Effect of Variable Delays to Reinforcement on Skill Acquisition of Tacts in Children with Autism

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by

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A thesis submitted to the School of Behavior Analysis of Florida Institute of Technology in partial fulfillment of the requirements for the degree of Master of Science in Applied Behavior Analysis and Organizational Behavior Management

Melbourne, Florida

July, 2023
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Abstract

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Basic research has established that immediate reinforcement produces the best outcome when learning a skill. More recent research has followed, showing that even 8-10 seconds of brief delays may impair learning. In one of the few applied studies on this topic, Majdalany et al. (2016) showed that participants with Autism Spectrum Disorder (ASD) acquired tacts more quickly with immediate reinforcement, compared to delays of 6s and 12s. However, no research has examined variable delays to reinforcement, which may be more common in classrooms and clinics. Thus, the purpose of the proposed study was to expand previous research by examining variable delays to reinforcement on the acquisition of tacts. Specifically, three conditions were compared: a 0s delay, a 4-8s delay and a 10-14s delay. Two of the three participants achieved the mastery criterion most quickly in the 0s delay condition. The results and implications of this finding are discussed.
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Chapter 1: Introduction

Reinforcement may be the most important principle in the field of applied behavior analysis (ABA). Cooper et al. (2019) defined the term positive reinforcement as “when a response is followed immediately by the presentation of a stimulus change that increases the future occurrence of similar responses (p.253).” Specifically, the term “positive” means the presentation of a stimulus and the term “reinforcement” means an increase in future responding. For example, if a teacher gives a child candy for raising his hand in class and he raises his hand more often in the future, this is an example of positive reinforcement. On the other hand, the term “negative reinforcement” means that the removal of a stimulus increases the future occurrence of similar responses. For example, a person may seek shade to escape the sun and then continue to do so when exposed to the sun in the future.

Hall et al. (1968) authored the first articles examining the effect of positive reinforcement on humans. Using a reversal design, the authors examined the effects of contingent teacher attention on the study behavior of 6 elementary school students. Study behaviors increased 20-30% compared to baseline when teacher attention was provided contingent upon studying behavior. The study did not conduct a reinforcer assessment to ensure that teacher attention functioned as a reinforcer for these students. However, it did lay the foundational concept that contingent presentation of certain stimuli can increase behavior.

Reinforcement has four key dimensions: schedule, magnitude, quality, and immediacy. The schedule or frequency of reinforcement refers to how often the
reinforcer is delivered. A reinforcer can be delivered on a fixed-ratio 1 schedule, also known as a continuous schedule of reinforcement. This is most often used when teaching a new skill. The behavior can also be on extinction, which means no reinforcer is delivered contingent upon the target response. Usually, a behavior targeted for reduction will be placed on extinction. The schedule of reinforcement can vary anywhere between those two schedule parameters (i.e., intermittent reinforcement).

The magnitude of reinforcement, as defined by Trosclair-Lasserre et al. (2008), refers to the quantity, or duration of reinforcement. Overall, the greater the magnitude, the more effective the reinforcer. For example, a child can be given one 10s break or a 1-min break for a correct response. Ferguson et al. (2019) used different magnitudes of reinforcement to increase variable responses by individuals with autism. When a large magnitude of reinforcement (four edible stimuli instead of one) was delivered contingent on variable communicative responding, a higher level of variability was observed.

The quality of the reinforcer is idiosyncratic to each individual. What a 4-year-old considers as a high-quality reinforcer is likely to differ from what a 24-year-old considers as a high-quality reinforcer. Generally, the quality is assessed through objective preference assessments such as a multiple-stimulus without replacement assessment (MSWO; DeLeon & Iwata, 1996). Higher ranked items from the assessment are considered to be of higher quality for the individual. Cividini-Motta and Ahearn (2013) compared different differential reinforcement strategies. They found the majority of the participants acquired skills fastest when the highest
preferred item was delivered for independent correct responding and low/moderately preferred items were delivered for prompted correct responses. This demonstrated the effects of using high-quality reinforcers for desired behaviors.

Finally, the immediacy of reinforcement refers to the time between emitting the response and the delivery of the reinforcer. Skinner (1938) was the first to establish that immediate presentation of reinforcement produced the most effective skill acquisition. Since then, the immediacy of reinforcement has been extensively studied in basic research. The majority of current basic and applied research relating to the immediacy of reinforcement is often on the subject of delay discounting and its effect on impulsivity. Delay discounting is the hyperbolic decline of the value of reinforcers with time (Odum, 2011). This is perhaps most famously demonstrated by the works of Mischel and Ebbesen (1970) who conducted the “marshmallow study.” In this study, children were given the choice between immediately eating a marshmallow in front of them or waiting for the experimenter to come back and get two marshmallows instead. Since the value of a reinforcer drops when a person has to wait for it, some children struggle to choose the larger, delayed reinforcer. The behavior of choosing the smaller, sooner reward is said to be more impulsive than choosing the larger, later reward.

On top of impulsivity, delay discounting also greatly affects skill acquisition. Sizemore and Lattal (1977) compared the effects of variable interval (VI), variable time (VT), and tandem VI-fixed time (FT) schedules on the key pecking behavior of pigeons. In the tandem schedule, the reinforcement is response-dependent (VI) but delayed (FI), and the time between responding and reinforcement varies. The
delays are not signaled and the pigeons are not given cues as to how long they have to wait after responding. Key pecking was greatly reduced in this schedule and the pigeons responded only intermittently. Combining the two factors resulted in substantially lower rates of responding than VI alone in this study.

Grice (1948) conducted an experiment with white rats and compared delays to reinforcement of: 0s, 0.5s, 1.2s, 2s, 5s and 10s. The dependent variable was the number of black and white discrimination problems solved. Results show steep decreases in performance as the delay increased. Grice found the rats showed no skill acquisition on a black and white discrimination problem when the rewards were delayed by 10s for three out of five groups. However, he also found the damaging effect of delays were mediated when a secondary reinforcer (i.e. conditioned reinforcer) was provided immediately after the correct response before the delayed primary reinforcer.

Sutphin et al. (1998) trained 8 rats to discriminate between the reinforcement lever and the no-consequence lever. Water was delivered after pressing the reinforcement lever with a delay of 8s, 16s, 32s or 64s. There was no signal between pressing the correct lever and the onset of water. All rats were more likely to press the reinforcement lever than the control group which had no reinforcement history on either level. With short delays, the rats showed clear discrimination and significantly more responding toward the reinforcement lever. Responding became less consistent at 16s of delay, and at a delay of 64s there was no discrimination in responding between the two levers. Basic research with pigeons and rats clearly
shows that even 8 to 10 second delays in reinforcement can be detrimental to effective learning.

Lattal (2010) published a literature review of basic research on delays to reinforcement. Lattal concluded that for experiments with good internal validity and tight control of confounding variables, delays to reinforcement can and typically do produce reduced response rates. He further asserted that some early studies that showed increased or undifferentiated responding between immediate reinforcement and delays to reinforcement often had compromised procedures that failed to control for other variables such as not controlling for overall reinforcement rate and increased post-reinforcement pause. With appropriate procedures, the effects of the delay most heavily depend on the temporal proximity (Grice, 1948; Sutphin et al., 1998) and reinforcement schedule (Sizemore & Lattal, 1977). With either variable, reduction of responding is the most common effect of delays to reinforcement.

More recently, Harris et al. (2012) compared different FR schedule of reinforcement and different lengths of delays using domestic hens. The dependent variable was key pecking. First, the hens were trained to recognize light signals with the corresponding schedule of reinforcement. Then light signals were used to indicate current and upcoming schedules of reinforcement. Signaled delays of 0, 4, 8, 16, and 32 seconds were compared with FR ratios of 1 up through 40 in increments of 5 responses. Results show increases in both response requirement and reinforcement delay increased response pause durations. However, the longest pauses of key pecking responses occurred at the transition from immediate reinforcer to delayed reinforcer. Harris et al. (2012) propose that pause duration is
another form of reduced responding and may be a good indicator of the value of reinforcement. The authors also noted that their findings are consistent with previous research on the effects of changes in response force, response requirement, and reinforcer magnitude.

While response training and shaping are frequently used in basic research to increase responding or teach discrimination in animals, discrete-trial training (DTT) is a more common way to teach skills in practice and applied research. DTT, sometimes referred to as discrete-trial instruction (DTI), is a unit of instruction consisting of: delivery of discriminative stimulus (instruction), prompt (if necessary), response, consequence, and intertrial interval (Smith, 2001). The consequence within DTT is always contingent on the response. Messy or incorrect responses as well as lack of responding after a predetermined time (usually within 5s) result in error correction, whereas clean and correct responses result in reinforcement. A messy response includes engaging in stereotypy while responding, responding before instruction was complete or not looking at target stimuli. On the other hand, a clean response occurred when the learner looked at the stimuli, waited until the instruction was complete before responding, and performed only the target response without any other responses. A typical DTT trial may look like this: the teacher provides the vocal instruction “jump,” then waits. If the student jumps within 5s without performing other actions (e.g., waving hands while jumping), the teacher provides vocal praise along with a tangible reinforcer. This way of breaking down a complex skill and teaching it in small units is commonly used to teach
functional skills for individuals with Autism Spectrum Disorder (ASD; Majdalany et al., 2014).

An intervention with multiple components such as DTT can be difficult to implement with fidelity. Unfortunately, studies reviewing treatment integrity of DTT in applied, natural environments such as schools and educational centers consistently reveal lower than suggested levels of treatment integrity. Treatment integrity refers to the extent to which the procedure is implemented as prescribed. Downs et al. (2008) trained 8 undergraduate students as participants on correctly administering DTT through an intensive 8-hour training. The researchers examined the ability to administer DTT across a large variety of learning tasks with children of varying diagnoses. Unlike Carrol et al. (2013) and other previous research that narrowly evaluated the participant’s DTT skills alone, Downs et al. (2008) developed a 30-item checklist to include supporting behaviors that are crucial for effective DTT. Some examples of supporting behaviors include effectively managing problem behaviors, selecting stimuli and reinforcers, and selecting teaching targets. The results of this study indicated the participants demonstrated the correct use of DTT and supportive skills in a public school setting only 63-80% of the time following training. Previous research has shown that the treatment integrity for DTT has to be above or equal to 90% to facilitate optimal learning (Koegel et al., 1977).

Studying DTT in the natural classroom environment, Carrol et al. (2013) also found that DTT has produced the best results when each of the components is administered with high treatment integrity. Carrol et al. (2013) observed children
with ASD in their typical classrooms and analyzed 168 DTT trials. They found that the three most common errors seen in the classroom are: presenting additional instructions, lack of prompts, and lack of praise or tangible reinforcement for correct responses. In the first experiment, two conditions were compared, the high treatment integrity condition and the low treatment integrity condition in which the three common errors were intentionally programmed. Results show only one of the six participants was able to reach the mastery criteria under low treatment integrity conditions, but all were able to reach mastery under high treatment integrity conditions. The study established the importance of DTT treatment integrity since low integrity conditions impeded learning. In the second experiment, Carrol et al. (2013) evaluated each of the treatment integrity errors individually. They found that the degree with which each of the errors impact learning was idiosyncratic to each learner. However, for one of the three participants, withholding the reinforcer following a correct response resulted in the lowest performance even when other components were implemented with high integrity. This again affirms the central role reinforcement plays during teaching any skill, especially in the context of DTT.

Basic research findings on the effect of reinforcement delay on skill acquisition has been robust, but few applied studies have examined this topic. To summarize past research on this topic, Barhold (2020) conducted a literature search with the following inclusion criteria: human participants, English language, skill acquisition in DTT, delay to reinforcement, single subject design, and graphed data. The literature search yielded only 4 articles that matched the inclusion criteria: Grindle and Remington (2004); Sy and Vollmer (2012); Carroll et al. (2016); and
Majdalany et al. (2016). This highlights the dearth of applied research studying effects of reinforcement delay on skill acquisition and the need for more applied research on this topic.

Hockman and Lipsitt (1961) performed one of the first applied experiments on the effects of delay to reinforcement on skill acquisition. Sixty fourth-grade students were randomly divided into an easy task group (two stimuli and alternatives) and a difficult task group (three stimuli and alternatives). The students were asked to press the correct button after showing successive light patterns. They were told that a red light (reward) would turn on only if the correct button was pressed. The onset of the red light by 0s, 10s or 30s, without an additional stimulus change indicating the delay. Hockman and Lipsitt found 10s and 30s delays did not impact discrimination learning for the easy task group but was detrimental for the difficult task group. Students in this group generally did not acquire discrimination. The authors concluded that increases in reward delays have a more harmful impact on discrimination learning when the learning task is more difficult. Although 60 students participated and were individually tested, data were reported in groups of 10 students as one data point per condition (e.g., Easy task-0s delay). Since only the average response of each condition was reported, it is difficult to parse out individual differences within each group. Idiosyncratic differences were erased and delays could affect certain individuals more than others.

The first applied study evaluating delay to reinforcement in the context of skill acquisition was conducted by Grindle and Remington (2004), who taught 5 children with ASD matching words to pictures. In an alternating treatment design, three
conditions were compared: cue-value, response marking, and delay only. The cue-value condition involved immediate verbal praise for the correct response, then verbal praise with tangible reinforcement 5s later. The response marking condition involved presenting a mand (“look”) immediately after any response. After a 5s delay in response marking condition, a tangible item was delivered for correct responses only, without representing the mand or other verbal statements. During the delay condition, the therapist ignored the child for 5s then presented the tangible for the correct responses. Grindle and Remington’s (2004) study was special in that it is the only study in which participants had zero experience with DTT prior to the experiment. This suggests that the participants’ responses were due to training from the experiment alone and not affected by reinforcement history with DTT.

Grindle and Remington (2004) found that both cue-value and response marking conditions resulted in more effective teaching than the delay only condition. One participant learned faster in each cue-value and response marking condition, and the other three performed the same in both. The authors concluded that only minor variation can be found between the cue-value and response marking conditions. This indicates that having any stimulus change after the response may be more beneficial to learning than pure delay without signal or cues. Grindle and Remington (2004) chose a brief, fixed time delay of only 5s for their study. In more natural environments, the actual delay may be longer.

With 4 experiments in one article, Sy and Vollmer (2012) looked into variable delays of reinforcement in applied research. Seven children with intellectual disabilities participated in the first experiment, which compared immediacy of
reinforcer with the following conditions: 0s, 20s, 30s and 40s delay. The therapist ignored the participant during the delay and gave no signal if the response was correct or not. Six of seven participants acquired discrimination with a 0s delay, of which four were able to acquire discrimination with the 20s delay. Three of the participants were able to acquire discrimination with both 30s and 40s delay. The following experiments increased the discrimination targets from two to four. The authors found that for one of the two participants in the second experiment, the increases in both discrimination alternatives and time delay reduced effective discrimination acquisition. Sy and Vollmer (2012) further evaluated if intertrial intervals interfered with skill acquisition. Intertrial intervals are inevitably longer during delay to reinforcement conditions compared to 0s delay conditions. They found that the lengths of intertrial intervals did not interfere with skill acquisition.

The authors concluded that some learners (four out of seven) acquired skills during DTT even with reasonable delays of 20s. However, some limitations of this study are the carryover effects between the conditions and the systemic evaluation of longer delays, which might have increased tolerance for delay to reinforcement, which may result in more participants learning in longer delays than they otherwise would.

Expanding on previous research, Carroll et al. (2016) taught tacts to 2 children with autism using DTT. In an adapted alternating treatment design, the authors compared immediate reinforcement, delayed reinforcement with immediate praise, and delayed reinforcement alone. First, participants were trained with a constant prompt-delay procedure; 0s prompt delay was provided until participants achieved
two consecutive sessions at 90% correct responses. Then 5s prompt delay was used where different experimental conditions were applied for the independent correct responses. During the immediate reinforcement condition, immediate praise and a tangible item were provided for independent responses. During the delay to reinforcement with immediate praise condition, contingent on independent responses, praise was provided with a 0s delay and a tangible item was provided after a 10s delay. This is very similar to the cue-value condition by Grindle and Remington (2004). During the delay to reinforcement condition, the therapist completely withheld interaction with the participant for 10s then provided general praise and tangibles together after the delay.

One participant, Billy, did not reach mastery criteria during either of the delay to reinforcement conditions. Oscar, on the other hand, performed equally well in both immediate reinforcement and delay to reinforcement with immediate praise conditions. For both participants, the delayed reinforcement condition greatly decreased the effectiveness of DTT. Carroll et al. (2016) noted that Oscar had been receiving DTT for almost a year longer than Billy. Praise may have been successfully established as a conditioned reinforcer for Oscar but not for Billy. A 10s fixed-time delay was used for this study, but in the natural environment, the lengths of the delay to reinforcement are most likely going to vary.

Majdalany et al. (2016) built on the work of Sy and Vollmer (2012) on delays by using DTT to teach 3 children with autism to tact shapes of countries. In a multi-element design with a baseline phase, the authors tested fixed-time delays to reinforcement of 0s, 6s and 12s. During baseline, the therapist asked “what
country?” then waited 12s before moving on to the next trial. No consequence was provided for responses. During training, a progressive prompt delay teaching procedure was used. The therapist provided a prompt at 0s until the participant said the response at the same time as the therapist for three consecutive trials. Then the therapist moved on to a 1s, 3s, and 5s prompt delay. Independent responses were scored when participants emitted the correct response within 12s of instruction without a prompt. With the 0s reinforcement delay, an edible item plus social praise was delivered immediately after a correct response. For the 6s and 12s reinforcement delay, a silent timer out of sight of the participant was used to ensure the delay was exact. The therapist looked at the table and ignored the participant during the delay. An edible item plus social praise was delivered 6s or 12s after the correct response, depending on the experimental condition.

Results of this study showed that two of the participants acquired the targets more quickly in the 0s reinforcement delay condition. However, there was no significant difference in trials to criterion between the 6s and 12s delay. The other participant, who performed relatively equally in all three conditions, had significantly better language skills than the other two participants. All participants eventually met mastery criteria. Majdalany et al. (2016) showed that fixed time delay to reinforcement may be detrimental to skill acquisition for some learners. This is in agreement with previous studies by Grindle and Remington (2004), and Carroll et al. (2016) but in slight contradiction with results by Sy and Vollmer (2012) who found little difference for 4 of 7 children, even with a 20s delay.
In the natural environment, it is unlikely that delays will be fixed. Carrol et al. (2013) found that teachers delivered tangible items after correct responses only 21% of the time and provided praise after correct responses only 58% of the time. In other words, the treatment integrity of DTT in clinical settings has been found to be poor. Ideally, therapists would be providing reinforcement with a 0s delay consistently, but delays occur for a myriad of reasons. The therapist may need to remove instructional materials before delivering the reinforcer, the edible might get stuck in the wrapper or bag, or the therapist might engage in other behavior such as putting in or graphing the data before delivering the reinforcer. Therefore, it is important to expand the current literature to include conditions more in line with how an actual therapist might run DTT.

The purpose of the current study is to extend Majdalany et al. (2016) by examining variable delays to reinforcement in the context of DTT. Specifically, this study evaluated the effects of a variable delay to reinforcement during DTT on the acquisition of tacts among children with autism.
Chapter 2: Method

Participants and Setting

Four children, all diagnosed with ASD, participated in this study. Cheryl was a six-year-old female-presenting individual who represented two or more backgrounds (black/white). She attended an academic school with behavior services built in. She scored cumulatively 100.5 on her most recent Verbal Behavior Milestones Assessment and Placement Program (VB-MAPP) Milestones Assessment. Kent was a seven-year-old, White, male-presenting individual who attended an academic school with behavior services built in. He scored cumulatively 80 on his most recent VB-MAPP Milestones Assessment. Tammy was a six-year-old, White, female-presenting individual who received 40 hours a week of ABA services in a center-based treatment facility. She scored cumulatively 138.5 on her most recent VB-MAPP Milestones Assessment. All participants were able to communicate vocally using at least one word.

Research sessions were conducted in a private treatment room at a center-based program or a school serving children with ASD. The private treatment room was approximately 3m by 3m and equipped with a table and two chairs. Country shapes were used as tacting targets (see Appendix 1 and 2). The tacting stimuli were two-dimensional images of a grey country shape cut out on a white background. The size of the pictures was identical (12.7cm by 7.62cm), but the shape of each country differed slightly in size. The tacting targets were chosen so that they were novel to the participant and each participant had minimal chance of contacting the
targets in environments outside of the sessions. More common shapes of countries (e.g., the United States) that may be familiar to the participant were omitted. Sixteen targets were chosen for each participant and randomly divided into four groups, four for each condition. Data were collected using pen and paper (see Appendix 3).

**Measurements**

**Independent variable**

This study compared a continuous baseline to three different reinforcement delay conditions: 0s, 4-8s, and 10-14s. A trial in this experiment was a single unit of DTT, which consisted of an instruction, a prompt, a response, a consequence, and an intertrial interval. Each session consisted of sixteen trials, four trials for each condition and one trial per tacting target. The order of presentation for each of the four conditions of baseline, 0s delay, 4-8s delay, and 10-14s delay was randomly alternated for each session. One session may have started with the baseline condition while a different session may have started with the 4-8s delay condition. The order of stimuli presentation within each condition was random as well. The sixteen tacting targets were randomly divided into the 4 different conditions; each target was included for only one condition (see Appendix 1). A different colored card was present on the table for each of the conditions to help the participants discriminate between the conditions. A 1-minute break with low to medium preferred toys, identified via a paired stimulus preference assessment (Fisher et al., 1992), were available between each of the conditions.
Dependent variable

The main dependent variable was the percentage of independent correct tacting responses. Independent correct responses were defined as vocally emitting the tact within 5s of the instruction “What is it?”. The percentage of independent correct responses was calculated by dividing the total number of independent correct responses by the total number of trials per condition (4 trials), then multiplying by 100. Articulation of the tact needed to be similar to the pronunciation of the original tact and consistent throughout the study. A prompted correct response was defined as echoing the vocal prompt within 5s of the prompt delivery. An error was defined as saying anything other than the original tact, including saying additional phrases. For example, saying “want Japan” instead of just “Japan” was counted as an error. No response was recorded if the participant did not emit any vocal response after 5s. The mastery criteria was 100% correct independent responding across two consecutive sessions.

Interobserver Agreement (IOA)

IOA data were collected by a second independent observer, using the same data sheet as the experimenter. The agreement was calculated by dividing the number of trials with agreement by the total number of trials, then multiplying by 100. IOA data were collected for 33% of sessions for Cheryl, and the mean was 99.5%. IOA data were collected for 32.5% of sessions for Kent; the mean IOA was 100%. IOA data were collected for 32.9% of sessions for Tammy; the mean IOA was 98.4%.
Treatment integrity

Treatment integrity was measured with a checklist (see Appendix 4). Measures of treatment integrity included whether the experimenter delivered the reinforcement within the specified time frame, offered the appropriate duration of break, and presented the correct target stimuli for each condition. A second independent observer collected treatment integrity data. Treatment integrity data were collected during 33% of sessions for Cheryl, and the mean was 100%. Treatment integrity data were collected during 32.5% of sessions for Kent, and the mean was 99.38%. Treatment integrity data were collected during 32.9% of sessions for Tammy, and the mean was 98.63%.

Experimental Design and Procedures

A multielement design with a baseline phase was used for this study. The experiment started with a baseline phase, then proceeded to the experimental phase. Before the first session of the day, the experimenter identified each participant’s preferred edible item with a brief MSWO preference assessment (Carr et al., 2000). The order of conditions within each 16-trial session was randomized from session to session. Each trial consisted of a single unit of DTT and started with the experimenter holding up the target stimuli and asking “What country?” Vocal prompts were provided according to the progressive prompt delay procedure. During the delay to reinforcement conditions, the highest preferred tangible item was delivered contingent on a correct, independent response on an FR1 schedule. The tangible item, paired with social praise, was delivered according to the
corresponding delay condition and remained consistent throughout the session. If there was more than one session conducted on the same day, a new MSWO was not conducted. Instead, the highest-ranked item from the MSWO conducted that day was used. Prompted responses resulted in social praise only, delivered according to the corresponding delay. Error responses resulted in error correction, which consisted of the experimenter saying the correct response in a neutral tone. No active response was required from the participant; the experimenter recorded whether or not the participant echoed the error correction. A fixed time intertrial interval of 5 seconds was used across all conditions, and the intertrial interval began once the consequence was delivered.

Baseline

A staggered baseline phase, as in a noncurrent multiple baseline design, was used to further demonstrate experimental control. The baseline phase was 3 sessions for Cheryl, 6 sessions for Kent, and 9 sessions for Tammy. During the baseline phase, the experimenter asked “What country?”, then waited 5 seconds before starting the next trial for all stimuli across all conditions. No consequence was provided for correct or incorrect responses. If the participant did not respond for 5s, no response was recorded and the experimenter began the next trial. After the initial baseline phase, only the four target stimuli in the baseline condition continued to be conducted with this procedure.
0s Reinforcement delay

For all three reinforcement delay conditions, an immediate prompt was provided until the participant said the response at the same time as the experimenter for three consecutive trials. Then, a progressive prompt delay procedure was used. Prompt levels of 1s, 3s, then 5s were provided, in this order. Once the participant reached the criteria of saying the response at the same time as the experimenter for three consecutive trials, the experimenter moved on to the next prompt level. A 5s prompt remained until the participant reached the mastery criteria. In the 0s reinforcement delay condition, the independent correct response resulted in an immediate tangible item and social praise. Prompted responses resulted in immediate social praise only.

4-8s Reinforcement delay

In this condition, procedures were identical to the 0s reinforcement delay condition except a 4-8s delay was inserted between the independent correct response and delivery of the tangible item and social praise. Prompted responses resulted in delayed social praise only, also after a 4-8s delay. During the delay, the experimenter looked at the table and did not interact with the participant. A timer not visible or audible to the participant was used to ensure the correct duration of the delay was inserted. The top-ranked edible items from the brief MSWO preference assessment were available in a tray in front of the participant. The experimenter did not reach for the edible item until the correct length of delay had elapsed.
10-14s Reinforcement delay
   In this condition, the procedure was identical to the 4-8s reinforcement delay condition except a 10-14s delay was inserted.
Chapter 3: Results

For all three participants who completed the study, none showed any correct responding in either the baseline phase or the extended baseline condition. All of the participants echoed the error correction 100% of the time even though no active response was required. Cheryl mastered the countries in the 0s delay to reinforcement condition in 23 sessions. Since each target is only presented once in each session, Cheryl mastered the four countries in the 0s delay to reinforcement condition within 23 DTT trials. She mastered the countries in the 10-14s delay to reinforcement condition in 30 sessions. Cheryl reached mastery criteria for the 4-8s delay condition last, with 33 sessions.

Kent mastered the countries in the 10-14s delay to reinforcement condition in 15 sessions. He mastered the countries in the 0s delay to reinforcement condition in 29 sessions, and mastered the countries in the 4-8s delay condition last, with 33 sessions.

Tammy reached mastery criteria for the 0s delay condition first, in 45 sessions. She mastered the countries in the 10-14s delay to reinforcement condition in 48 sessions. Tammy needed 74 sessions to master the countries in the 4-8s delay to reinforcement condition.
Chapter 4: Discussion

The current study contributes to the existing literature by evaluating variable delays, which may be more likely in clinical settings instead of fixed-time delays that are more likely to be found in experimental settings. Two of the participants (Cheryl, Tammy) in this study reached the mastery criteria of 100% correct independent responding across two consecutive sessions in the 0s delay to reinforcement condition first. The other participant (Kent) reached the mastery criteria in the 10-14s delay to reinforcement condition first. All three participants reached the mastery criteria in the 4-8s delay to reinforcement condition last. None of the participants showed any skill acquisition in the baseline phase or extended baseline condition.

These results are consistent with the findings by Majdalany et al. (2016), even though the current study employed variable delays whereas Majdalany et al. employed fixed delays. Two out of three participants reached the mastery criteria first in the 0s delay to reinforcement condition in the current study and in the study by Majdalany et al. (2016). Both studies aimed to examine the effects of delays to reinforcement during DTT on the acquisition of tacts among children with autism. The current study employed similar methods to Majdalany et al.; both utilized unsignaled reinforcement delays, silent timers, and asked the participants to tact shapes of countries. However, the current study inserted a variable delay instead of fixed time delay and paired each of the study conditions with a colored card. The purpose of the colored card was to assist participants in discriminating among the
reinforcement conditions and to assist with collecting social validity data from the participants. Social validity data were not reported by Majdalany et al.

In Majdalany et al. (2016), the two participants who learned the fastest in immediate reinforcement conditions also had lower language skills. The third participant had significantly higher language skills and learned equally well in all three delay conditions. The authors hypothesized that the effect of immediate reinforcement was more noticeable in individuals with lower levels of language skills. In the current study, all three participants scored high on the VB-MAPP. Tammy and Cheryl communicated in complete sentences, and carried out full conversations with the experimenter. Kent, who mastered the countries in the 10-14s conditions first, typically communicated with 3-4 words but could use complete sentences. However, he did not carry out full conversations with the experimenter. The participants with relatively higher levels of language skills in the current experiment learned best in the immediate reinforcement condition. This differs from Majdalany et al. Future research should report the language level of the participants in order to further analyze the various language skills exhibited by participants, as this may moderate the effects of delays to reinforcement.

Carroll et al. (2016) compared the effects of delays to reinforcement on skill acquisition using the following conditions: immediate reinforcement, delayed reinforcement with immediate praise, and delayed reinforcement alone. One participant did not reach the mastery criteria during either of the delay to reinforcement conditions. The other participant acquired the skills equally in both immediate reinforcement and delay to reinforcement with immediate praise.
conditions. Carroll et al. noted that the delay to reinforcement alone condition greatly increased the number of trials to the criterion needed for participants to acquire new tacts. The current study evaluated different conditions from Carroll et al. (2016); a delayed reinforcement with immediate praise condition was not used. A fixed time delay of 10s was utilized for both of the delay conditions in the study by Carroll et al., whereas a variable delay was utilized in the current study. The current study also drew the conclusion that delays to reinforcement negatively impacted learning for the majority of the participants.

Results by Grindle and Remington (2004) showed that no stimulus change after the response was detrimental to learning among some children with ASD. Grindle and Remington evaluated cue-value, response marking, and delay only conditions. A fixed timed delay of 5s was used across conditions. All five of the participants acquired skills the slowest in the delay only condition. A stimulus change right after the response aided learning. The 0s delay to reinforcement condition in the current study provided an immediate stimulus change after the response. The results of the study by Grindle and Remington support the current study’s findings in that most participants learned best in the immediate reinforcement condition.

However, results of the current study indicate that the differences in the number of DTT trials needed to reach the mastery criteria between conditions were small for the two participants who reached mastery in the 0s delay to reinforcement condition first. Cheryl reached the mastery criteria in 10-14s delay 7 sessions after she reached mastery in the 0s delay. Tammy reached the mastery criteria in 10-14s
delay 3 sessions after she reached mastery in the 0s delay. Majdalany et al. (2016) also found minimal differences in the number of sessions needed to reach the mastery criterion across conditions. For both of the participants who showed acquisition differences between the reinforcement delay conditions in their study, the participants reached the mastery criteria for the 6s delay conditions 7 sessions after they reached the mastery criterion in the 0s delay. Between the current study and the study by Majdalany et al., the range of difference in trials to criterion between the conditions was 3-7 sessions. In the current study, each stimulus was only presented once per session, so the range of difference in trials to criterion between the conditions was 3-7 DTT trials.

As backed by basic research (Grice, 1948; Lattal, 2010; Sutphin et al., 1998) and recent applied studies (Carroll et al., 2016; Grindle and Remington, 2004; Majdalany et al., 2016) immediate reinforcement produced the least number of trials to criterion for the majority of the participants in this study. Yet, in clinical settings, a difference of 3-7 trials of DTT may not be as critical to effective learning. As Downs et al. (2008) pinpointed, there are up to 30 different supporting behaviors that are crucial for effective DTT. Supervisors may consider emphasizing other aspects of DTT that may have a high impact on learning, instead of the immediacy of reinforcer delivery. As Carroll et al. (2013) pointed out, technicians may forget to tangible items or praise contingent on correct responding on as many as 21% and 58% of the sessions, respectively. To maximize learning, supervisors may focus on technicians providing reinforcement after correct responding instead of the immediacy of reinforcement being provided.
The current study also showed that for one of the three participants (Kent), the 10-14s delay to reinforcement conditions required the least number of teaching trials to achieve mastery. This echoes the findings by Sy and Vollmer (2012) who found that four of the seven participants in their study were able to acquire the skill taught with a 20s delay. Sy and Vollmer (2012) evaluated the effects of fixed time, unsignaled delays of 0s, 20s, 30s and 40s on the acquisition of a conditional discrimination. The current study is similar to the study by Sy and Vollmer (2012) in that the evaluation of delays to reinforcement is the main subject of the study. The two studies differ in that Sy and Vollmer (2012) systematically taught the participants using longer and longer delays. Only the participants who reached mastery criteria in the shorter delay condition were progressed to be included in the longer delay condition. An alternating treatments design was used for the current study in which the participants were exposed to different lengths of delay in the same session.

According to verbal reports from Kent’s behavior technician and case manager, Kent does not like praise, especially enthusiastic, loud praise. The experimenter also observed in the initial teaching sessions that Kent engaged in short negative vocalizations, and minor self-injurious behavior in the form of banging his head against the table right after the experimenter delivered praise. Praise for Kent was modified to be short and quiet (e.g., only saying “Yes” in a volume slightly below normal conversational volume with a positive facial affect). Kent mastered the names of countries in the longest delay (10-14s) to reinforcement first. He reached mastery in 0s delay 14 sessions after he reached mastery in 10-14s
delay. Since the experimenter did not interact with Kent at all during the delays, a longer delay may be preferred. This highlights the need to consider idiosyncratic differences and individual preferences in service delivery to maximize the effectiveness of DTT.

At session number 40, a delayed break procedure was implemented with Tammy. For six consecutive sessions prior to session number 40, Tammy acquired no tacts and responded “I don’t know” to all unmastered targets. The experimenter hypothesized that the 1-minute breaks between conditions were reinforcing for Tammy. The error correction procedure, which involved saying the correct responses, was too easy for her to do relative to actively answering correctly. The experimenter gave Tammy a rule “You need to try to guess a country name. If you say I don’t know, then we are not taking a break.” Instead of the non-contingent break, the experimenter continued on to the next condition if Tammy responded with “I don’t know” to any of the four targets in a condition. The experimenter reminded Tammy of the rule each time a break was not delivered. Immediate improvement in independent correct responding was seen after the implementation of the rule.

Each of the conditions was paired with a color. The corresponding color card was always present when the experimenter presented trials in a particular condition. To assess social validity, the experimenter recorded each time the participant made statements about the colors of the condition throughout the study. At the end of the study, the experimenter laid out all four color cards and asked “Which color is your favorite?” Both Tammy and Cheryl expressed that they
preferred orange, the condition associated with 0s delay. Tammy and Cheryl reached the mastery criteria first in the 0s delay to reinforcement condition. Tammy also said “I don’t know blue,” the condition associated with baseline. Tammy repeatedly asked the experimenter to tell her the names of countries in the blue condition. Additionally, Tammy expressed that green, the condition associated with 4-8s delay, was hard for her. Tammy mastered the 4-8s delay condition 26 sessions after the mastered the other two conditions. Kent never made any statements relating to the color or preference of the conditions. He also did not respond when the experimenter asked about his favorite color in the study. Two of the participants (Cheryl, Tammy) preferred the learning environment associated with faster skill acquisition for them, which also resulted in a higher density of reinforcer delivery.

For this study, data collection continued for all conditions until the participant reached 100% correct independent responding for all reinforcement conditions for two consecutive sessions. Data were collected for conditions in which the mastery criteria was met if the mastery criteria was not met for all conditions. For example, the experimenter continued to run the 0s delay condition for Cheryl, even after she had met the mastery criteria for the 0s delay condition, until Cheryl reached 100% correct independent responding for all three reinforcement conditions for two consecutive sessions. This differed from procedures by Majdalany et al. (2016), and the majority of other applied studies. The continued data collection allowed the experimenter to observe decreases in independent correct responding after the criterion had been met, which occurred for all three participants. Notably, the participants occasionally mixed up the newly
acquired tacts with the mastered tacts. When Tammy acquired the tact for Australia in the 4-8s delay condition, she responded “Australia” to the stimuli for China in the 0s delay condition, which had been mastered. The cutouts of the two countries do appear similar; both are large landmasses with wedges. Had data collection stopped for the condition that reached the mastery criteria, the decreases in responding would not have been observed.

This study has limitations. One of the limitations is that the target stimuli chosen are not practical for the learner. Five to seven-year-old children do not need to learn to tact the shape of countries. Even when adults learn the shapes of countries, it is most commonly in the context of adjacent countries, not a cutout shape with a white background. These specific stimuli were selected because they were novel to the participants and there were minimal chances that the participants were contacting the stimuli in environments outside of the research sessions. Any contact with the target stimuli outside of the session may have influenced learning within the session. As a result of choosing less practical stimuli, any gains in skill acquisition are most likely a direct result of the study. Future researchers should conduct consecutive experiments. First, a set of more arbitrary stimuli might be used to determine which duration of delay results in acquiring tacts most efficiently. Then, a set of more practical stimuli can be used to expand upon the literature.

Another limitation is that the duration of the session varied depending on the participant’s edible of choice. Sessions averaged 10-15 minutes long. If M&M™ was the most preferred item from the brief MSWO, the sessions tended to be shorter. Whereas if Skittles™ was the most preferred item from the brief MSWO,
the sessions tended to be longer. Because the experimenter waited until the edible was fully consumed before presenting the next trial, the intertrial interval for the sessions with Skittles™ as reinforcers were longer, which may have resulted in the participants accessing the break more quickly. For a participant like Tammy who perhaps found the breaks to be more reinforcing than actively answering correctly, correct independent responding may be lower.

The presentation of four sets of countries in a particular condition with a colored card may be another limitation. The participants may have learned the specific four countries because each was associated with a specific color. For example, the participants may have learned that green (color for 4-8s delay) was associated with Taiwan, in addition to learning Taiwan based on the country’s shape. The current study did not note if the participants were more likely to error by saying other countries in the same condition or by saying countries in different conditions. If the participants were more likely to error by saying countries across conditions, then it may suggest that the country shapes had more stimulus control over the tacting responses. On the other hand, if the participants were more likely to error by saying countries within the same condition, then it may suggest that the colored card held significant stimulus control over the tacting responses.

For all three of the participants, the 4-8s delay condition required most trials to criterion. The reasons for this are unclear. It is possible that the number of syllables played a role; the number of syllables in each of the countries in each condition was not accounted for when assigning the countries. However, the cumulative number of syllables for each condition turned out to be similar. In the 0s
delay condition, a total of 11 syllables were required, and a total of 14 syllables were required for both 4-8s delay and 10-14s. Future research should distribute the cumulative number of syllables for each condition more evenly or make sure each condition requires the same number of syllables when tacting.

All three participants had been receiving autism services for at least two years prior to the beginning of this study. The participants all have had a long history with DTT. With their learning history, a correct response usually results in reinforcer delivery. In natural learning environments, the immediacy of the reinforcer delivery may have been delayed in the past. The participants may have had a learning history of receiving reinforcers in variable, delayed conditions. This may have resulted in the participants learning effectively in the delay to reinforcement conditions. Future research might emulate Grindle and Remington’s (2004) approach and recruit participants without learning history of DTT, or with very brief history.

The current study utilized only edible items as reinforcers. Future studies might utilize activity-based reinforcers, to further replicate reinforcement conditions commonly observed in clinical settings. It is also important to replicate this study with not just children diagnosed with ASD, but typically developing children as well as children with other diagnoses. Strategies to maximize the effectiveness of teaching are important for individuals across populations. Also, tacting is not the only skill important for learners to acquire. Future research may consider replicating the study with other verbal operants, social skills, or pre-academic skills. Different reinforcement delay variations can also be tested. Sy and Vollmer (2012)
showed that some participants successfully acquired discrimination with up to 40s of fixed-time delay. The current study only tested variable delays up to 10-14s.

In conclusion, this study contributes to the existing literature by evaluating the effects of variable delays to reinforcement on the acquisition of tacts. Two of the three participants achieved the mastery criterion most quickly in the 0s delay condition. However, the differences in trials to criterion between conditions were relatively small. One of the participants reached the mastery criterion fastest in the condition with the longest delay (10-14s). The current study supports previous findings that the immediacy of reinforcement plays a role in the speed at which tacts are acquired. However, a closer evaluation of the effects of delays to reinforcement may be needed.
References

Barhold, T. "Evaluating the Effects of Reinforcement Delay on Acquisition During Discrete Trial Training: A Literature Review" (2020). *USF Tampa Graduate Theses and Dissertations.*


Figure 1.
Acquisition of Tacts Across Conditions
Figure 2.
Acquisition of Tacts Across Conditions
Figure 3.
Acquisition of Tacts Across Conditions
Figure 4.
Acquisition of Tacts in All Conditions Across Participants
## Appendix One

### Countries in Each Condition

<table>
<thead>
<tr>
<th>Condition</th>
<th>Country</th>
</tr>
</thead>
</table>
| **Baseline**                     | Algeria  
                                       Germany  
                                       Russia  
                                       Turkey  |
| **0s Reinforcement Delay**       | Chile  
                                       China  
                                       Italy  
                                       Somalia  |
| **4-8s Reinforcement Delay**     | Australia  
                                       India  
                                       Indonesia  
                                       Taiwan  |
| **10-14s Reinforcement Delay**   | Japan  
                                       Madagascar  
                                       Panama  
                                       South Africa |
Appendix Two

Example of Country Shape (China)
Appendix Three

Data Collection Sample Data Sheet

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<th>Participant:</th>
<th>Sheet 1</th>
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## Appendix Four

### Treatment Integrity Sample Data Sheet

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<th>Name of the observer</th>
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<td>Score for each trial</td>
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<td>Trial 2</td>
<td>Trial 3</td>
<td>Trial 4</td>
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<tr>
<td>Therapist waited until edible was fully consumed before starting trial?</td>
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<tr>
<td>The correct color card corresponding to the condition was present?</td>
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<tr>
<td>Therapist used the correct prompt for the target?</td>
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<tr>
<td>Therapist delivered the praise+ edible for independent responses?</td>
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</tr>
<tr>
<td>Or</td>
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<tr>
<td>Therapist delivered praise only for prompted responses?</td>
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<td>Or</td>
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<tr>
<td>Therapist error corrected by saying the correct response in neutral tone?</td>
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<tr>
<td>Therapist waited for the appropriate duration before delivering the consequence? (0s, 4-8s, or 10-14s)</td>
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<tr>
<td>Therapist did not interact with the participant during the delay?</td>
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<tr>
<td>Is the intertrial interval 5s?</td>
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<table>
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<th>Score for the entire session</th>
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<tr>
<td>Randomized testing conditions? (compare to previous sessions)</td>
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<tr>
<td>Randomized trials within each condition? (compare to previous sessions)</td>
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<tr>
<td>A 1min break was offered between conditions?</td>
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<tr>
<td>Low preference toys present during the break?</td>
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