*SELF-CONTROL: TEACHING TOLERANCE FOR
DELAY IN IMPULSIVE CHILDREN*

JULIE B. SCHWEITZER AND BETH SULZER-AZAROFF

UNIVERSITY OF MASSACHUSETTS, AMHERST

We investigated a procedure to increase the selection of larger, more delayed reinforcers (i.e., more advantageous in the long run) over smaller immediate reinforcers, in an effort to increase a key aspect of self-control in children. Six preschoolers, including one comparison subject, identified by their teachers as impulsive, were preassessed and found consistently to select smaller immediate reinforcers over larger, more delayed ones. The teaching procedure consisted of gradually increasing the durations of the delay interval over many sessions. The follow-up assessments showed that 5 of these children increased the proportion of their choices of the delayed reinforcers. Before training, indifference points ranged from 1.7 to 51.7 s; following treatment, points rose to a range of 37.5 to at least 90 s, with 3 children preferring the larger reinforcer at all delay intervals tested. The results demonstrated the feasibility of teaching young children to make choices more advantageous to them in the long run.

Key words: self-control, impulsivity, delayed reinforcement, indifference point, choice, choosing box, children

Organisms are said to be exhibiting self-control when they "maximize," that is, when they behave in such a manner that permits them to gain access to larger reinforcers after a relatively longer delay rather than those producing smaller reinforcers after a short delay. A number of behavioral researchers have analyzed self-control from this perspective (Ainslie, 1974; Fantino, 1966; Mazur & Logue, 1978; Navarick & Fantino, 1976; Rachlin & Green, 1972), presenting alternatives differing in amount and delay of reinforcement. Studies analyzing the distribution of choice (Ainslie & Herrnstein, 1981; Green, Fisher, Perlow, & Sherman, 1981) have found that an organism's behavior could often be described by the matching law (Herrnstein, 1970), which predicts a match between the proportion of responses and the proportion of reinforcers for that response. Baum and Rachlin (1969) proposed a modification of the matching law that

incorporated delay of reinforcement as a variable; namely, that the relative preference for a response is proportional to the relative value of the consequence for that response, "value" being a function of amount, rate, and immediacy of reinforcement.

Experiments with both pigeons and humans have shown that the length of the delay between the response and the reinforcer can affect choice, with the effectiveness of the reinforcer declining as the delay increases (Ainslie, 1975; Chung & Herrnstein, 1967; Millar & Navarick, 1984; Navarick, 1982; Solnick, Kannenberg, Eckerman, & Waller, 1980). Thus, with shorter response-reinforcer delays, responses followed by a smaller reinforcer are more probable than those followed by a more delayed but larger reinforcer. The matching law predicts a reversal in choice from the larger, more delayed reinforcer to the smaller, less delayed one as delays to both reinforcers decrease (Ainslie & Herrnstein, 1981; Green et al., 1981). Previous research has illustrated this phenomenon by showing that children and pigeons tend to select smaller, less delayed reinforcers, even when offered the alternative of larger reinforcers that are available only after a delay (Ainslie, 1974; Ainslie & Herrnstein, 1981; Burns & Powers, 1975; Green et al., 1981; Green & Snyderman, 1980).

An alternative model of choice behavior, the delay-reduction hypothesis, first proposed by Fantino (1969), suggests that an organism will

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choose stimuli correlated with the greatest reduction in time to primary reinforcement. Thus, this model also predicts choice of the smaller, more immediate reinforcer over the larger, more delayed reinforcer as time to the larger reinforcer increases (Fantino, 1966; Ito & Asaki, 1982; Navarick & Fantino, 1976).

In addition to the variables included in the models just described, research with humans shows that the selection of delayed reinforcers is also related to age and verbal ability (Miller, Weinstein, & Karniol, 1978). Very young children, perhaps because they are less likely to verbalize or use other behaviors to help them delay, tend to choose the smaller, less delayed reinforcers (Mischel & Mischel, 1983; Miller et al., 1978; Sarafino, Russo, Barker, Consentino, & Titus, 1982). Older children and adults more often choose larger, more delayed reinforcers.

Training and history also have been found to influence choice behavior. Several researchers have attempted to discover whether or not subjects can be taught to increase their relative rates of selecting more ultimately advantageous consequences (i.e., to increase their self-control). Techniques have included a systematic program of increasing gradually the delay interval preceding reinforcement. Ferster (1953) performed one of the earliest studies with nonhumans, exposing pigeons to short delays and gradually increasing them to 60 s. Mazur and Logue (1978) developed a similar method for increasing pigeons' choice of larger, more delayed reinforcers by delaying access for 6 s to either 2 s or 6 s of grain. Pigeons continued to choose the larger reinforcer while the delay to the smaller reinforcer was gradually reduced to zero, choosing the larger reinforcer despite its being the more delayed alternative. In addition, procedures requiring an advanced commitment to a later choice of a large reinforcer have been effective in increasing self-control in pigeons (Ainslie, 1974; Rachlin & Green, 1972).

Children have also been the subject of studies designed to modify choice via contingency shaping. For instance, Walls and Smith (1970) imposed a gradually increasing delay procedure to increase children's choices of larger delayed reinforcers. A number of researchers (Mischel & Ebbesen, 1970; Mischel, Ebbesen, & Zeiss, 1972; Yates & Revelle, 1979) have conducted research on young children's use of

self-control strategies within choice situations. These studies examined stimulus conditions (such as "distractors") and alternative behaviors in which children could engage during delay periods. Mischel and his colleagues found that children waited longest when neither delayed nor immediately available rewards were visible and when they distracted themselves during delays with "fun" or relaxing irrelevant distractors, such as talking to themselves or singing. In general, these studies demonstrate that distractors serve to facilitate children's choices of larger, more delayed reinforcers.

In applied work, self-instruction (reciting rules to oneself) and cognitive modeling have been the most common procedures used to promote self-control (Abikoff & Gittelman, 1985; Bornstein & Quevillon, 1976; Coats, 1979; Finch, Wilkinson, Nelson, & Montgomery, 1975; Friedling & O'Leary, 1979; Heider, 1971; Kendall & Braswell, 1985). Although initial success was reported, researchers (e.g., Abikoff, 1985; Abikoff & Gittelman, 1985; Barkley, 1981) increasingly have been encountering difficulties with these training packages. The methods have failed to remedy consistently problems with academic skills and deportment, as promised by early reports (Douglas, Parry, Marton, & Garson, 1976). Additionally, the effectiveness of the programs appeared to cease after intervention was discontinued, with generalization not extending beyond the training situation. Furthermore, the self-instructional programs were not appropriate for younger children, who lacked a sophisticated verbal repertoire.

The present study was concerned with teaching young children to tolerate delayed reinforcement. Specifically, we examined the effectiveness of a procedure designed to increase the proportion of children's choices of larger delayed over smaller immediate reinforcers. Beginning by offering both large and small reinforcers immediately, delivery of the larger reinforcer was delayed very gradually over time. Children could continue to select the choice correlated with a relatively greater amount of reinforcement while the time to obtaining that alternative was gradually increased. We thus attempted to teach preschool children who had been identified by their teachers as impulsive to make choices more advantageous to them in the long run.

Table 1

Sex and age in years and months of subjects at the beginning and end of study.

Subject	Sex	Age	
		Beginning	End
A	F	4 years 9 months	5 years 3 months
B	M	4 years	4 years 4 months
C	F	3 years 6 months	3 years 8 months
D	M	4 years 5 months	4 years 10 months
E	M	5 years 8 months	6 years
F	F	4 years 8 months	4 years 11 months

METHOD

Subjects and Setting

Six children attending two different pre-schools participated in this study. All were identified by their teachers as showing some form of impulsive or hyperactive behavior, or both. To help identify potential subjects, teachers were given a list (taken from the *Diagnostic and Statistical Manual of Mental Disorders*) of behaviors typical of children diagnosed as Attention Deficit Disorder with Hyperactivity (American Psychiatric Association, 1980).

Subject A participated in a pilot test of the procedure. Consequently, some of the features of the procedure used with the other children differed from those with this subject. Subject F participated in only the assessment phase. Table 1 presents the sex of each subject and age at which each subject began and ended the experiment.

Apparatus and Materials

The apparatus constructed for presentation of stimuli and reinforcers also screened the experimenter from the subject's view. (See Figure 1 for a diagram of the apparatus. In this illustration, both boxes are presented, as in the choice situation.) A door viewer (or peep hole) in the screen enabled the experimenter to observe the child inconspicuously during sessions. On the side facing the child was a picture of a clown's face with light bulbs for the nose and eyes. These could be illuminated to indicate the onset of a trial. Indicator lights beneath the clown's face were designed to be illuminated during the delay periods following the choice response. At the bottom of the partition were two apertures through which two boxes (13.5 cm by 23 cm), serving as containers for rewards, could be presented. Each box con-

Fig. 1. Drawing of the apparatus as it appeared during a choice trial.

tained a plastic margarine dish, into which rewards could be placed. A screw in the hinge of each box top could be removed easily, permitting different colored tops to be exchanged readily. Boxes operated similarly to the drawers in a piece of furniture, with gliders to guide them, and were constructed so that during delay and intertrial interval periods, they could be retracted behind the screen, out of the child's view with only the front of the box remaining visible (just like the face of a closed drawer in a piece of furniture). When the subject selected a box, it was extended only seven eighths of the way, ensuring that the child could not lift the lid until the reinforcement period was in effect. To permit access to its contents at the end of a delay period, the experimenter needed only to extend the box completely.

Rewards were matched to children's and teachers' preferences and varied from child to child and also from trial to trial (to minimize satiation effects). Subjects A, B, and C chose from an array of edibles and peel-off pictures (stickers), and Subjects D, E, and F received various peel-off pictures throughout. At the beginning of each session the experimenter showed the children the array of reinforcers and asked them to identify those for which they would like to work. Thereafter, at the beginning of each trial the child indicated what

particular reinforcer he or she would like to obtain. A typical array for Subjects A, B, and C consisted of raisins, cheese crackers, and carob-peanut clusters cut into 1-cm pieces, and a variety of stickers. Subjects D, E, and F's array simply contained the variety of stickers. A cardboard box (10 cm by 15 cm) was also available in which children could store their reinforcers by depositing them through a slit in the top. This device served to keep reinforcers out of view because previous research (Grosch & Neuringer, 1981; Mischel & Ebbsen, 1970) demonstrated that the continual presence of the reinforcing stimuli might set the occasion for behaviors that interfered with the choice task.

Observational Recording

The experimenter observed the subject through the door viewer and recorded on a score sheet any unusual circumstances such as conduct problems, interruptions, and excessive noise, as well as other relevant information about each response (e.g., an unusually long delay before the child responded). Also noted were any other details about recent events, such as changes in school schedules or attendance, that might influence the child's performance. Within the session, details regarding the stimuli (color of box top; delay interval), choice responses, and consequences (number and type of reinforcers) of each trial were indicated on a recording form.

To provide an estimate of observer reliability, videotape recordings were taken periodically and were independently scored by two research assistants and the experimenter. Each taped session was compared on a trial-by-trial basis with the data that had been collected by the experimenter within the session. Trials were scored as being in agreement if the color of the box chosen by the subjects on the score sheet matched the color of the box, based on the tape recording. Agreement was 100% across trials and subjects. The number and percentage of sessions upon which inter-observer agreement checks were calculated are as follows: Subject A—35 of 47 (74%); Subject B—19 of 49 (39%); Subject C—10 of 21 (48%) and 11 of 38 (29%); Subject D—11 of 38 (29%); Subject E—7 of 31 (23%); and Subject F—5 of 18 (28%).

Analytic Methods

Subjects' choices (indicated by touching one of the two boxes) between a more immediate small reward and a larger delayed reward were assessed before the intervention (preassessment), during the intervention (training), and after the intervention (postassessment). (Because it was not possible to establish a stable, "impulsive" pretraining assessment for Subject F, she was not exposed to the intervention. Her data have been retained, however, to display the impact of repeated practice and passage of time alone.) To control for time-dependent variability, children were tested with baselines of varying lengths with the treatment replicated at different points in time (i.e., in multiple baseline fashion; Baer, Wolf, & Risley, 1968).

Orientation and General Procedure

Initially the experimenter accompanied each child to a room (where the apparatus was placed on a table) and explained that they were going to play a game. During the first one or two sessions, the apparatus and the "clown game" were described to the child until the child touched or tapped the box's lid without guidance. The experimenter demonstrated how the box operated by fully extending it and raising the box tops to show their contents: three reinforcers in one box or one in the other. The child was then asked to practice choosing boxes by making physical contact with the top of the lid with a finger. The experimenter then read the following instructions to the subjects.

First one box will come out at a time. Then two boxes will come out. When the clown's eyes and nose come on the box will come out. First the [color] box will come out. (The first box was pushed toward the child.) Now I want you to touch it for me. Now you have to wait (if a delay condition was in effect, and the box was retracted). You can open the box now and take out your [reinforcer(s)]. How many [reinforcers] did you get with the [color] box? Right (if the child was correct or, if the child was incorrect) no, you've got [number of reinforcer(s)]. So, how many did you get? Now let me show you again (and the procedure was repeated with the other color).

At this point the experimenter explained that the boxes changed sides sometimes. After the

Fig. 2. Diagram of a choice trial during pre- and postassessments.

explanation and a demonstration, both boxes were presented to permit a choice trial. The experimenter gave the following instructions: "Now you're going to get two boxes, just choose one." The remainder of the trial continued as above. (See Figure 2 for a diagram of the choice procedure.)

Successive approximations were praised until the child mastered the choice response. If a subject touched the two boxes simultaneously, the experimenter reviewed the correct procedure

and instructed the child to proceed by choosing only one box at a time. If a child continued to respond inappropriately, the boxes were withdrawn completely. After 5 s, the boxes were presented again and the child was permitted to try again. The experimenter also explained and demonstrated under which conditions each type of light would be illuminated. Every session thereafter the correspondence between the color of each indicator light and its matching lid was reviewed with the child.

During all phases, the experimenter gave the following instructions:

Let me show you how many are in each box. (Lift top of first box.) In this [color] box there will be [number of reinforcers]. (Lift top of other box.) In this [color] there will be [number of reinforcers]. So, how many in the [color] box? How many in the [other color] box? Right (if correct answer was given). No, there are [number of reinforcers in particular color]. So, how many in the [color] box? (If incorrect answer was given.)

After showing the subject the amount of reinforcement in each box, a brief statement on the length of delay was given: "Today you'll have to wait longer for the [color of longer delay] box." When both choices were immediate (e.g., 0 vs 0 s) the experimenter said the following: "Today you'll have to wait the same time for the [color] box as the [other color] box." When a child asked about the delays or colors, the experimenter either repeated the instructions or ignored the child's question, but if the child looked confused the instructions were repeated or paraphrased until the child appeared to understand.

Each day the children were told the respective colors of the boxes containing one or three reinforcers. Subjects were then asked to repeat which color corresponded with each quantity of reinforcers. Throughout each session, the two differently colored boxes were alternated in a preset randomized position to prevent development of a position preference. During any particular session, however, a specific color corresponded to one reinforcer and another color corresponded to three reinforcers. Occasionally, subjects would ask which was the "better" or "correct" choice. The experimenter said she did not know and that the subjects must decide that for themselves.

Preassessment. Assessment and training sessions were held two to three times per week. The primary purpose of the pre- and postassessments was to determine the value of the indifference point—the delay selected equally often by each subject. The smaller reinforcer was delivered immediately throughout, whereas the delay for the larger one varied among sessions from 0 to 90 s.

Assessment sessions included four forced-choice trials, consisting of two presentations of one of the boxes alone and then the other box

alone, to acquaint the subject with the delay period for the longer reinforcer for that session. (The other box was removed during these four forced trials.) These sessions were usually followed by 10 assessment trials in which the child was permitted to choose between the two simultaneously presented boxes. Because of time constraints and other situational factors, on three occasions fewer than 10 assessment trials were conducted (seven and nine for Subject A, nine for Subject B).

Intertrial intervals. Within each session, the intertrial intervals (time between onset of successive trials) were held constant so that the overall rate of reinforcement did not depend on the choice behavior of the subjects. Intertrial intervals were large enough to include the time it usually took the child to respond, the delay period, and the time the child typically took to consume or look at the reinforcer. To simplify time keeping, the intertrial interval always was a multiple of 15 s.

Randomization of colors. During approximately the first half of the preassessment sessions, only two colors of box tops were used, with yellow signifying three reinforcers and blue signifying single reinforcers. Later (except for Subject A, for whom the colors remained invariant), colors of box tops were changed randomly from one session to the next. For example, in Subject B's sixth session, the tops were purple (one reinforcer) and green (three reinforcers) throughout the session; in Session 7, they were white (one reinforcer) and pink (three reinforcers). This was done to heighten the discriminability of changes in the delay periods and to decrease any transfer from previous sessions. We decided to introduce box tops of different colors each time a new delay period was introduced when some children chose the box with three rewards less than 70% of the time in sessions when the large reward could be obtained as quickly as the single one and when subjects began to make comments such as, "I hate yellow, you have to wait so long for it," even when the triple rewards were immediate. Once the colors were changed between sessions, it was observed that the children switched their choice to the box containing the multiple rewards when the delay for the larger reward was relatively brief. The color of Subject C's box lids varied throughout her preassessment because by the time her responding was assessed the procedure had been

Table 2
Order of long delays in seconds during pre- and postassessments.

Subject										F
A		B		C		D		E		Assess- ment (control)
Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	
60*	<u>5*</u>	10	<u>15</u>	<u>5</u>	<u>5</u>	30	<u>30</u>	30	<u>90</u>	30
30*	<u>60</u>	30	<u>10</u>	<u>0</u>	<u>30</u>	15	<u>15</u>	15	<u>5</u>	15
15*	<u>35</u>	15	<u>30</u>	<u>60</u>	<u>15</u>	10	<u>90</u>	5	<u>60</u>	5
10*	<u>60*</u>	0	<u>60</u>	<u>15</u>	<u>60</u>	5	<u>5</u>	0	<u>0</u>	5
5*	<u>10*</u>	60	<u>0</u>	<u>30</u>	<u>0</u>	0	<u>0</u>	60	<u>15</u>	0
5*	<u>35</u>	0	<u>—</u>	<u>10</u>	<u>—</u>	60	<u>60</u>	90	<u>—</u>	60
5*	<u>—</u>	<u>45</u>	<u>—</u>	<u>—</u>	<u>—</u>	90	<u>45</u>	0	<u>—</u>	90
30*	<u>0</u>	<u>0</u>	<u>—</u>	<u>—</u>	<u>—</u>	0	<u>10</u>	0	<u>—</u>	0
60	<u>0</u>	<u>0</u>	<u>—</u>	<u>—</u>	<u>—</u>	0	<u>—</u>	<u>90</u>	<u>—</u>	0
45	<u>—</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>90</u>	<u>—</u>	0	<u>—</u>	<u>90</u>
35	<u>—</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>—</u>	0	<u>—</u>	<u>—</u>	<u>—</u>	0
	<u>—</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>45</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>45</u>
	<u>—</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>60</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>60</u>
	<u>—</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>30</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>30</u>
	<u>—</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>90</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>45</u>
	<u>—</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>—</u>	0
	<u>—</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>—</u>	0

* Delay for small reinforcers was 5 s. All other delays to small reinforcer were 0 s.

Note. Numbers underlined indicate randomization of box top colors. Colors were randomized for all subjects during postassessment.

refined. During the postassessment, the lids changed throughout for all subjects. Throughout the training sessions, blue signified a single reinforcer and yellow signified triple reinforcers. Table 2 shows the order of delays used and indicates the point at which the colors of the box lids began to be changed for each subject for the pre- and postassessment phases of the study. Each long-delay period represents one session.

Training. Delay values for the two alternatives began at 0 s each. Subsequently, the delay for the larger reward was increased by 5-s increments each time the subject reached a criterion for stability (i.e., the child selected the box with three reinforcers on four of five trials). Each time a new delay period was introduced, four forced-choice trials (two of each type) were presented. For all subjects but one, training was discontinued when the school year ended. The criterion for terminating Subject E's training was reached when the child failed to choose the larger reward at least four of five times over a block of 45 trials. Training was discontinued after the delay period had reached

65 s for Subject A, 30 s for B, 40 s for C, and 20 s for D and E.

Postassessment. During the postassessment, delay values were randomly selected from the set used in the preassessment phase to redetermine points of indifference. The colors of the box tops, signifying their corresponding delay values, were randomly varied from session to session for all participants.

Individual subject variations. As the procedure was refined and the experiment progressed, variations were required for particular subjects. Subject A at first earned tokens, exchangeable for rewards at the end of each trial, during a portion of the preassessment phase, whereas other subjects received the reinforcers immediately. In an effort to identify the optimal delay periods, Subject A was tested on varying time delays versus a 5-s as well as the 0-s delay. When, after a few sessions, it became clear that Subject A would choose the smaller reward after triple rewards had been delayed only 15 to 30 s, the 5-s short-delay period was reduced to immediate presentation. (When this was shown to be effec-

Table 3
Number of trials to criterion during training as a function of delay to the larger reinforcer.

Subject	Delay interval (in seconds)														
	0	2.5	5	10	15	20	25	30	35	40	45	50	55	60	65
A	5		4	5	4	5	4	5	5	4	5	5	4	5	7
B	4		4	4	4	5	5	5	47 ^a						
C	8	5	4	10	13	4	4	4	4	4					
D	5		4	42		35									
E			6	30	7	6									

^a A 2-week vacation between sessions for Subject B.

tive in the procedure, it was adopted for the other children.) In addition, this subject was also exposed to the 0- versus 35-s choice twice during the postassessment.

During the assessment phases, testing of Subjects B and C for a particular set of delays occasionally took 2 days because of time constraints. Throughout C's preassessment, the colors of the box lids on the apparatus were randomized. Finally, at one point for Subject D, the delay for the box with three reinforcers was increased by 10 rather than 5 s.

Probes. Probes were performed (when there was extra time on experimental days) to test whether or not the subjects might delay for longer periods based upon their behavior during the sessions. Three probe sessions were conducted with Subject A during postassessment and one with Subject D during training. These consisted of four forced-choice trials and four choice trials with the corresponding durations of delay.

RESULTS

Trials to Criterion During Training

Table 3 shows the number of training trials each subject required to reach criterion for each particular delay interval. Most subjects reached the training criterion within five choice trials (with a median of 4.73 choice trials).

Pre- to Postassessment Changes

An analysis of changes from pre- to postassessment showed that 4 of the 5 subjects shifted substantially toward more self-control (i.e., subjects began to tolerate progressively longer delays leading to the larger reinforcer). Figure 3 shows the average number of large reinforcer choices at each delay interval during pre- and postassessments. During the preassessment, subjects (except Subject D) almost exclusively selected the box with the smaller reinforcer at

delays exceeding 15 s. After training, 4 of 5 subjects selected the box with the larger reinforcers at delays of longer durations than previously. Additionally, the postassessment revealed that 3 of 5 subjects (Subjects B, C, and E) chose the larger reinforcer at delays exceeding the durations used during the training phase. Subject F, who received no training, showed no distinctive pattern in her choices, other than selecting the larger reinforcer about half the time when both options were offered immediately. Otherwise, she tended to select the immediate reinforcer about 80% of the time.

Table 4 displays all of the delays presented, with the corresponding percentages of the subjects' choices of the large reinforcer. (The averages in Figure 3 were based on these figures.) Table 4 also presents probe data for Subject A taken during the postassessment and for Subject D taken during his training sessions. In the probe sessions, Subject A selected large reinforcers with delay periods extending beyond those experienced during training.

Indifference Points

Figure 4 summarizes the changes in indifference points during pre- and postassessment for each child. The points were determined by linear interpolation between the two delay values tested on either side of the indifference point. For example, during preassessment Subject E chose the large delayed reinforcer equally as often as the small immediate reinforcer (indifference point) at delays averaging 1.7 s. After training, his point of indifference averaged 37.5 s. Indifference points after training were not determined for Subjects A, B, and C, because postassessment checks included only delays to 60 s for Subjects B and C and 90 s for Subject A, values at which the subjects were still continuing to choose the larger reinforcer. (Because of the time constraints imposed by the ending of the school year, it was not pos-

Fig. 3. The average percentage of trials in which the large reinforcer was chosen for each delay interval. Arrows indicate delay at which training ceased. Note that the short delay was fixed at 0 s, except for Subject A who was given some trials with a 5-s delay interval (dashed lines).

sible to complete additional sessions or to test delays beyond 60 or 90 s.) More than one indifference point is plotted on the figure for Subject D because his data were more variable and crossed the 50% line more than once. A t test showed there were significant differences between the pre- and postassessment indifference points, $t(4) = 7.25$, $p < .05$. In determining significance for Subjects A, B, and C, the highest value tested during the postassessment was used. For Subject D, comparisons were made between the postassessment indifference value and the preassessment delay at which responding first crossed the indifference point.

DISCUSSION

The results indicated that gradually introducing delays of increasing duration can effectively teach young children to choose larger

delayed reinforcers over more immediate smaller reinforcers. Despite variations in the assessment procedure, the effects of the training were reproduced across subjects. After training, Subjects B, C, and E selected the larger delayed reinforcer at durations exceeding the values used during training. Based on her postassessment probe data, Subject A also chose the larger reinforcer at delays greater than those employed in the training sessions. Subjects D and E showed signs of satiation. For example, these children occasionally would put their stickers back in the box and push them toward the experimenter, remarking that they were for her. Unfortunately, the school attended by Subjects D, E, and F would not permit other potentially more potent reinforcers, such as edibles, to be used.

Subjects A, B, and C showed the greatest change from pre- to postassessment for delay values experienced during training, even

Table 4
Percentage of large reinforcer choice.

Subject	Phase	Length of long delay (in seconds)								
		0	5	10	15	30	35	45	60	90
A	Preassessment						40	10	10	
	5 s for short delay		20 86 89	50	10	0 50			10	
	Probe (during postassessment)									75 50 100
	Postassessment						60 70		70	
	5 s for short delay		80	100					70	
B	Preassessment	60 80 90 90		30	0	20		0	0	
	Postassessment	100		90	70	80			77	
C	Preassessment	80	90	0	10	0			0	
	Postassessment	100	100		90	100			40	
D	Preassessment	60 90 10 100	50	50	20	30 20		70	10 40	10 20 0
	Probe (during training)							50		
	Postassessment	60	60	80	70	90		40	20	20
	Preassessment	40 80 80 80	10		10	40			10	20 20
	Postassessment	100	90		70				30	0
F	Assessment (control)	30 30 50 50 70 50	0 30		0	0 30		20 0	30 0	10 30

though on occasion during the postassessment they did select the multiple reinforcers at durations beyond those experienced during training. For Subject E, who failed to reach criterion beyond the 20-s delay during training, the greatest changes from pre- to postassessment occurred at delays of 20 s or less.

Subject F's data are presented to illuminate possible uncontrolled time-dependent influences. Although behavior remained fairly stable throughout the assessment, one cannot draw conclusions about any uncontrolled variable based on a single subject. Only further lengthy replications across a number of subjects will reveal the effects of time passage alone. How-

ever, if this one case is at all representative, the time factor alone is unlikely to be very powerful.

The findings in this study are consistent with those found in investigations using pigeons and children as subjects in delay and self-control studies (Burns & Powers, 1975; Logue & Mazur, 1981; Logue, Rodriguez, Peña-Correal, & Mauro, 1984; Mazur & Logue, 1978). As in this study, subjects in the previous studies frequently chose the smaller less delayed reinforcer before training. Furthermore, after training, the subjects chose the larger more delayed reinforcers more often than previously. However, no evidence suggests that

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Fig. 4. Delays at which subjects chose either alternative equally often (indifference points). Numbers below indicate the indifference points arrived at by linear interpolation. ("*" indicates that the value of the indifference point was not found.)

pigeons would have responded as the children did by choosing delays longer than those they had experienced during the training sessions.

The results of the pre- and postassessments are consistent with those predicted by the matching law and the delay-reduction hypothesis. Both models predict a change in preference from the larger to the smaller reinforcer as a function of delay, with the effectiveness of the larger reinforcer declining as a function of the increase in delay interval. Pre- to postassessment changes do not readily fit either model because neither one includes a training-history parameter, such as that supplied by the training in this and other studies (e.g., Ferster, 1953; Mazur & Logue, 1978). The choice of the larger reinforcer during the postassessment at delays presented beyond those during training must also be examined under the matching law and delay-reduction hypothesis. It is possible that training increased sensitivity to rein-

forcer magnitude or enhanced preference for the large reinforcer.

These findings are also similar to those in research conducted with adults under negative reinforcement contingencies (Navarick, 1982; Solnick et al., 1980), where impulsive responding was found. These results differ, however, from those with adults under positive reinforcement. Adults in the study by Logue, Peña-Correal, Rodriguez, and Kabela (1986) usually selected the larger amount when money was the reinforcer. The adults consistently chose the larger, more delayed reinforcer rather than distributing choices by following a matching strategy. In the Logue et al. (1986) study, responding appeared to be controlled more by the reinforcer amount than by delay.

The differences found between the responding of both young children and pigeons (i.e., failing to "maximize") and of adults could be the result of several factors. The adult subjects

in the Logue et al. (1986) study, who frequently selected the large reinforcer, worked for points exchangeable for money that could not be spent until a session was over. In contrast, the children in the present study received their rewards immediately following each trial. Another possibility is that our subjects may have responded more impulsively in this specific setting than typical children would have, especially because impulsivity was a criterion for their selection as subjects. Additionally, the difference between adults' and children's verbal skills may have a powerful influence. Logue et al. (1986) suggested that verbal ability may partially account for the differences obtained between research with humans and nonhumans. We also assume that arithmetic skill plays a role, enabling adults more competent in calculating to estimate cost-benefit probabilities.

In the future, researchers should systematically study developmental factors among "typical" children, determining the sizes of delays and reinforcers that children tend to choose at varying ages. A pilot investigation using three reinforcers versus one with a female (age 3 years, 7 months) showed that she elected to delay (during 30 trials) 100% of the time up to delays of 60 s. Whether or not this pilot subject represented "typical" children, however, is impossible to determine. Only large populations of subjects will enable this question to be answered.

Several possible explanations can be offered for the effectiveness of the procedure used in this study. Perhaps the procedure helped shape or strengthen behavior emitted during the delay times, such as humming, talking to the apparatus, or attempting to take it apart, because reinforcement was delivered while this behavior was occurring. Although the larger reinforcers may have served as powerful reinforcers to shape and strengthen intervening behavior, the unmeasured mediating behavior could also have been providing its own schedules of reinforcement. For example, behavior such as singing or banging on the table may have been intrinsically reinforcing. Other researchers (Mischel & Ebbesen, 1970; Mischel et al., 1972; Yates & Revelle, 1979) have observed their child subjects emitting similar behavior. They found that children successfully increased delay times by distracting themselves (e.g., by playing games with their hands and

feet, singing, resting their heads on their arms, talking to themselves, or trying to fall asleep). A more thorough examination of the behavior that occurs during the delay periods is suggested.

Another explanation may involve the stimuli used during delay times. As Logue and Mazur (1981) noted, it is possible that the indicator lights functioned as conditioned reinforcers. Because the lights were presented immediately after choice responses, they may have served to strengthen the response of choosing the larger reinforcer (cf. Fantino, 1969).

Another possibility is that because these children were verbal, they may have been extracting rules after exposure to the contingencies, stating rules overtly or covertly and then following them. For instance, children who occasionally counted out loud may have been following the rule, "If I count to 20 I'll wait and I'll get three stickers." The development of rule-governed behavior may have first depended upon the reinforcement of intervening behavior during the delay times, the establishment of events or stimuli as conditioned reinforcers, or both to mediate the delay times during the intervals. In subsequent research it would be interesting to examine children's ability and accuracy in describing contingencies within paradigms such as these.

Because this was exploratory research, aspects of our procedure were not as tightly controlled as one might expect in a more mature program of research. We recommend that future experiments involving children in school settings begin earlier in the school year to avoid some of the difficulties we encountered in conducting our study in a setting with a fixed calendar. In addition, we suggest that future researchers concerned with investigating similar responding in children (a) randomize the colors signifying the corresponding delay durations each time a new delay duration is presented, to increase the discriminability of new delay intervals and reduce choice variation at equal delay times; (b) ensure that a wide range of stimuli will be available and permissible as reinforcers in the experimental setting; (c) perform occasional probes to determine the value of the reinforcers (one could test their value by presenting differing magnitudes of reinforcers at equal delays); and (d) include control groups to account for developmental (i.e., time-related) differences or to compare levels of im-

pulsivity between subjects identified as typical or impulsive.

In this experiment, self-control was conceptualized as choosing larger more delayed reinforcers over smaller more immediate reinforcers. The purpose was to determine whether a procedure could increase impulsive children's self-control choices in a circumscribed setting. The results demonstrated that for this type of choice situation, systematically increasing the lengths of delays to larger rewards could alter the selection patterns of preschool children who had been identified as impulsive. These findings, therefore, have implications for the treatment of children who tend to respond impulsively and perhaps even for those exhibiting hyperactive behavior and conduct problems in school and at home. However, the variables that accounted for the increase in selection of the relatively larger more delayed (i.e., more advantageous) reinforcers remain to be determined.

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