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Evaluating the Effects of Reinforcement Delay on Acquisition During Discrete Trial Training: A Literature Review

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Evaluating the Effects of Reinforcement Delay on Acquisition During Discrete Trial Training: A Literature Review

by

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ABSTRACT

This review of literature analyzes the use of immediate and delayed reinforcement within discrete trial training (DTT). Criteria for inclusion in this review consisted of articles published in English, human participants, single subject design, targeting skill acquisition in a DTT format, and inclusion of at least one delay to reinforcement condition. Four articles, with a total of 18 participants and 23 datasets, were identified in this review. Data on participants' characteristics and procedural modifications (i.e., target response, type of prompt, delivery of praise, use of an error correction procedure, type of reinforcer, and delay to reinforcement) were extracted. Results indicate that immediate reinforcement conditions required the fewest sessions to mastery for various skills across the majority of participants. In addition, in various articles immediate or delayed praise was delivered alongside with other reinforcers; result suggest that immediate praise may mediate delayed access to other reinforcers.

CHAPTER ONE:

INTRODUCTION

Individuals diagnosed with an Autism Spectrum Disorder (ASD) often experience deficits in communication and social interaction (American Psychiatric Association, 2013). Furthermore, some individuals with an ASD display problem behaviors that hinder their ability to acquire skills that would result in increased independence (Dominick et al., 2007). However, individuals are less likely to exhibit problem behaviors when they can communicate their wants and needs; effective communication allows individuals to contact more reinforcement (Kahng et al., 1997). A reduction in problem behavior through the acquisition of effective communication skills may increase social interaction and acceptance (Carr & Durand, 1985). Thus, we must teach individuals communication skills.

Typically developing children acquire language in stages; this acquisition begins with babbling which transforms into isolated sounds and followed by words and sentences (Oller & Eilers, 1988). Results of a study by Lovaas et al. (1966) indicated that typically developing children often acquire language through hearing others around them and imitating the sounds produced by members of their verbal community. However, for many individuals with an ASD the use of behavioral intervention is necessary to acquire and expand upon their vocal verbal behavior (Drash et al., 1999; Esch et al., 2005; Miguel et al., 2002; Rader et al., 2014; Stock et al., 2008; Tarbox, et al., 2009). Behavior analysts analyze and teach verbal behavior through Skinner's (1957) analysis of verbal behavior. Skinner categorized verbal behavior into various operants (i.e., mand, tact, intraverbal, textual, and echoic) based on the variables (i.e., discriminative stimulus, reinforcers) controlling these responses. According to Skinner (1957), echoic responses consist of vocalizations that have point-to-point correspondence between the speaker and listener and are reinforced by generalized conditioned reinforcers.

An echoic repertoire is an essential foundation for acquisition of other verbal operants (Ingvarsson, 2016). Once an echoic repertoire is established, echoic prompts can be used to teach other verbal operants (i.e., manding for information; Sundberg et al., 2002). Additionally, the implementation of behavior analytic principles in training procedures can help reduce communication deficits and increase echoics (Carbone, 2012). Few behavioral analytic procedures have resulted in the acquisition of echoic responses by individuals with an ASD. These include vocal imitation training, stimulus-stimulus pairing, and chaining procedures.

Vocal imitation training (VIT) involves a therapist presenting a sample vocalization to a participant and delivering reinforcement contingent on the participant emitting a vocalization that is similar to the therapist's response (Cividini-Motta et al., 2016). Several studies have used VIT to establish or increase an individual's vocal repertoire (e.g., Baer et al., 1967; Cividini-Motta et al., 2016; Lovaas et al., 1966). For instance, Baer and colleagues reinforced correct imitation using food reinforcers and chained together responses to produce more complex responses. For two out of three participants in this study, VIT resulted in an increase in participant's echoics. Similarly, Cividini-Motta et al. (2016) compared the impact of VIT, stimulus-stimulus pairing (SSP), and a mand-model (MM) procedure on acquisition of echoic responding. In this study, across the six participants, VIT was the most effective procedure in three of the twelve comparisons and was found as an effective procedure in seven of twelve comparisons.

Stimulus-stimulus pairing (SSP) is a procedure that involves pairing vocalizations with an established reinforcer (Rader et al., 2014) in order to condition vocalizations as reinforcers.

The efficacy of this procedure has been assessed in a variety of studies attempting to increase the frequency of novel (e.g., Sundberg et al., 1996) and known (e.g., Carroll & Klatt, 2008) vocalizations. Although there were procedural variations across studies (e.g., number of times sound was presented, type of reinforcer, number of pairing trials; Shillingsburg et al., 2015) results of these studies suggest that in general, the procedure is moderately effective, as determined by effect sizes, in increasing vocalizations. However, it appears that SSP alone is seldom used to teach echoic responding. One exception is a study completed by Cividini-Motta et al., (2016) comparing the effects of VIT, SSP, and a mand-model procedure on the acquisition of echoics for six individuals. In this study, SSP resulted in the acquisition of some echoic responding by three of the six participants.

Chaining is a procedure that has been utilized to increase the complexity of echoics (e.g., Tarbox et al., 2009). Chaining is a process that involves breaking a behavior or behaviors into smaller components and sequentially teaching individual components until mastery is acquired (Slocum & Tiger, 2011). For instance, in the study by Tarbox and colleges, each target echoic response was divided into 1-3 syllables (i.e., Monday was split into “mun” and “day”). During chaining, reinforcement was contingent on correct imitation of the prescribed sound, and errors resulted in a single repeated trial. If the participant correctly imitated the prescribed sound (i.e., “mun”), a reinforcer was provided. Then the next sound of the terminal word was presented (i.e., “day”); if the participant emitted the second sound correctly to criterion, reinforcement was adjusted to be contingent on both the initial and subsequent part of the target sound (i.e., “Monday”). This process continued until the participant acquired the terminal target echoic response. In this study, chaining effectively increased the complexity of the echoic responses for three individuals with an ASD or developmental delay.

As demonstrated in previous studies evaluating the efficacy of behavioral procedures in teaching echoic behavior, direct reinforcement plays a vital role in echoic control (e.g., Baer et al., 1967; Carroll & Klatt, 2008; Tarbox et al., 2009;). There are various recommendations for implementing reinforcement to advance the efficiency and efficacy of instructional procedures. For example, literature suggests delivering a more potent reinforcer for correct independent responses, while correct prompted responses result in access to a less potent or no reinforcer (Anderson et al., 1996; Lerman et al., 2016). Additionally, research suggests that the specific type of reinforcer delivered may affect the rate of acquisition. For example, Leaf et al. (2014) assessed the use of four different consequences (edibles, social reinforcers, tangibles, and feedback) on acquisition. They found that although acquisition occurred across the use of all consequences; the most efficient procedure (i.e., fewer session to mastery) for all participants included condition with edible reinforcers. An additional recommendation is to deliver a reinforcer immediately after correct responding occurs (e.g., Lovaas, 2003).

Results of previous studies with non-humans indicate that even a small delay in the delivery of a reinforcer can impact response accuracy, rate, and acquisition (Lattal, 2010). Nevertheless, the majority of findings with non-human participants across various species demonstrate acquisition can occur with delays up to 30s (e.g., Lattal & Gleeson, 1990; Lattal & Metzger, 1994); however, much of this literature assessed if acquisition could occur with a delay and not if there was a difference in the rate of acquisition across delays. Recently, Kouroda and Mizutani (2018) assessed response acquisition by zebrafish across a 0 s, .5 s, 1 s, 3 s, 6 s, or 12 s delay. All zebrafish acquired the target response when the delay to reinforcement was 1 s or less, half of the zebrafish acquired the response with the 3 s delay, one zebrafish acquired the response with the 6 s delay, and no zebrafish acquired the response with the 12 s delay. The results of this study differ from other studies with non-human participants in that in this study response acquisition decreased as the delay to reinforcement increased.

Previous studies with humans have also shown that the immediacy of reinforcer delivery within discrete trial training (DTT) impacts speed of acquisition (e.g., Carroll et al., 2016; Majdalany et al., 2016). That is, more immediate reinforcer delivery leads to faster acquisition. For instance, Carroll et al. (2016) evaluated tacting in a DTT format in conditions of immediate reinforcement in which a correct response resulted in immediate access to reinforcing item and praise, delayed reinforcement with immediate praise in which a correct response resulted in immediate praise and access to a reinforcing item after a 10 s delay, and a different delayed reinforcement condition in which a correct response resulted in access to a reinforcing item and praise after a 10 s delay. In this study one participant met mastery criteria in all conditions; however, more sessions were needed to reach mastery criteria in the two conditions where access to the preferred item was delayed by 10 s. In addition, the other participant only met mastery criteria in the immediate reinforcement condition. Results indicated that the delay to reinforcement decreased effectiveness for one participant and efficiency for the other (Carroll et al., 2016). Similarly, Majdalany et al. (2016) assessed acquisition of tacting under shorter 0 s, 6 s, and 12 s delay to reinforcement. All participants met mastery criteria across all conditions; however, two of the three participants acquired the responses in fewer sessions in in the immediate reinforcement condition (i.e., 0 s). Results of this study indicated that even a brief delay to reinforcement (6 s) may hinder skill acquisition. Furthermore, Carroll et al. (2013) assessed teachers' implementation of DTT and found that in 80% of the opportunities, teachers did not deliver a reinforcer within 5 s of a correct response. These results suggest that, even when immediate reinforcer delivery is prescribed, it is likely the case that reinforcer delivery is often delayed by more than 5 s.

To date, few studies have investigated the impact of delays to reinforcement on the skill acquisition of individuals with an ASD and other disabilities. The results of these studies indicate that delays to reinforcement may impact instructional efficiency and efficacy and thus hinder acquisition of novel skills (e.g., Carroll et al., 2016; Grindle & Remmington, 2004). To guide best clinical practice and future research, it is imperative that the findings of these previous studies on the impact of delays to reinforcement on acquisition be reviewed and summarized. Therefore, the purpose of this literature review was to synthesize the results of previous studies evaluating the impact of various delays to reinforcement skill acquisition for individuals with an ASD or developmental disability. Given the scarcity of research in this area focusing on verbal behavior, this literature review will include all articles that evaluated the impact of delays to reinforcement on acquisition of skills during a DTT program.

CHAPTER TWO:

METHOD

Literature Search

An electronic database literature review was conducted using ERIC (EBSCO), PubMed, and Web of Science. The Boolean search phrases used were *immediate reinforcement* AND *acquisition, immediate reinforcement* AND *autism, immediate reinforcement* AND *discrete trial-training, delayed reinforcement* AND *acquisition, delayed reinforcement* AND *autism, delayed reinforcement* AND *discrete trial-training, reinforcement delay* AND *acquisition, reinforcement delay* AND *autism*, and *reinforcement delay* AND *discrete trial-training*. The initial literature search yielded 129 studies.

The title and abstract of all of these articles were reviewed to determine if the articles included human participants, were published in English, focused on acquisition of skills within DTT, and included at least one delay to reinforcement condition. Studies were then removed if they did not meet the inclusion criteria. A total of 118 articles were removed due to lack human participants (n = 82), lack of skill acquisition (n = 30), and if they were a review of previous literature (n = 6). Eleven articles met this criterion and went under a full inclusion review.

The articles identified during the title and abstract review were then fully reviewed to determine if they met the full inclusion criteria. Articles were excluded if they did not focus on skill acquisition in a DTT format (n=5), did not utilize a single-subject design (n=1), were not published in English (n=1). Addition inclusion criterion consisted of visual representation of the results. Four articles met the criteria. An extended search of the references of all four of these articles did not identify any additional articles for inclusion, thus a total of four articles were reviewed (see Figure 1).

Descriptive Synthesis

All of the articles selected for inclusion were reviewed and data were extracted on participants' characteristics (i.e., age, sex, diagnosis, and verbal repertoire), procedural variations (i.e., target response, type of prompt, delivery of praise, use of an error correction procedure, type of reinforcer, and delay to reinforcement), and outcomes (i.e., efficacy and efficiency).

Participant Characteristics

Data were extracted on the reported diagnosis, chronological age, and sex of each participant. In addition, data were collected on each participant's verbal repertoires. These data were coded as communicating with no intelligible speech (none), between 1 and 3 vocal utterances, between 3 and 6 vocal utterances, and more than 6 vocal utterances.

Procedural Variations

Given the many procedural variations across study, the method section of each article was reviewed, and data were gathered and coded on each of the following:

Target Response. The specific target response (s) for each participant were extracted. These included verbal responses (tacts or listener responding) and matching (i.e., word-to-pictures).

Prompts. The type of antecedent prompt and prompting procedure implemented within the DTT program were extracted. Prompts included any assistance provided by the experimenter following the presentation of the discriminative stimulus and prior to the participant emitting a response. These were coded as type of prompt (e.g., vocal, physical) and the type of prompt fading procedure (e.g., time delay, least-to-most).

Praise. Data were extracted on whether the experimenter delivered a praise statement following a correct response and the latency from a correct response to the delivery of praise. Praise consisted of a vocal statement delivered after a target response (e.g., “good job”).

Error correction. Data were extracted on whether studies included an error correction procedure and details of the procedure (e.g., verbal “no, this is a ___”) when applicable. Error correction consisted of the experimenter prompting a correct response, modeling the correct response, or providing constructive feedback (i.e., “no, that is not correct”) following an incorrect response by the participant.

Type of Reinforcer. Data were collected on the tangible items delivered following a correct response. Data were extracted on the type of reinforcer used for each participant (e.g., edible, leisure item).

Delay to reinforcement. Data on the duration of the delays to the delivery of reinforcers were extracted. This was defined as the latency, in seconds, between the emission of a correct response by the participant and the delivery of a reinforcer by the experimenter. This information was coded specific to the conditions used in each study. The exact delays included 5 s (Grindle & Remmington, 2004), 6 and 12 s (Majdalany et al., 2016), 10 s (Carroll et al., 2016), and 20, 30 or 40 s (Sy & Vollmer, 2012).

Outcomes

Data were collected on the effectiveness and efficiency of results. A procedure was coded as effective if the participant met the mastery criteria, as described in the study, specific to that condition. To determine the efficiency of a procedure the number of sessions to meet mastery for each of the conditions was compared. If mastery criteria, as specified in the study, was met in fewer sessions in a specific condition, that condition was coded as most efficient. For studies that reported the number of trials to criterion, the cumulative number of sessions to meet mastery was calculated by dividing the number of total number of trials to mastery by the number of trials in each session, as reported in the method section of the article.

Interrater Agreement (IRA)

The primary researcher and a trained research assistant (RA) independently conducted a review of the initial search using the same Boolean phrases and the same databases. For the initial search, there was 100% agreement; this indicates all of the same articles populated without any additional articles. IRA was also conducted for the title and abstract review; for this review, 34% the titles and abstracts from the initial search were compared with inclusion criteria. The inclusion criteria for this search included human participants, were published in English, focused on acquisition of skills within DTT, and included at least one delay to reinforcement condition. Both reviewers coded each article as 1 if it met the inclusion criteria or 0 if it did not meet the criteria. Agreement was calculated by comparing the scores (i.e., 1, 0) given by the primary researcher and the RA, calculating the number of articles with agreements, dividing by the total number of agreements plus disagreements, multiplied by 100. The agreement for the title and abstract review was 96%. IRA was conducted for the 11 remaining articles. These articles underwent a full review using the inclusion criteria of human participant, skills acquisition in a DTT format, delay to reinforcement, publication in English, single subject design, and visual depiction of the results. Agreement was calculated by having the RA review every third article and code each article as meeting the inclusion criteria (1) or not meeting the criteria (0). For the full inclusion review, agreement was 100%.

CHAPTER THREE:

RESULTS

Only four articles met the full inclusion criteria (Carroll et al., 2016; Grindle & Remmington, 2004; Majdalany et al., 2016; Sy & Vollmer, 2012) and data from these studies are synthesized below. Given that the number of participants differed across studies and that results for some participant were idiosyncratic, data were summarized by datasets and not participant. In addition, one of the articles (Sy & Vollmer, 2012) included multiple experiments and some participants were included in more than one experiment. There were 18 participants across the four articles, and 23 datasets. Each dataset consisted of a comparison between immediate reinforcement and at least one delayed reinforcement condition. Thus, if a participant was included in multiple experiments (i.e., evaluated the effects of immediate reinforcement and delayed reinforcement with a different array size), the data from each experiment were considered datasets. The data extracted from these articles are on Table 1.

Participant Characteristics

Age

The average age of participants across studies was 7.45 years (range; 3-10 years). Of the 18 participants, five were 3-4 years old (Carroll et al., 2016; Sy & Vollmer, 2012), seven were 5 years old (Carroll et al., 2016; Grindle & Remmington, 2004; Majdalany et al., 2016), and six were 6-10 years old (Grindle & Remmington, 2004; Sy & Vollmer, 2012).

Sex

The majority of participants were male (*n*=13; 72%) and all of the female participants (*n*=5; 28%) were from a single study (Sy & Vollmer, 2012).

Diagnosis

The majority of participants (*n*=13) had a diagnosis of an ASD (72%); other diagnosis included developmental delay (*n*=3; 16%), intellectual disability (*n*=1, 5%), and down syndrome (*n*=1; 5%).

Verbal Repertoire

All participants across the various studies included in this reviewed were described as communicating using vocal responses. Of the participants for whom verbal repertoire was included in the article, the majority (*n*=4; 22%) emitted between 1-3 vocal utterances, some (*n*=3; 16%) between 3-6 vocal utterances, and only one (5%) them emitted more than 6 vocal utterances. For eight participants (50%) the extent of their vocal repertoire was not reported. One participant used PECS and some vocal responses (Carroll et al., 2016) and another participant was reported to have no intelligible speech (none; Grindle & Remmington, 2004).

In regard to participants' characteristics, 95% of the participants acquired the target skills in the immediate reinforcement condition whereas 78% of the participant met mastery criteria in the delayed to reinforcement condition. In regard to age, 60% of younger participants (younger than 5 years) met mastery criteria in all conditions. Of participants 5 years of age, 71% met mastery criterial in all conditions, and 83% of older participants (older than 5 years) met mastery criteria in all conditions. Furthermore, participants with a larger vocal verbal repertoire (i.e., 3 or more vocal utterances) met mastery criteria in the delayed reinforcement condition less often (75%) than individuals with fewer vocal utterances (fewer than 3 utterances; 100%).

Procedural Variations

All of the studies included in this review evaluated the impact of delayed reinforcement on skill acquisition; however, latency to reinforcer delivery and other components of the instructional procedures varied amongst studies.

Target Response

Across the four studies the response targeted during acquisition was tacts (i.e., countries, actions) for five datasets across five participants (Carroll et al., 2016; Majdalany et al., 2016), listener responding (i.e., auditory-visual discrimination) for 13 datasets across eight participants (Sy & Vollmer, 2012), and matching words to pictures of objects (i.e., visual-visual discrimination) for five datasets across five participants (Grindle & Remmington, 2004). Results across studies indicate a possible correlation between outcomes and the target responses. Specifically, in regard to efficacy, when tacts were taught mastery criteria were met in both the immediate and delayed reinforcement conditions in four out of five datasets (80%), in eight out of 13 datasets (62%) when participants were taught listener responding, and in five out of five datasets (100%) when participants were taught to match words to pictures of objects.

In regard to efficiency, mastery criteria were met in fewer sessions in the immediate reinforcement condition in four out of five (80%) datasets when tacts were the target response, 10 out of 13 datasets (77%) when listener response was the target response, and one out of five (20%) datasets when matching was the target response.

Prompts

Instructional procedures included antecedent prompts in 10 datasets (43%). In five datasets a vocal prompt was used and for the other five datasets a gestural prompt was used. In regard to prompt fading procedures, a time delay was used in five datasets and most-to-least prompting was used in the other five datasets. Results of the studies included in this review suggest that the use of prompts may impact results. More specifically, when prompts were used mastery criteria was met across the immediate and delayed reinforcement conditions in nine out of the 10 datasets (90%); when prompts were not used, mastery criteria were met across all conditions in eight out of 13 datasets (62%). Although there are other variables in effect, these results suggest that when prompts are used, acquisition may still occur when reinforcer delivery is delayed.

Praise

Praise was delivered across all reinforcement conditions in two studies which included a total of five datasets (Carroll et al., 2016; Majdalany et al., 2016). For one of these studies (2 datasets), the latency to praise delivery was manipulated across conditions (Carroll et al., 2016). This study included conditions in which praise was with other reinforcers delivered immediately after a correct response, praise was delivered immediately but other reinforcer was delivered after 10 s, and a condition in which praise and other reinforcers were delivered after 10 s. The results of this study indicated that when praise and a reinforcer were delivered immediately mastery criteria was met in all datasets, when praise was delayed mastery criteria was met by only on one out of two datasets and when praise was delivered immediately but the other reinforcer was delivered after a 10 s delay, mastery criteria was met in one out of two datasets.

For one study (five datasets), praise was delivered in only one condition (i.e., value condition; Grindle & Remmington, 2004). In this condition, general praise (i.e. “good!”) was delivered immediately for a correct response and was delivered again, alongside other reinforcers, after 5 s elapsed since the participant emitted a correct response (Grindle & Remmington, 2004). This condition was compared to two other conditions, response marking which a prompt (i.e., “look”) was delivered immediately after correct or incorrect response (no praise was provided and other reinforcers were delivered after 5 s), and delayed reinforcement (responses and the reinforcer was delivered 5 s after a correct response). This study mastery criteria were met in the response-value condition in an average of 1.6 sessions (range; .4-2.4), in the response marking in an average of 1.5 sessions (range; .4-2), and in an average of 3.2 sessions (range; .9-5) in the delay condition. Thus, the response marking condition was most efficient.

These results suggest that the use of praise may mediate the delivery to reinforcement because mastery criteria was met in fewer sessions in the condition that included immediate praise but delayed reinforcement as compared to delayed reinforcement and praise (Carroll et al., 2016) or delayed reinforcement and no praise (Grindle & Remmington, 2004).

Error Correction

Across studies an error correction procedure was in effect for 10 datasets (43%) and different error correction procedures were employed. Specifically, a model prompt was used with two datasets (Carroll et al., 2016), least-to-most prompting with five datasets (Grindle & Remmington, 2004), and verbal feedback (i.e., saying “no” plus the correct response) with three datasets (Majdalany et al., 2016). Out of the datasets that included error correction, correct responding within error correction resulted in praise only in two datasets (Carroll et al., 2016), and no reinforcer in eight datasets (Grindle & Remmington, 2004; Majdalany et al., 2016).

Results indicated that the use of an error corrections related to efficacy of the procedures. Specifically, when error correction procedures were used mastery criteria was met in all conditions more often as compared to when error correction procedures were not employed. More specifically, datasets that used error correction procedures met mastery criteria across all conditions for nine out of 10 datasets (90%); when error correction procedures were not used mastery criteria were met across all conditions in eight out of 13 datasets (62%). Although there are other variables in effect, these results suggest that when an error correction is used, acquisition may still occur when reinforcer delivery is delayed.

Type of Reinforcer

All studies utilized either edible or leisure items as reinforcers. Out of the 18 participants included across the four studies, edible reinforcers were delivered for four participants (4 datasets; Carroll et al., 2016; Majdalany et al., 2016), leisure items were provided for six participants (6 datasets; Carroll et al., 2016; Grindle & Remmington, 2004), and a mix of either edible or leisure items were delivered for the remaining eight participants based on preference selection prior to each training session (13 datasets; Sy & Vollmer, 2012). It is unclear which participants from the study completed by Sy and Vollmer received edible or tangible.

Of the four datasets in which edibles were delivered as reinforcer, mastery criteria were met across all conditions for four out of four datasets (100%) whereas mastery criteria were met across all conditions in five out of six datasets when leisure items were used as reinforcer. Additionally, regarding efficiency, mastery criteria were met in a mean of 14.2 sessions (range; 3.5-32) when edibles were delivered as reinforcers in comparison to a mean of 2.3 sessions (range; .4-6) when participants received access to leisure items.

Delay to Reinforcement Delivery

All participants included in this literature review were exposed to an immediate reinforcement condition and at least one other condition including varying delays to reinforcement. For 16 datasets (Majdalany et al., 2016; Sy & Vollmer, 2012) praise was delivered immediately whereas edibles or leisure items were delivered after a certain delay. Out of these datasets, three were exposed to 6 s and 12 s delays (Majdalany et al.), four were exposed to 20 s delay only (Sy & Vollmer), four to 20 s and 30 s delays (Sy & Vollmer), four to 20 s, 30 s, and 40 s delays (Sy & Vollmer), and one to 40 s delays only (Sy & Vollmer)

Results indicated immediate reinforcement with immediate praise (*n*=5), or delayed reinforcement with response-marking (i.e., the prompt “look” after a correct or incorrect response, and prior to the delay period with no interaction; *n* = 4) conditions were most efficient and most efficacious. In regard to efficacy, out of the 23 datasets included in this review, for 17 datasets mastery criteria were met across all conditions and all delays but for six datasets mastery criteria was not met in any of the delay conditions, independently of whether the delay condition included response-marking, immediate praise, or delayed praise. In addition, multiple conditions were equally efficient (i.e., same number of sessions to mastery) for four datasets. For the datasets (*n*=19) in which one condition was the most efficient, mastery criteria in the immediate reinforcement condition with immediate praise was met in an average of 9.8 sessions (range; 6-21) whereas an average of two sessions were required to meet mastery criteria (range; 1.9-2) in the immediate response-making and delayed reinforcement. In addition, when the delivery of the reinforcer was delayed (delay ranged 6-10 s), mastery criteria were met in the most efficient condition in an average of 15 sessions (range; 4-28).

Summary of Outcomes

Overall, results of the studies included in this review indicate that mastery criteria were met more often in the immediate reinforcement (95%) than in the delayed reinforcer with immediate praise or response-marker (85%) or the delay reinforcer and delayed praise conditions (73%). As a result, instructional procedures that employ immediate reinforcement may be more efficacious than those in which reinforcement delivery is delayed. In regard to efficiency, mastery criteria were met in fewer sessions when reinforcement (i.e., edibles, leisure items) was delivered immediately (*M* = 8) as compared to when praise or a marker was provided immediately but reinforcement was delivered following a delay (*M* = 2.3) and when both praise and reinforcement were delivered after a delay (*M* = 9.3). Thus, the immediate delivery of praise seems to help mitigate any potential negative impact on acquisition of delayed reinforcer delivery.

CHAPTER FOUR:

DISCUSSION

This literature review summarized current research on the effects of immediate and delayed reinforcement on skill acquisition during DTT. Data were extracted from four articles and coded by dataset to synthesized information about participant characteristics, procedural modifications, and outcomes. Overall, most participants acquired the target skills in fewer sessions when reinforcers were delivered immediately following a correct response. Additionally, when the delivered of the reinforcer was delayed, participants acquired skills in fewer sessions when praise was delivered immediately following the correct response in comparison to when no immediate consequences (i.e., no praise or other reinforcers) were provided for correct response. Thus, it appears that the delivery of an immediate response marker (i.e., “look”; Grindle & Remmington, 2004), following correct responses may mediate the delay to reinforcement.

This line of research has several limitations. In this review, participants ages ranged from 3-10 years old. Although, 3-10 years old is a substantial age range, the generality of these findings to older participants is unclear. Additionally, regarding participant skillset, only one study included a direct assessment of the participants’ verbal skills (Sy & Vollmer, 2012). Although other studies (Carroll et al., 2016; Grindle & Remmington, 2004; Majdalany et al., 2016) provided information about their participant’s verbal skillset, this information was gathered informally (e.g., indirect through services prior to study) and thus may not be entirely accurate. Given that chronological age of person with disabilities is not an accurate index of the individual's skillset, it is important that future research provide additional information about each participant's skills repertoire to help determine whether delayed reinforcement is more likely to hinder acquisition of individuals with a specific set of skills.

Praise was delivered following correct responses across the majority of the datasets and, as noted previous, the immediate delivery of praise appears to lessen any potential negative impact of delayed reinforcement on skill acquisition. However, participants history with praise may have affected these outcomes. If praise functioned as a reinforcer, potentially due to previous pairings with other reinforcing stimuli, then correct responses were followed by the delivery of an immediate reinforcer making the immediate praise and delayed reinforcer conditions analogous. In addition, it is plausible that praise, edible, and leisure items differed in their reinforcing properties. However, none of the studies included a reinforcer assessment for praise. Thus, future research should consider directly assessing whether praise has reinforcing properties and determining the relative reinforcing properties of all reinforcers.

The articles included in this literature review focused on the acquisition of differing target responses, including tacting (Carroll et al., 2016; Majdalany et al., 2016), listener responding (Sy & Vollmer, 2012), and matching words to pictures of objects (Grindle & Remington, 2004). In general, the likelihood of acquisition of the target responses in both the immediate and delayed reinforcement condition differed across target responses. Specifically, for 20% of the datasets focusing on acquisition of tacts, acquisition did not occur in the delayed reinforcement condition whereas for 38% of the datasets focusing on acquisition of listener responding acquisition, did not occur in the delayed reinforcement condition. However, for all dataset's mastery criteria was met in both the immediate and delayed reinforcement conditions when the target response was matching of words to pictures. However, given that each of these studies employed a adapted alternating treatments design to assess the impact of immediate and delayed reinforcement on acquisition of differing responses (e.g., tact of various countries), equating the difficulty of targets is essential to ensure the independent variable (i.e., delay to reinforcement) is responsible for differences in efficiency or efficacy outcomes (Cariveau et al., 2020). That is, if certain targets are easier for a participant to acquire, they may meet mastery criteria for those targets in fewer sessions thus skewing the results. Although equating targets for difficulty is important, only one of the studies included in this review explicitly stated equating targets for difficulty (Carroll et al., 2016), while the others only mentioned that the skills targeted were novel to the participant. Future research should equate targets for difficulty in order to eliminate the impact of this potential confounding variable (i.e., differing difficult levels) on measures of efficiency and efficacy.

Multiple textbooks recommend the immediate delivery of reinforcers following correct response when teaching new skills as well as to maintain previously acquired responses (e.g., Miltenberger, 2016; Skinner, 1953). The results of this literature review support this recommendation because, in general, skills were acquired in fewer sessions when instructional procedures included immediate reinforcement or delayed reinforcement with an immediate response marker compared to delayed reinforcement conditions. Thus, immediate reinforcement appears to enhance instructional efficiency. However, it has been proposed that in clinical settings short delays in reinforcer delivery are likely to occur during instructional sessions because of the time required to retrieve the reinforcer or to record data (Majdalany et al., 2016). The studies included in this literature review had varying delay durations of 5-40 s and the impact of short delay (e.g., 5 sec or less) was only evaluated across a few datasets. Therefore, additional research is needed to determine the extent to which short delays in reinforcer delivery impact acquisition. However, given that, across all datasets included in this review, mastery criteria was met in fewer sessions in the immediate reinforcement condition or when a response marker was delivered immediately, it is important that clinical settings consider ways to minimize the delay to reinforcer delivery (e.g., ensure that data collection is completed after reinforcer delivery; retrieve reinforcer prior presenting an instructional trial) or at least ways to ensure that praise, or another marker, is delivered immediately following a correct response. Additionally, although long delays to reinforcement may occur in certain environments such as a classroom (Carroll et al., 2016), future research should identify the duration of the latency to receiving a reinforcer that is more common in clinical settings and include such duration in future experiments comparing acquisition under immediate and delayed reinforcement conditions. Furthermore, it is important to consider other ways to mediate the delay to reinforcer delivery. For instance, the use of auditory feedback in the form of a clicker, may be used to immediate reinforcement for correct responding.

Limitations

This literature review has a few limitations. First, the current literature review included a very small sample size because few studies have evaluated the impact of immediate and delayed reinforcement of acquisition of skills by human participants. Second, although information about a variety of participant characteristics and procedural variations were extracted, some variables were not considered. For instance, participants skillset aside from verbal repertoire. Finally, most articles included in this study evaluated acquisition based on a certain percentage of independent correct responding across a specific number of sessions however the number of trials per sessions different across studies. Thus, a better index of efficiency across procedures and study is the number of trials to mastery.

Conclusions

Overall, the results of this literature review suggest that delays to reinforcement may decrease instructional efficacy and efficiency. Additionally, results of this review suggest that a response marker such as praise may mediate the delay to reinforcement. Thus, it is important that reinforcers are delivered immediately following correct responses and that response-markers are used whenever delay to reinforcement cannot be prevented.

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APPENDICES:

Appendix A: Table 1

Comparison of Participant Characteristics and Procedural Variations

Study and Conditions	Participant #: Age/Sex	Diagnosis/ VB Skills	Target Response	Prompt Type	Prompt Fading	Error Correction	Type of Reinforcer	Effective	Efficiency
Carroll et al., 2016									
Experiment 1	1: 4/M	ASD/1-2	Tact	Vocal	Delay	Prompt[b]	Edible	Yes	IR; IPR; DR
Immediate reinf.; immediate praise and reinf.; delayed praise and reinf. (10s)	2: 5/M	ASD/3-4	Tact	Vocal	Delay	Prompt[b]	Leisure item	Only 0s	IR
Grindle & Remmington, 2004	1: 9/M	ASD/2-3	Matching	Gestural	L-M	L-M	Leisure item	Yes	DRIP; RM; DR
Experiment 1	2: 10/M	ASD/0	Matching	Gestural	L-M	L-M	Leisure item	Yes	DRIP; RM; DR
Value condition, Response-marking, and delayed reinforcement (5s)	3: 5/M	ASD/4-6	Matching	Gestural	L-M	L-M	Leisure item	Yes	DRIP; RM; DR
	4: 7/M	ASD/7-8	Matching	Gestural	L-M	L-M	Leisure item	Yes	DRIP; RM; DR
	5: 6/M	ASD/2-3	Matching	Gestural	L-M	L-M	Leisure item	Yes	DRIP; RM; DR
Majdalany et al., 2016	1: 5/M	ASD/1-2	Tact	Vocal	Delay	Vocal	Edible	Yes	IR; DR
Experiment 1	2: 5/M	ASD/1-2	Tact	Vocal	Delay	Vocal	Edible	Yes	IR; DR
Immediate reinf.; 6s delay; 12s delay	3: 5/M	ASD/3-4	Tact	Vocal	Delay	Vocal	Edible	Yes	IR; DR
Sy & Vollmer, 2012[a]	1: 4/M	ASD	Listener	N/A	N/A	N/A	Mixed	Yes	IR; DR
Experiment 1	2: 5/F	DD	Listener	N/A	N/A	N/A	Mixed	Until 20s	IR
0s vs 20s delay, 0s vs 30s delay, and/or 0s vs 40s delay	3: 4/M	ASD	Listener	N/A	N/A	N/A	Mixed	Yes	IR; DR
	4: 5/M	ASD	Listener	N/A	N/A	N/A	Mixed	Yes	IR; DR
	5: 3/F	DD	Listener	N/A	N/A	N/A	Mixed	Yes	IR; DR
	6: 7/F	DS	Listener	N/A	N/A	N/A	Mixed	Until 20s	IR
	7: 8/F	ID	Listener	N/A	N/A	N/A	Mixed	Yes	IR; DR
	8: 4/F	DD	Listener	N/A	N/A	N/A	Mixed	No	
Experiment 2	3: 4/M	ASD	Listener	N/A	N/A	N/A	Mixed	Yes	IR; DR
0s vs 20s delay, 0s vs 30s delay, and/or 0s vs 40s delay	5: 3/F	DD	Listener	N/A	N/A	N/A	Mixed	Yes	IR; DR
	8: 4/F	DD	Listener	N/A	N/A	N/A	Mixed	Until 20s	IR
Experiment 3	1: 4/M	ASD	Listener	N/A	N/A	N/A	Mixed	Until 40s	IR
0s vs 20s delay, 0s vs 30s delay, and 0s vs 40s delay	5: 3/F	DD	Listener	N/A	N/A	N/A	Mixed	Yes	IR; DR

Note: There were 18 participants and 23 datasets total (denoted by the same participant number across multiple experiments); Reinf.=reinforcement; DD= developmental delay, DS= down syndrome ID= Intellectual disability, IR=immediate reinforcement; IPR=immediate praise and reinforcement; DR: delayed reinforcement; DRIP: delayed reinforcement and immediate praise DRRM: delayed reinforcement and response-marking;

[a]Different or multiple delays assessed across different participants; [b]Error correction included praise for correct responding.

Appendix B: Figure 1

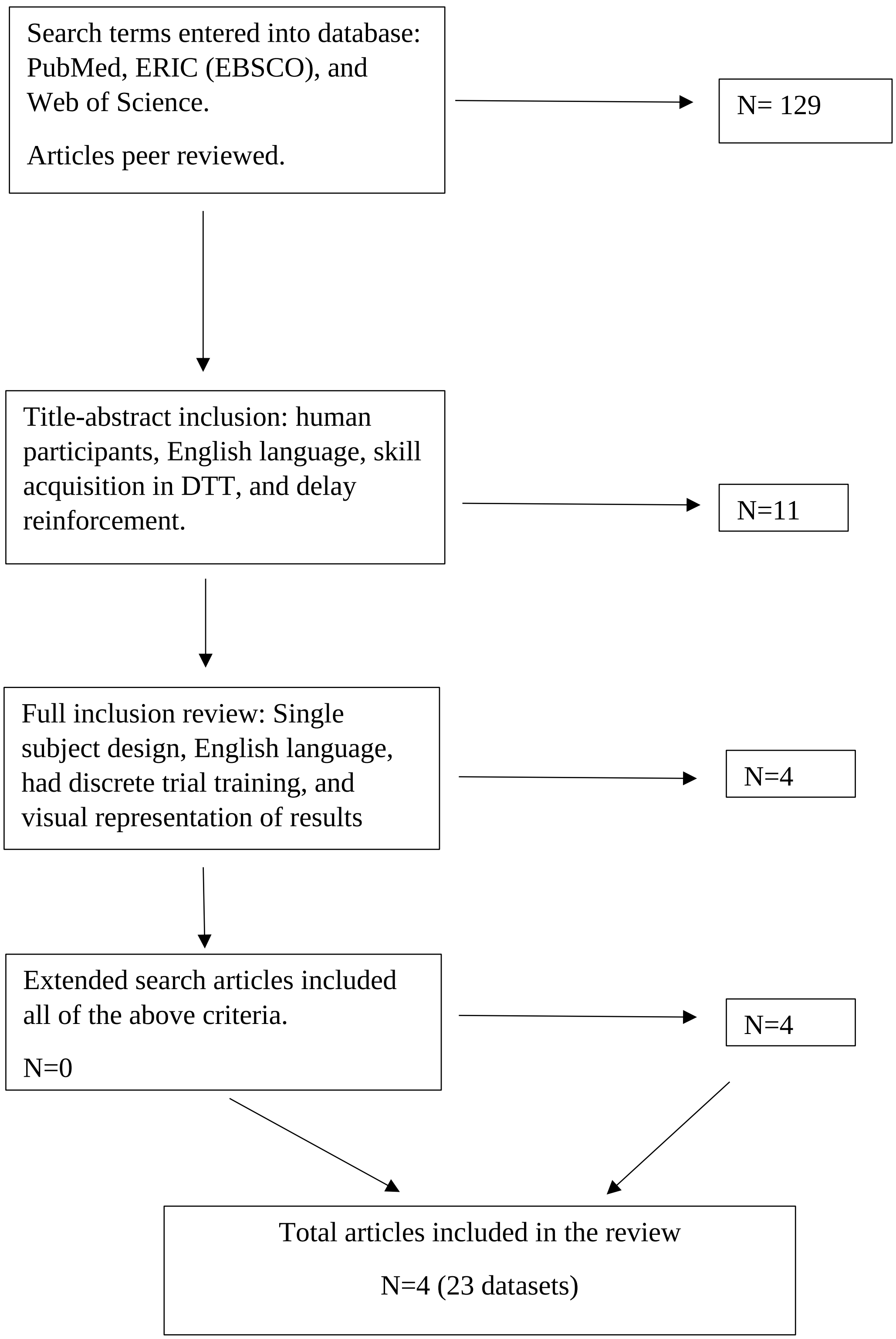

Figure 1. This figure shows the inclusion criteria, and number of articles for review from each step of the search process.