EFFECTS OF DELAY FADING AND SIGNALS ON SELF-CONTROL CHOICES BY CHILDREN

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The current study is a systematic replication and extension of work by Schweitzer & Sulzer-Azaroff (1988). The effects of delay fading alone and in combination with signals on choices between larger, delayed reinforcers and smaller, immediate reinforcers by four children with language deficits were examined. For one of the two children exposed to delay fading alone, larger reinforcers were selected at longer delays relative to the initial self-control assessment. For all four children, the delay-fading-plus-signal condition resulted in selection of larger reinforcers at considerably longer delays relative to the self-control assessment.

Key words: delay fading, self-control, signaled delays

Self-control can be defined as selection of larger, delayed reinforcers over smaller, immediate reinforcers (Rachlin & Green, 1972), and can be increased via intervention. Signaling the delay to the larger reinforcer has been shown to reliably increase self-control. For example, Vollmer, Borrero, Lalli, and Daniel (1999) found that adolescents with severe behavior disorders engaged in more impulsive behavior (aggression) when aggression resulted in one chip (or a 15-s video clip) immediately, and a self-control response (mand) resulted in three chips (or a 30-s video clip) following an unsignaled delay. However, these same participants were more likely to mand and less likely to engage in aggression when the delay to reinforcement was signaled. For one participant, the delay remained constant at 10 s. For the other participant, the delay was gradually increased from 10 s to 10 min. Ensuring maintenance of desired behavior under delayed reinforcement when immediate reinforcement is concurrently available for alternative responses is important because reinforcement may often be delayed in home or school settings (Ghaemmaghami, Hanley, & Jessel, 2016).

Another method shown to increase self-control is delay fading (e.g., Dixon et al., 1998;

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Gokey, Wilder, Welch, Collier, & Mathisen, 2013; Mazur & Logue, 1978; Schweitzer & Sulzer-Azaroff, 1988). Delay fading involves providing choices between a smaller, immediate reinforcer and a larger, immediate reinforcer, the delay to which is gradually increased, or between a larger, delayed reinforcer and a smaller, delayed reinforcer, the delay to which is gradually decreased. For example, Schweitzer and Sulzer-Azaroff (1988) found that six preschoolers were initially more likely to choose one preferred item available immediately over three preferred items available after a delay. Following a procedure in which both options were initially available immediately, and the delay to the larger magnitude was gradually increased in 5-s increments each time the larger magnitude was selected during four out of five trials, selection of the larger, delayed magnitude increased. Because delays were signaled with both instructions about the contingencies (i.e., the length of the delay and colors paired with one immediate preferred item and three delayed preferred items) and an indicator light which remained on during the delay, delay fading was not evaluated in isolation. In addition, delay fading was discontinued for four of five participants due to time constraints, as opposed to participant responding (i.e., failure to choose the delayed option on four of five trials). Thus, the effects of unsignaled delay fading, which continues until selection of the delayed option is no longer maintained, are unknown.

The purpose of the present study was to systematically replicate and extend the work by Schweitzer and Sulzer-Azaroff (1988) by examining the combined effects of delay fading and signals and the isolated effects of delay fading on the maximum delay at which four children with developmental disabilities selected larger, delayed reinforcers over smaller, immediate reinforcers. Systematic replications may provide additional information about the generality of treatment effects, thus enhancing the external validity of single-subject research.

METHOD

Participants and Setting

Four male children, 3-5 years of age, were recruited from a program for students with developmental delays. Teachers identified students with at least moderate receptive and expressive language delays who had difficulty following directions and engaged in "impulsive" behavior. Garrett had a medical diagnosis of autism and used limited language, mostly echolalia or one-word requests for preferred items. Jonah had a medical diagnosis of autism, was nonvocal, and communicated using picture exchange. Noah had a medical diagnosis of autism and an educational diagnosis of language and speech impairment. He communicated using words, short phrases, and picture exchange. Diagnostic information was not available for Joel, but he engaged in disruptive and off-task behavior (e.g., grabbing items without permission, crawling under tables), and emitted limited (mostly unintelligible) vocal behavior. All four children received services to address language deficits. Sessions for the present study were conducted in a room separate from the classroom.

Measures and Data Collection

Choices between options were recorded, and data were summarized by dividing the number of trials the child selected one option by the total number of trials in each session, and multiplying by 100. Data were also collected on obtained delays to reinforcement during 20% of sessions to evaluate procedural integrity. Trained observers used digital timers to record obtained delays. A trial was considered correctly implemented if the obtained delay matched the programmed delay to the second. Procedural integrity was calculated within each session by dividing the number of trials implemented correctly by the total number of trials and multiplying by 100. Procedural integrity averaged 97% across participants.

Interobserver agreement data were calculated for participant choices during at least 17% of sessions for each participant. An agreement was scored for a trial if two independent observers recorded the same response, and mean agreement across all evaluations and children was never less than 99%.

Experimental Design and Procedures

A concurrent operants arrangement was used in each condition.

Preference assessment. A multiple-stimulus-without-replacement preference assessment (DeLeon & Iwata, 1996) was conducted with eight edibles, identified as preferred via parent report, to identify the three most-selected. The children chose one of these three edibles prior to each session as the reinforcer for that session. These procedures differed slightly from those of Schweitzer and Sulzer-Azaroff (1988), who allowed children to select rewards at the beginning of each trial and who did not use edible items due to restrictions imposed by the school setting.

Exposure trials. Prior to each session of the magnitude assessment, delay-sensitivity assessment, delay-discounting assessment, and delay-fading and delay-fading-plus-signal treatments (described below), the children were exposed to the consequences of each option. One plastic zip-top bag was placed in front of the child with one of the options inside. The child was given the instruction, "Take that one." Once the child touched the bag, the experimenter removed the edible(s) from the bag and placed it on the table in front of the child either immediately or after a prespecified delay. The order in which exposure trials were conducted was counterbalanced across sessions. These procedures differed slightly from Schweitzer and Sulzer-Azaroff (1988), who provided two exposure trials per option prior to all assessment sessions as well as each time the delay changed during delay fading.

Magnitude assessment. This assessment was conducted to ensure sensitivity to reinforcer amount and was similar to some trials of the assessments conducted by Schweitzer and Sulzer-Azaroff (1988). During each trial, one and three pieces of the same edible were placed approximately 30 cm in front of the child in zipper bags, and the experimenter said, "Pick one." Following selection, the experimenter presented the item(s) as quickly as possible. Five trials were conducted per session, and sessions continued until the larger amount was selected during at least 80% of opportunities for three consecutive sessions. A total of three or four sessions were conducted per child, all on the same day.

Delay-sensitivity assessment. The delay-sensitivity assessment was conducted to ensure sensitivity to delay and was not conducted by Schweitzer and Sulzer-Azaroff (1988). On each trial, the child chose between one edible delivered immediately and one edible delivered after a 10-s delay. Unique discriminative stimuli (i.e., index cards) were placed in each bag with the edibles to enhance discrimination. Prior to each session, one stimulus was randomly assigned to the immediate option and another stimulus to the delayed option. This pairing procedure was similar to that used by Schweitzer and Sulzer-Azaroff during the second half of the preassessment for all but one participant, and during the postassessment for all participants. Although stimulus-option pairings changed across sessions, exposure trials were conducted to pair stimuli with associated consequences. For Garrett, Jonah, and Noah, stimuli consisted of black and white index cards. For Joel, preference for discriminative stimuli was suspected, so stimuli were changed after he vocally labeled one stimulus multiple times within a single session or selected one stimulus more than the other during at least two sessions, regardless of the option with which it was associated. Stimuli were changed to black with white dots and white with black dots, to red and yellow, to white with horizontal green stripes, and white with vertical green stripes until preference was eliminated (i.e., vocal labeling did not occur, and Joel selected the immediate option during at least 80% of trials across three consecutive sessions). Five trials were conducted per session, and two to six ses- sions were conducted per day. If a child did not select the immediately available edible dur- ing at least 80% of trials across three consecu- tive sessions, and preference for discriminative stimuli was not suspected, and there was not an increasing trend in selection percentage, the delay was increased to 20 s.

Self-control assessment. This assessment was conducted to measure self-control (i.e., choice of three edibles delivered after a delay or one edible immediately), and served as a baseline for the subsequent treatment(s). It differed from the delay-sensitivity assessment because the amount of the delayed outcome was larger, and arbitrary discriminative stimuli were not presented (although differences in number of edibles may have acquired discriminative prop- erties). On each trial, options were presented inside clear bags in front of the child, and the experimenter said, "Pick one." If the child chose the bag with one edible, the experimenter removed the edible from the bag and presented it as quickly as possible. If the child chose the bag with three edibles, the bag with one edible was removed, and the selected bag remained visible during the delay. If the child attempted to access the edibles during the delay via reach- ing or manding, the experimenter blocked access and said, "Wait," after each attempt. Attention was otherwise not provided. After the delay elapsed, the experimenter removed the edibles from the bag and presented them as quickly as possible. If the child selected both options, bags were removed and re-presented until a single option was selected. If a child chose neither option within 5 s, "Pick one" was repeated. Children always made a selection fol- lowing the second instruction.

Each trial was followed by a pause to equate intertrial intervals. The pause was 5 s following selection of the larger edible, and was equal to the delay to the larger edible plus 5 s following selection of the smaller edible. Five trials were conducted per session, and one to nine sessions were conducted per day. When the child selected the larger edible during at least 80% of trials across three consecutive sessions, the delay to the larger edible was increased from 10 s to 20 s, 40 s, and 80 s. This assessment ended when the child selected the larger edible during less than or equal to 60% of trials across each of three consecutive sessions.

Delay-fading treatment. Noah and Joel were initially exposed to a delay-fading treatment. Sessions were identical to those in the self- control assessment except the delay started at 5 s (similar to Schweitzer & Sulzer-Azaroff, 1988) and increased in smaller step sizes to promote selection of the larger reinforcer. When the child chose the larger edible during at least 80% of trials across three consecutive sessions, the delay increased by 5 s. If the child chose the larger edible during at least 40% of trials across three consecutive sessions, the condition ended. Once delays reached 80 s, four trials were conducted per session to minimize session duration, and delays were increased if the child selected the larger edible on at least three of the four trials across three consecutive sessions.

Delay-fading-plus-signal treatment. For Noah and Joel, this treatment began after delay fading, and the initial delay equaled the last delay that maintained selection of the larger edible. For Garrett and Jonah, this treatment began after the self-control assessment, and the initial delay was 5 s. The treatment was identical to delay fading except a cell phone countdown timer ("Clock" app on the Samsung Galaxy S5, screen size 12.95 cm) was on the table. At the start of a trial, the timer was face down approximately 91.4 cm from the participant. If the participant selected the delayed option, the timer was moved face-up 30.5 cm from the participant during the delay. Instructions about the timer were not provided, but all children had prior exposure to timers in their classrooms. Following a timer beep, the experimenter removed edibles from the selected bag and presented them quickly. Between one and nine sessions were conducted per day. This evaluation was terminated once a child no longer selected the larger reinforcer on at least 80% of trials across three consecutive sessions. Shorter (Garrett and Jonah) and longer (Garrett) delays were re-presented to demonstrate replicability and experimental control.

RESULTS

Data from magnitude and delay-sensitivity assessments are not shown (but are available from the corresponding author upon request). During the magnitude assessment, Noah, Joel, Garrett, and Jonah selected the larger reinforcer on 100%, 100%, 100%, and 93.3% of trials, respectively, over the last three sessions. During the delay-sensitivity assessment, Noah, Joel, Garrett, and Jonah selected the immediate reinforcer on 93.3%, 86.7%, 93.3%, and 80% of trials, respectively, over the last three sessions when the delay was 10 s (Garrett and Joel) and 20 s (Noah and Jonah). Thus, results verify sensitivity to reinforcer magnitude and immediacy.

Figure 1 displays results for Noah and Joel. During the self-control assessment, Noah and Joel were more likely to select the larger, delayed reinforcer over the smaller, immediate reinforcer when the larger reinforcer was delayed up to 40 s and 20 s, respectively. During the delay-fading treatment, larger, delayed reinforcers were selected more often than smaller, immediate reinforcers as delays increased to 90 s (Noah) and 25 s (Joel). Thus, although this intervention increased delay tolerance for Noah, it did not noticeably increase delay tolerance for Joel. During the delay-fading-plus-signal treatment, preference for the larger, delayed reinforcer was maintained as delays increased to 100 s (Noah) and 40 s (Joel). Thus, the signal increased delay tolerance only moderately above that already produced via delay fading.

Figure 2 displays results for Garrett and Jonah. During the self-control assessment (first condition), Garrett and Jonah were more likely to select the larger, delayed reinforcer over the smaller, immediate reinforcer up to delays of 20 s and 40 s, respectively. During the delay-fading-plus-signal treatment (second condition), Garrett and Jonah were more likely to select the larger, delayed reinforcer over the smaller, immediate reinforcer as delays increased to 70 s and 100 s, respectively. Preference switched once delays reached 75 s and 105 s for Garrett and Jonah, respectively. Similar patterns of selection occurred during replications, in which the first delay that no longer maintained predominant selection of the larger, delayed reinforcer (75 s; Garrett) and the last delay that did (70 s and 100 s for Garrett and Jonah) were [illegible]mmed. These results further suggest that delay fading plus signals can increase delay tolerance.

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DISCUSSION

Our results replicate and extend work by Schweitzer and Sulzer-Azaroff (1988) and support the notion that self-control is mutable and dependent on context. The delay-fading-plus-signal condition, when compared to the self-control assessment, increased the delay that maintained selection of the delayed reinforcer. These results are similar to those obtained by Schweitzer and Sulzer-Azaroff. Unsignaled delay fading, which was not evaluated by Schweitzer and Sulzer-Azaroff, increased the maximum delay that maintained selection of delayed reinforcers for Noah but had little or no effect for Joel. Some variability within phases may be related to reinforcer variability

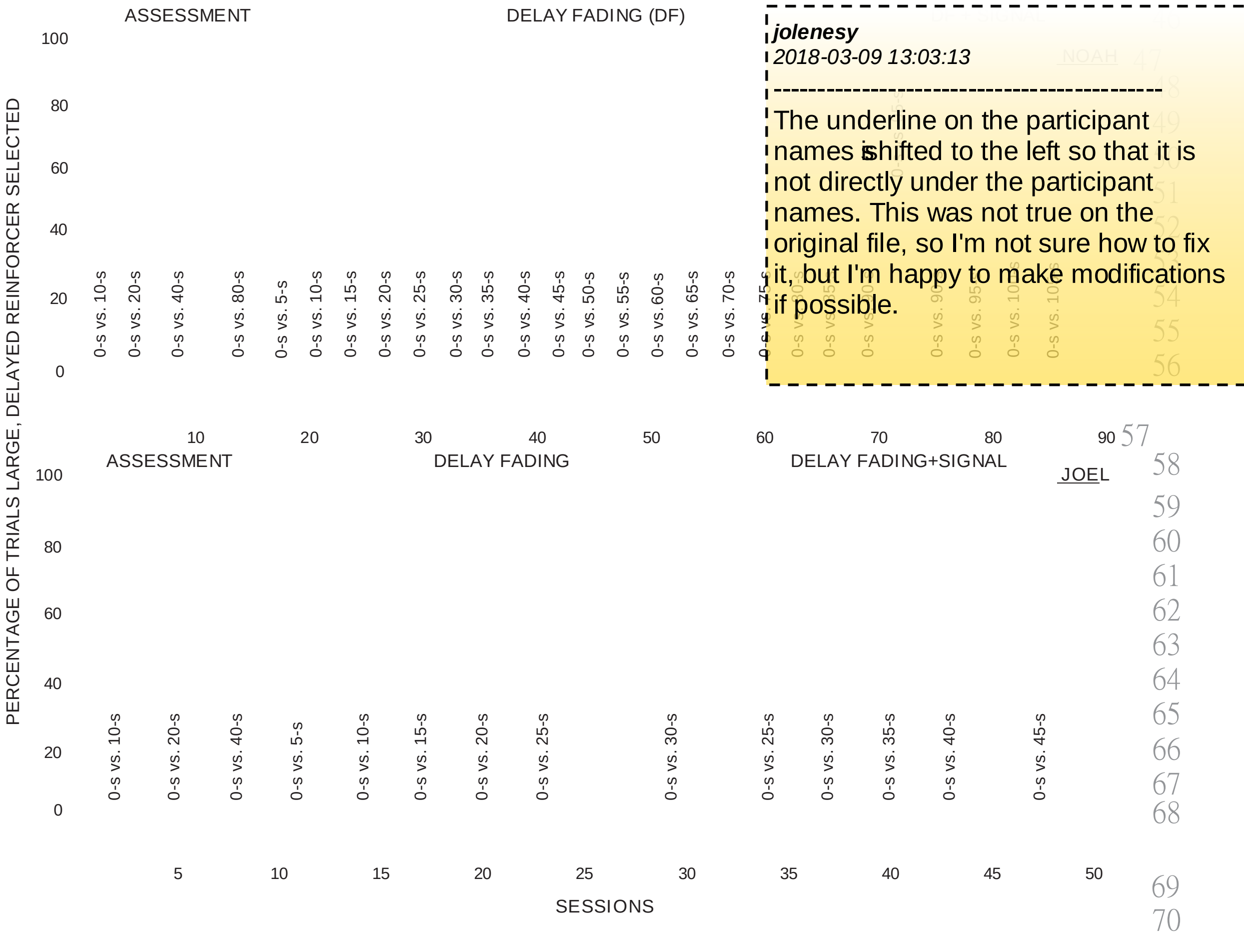

Figure 1. Percentage of trials in which the large, delayed reinforcer was selected during the self-control assessment, delay-fading (DF) treatment, and delay-fading-plus-signal (DF + Signal) treatment for Noah and Joel. At the bottom of each phase, the shorter duration indicates the delay to the smaller reinforcer and the longer duration indicates the delay to the larger reinforcer.

(participants chose among their top three preferred items). However, systematic changes in selection did not co-occur with changes in levels of responding; thus, it is unlikely that variability within phases was influenced by changes in preference.

The effectiveness of delay-fading (for one child) and delay-fading-plus-signal (for all children) treatments may have been due to the smaller step-size change (5 s) than those used in the self-control assessment (10 s, 20 s, 40 s, and 80 s). Smaller step sizes might be more likely to maintain selection of the delayed reinforcer because delay increases may be less discriminable. The delay-fading-plus-signal treatment resulted in selection of the larger reinforcer at delays of 100 s, 40 s, 70 s, and 100 s for Noah, Joel, Garrett, and Jonah, respectively. However, it is unclear if these delays mirror delays these individuals contacted in their home and school environments. It remains to be seen whether the increases in the delay at which at which the larger, delayed reinforcer was selected over the smaller, immediate reinforcer are clinically significant for these participants or other children who are described as impulsive. Future researchers might increase these delays even further by providing preferred items during the delay (Newquist, Dozier, & Neidert, 2012), or programming a response

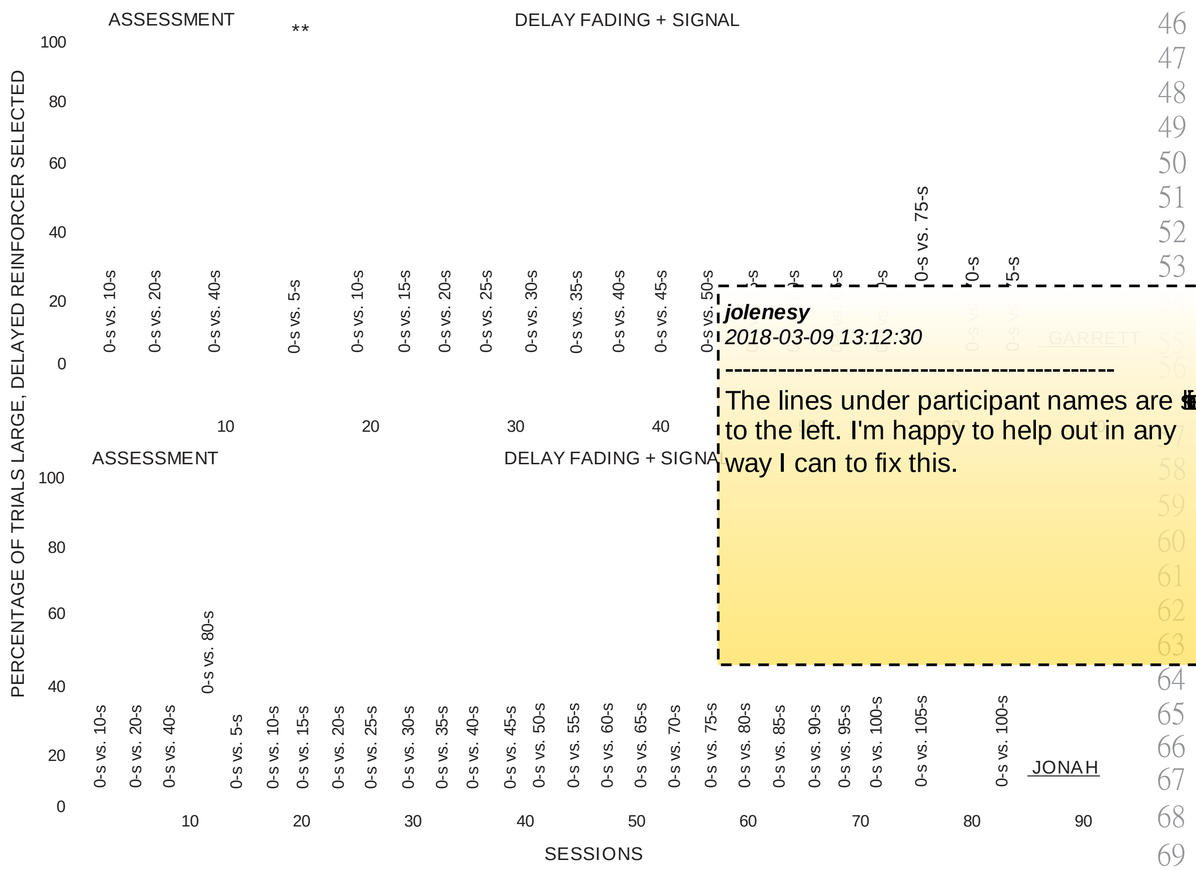

Figure 2. Percentage of trials in which the large, delayed reinforcer was selected during the self-control assessment and delay-fading-plus-signal (DF + Signal) treatment for Garrett and Jonah. For Garrett, asterisks indicate points at which the signal topography changed. At the bottom of each phase, the shorter duration indicates the delay to the smaller reinforcer and the longer duration indicates the delay to the larger reinforcer.

requirement between the onset of the delay and the delivery of the reinforcer (Dixon, Rehfeldt, & Randich, 2003; Ghaemmaghami et al., 2016).

Effective methods for increasing self-control may be useful in schools. For example, it is in students’ long-term best interest to choose academic work completion that produces delayed, larger reinforcers (e.g., recess), in lieu of other responses (e.g., disruptive behavior) that might produce immediate, brief reinforcers (e.g., peer attention). This example illustrates how parameters other than reinforcer magnitude may differ across alternatives that produce immediate and delayed reinforcement. Researchers have examined how reinforcer rate, reinforcer quality, and response effort interact with reinforcer delay to influence choice between concurrently available alternatives (e.g., Neef, Bicard, & Endo, 2001). Because choices between immediate and delayed outcomes that differ along multiple parameters may be common in school settings, future research should evaluate signals that are easy to deliver in a classroom, such as contingency-specifying instructions (e.g., “Finish your worksheet, then you can play”).

The present results should be considered in light of three limitations. First, sequence effects must be considered. Repeated testing alone may be responsible for some intervention effects. Future researchers might use multiple-baseline designs to evaluate the effect of repeated testing. Second, for Noah and Joel, within-subject replications of the last value that produced preference for the delayed option were not conducted. However, results were replicated when reversals were conducted for Garrett and Jonah. Future research might include a control (i.e., no consequence) option to further demonstrate experimental control. Third, in the delay-fading-plus-signal condition for Noah and Joel, initial delays were not reset to 5 s; thus, the probability that the signal would acquire reinforcing properties may have decreased, making this condition less effective.

In summary, we replicated and extended work by Schweitzer and Sulzer-Azaroff (1988) by continuing delay fading until preference switched to the immediate option and by evaluating delay fading in isolation for two participants. Both delay-fading and delay-fading-plus-signal conditions produced moderate increases in self-control. These results add to the research on the use of signals and delay fading as methods for increasing self-control.

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