 2, the larger reinforcer was preferred when it was delayed by 25 s and the smaller reinforcer was delayed by 5 s. Subject 3 never directed the majority of choice responses to the stimulus correlated with the larger reinforcer. At all delays other than that initially evaluated, when the smaller reinforcer was preferred, Subject 3 chose the larger reinforcer on 50% of all trials. Under these conditions, a strong position preference was evident in this subject; he always chose the stimulus presented to his right.

DISCUSSION

Several studies with pigeons have examined the effects of delay and magnitude of food delivery and their interaction. Unless given special and extensive training in which delays are very gradually increased (e.g., Logue & Mazur, 1981; Logue et al., 1984; Mazur & Logue, 1978), the birds often prefer the smaller, but less delayed, of two reinforcers. This relation has been demonstrated using concurrent-chains schedules (e.g., Green & Snyderman, 1980; Navarick & Fantino, 1976; Rachlin & Green, 1972; Snyderman, 1983) and discrete-trial procedures (e.g., Ainslie, 1974; Green et al., 1981; Hall-Johnson & Poling, 1984; Logue & Peña-Correal, 1984).

Although pigeons often behave impulsively in the sense of choosing the smaller, less delayed, reinforcer, they do not always do so. One variable that influences the probability of pigeons choosing the larger, but more delayed, of two reinforcers is the time between emission of the choice response and delivery of each of the alternative reinforcers. In general, preference for the larger more delayed reinforcer increases as the delay to the alternative outcomes increases (e.g., Ainslie, 1974; Green & Snyderman, 1980; Green et al., 1981; Logan & Spanier, 1970; Rachlin & Green, 1972). For example, Green et al. (1981) gave pigeons a choice between 2-s and 6-s food deliveries under conditions in which delay to the larger reinforcer was always 4 s longer than delay to the smaller reinforcer. When the delay to the smaller reinforcer was increased gradually from

2 to 28 s, every pigeon reversed its preference from the smaller to the larger more delayed reinforcer.

Comparable results were reported by Rachlin and Green (1972). In their study, pigeons were exposed to a concurrent-chains schedule in which a ratio schedule was programmed in the initial links. If the 25th response in the initial link occurred on the right key, a t -s blackout was followed by a choice between an immediate 2-s grain delivery and a 4-s delivery delayed by 4 s. If the ratio was completed on the left key, the t -s blackout was followed by 4-s grain delivery delayed by 4 s. When the value of t was low, subjects generally preferred (i.e., completed the fixed-ratio 25 under) the initial link that produced a choice in the terminal link; when the terminal link was reached, they always chose the smaller, immediately available, reinforcer. As t was increased to 16 s, preference switched to the initial link that produced the terminal link that offered no choice and yielded the larger delayed reinforcer.

A related experiment was conducted by Navarick and Fantino (1976). They arranged a concurrent-chains schedule with equal variable-interval components in the initial links and fixed-interval components of t and $t - 10$ s in the terminal links. Incrementing the value of t , which increased the temporal distance between choice responding and food delivery, increased responding in the initial link that led to delivery of the larger delayed reinforcer.

Two studies in which adult humans responded to terminate white noise have also shown that the smaller less delayed reinforcer was preferred under some conditions, and that preference shifted to the larger more delayed reinforcer when the delay to the alternative outcomes was increased sufficiently (Navarick, 1982; Solnick et al., 1980). These findings are comparable to those of the present study. In this investigation, mentally retarded adolescents consistently preferred three pieces of breakfast cereal to one piece when neither alternative was delayed. Imposing a delay to

delivery of the larger reinforcer and gradually increasing the delay produced in all subjects preference for the smaller immediately available reinforcer. Under conditions in which the larger reinforcer initially was sufficiently delayed to result in preference for the smaller one, progressively increasing in 5-s increments the delay to both reinforcers increased the percentage of trials with the larger reinforcer chosen. At sufficiently long delays, two of the subjects consistently chose the larger more delayed reinforcer and the third subject chose that reinforcer on half of the trials. These findings, like those reported by Navarick (1982) and Solnick et al. (1980), are generally consistent with the nonhuman data described above. They differ markedly, however, from the results obtained by Logue et al. (1986), who employed adult humans in a study in which reinforcer delay and amount were varied both independently and together. In that investigation, subjects responding under discrete-trial procedures and concurrent schedules earned points that could be exchanged for money after each session. The subjects usually chose the larger of two alternative reinforcers irrespective of delay and, when queried after the experiment, revealed that they attempted to earn the maximum number of points each session. Logue et al. (1986) noted that the nature of the reinforcer may have strongly affected their results: "All of the previous experiments with pigeons . . . used food-deprived pigeons and food as the reinforcer. In such situations, depending on the degree of food deprivation, there might be some advantage to obtaining food quickly" (p. 52).

When compared to those of Solnick et al. (1980), Navarick (1982), and the present study, the results reported by Logue et al. (1986) intimate that the nature of the reinforcer may determine in part the extent to which subjects choose delayed reinforcers. This effect may not be limited to self-control procedures. A series of studies by Navarick (Millar & Navarick, 1984; Navarick, 1982, 1985, 1986) suggests

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Fig. 1. Percentage of trials in which each of three mentally retarded adolescents chose three pieces of breakfast cereal over one piece during the last three sessions of each condition of Phase 1. During this phase the smaller reinforcer was not delayed and the larger reinforcer was delayed by the value listed on the abscissa. Data for each session represent 10 choice trials.

that the nature of the reinforcer may influence preference when humans are given a choice between reinforcers that are of equal magnitude but delivered after unequal delays, as well as under conventional self-control procedures.

Although too little research has been conducted to support any strong conclusion, the available data suggest that different results may obtain with primary and conditioned reinforcers. Examining the performance of verbal adult humans under self-control procedures involving primary positive reinforcement would provide an important test of this suggestion. Verbal behavior is known to play an important role in controlling human operant behavior, and Mawhinney (1982) has speculated that subject-generated rules contribute to self-control. The participants in the present study had very limited verbal skills; this variable, as well as the kind of reinforcer used, may have influenced their behavior.

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Fig. 2. Percentage of trials in which each of three severely mentally retarded adolescents chose three pieces of breakfast cereal over one piece during the last three sessions of each condition of Phase 2. During this phase, the smaller reinforcer was delayed by the value indicated on the abscissa and the larger reinforcer was delayed by that value plus the value indicated at the top of each frame. Data for each session represent 10 choice trials.