An Examination of the Effects of Delayed Reinforcement on Skill Acquisition

A Thesis Presented

By

Heather Lynn Amtmann

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Author: Heather Lynn Amtmann

Department: Counseling and Applied Educational Psychology

Approved for Thesis Requirements of Master of Science Degree

_________________________________________________  ____________
(William Ahearn, Ph.D., BCBA)

_________________________________________________  ____________
(Richard Graff, M.S., BCBA)

_________________________________________________  ____________
(Jason Bourret, Ph.D., BCBA)
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Heather Lynn Amtmann

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An Examination of the Effects of Delayed Reinforcement on Skill Acquisition

A. Abstract........................................................................................................... 6
B. Introduction
   a. Animal Studies.......................................................................................... 7
   b. Human Studies.......................................................................................... 11
   c. Summary and Current Study..................................................................... 14
C. Method
   a. Participants and Settings......................................................................... 14
   b. Materials.................................................................................................... 14
   c. Measurement and Inter-observer Agreement......................................... 15
   d. Design......................................................................................................... 15
   e. Preference Assessment............................................................................. 16
   f. Procedure..................................................................................................... 16
   g. Assessment.................................................................................................. 17
D. Results............................................................................................................. 17
E. Discussion........................................................................................................ 20
F. References....................................................................................................... 23
G. Table............................................................................................................... 25
H. Appendix......................................................................................................... 26
I. Figure Captions.............................................................................................. 27
J. Figures............................................................................................................. 28
Abstract

Basic research on delayed reinforcement indicates that reinforcement delays degrade the effectiveness of reinforcers. Therefore, in practice there is an emphasis on delivery of the reinforcer immediately following a target response. Research has shown that, in non-humans, reinforcement delays of up to 16 s can enhance performance but the effectiveness of a reinforcer is decreased relative to when it is presented immediately following responding. However, there is little research studying the effects of delayed reinforcement with humans. In this study, the effects of delayed reinforcement are examined with 4 participants diagnosed with autism. In an alternating treatments design, relations between arbitrarily matched novel stimuli were taught using 3 conditions: immediate reinforcement, 30 s delayed reinforcement, and no consequence. Results showed that skill acquisition occurred for 2 participants only in the immediate reinforcement condition. With the 3rd participant, skill acquisition occurred in both immediate reinforcement and delayed reinforcement conditions.
Evaluation of Delay of Reinforcement in Both Animal and Human Research

Reinforcement is a necessary component of establishing or increasing operant behavior. Behavior can be changed through both positive reinforcement (adding a stimulus), and negative reinforcement (removal of a stimulus; Cooper, Heron, & Heward, 1987). Reinforcement is most effective when delivered immediately following a response (Sutphin, Byrne, & Poling, 1998). In many natural settings, however, there may be a delay between the response and reinforcer delivery due to other events in the surrounding environment. Many studies have been conducted on the effects of delay of reinforcement by examining the length of time that passes between responding and reinforcement and the subsequent occurrence of reinforced behavior. These studies generally imply that the reinforcer loses its reinforcing effect with delay (Sutphin et al.).

One recent study sought to compare lever pressing followed by no-consequence, cancellation, and reinforcement to study sensitivity to delayed reinforcement (Sutphin et al., 1998). The subjects included 8 experimentally naïve rats who were water deprived. Contingent on pressing the reinforcement lever, water was delivered for 4 s. The cancellation lever canceled any scheduled reinforcement from a reinforcement lever press, and the no-consequence lever condition served as a control. Delays were set at 8, 16, 32, and 64 s. Results showed that following a delay of consequences of 16+ s, there was no differential responding between the reinforcement lever and the no consequence lever. These results suggest that a delay of 16 s or above is ineffective for reinforcement to alter responding. Sutphin et al. suggested that using a cancellation procedure is most efficient for testing immediacy of reinforcement, because with just the reinforcement vs.
no-consequence lever there is a possibility of adventitious reinforcement of the no-
consequence lever. When switching from the no-consequence lever to the reinforcement
lever, the responses from the former lever may be followed by food with little or delay.
This could establish conditioned reinforcers such as the sound the pressing of a lever
produces, or the feel of the movement of a lever.

Various schedules of delayed reinforcement have been examined. Richards
(1972) sought to determine if behavioral contrast would be produced if reinforcement
was delayed during one component of a multiple variable interval (VI) 1-min VI 1-min
schedule. He also examined the relationship between the amount of behavioral contrast
and the duration of the reinforcement delay. Subjects included 35 pigeons that underwent
a training procedure prior to treatment. Reinforcement was available on a multiple VI 1-
min VI 1-min schedule and was delayed at either 2.5 s, 5 s, 10 s, or 120 s. Another group
experienced multiple VI 1-min extinction training. Results showed that delay of
reinforcement of one component of the multiple schedule did produce behavioral
contrast, and that it occurred more consistently with longer delays or extinction.
However, the author did not find a relation between the duration of the reinforcement
delay and behavioral contrast.

Neuringer (1969) examined whether pigeons would choose delayed reinforcement
or a fixed-interval (FI) schedule of reinforcement. Subjects included 10 pigeons. In
Experiment 1, a concurrent-chains schedule was used. Two keys on VI schedules were
available during the initial link. Responses on one key led to the occasional presentation
of a FI terminal link, and responses on the other key led to the occasional presentation of
delayed reinforcement. A blackout occurred during the delay-of-reinforcement terminal
link when both keys were inactivated and the chamber was completely dark. Results showed that when choice of fixed interval was measured, there was a small preference for the FI condition. For choice responses per min and responses per min, however, preferences did not vary although response rates decreased during the FI condition as time to reinforcement increased. In Experiment 2, the procedure was the same as Experiment 1, except that the duration of delay and fixed intervals differed. Results were similar in that subjects displayed a small preference for FI schedules. Experiment 3, implemented the same procedure, however, without a blackout. Results showed that the slightly lower preference for delayed reinforcement relative to the fixed interval schedules in Experiments 1 and 2, were likely due to the blackout periods. This is because removing or controlling blackouts allowed the subjects to choose equally between the delay and fixed-interval choices.

Cicerone (1976) examined whether preferences would be identified between a delay imposed on a mixed length reinforcement schedule on one lever and a delay imposed on a constant reinforcement schedule on the other lever. Subjects included 6 pigeons that underwent a pretraining procedure. During the delay training procedure phase, one lever produced reinforcement at mixed delays of 30 s, 15 s and 45 s, 5 s and 55 s, and 0 s and 60 s. The other lever produced reinforcement at constant delays of 0 s, 8 s, 15 s, and 32 s. Results showed that the pigeons preferred mixed delay relative to constant delay of reinforcement.

Lattal and Ziegler (1982) compared delay of reinforcement of variable-interval schedules to a differential-reinforcement-of-low-rate schedule (DRL). In addition, delays were signaled, unsignaled, or unsignaled with a requirement of no responding within the
0.5 s interval immediately preceding reinforcement. The purpose was to compare interresponse time (IRT) distributions generated across conditions. Subjects used were 4 pigeons that were trained to peck the response key and to eat from a food hopper. Results showed that response rates and IRT distributions covaried. During the signaled delays, response rates were low and the frequency of short IRTs decreased. During the unsignaled delays, response rates increased and the frequency of short IRTs increased as well.

Along the signaled delays research, Richards (1981) examined the generality of effect of signaled and unsignaled delays at varied durations while also including schedules of VI 60 s and DRL 20 s. Subjects were 9 pigeons, 4 of which were assigned to the VI schedule, and the remaining 5 were assigned to the DRL schedule. Following VI schedule pretraining, the subjects experienced reinforcement at delays of 10 s, 5 s, 2.5 s, 1 s, and 0.5 s with both signaled and unsignaled delay conditions. Following DRL pretraining, subjects then experienced a DRL 20-s schedule with both signaled and unsignaled delay conditions. Results showed no significant difference in responding between VI 60-s or DRL 20-s schedules. However, there was a moderate decrease in responding during signaled delays up to 10 s, and large decreases in responding occurred during unsignaled delays of 5 and 10 s.

Concurrent and progressive schedules associated with delay of reinforcement were examined by Davison (1988). In Experiment 1, 6 pigeons were presented with two initial link keys that led to terminal link keys delivering the first reinforcer following 1 s (Experiment 1A) or 5 s (Experiment 1B), depending on which key they pecked. Second reinforcers were then either available after a 10-s delay, or the delay was varied. The
pigeons showed very little preference to either schedule. In Experiment 1C, both delays were 10 s on one key, while the other was varied. Preferences for the varied key were found. In Experiment 2, the terminal link reinforcer was delivered at either 0.2 s or 19.8 s, and the initial link provided access to the terminal link at varied rates. Results showed that as the initial link duration increased, preference for shorter delay of the terminal link decreased.

Human research has also been conducted using various schedules of delayed reinforcement, such as Hanley, Iwata, and Thompson (2001). The purpose of the study was to evaluate various methods of thinning differential-reinforcement-of-alternative-behavior (DRA) schedules. The DRA intervention used with the 3 participants included functional communication training (FCT) as well as extinction of problem behavior. Study 1 examined the effects of reducing problem behavior using three conditions: FR1 (access to popcorn) with increasing delays for an alternative response using a functional communication response (FCR), a graduated FI schedule, and a graduated multiple schedule. Results showed in the first condition there was extinction of alternative behavior (pressing a microswitch emitting the sound, “more please”), in the second condition there were undesirably high rates of alternative behavior, and in the third condition there were moderate and stable levels of alternative behavior. Study 2 examined the effects of altered reinforcement durations (10 s access to reinforcement) as well as extinction under both mixed (unsigned periods of reinforcement alternating with extinction) and multiple (signaled periods of reinforcement alternating with extinction) schedules. Results showed that problem behavior remained low, and during a multiple
A comparison of delayed reinforcement and a DRO with infant vocalizations was conducted by Reeve, Reeve, Brown, Brown, and Poulson (1992). Three 4- to 6-month-olds participated. An operant baseline was taken with the parent playing with the infant while talking, touching, or presenting toys. Vocalizing was reinforced by their parents on a delay in one condition, while social attention was provided on a DRO schedule in another condition. These conditions alternated in a repeated-reversal design. Under the delayed reinforcement condition following the DRO condition, there was an increase in vocalizations. Under the DRO condition following the delayed reinforcement condition, a decrease in vocalizations occurred.

Other experimenters extended research on delayed reinforcement by examining impulsive choice making in terms of choosing a short delay followed by a small reinforcer vs. a long delay followed by a large reinforcer (e.g., Shull, Mellon & Sharp, 1990). The pigeons in this study were given a choice between two terminal links, one leading to two food deliveries and the other leading to five. The timing of the food deliveries was varied during the five-food terminal link, with the first delivery after the choice, the second delivered 2 s, the third 3 s, and the fourth 4 s. Forced trials consisted of only one lit key, and choice trials had both keys lit. Latencies for responding to the terminal links were measured. The pigeons’ responding suggested a preference for the terminal link associated with the “higher sum of immediacies (the sum of the reciprocals of the delays to each of the reinforcers following the choice, with all delays measured from the choice)” (Shull et al., p. 235). The relation between choice and
latency suggested that response tendencies were affected by conditioned reinforcement
due to the decreasing function of the delay of the reinforcer and the size of each
reinforcer’s contribution.

Neef, Mace, and Shade (1993) extended research on impulsive choice making by
carried out an experiment with 2 students in a special education program. In Study 1,
conditions of unequal rates of reinforcement and equal vs. unequal delays were
implemented in a ABCBC reversal design. Results suggested impulsive choice making
by the participant with a preference for shorter delays. In Study 2, they added high
quality reinforcers following long delays vs. low quality reinforcers following short
delays. Results showed 1 participant preferred higher quality reinforcers with the long
delay, while the other student showed impulsivity.

Continuing research on impulsivity in humans, Dixon, Rehfeldt, and Randich
(2003) exposed 3 participants to choices between high quality reinforcer following a long
delay or a low quality reinforcer following a short delay. Results at first suggested
impulsivity with a preference for the low quality reinforcer following a short delay, but
later sessions suggested self-control with a preference for the high quality reinforcer
following a long delay. Dixon et al. found that progressive increases in delay with high
quality reinforcers can help establish self-control.

Finally, Dixon and Falcomata (2004) provided choices between a small
immediate reinforcer, a large reinforcer following a fixed delay, and a large reinforcer
following a delay that was progressively increased across reinforcer deliveries in an
attempt to increase self-control and head holding of a man with traumatic brain injury.
Results showed a preference for the progressive-delay condition.
Overall, there has been an extensive amount of research on delayed reinforcement that can be further evaluated. However, there is no human research on delayed reinforcement in terms of the “reinforcer” losing its reinforcing effect over larger delays. The animal research on delayed reinforcement has been assumed to have the same effect on humans. However, it is significant to show the effects on humans, particularly those with autism, in order to emphasize the importance of immediate reinforcement. The purpose of the study was to examine the effects of delayed reinforcement on skill acquisition.

Method

Participant and Setting

The students who participated in this study were all diagnosed with an autism spectrum disorder. They ranged in age from 5 to 8 years old. Tim was 5 years old and diagnosed with autism. Ian was 8 years old and diagnosed with pervasive developmental disorder. Meg was 5 years old and diagnosed with autism. All participants attended a day or residential program at a school for children with autism or related disorders. The experiment took place in classroom settings such as a cubby with table, chairs, and materials on shelves, or a small room with a similar setup.

Materials

Materials used included 6 sets of arbitrarily matched stimuli used for a three-member comparison array, a foam white discrimination board to display comparison stimuli, a silent timer, as well as highly preferred edibles based on the results of the preference assessments. See Table 1 for the sets of stimuli used for this experiment.
Stimuli were individually printed on pieces of white paper 25 mm x 25mm and laminated.

*Measurement and Interobserver Agreement (IOA)*

Correct responses were defined as the participant’s point to the correctly matched stimulus (S+) from the three member comparison array independently within 2 s or prompted after no response following a 2-s delay. Picking up the sample stimulus and placing it on top of the correctly matched stimulus (S+) was also counted as correct. The correctly matched stimuli were predetermined (see figures above). Incorrect responses were defined as following the participant’s point to the sample stimulus, the participant then points to an incorrect stimulus (S-) within a 2-s delay. No response (NR) was defined as following the participant’s point to the sample stimulus, the participant then did not point to a member of the comparison array within 2 s. See Appendix for data sheet. Interobserver agreement (IOA) data were collected during 37% of the sessions. IOA was determined by dividing the total number of agreements by the total number of agreements plus disagreements and then multiplying by 100; IOA was 99%.

Procedural integrity probes were conducted for 14% of sessions. During these probes, a second observer recorded the accurate presentation of stimuli as well as delivery of the correct consequence were measured. Mean procedural integrity was 99%.

*Experimental Design*

The experiment was conducted in a an alternating treatments design. Comparisons across three conditions were used to assess the relative effects of reinforcement on skill acquisition. The conditions consisted of either immediate reinforcement, 30 s delayed reinforcement, and no consequence (see condition
descriptions below). The order of condition was quasi-randomized with each condition occurring once before all other conditions repeat. Sessions consisted of 9 trials, with at least 10 min between each session. Two assessments were conducted with each participant. In order to equalize the inter-trial intervals across conditions, 30 s was added following reinforcement during the immediate reinforcement and no consequence conditions.

Preference Assessment

Based on the paired stimuli preference assessment by Fisher et al. (1992) on each trial, two items were presented simultaneously in a predetermined order approximately 25 mm in front of the participant and 25 mm apart. At the beginning of each trial, the experimenter stated, “choose”, and the participant was given access to consume the item that was selected. During each session, each item was paired with every other item twice, with position counterbalanced across presentations. Each session consisted of 21 trials, and 2 sessions were conducted with each participant.

Procedure

Prior to a session, the participant was given a choice between the two highly preferred edibles based on the preference assessment results. The exception to this was Meg, who had a limited variety of edibles she could earn.

A trial began when the experimenter presented the sample stimulus with the three-member comparison array covered. Once the participant touched the sample, the comparison array was uncovered. If the participant did not independently touch the sample, the experiment provided a prompt with a light physical touch. Once the
participant touched a stimulus from the comparison array, the experimenter delivered consequences depending on the condition.

*Discrimination Assessment.* During the assessment, 3 conditions were alternated and counterbalanced: no consequence (serving as a control), immediate reinforcement, and 30 s delayed reinforcement. One set of arbitrary stimuli was paired with no consequence. During this condition, the participant’s responses were followed with no edible. Inter-trial interval was 30 s. During the immediate reinforcement condition, correct responses were immediately followed with delivery of the edible by the experimenter. Inter-trial interval was 30 s. During the 30-s delay condition, correct responses were followed with delivery of the edible by the experimenter following a 30-s delay. During the delay, the experimenter prepared the stimuli for the next trial and had no interactions with the participant. During the prompting phase, the prompts were implemented as follows: Step 0 – Immediate manual guidance, Step 1 – 2 s delay then manual guidance if no independent responding, Step 2 – 2 s delay then light touch/shadow if no independent responding, and Step 3 – Independent (no prompting). Criteria to increase step: 1 session with >90% correct. Criteria to discontinue session and decrease step: 2 consecutive errors or 3 total errors within a session. No correction procedure followed incorrect responses. No verbal praise was provided throughout the study.

**Results**

*Preference Assessment.*

Results show that one or two high-preference edibles were identified for each participant. The high-preference items for Tim were Ring Pop, Nesquik, Cheetos, Stackers, and a toy vacuum cleaner (see Figure 1). The high-preference items for Ian
were Honey Teddy Grahams, Cheezits, and Doritos (see Figure 2). The high-preference item for Meg was pretzels (see Figure 3).

**Pretest.**

Results showed that all participants could perform identity matching but could not reliably match the arbitrarily-related stimuli. For the first pretest for Tim, he performed identity matching with 100%, 100%, and 90% accuracy; in comparison, he performed with 30%, 30%, and 20% accuracy with matching the novel stimuli as shown in the top panel of Figure 4. For the second pretest for Tim, he performed identity matching with 100%, 100%, and 100% accuracy; in comparison, he performed with 30%, 20%, and 30% accuracy with matching the novel stimuli as shown in the bottom panel of Figure 4. For the first pretest for Ian, he performed identity matching with 100%, 100%, and 100% correct; in comparison, he performed 30%, 10%, and 10% correct with matching the novel stimuli as shown in the top panel of Figure 5. For the second pretest for Ian, he performed identity matching with 100%, 100%, and 100% correct; in comparison, he performed 10%, 30%, and 20% correct with matching the novel stimuli as shown in the bottom panel of Figure 5. For the first pretest for Meg, she performed identity matching with 100%, 100%, and 100% correct; in comparison, she performed 10%, 20%, and 30% correct with matching the novel stimuli as shown in the top panel of Figure 6. For the second pretest for Meg, she performed identity matching with 100%, 100%, and 100% correct; in comparison, she performed 30%, 50%, 20%, and 20% correct with matching the novel stimuli as shown in the bottom panel of Figure 6. Set B was evaluated twice, because in the first session she performed 50% correct. With the second session she performed 20% correct.
Assessment.

The results of the assessments showed some variability, but overall for Tim and Ian, delayed reinforcement did have a negative effect on skill acquisition; and for Meg, delayed reinforcement did not have a negative effect on skill acquisition. None of the participants acquired the skill in the no consequence condition.

Tim. Figure 7 shows the results for Tim’s assessments. During the first assessment, responding was low but variable. Following prompting, there was an increase in accuracy up to 89% across two people and two settings, and finally reaching 100% in the last session in the immediate reinforcement condition. Accuracy in the delayed and no consequence conditions remained stable at 0% independent correct. During the second assessment, with the exception of the first session, the data showed variability at a low level during the no prompting phase. Following prompting, there was some variable independent correct responding across conditions, but he never met the mastery criteria.

Ian. Figure 8 shows the results for Ian’s assessments. During the first assessment, the data showed variability at a low level during the no prompting phase. Following prompting, there was a gradual increase in independent responding up to 100% across the delayed and no consequence conditions. The data in the immediate reinforcement condition remained stable at 0% independent percentage correct with the exception of one session. During the second assessment, with the exception of one session in the delayed condition, the data showed variability at a low level during the no prompting phase. Following prompting, there was an increase in independent responding up to 100% across people and settings in the immediate reinforcement condition.
Responding in both the delayed and no consequence conditions remained at low variable rates.

*Meg.* Figure 9 shows the results for Meg’s assessments. During the first assessment, there was an increase in independent responding up to 89% across two people and two settings, and finally reaching 100% in the last session in the delayed condition. With the exception of one session in the no consequence condition, the data in the immediate reinforcement and no consequence conditions remained stable at 0% independent correct. During the second assessment, there was a gradual increase in independent responding to 100% across people and settings in the immediate reinforcement and delayed conditions. Although there was a gradual increase in responding in the no consequence condition up to 89%, it quickly decreased to a low variable level.

**Discussion**

Sutphin et al. (1998) studied the effect of various delays of reinforcement of lever pressing with rats, and found that delaying reinforcement did have a negative effect on lever pressing. The purpose of this study was to evaluate effects on skill acquisition of 3 conditions: immediate reinforcement, 30 s delayed reinforcement, and no consequence. All pretests showed that the participants had identity matching skills, and it also shows the novelty of the arbitrarily matched stimuli.

For two participants, data showed that delayed reinforcement did have an effect on skill acquisition as compared to the immediate reinforcement condition. There were also substantial differences in performance when comparing the three conditions. In the immediate reinforcement condition and the delayed condition, Tim waited for the prompt
almost every time at Steps 1 and 2; however, most of the time in the no consequence condition, he did not wait for the prompt and even chose an incorrect answer following a light physical prompt to the correct answer. In this case, it is important to emphasize the significance of immediate reinforcement and encourage his teachers across the day to deliver the reinforcer as quickly as possible following a correct response.

For Meg, it seemed that reinforcement, whether immediate or delayed, did produce skill acquisition. This could be due to her past history with conditioned reinforcers such as tokens, or higher academic abilities. She did not, however, acquire the skill in the no consequence condition.

It is interesting that Ian did not acquire the skill in the immediate reinforcement condition in the first assessment. Perhaps if we continued the first assessment for more sessions, he may have later have acquired the skills; however, not in the same amount of time as the other conditions. It is possible that matching the stimuli assigned for the immediate reinforcement condition was a more difficult task than matching the stimuli in the other conditions. However, it is interesting that in the second assessment he acquired the skill only in the immediate reinforcement condition. Change in preference could have also been a confound, if he believed he was limited to choosing only one of the two highly preferred edibles offered for him to earn. He also currently uses a token economy across the day; therefore, edible reinforcement may have been a confound as well based on a past history of earning tokens in exchange for toy breaks. Toy breaks may be more reinforcing than direct edibles.
Variability for Tim in the second assessment and Meg in the first assessment, may have been due to the difficulty of the particular stimuli assigned to the conditions. Tim may have also been entirely unmotivated after so many sessions from both assessments.

Other limitations of the study could be that, for Meg, we decided not to start with a no prompting phase. We decided to discontinue the no prompting phase, because there was no skill acquisition for the first two participants during this phase. Future research should evaluate the effects on skill acquisition with delayed reinforcement using conditioned reinforcers such as a token economy. Future research should also evaluate the effect of smaller and larger delays on skill acquisition. It would also be interesting to find some students who can acquire skills in a no consequence condition; therefore, edible reinforcement may not be necessary.

With all the variables that could affect learning such as: competing activities or distractions, prompting technique, procedural integrity, and delayed reinforcement, emphasizing the significance of immediate reinforcement could help improve skill acquisition.
References


Table 1

*Six sets of stimuli used in the experiment. Set 1-6 are the comparison stimuli, Set 1.1-6.6 are the sample stimuli.*

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Appendix

Example Data Sheet.

STUDENT: Tim

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Figure Captions

Figure 1. Preference assessments for Tim using eight edibles.

Figure 2. Preference assessments for Ian using eight edibles.

Figure 3. Preference assessment for Meg using eight edibles.

Figure 4. Pretests 1 and 2 for Tim comparing identity vs. arbitrary matching.

Figure 5. Pretests 1 and 2 for Ian comparing identity vs. arbitrary matching.

Figure 6. Pretests 1 and 2 for Meg comparing identity vs. arbitrary matching.

Figure 7. Assessments 1 and 2 for Tim displaying independent percentage correct responding across conditions (immediate reinforcement, 30 s delayed reinforcement, and no consequence).

Figure 8. Assessments 1 and 2 for Ian displaying independent percentage correct responding across conditions (immediate reinforcement, 30 s delayed reinforcement, and no consequence).

Figure 9. Assessments 1 and 2 for Meg displaying independent percentage correct responding across conditions (immediate reinforcement, 30 s delayed reinforcement, and no consequence).
Figures

Preference Assessment 1

Preference Assessment 2

Preference Assessment 3

Activity Preference Assessment

Stimuli

Figure 1
Figure 2
Figure 3

Preference Assessment

Percentage Chosen

Stimuli

Pretzels, Banana, Popcorn, Chips, Raisins, Strawberries, Kix, Blueberries

HP

Figure 3
Figure 4
Figure 5
Figure 6
Figure 7
Figure 8
Figure 9