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An Evaluation of Magnitudes of Reinforcement and Mand Variability in the Treatment of Problem Behavior in Individuals with Autism Spectrum Disorder

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Abstract

An Evaluation of Magnitudes of Reinforcement and Mand Variability in the Treatment of Problem Behavior in Individuals with Autism Spectrum Disorder

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Interventions aimed at increasing behavioral variability hold particular importance in individuals with autism spectrum disorders (ASD). Several procedures have been demonstrated in the applied and translational literature to increase response variability including extinction and lag schedules of reinforcement. However, little is known about the relationship between reinforcer magnitude and response variability. In the basic literature, Doughty, Giorno, and Miller (2013) evaluated the effects of reinforcer magnitude on behavioral variability by manipulating reinforcer magnitude across alternating variability thresholds, with results suggesting that larger reinforcers induced repetitive responding. Recently, Ferguson, Falcomata, Ramirez-Cristoforo, and Vargas-Londono (2019) translated these findings to evaluate the relative effects of different magnitudes of reinforcement on mand variability in children with ASD. Inconsistent with basic findings, the results from Ferguson et al. showed higher levels of variable responding associated with the larger magnitude of reinforcement. The purpose of the present study was to evaluate the effects of different magnitudes of reinforcement on variable responding in the treatment of problem behavior. Using a nonconcurrent multiple baseline design with an embedded multielement design, phase A represented baseline data with no programmed response for variability or problem behavior. In phase B, a Lag 1 schedule of reinforcement was implemented within a multielement design, with the durations of reinforcement provided for variable responding varying across small and large magnitude conditions. Results demonstrated dramatic decreases in problem behavior for all participants in both small and large magnitude conditions. The results also suggest that larger magnitudes of reinforcement may increase variable responding more effectively than smaller magnitudes of reinforcement.

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Chapter 1: Introduction

Individuals with autism spectrum disorder (ASD) often engage in repetitive and restrictive behaviors and exhibit deficits in communication skills. These characteristics are defined as part of the diagnostic criteria for ASD (American Psychiatric Association, 2013). Rodriguez and Thompson (2015) identify the presence of repetitive and restrictive behaviors in communication as a problem of invariance, or invariable responding. Invariable behavior can produce several challenges for individuals with ASD, especially in situations when variable responding is advantageous (e.g., solving problems, accessing novel reinforcement, when a previously reinforced response is extinguished; Rodriquez & Thompson, 2015). As a result of these communication deficits, many individuals with ASD also utilize problem behaviors as a means to communicate (Carr & Durand, 1985).

Behavior variability is considered an operant dimension of behavior that can be shaped by the consequences delivered (Neuringer, 2002). Several studies in the applied literature have identified interventions specifically aimed at increasing communicative response variability (e.g., Adami, Falcomata, Muething, & Hoffman, 2017; Betz, Higbee, Kelley, Sellers, & Pollard., 2011; Contreras & Betz, 2016; Duker & Van Lent, 1991; Esch, Esch, & Love, 2009; Ferguson, Falcomata, Ramirez-Cristoforo, & Vargas-Londono, 2019; Heldt & Schlinger, 2012; Koehler-Platten, Grow, Schulze, & Bertone, 2013; Lee, McComas, & Jawor, 2002; Lee & Sturmey, 2006; Lee & Sturmey, 2014; Muething, Falcomata, Ferguson, Swinnea, & Shpall, 2018; Silbaugh & Falcomata, 2018; Silbaugh, Falcomata, & Ferguson, 2017; Susa & Schlinger, 2012). The methods applied to increase communicative response variability include lag schedules of reinforcement (e.g., Adami et al., 2017; Contreras & Betz, 2012; Esch et al., 2009; Falcomata et al., 2018; Ferguson, et al., 2019; Heldt & Schlinger, 2012; Koehler-Platten et al., 2013; Lee et al., 2002; Lee & Sturmey, 2006; Lee & Sturmey, 2014; Silbaugh & Falcomata, 2018; Silbaugh et al., 2017), extinction (e.g., Duker & van Lent, 1991), delays to reinforcement (e.g., Muething et al., 2018), and the combination of script training, reinforcement of novel responses, and the application of extinction (e.g., Betz et al., 2011).

A limited number of these studies have focused on dimensions of reinforcement and their effects on communicative response variability (i.e., Lee & Sturmey, 2006; Muething et al., 2018, Ferguson et al., 2019). For example, Lee and Sturmey (2006) evaluated the effects of quality of reinforcement on variable communicative responding by providing high-preferred items as reinforcement between a Lag 0 schedule of reinforcement (i.e., all responses reinforced on FR 1 schedule) and Lag 1 schedule of reinforcement (i.e., the emitted response must vary from the previously emitted response to contact reinforcement). Using a multielement design embedded within an ABAB design, the authors found that participants did not vary responding in the Lag 0 condition and 2 of 3 participants varied responding in the Lag 1 condition. For the two participants whose responses varied under the Lag 1 schedule, the authors reported the quality of reinforcement did not appear to have an effect on response variability.

Muething et al. (2018) examined the effects of delays to reinforcement on communicative response variability using an ABCBC design. The authors measured response variability and problem behavior across two conditions (i.e., FCT and FCT with a programmed delay to reinforcement). In the delay evaluation, the authors found that delays to reinforcement increased variable communicative responding for 3 of 4 participants; however, the variability did not persist when the delay was removed. Muething et al. hypothesized the observed increase in variability during the delay was likely attributed to extinction-induced variability. Another interesting finding was that problem behavior was extinguished for all participants when FCT was implemented with the delay. The authors taught and provided at least four mand modalities for all FCT sessions, suggesting that the availability of multiple responses may have prevented the recurrence of problem behavior.

Ferguson et al. (2019) evaluated the effects of reinforcement magnitude on response variability in a study intended to translate the findings of Doughty, Giorno, and Miller (2013). Using a multielement design, Ferguson et al. (2019) alternated between providing small and large magnitudes of reinforcement for responses that met the variability requirement of a Lag 1 schedule. Specifically, one small piece of an edible was provided as reinforcement during the small magnitude condition and four small pieces of an edible were provided during the large magnitude condition. Similar to Muething et al. (2018), four mand modalities were presented at the start of each trial. Ferguson et al. reported higher levels of variable communicative responding in the large magnitude condition for all four participants.

The findings of Ferguson et al. (2019) are inconsistent with findings from the basic literature. In particular, two basic studies have examined the effects of reinforcement magnitude on response variability (i.e., Stahlman & Blaisdell, 2011; Doughty et al., 2013).

Stahlman and Blaisdell (2011) evaluated the effects of reinforcement magnitude on the spaciotemporal variation of pecking responses emitted by pigeons. Five colored discs were programmed to deliver an associated magnitude of reinforcement and response variability was measured by the placement of the pigeon's pecks on the pecking device. Supporting the theory that larger reinforcers may induce greater response repetition, the authors found that large magnitudes of reinforcement reduced the pigeons' response variability. Doughty et al. (2013) extended Stahlman and Blaisdell by assessing the effects of reinforcement magnitude on response variability through manipulating the duration of access to feed provided to pigeons across small and large magnitude conditions (i.e., 2-s and 6-s, respectively). Two frequency thresholds were utilized to establish response variability requirements. Specifically, a response sequence was reinforced if its relative frequency occurred below the set thresholds (i.e., 0.05 in the high variability requirement and 0.30 in the low variability requirement). Consistent with Stahlman and Blaisdell, Doughty et al. found that higher reinforcement magnitudes were associated with higher behavioral repetition, and higher levels of response variability were associated with smaller magnitudes of reinforcement. These outcomes, contrasted with the results of Ferguson et al., hold potential implications when designing and implementing interventions aimed at increasing response variability in individuals with ASD and developmental disabilities.

The effects of reinforcement magnitude on behavior are still largely unknown, given the disparity in results between basic and applied findings. A synthesis by Ferguson (in preparation) summarized 16 studies which directly examined the effects of reinforcement magnitude in individuals with developmental disabilities. Through the study of varying reinforcement interval durations, some evaluations identified shorter reinforcement intervals as desirable (e.g., Lerman, Kelley, Vorndran, Kuhn, & LaRue, 2002; Volkert, Lerman & Vorndran, 2005; Paden & Kodak, 2015). For example, Lerman et al. (2002) and Paden et al. (2015) found that shorter and longer reinforcement intervals maintained similar treatment outcomes, suggesting that overall intervention durations (e.g., DTT) could be reduced by using shorter reinforcement intervals. Similarly, Volkert et al. (2005) showed that functional analyses outcomes were similar when varying magnitudes of reinforcement were provided, suggesting reinforcement intervals could be selected based on individual concerns.

In contrast, some studies have identified larger reinforcement magnitudes to be desirable. For example, Trosclair-Lasserre, Lerman, Call, Addison, & Kodak (2008) and Fiske, Cohen, Bamond, Delmolino, LaRue, & Sloman (2014) demonstrated individual preference for larger magnitudes of reinforcement using magnitude preference assessments. Three of the four studies evaluating reinforcement magnitude and NCR found higher response reduction rates with higher magnitudes of NCR (Carr, Bailey, Ecott, Lucker. & Weil, 1998; Wilder, Fisher, Anders, Cercone, & Neidert, 2001; Roscoe, Iwata, & Rand, 2003). Also, some studies demonstrated that reinforcement magnitude can influence choice allocation, with individuals allocating more responses to the choice associated with larger magnitudes of reinforcement (Hoch, McComas, Johnson, Faranda, & Guenther, 2002; Reed, Hawthorn, Bolger, Meredith, & Bishop, 2012; Ward-Horner, Pittenger, Pace, & Fienup, 2014). This could hold particular importance in the development of interventions when extinction is undesirable (e.g., treatment of severe problem behavior). Given the inconsistent outcomes associated with reinforcement magnitude research, further evaluations are warranted.

The purpose of the present study is to replicate and extend the work of Ferguson et al. (2019) by evaluating the effects of reinforcement magnitude on response variability in individuals with ASD with problem behavior. Using a Lag 1 schedule of reinforcement, participants alternated between small and large magnitude conditions where varying durations of access to reinforcement were provided as reinforcement for variable communicative responding.

Chapter 2:

Magnitudes of Reinforcement and Developmental Disabilities: A Systematic Review

Magnitude is a widely studied dimension of reinforcement, with a growing body of basic and applied literature focused on its effects. Reinforcement is integral to applied behavior analysis, with assessment and treatment focused on the consequences that increase, decrease, or maintain behaviors. While other dimensions of reinforcement have been more widely studied (e.g., quality, immediacy), the effects of the amount of reinforcement selected for the assessment, treatment, or training of behaviors remains largely unknown. The quantity of reinforcement selected for treatments such as differential reinforcement of alternative behavior (DRA) or noncontingent reinforcement (NCR) could have a significant impact on intervention outcomes. Additionally, reinforcement magnitude could influence overall time spent in reinforcement, intervention duration, overall response rate, and duration of the post reinforcement pause (Lerman et al., 2002).

The consideration of reinforcement magnitude holds particular importance when working with individuals with ASD, as researchers and clinicians aim to find the most effective approach to reduce inappropriate behaviors and reinforce appropriate behaviors. Basic research has demonstrated reinforcement magnitude to have an effect on response rates, response allocation, and response variability (e.g., Catania, 1963; Reed, 1991; Stahlman & Blaisdell, 2011; Doughty et al., 2013). In contrast, findings on the effects of reinforcement magnitude in the applied research have been somewhat mixed. Given the discrepancy in outcomes and the increased attention reinforcement magnitude has received in the literature, a synthesis of the available research is warranted to summarize the work that has been completed and identify areas requiring further evaluation.

METHODS

Search Strategy

This review focused on studies that manipulated the magnitude of reinforcement provided to individuals with autism and developmental disabilities during assessments and interventions. An electronic database search was completed using ERIC, MEDLINE, Psychology and Behavioral Sciences Collection, and PsycINFO through EBSCO, an electronic journals service. The keywords used in the search were "magnitude* of reinforcement" and "autis*" or "dev* dis*". The search was limited to peer-reviewed studies, with the initial search yielding 31 studies. An additional three studies were identified though ancestry and reference searches. A paper recently accepted by the first author did not show up on database searches, however, it was also included for review. All 35 studies were screened for inclusion in the synthesis.

Inclusion Criteria

To be included for review, the study had to (a) be published in a peer-reviewed journal; (b) include a participant with a diagnosis of ASD or a developmental disability; and (c) manipulate or evaluate magnitude of reinforcement as the primary independent variable.

After screening the studies against these criteria, 19 studies were excluded. The majority of these studies were excluded because they did not meet independent variable-based criterion. Specifically, a few studies evaluated all dimensions of reinforcement, rather than evaluating the specific effects of reinforcement magnitude. A total of 16 studies published between 1998 and 2019 were identified that met inclusion criteria.

Data Extraction

Studies were summarized in terms of (a) participant characteristics, (b) evaluation procedures, (c) dependent variables, and (d) results of the study. The dependent variables and evaluation outcomes are summarized within six categories: functional analyses, noncontingent reinforcement, extinction procedures, choice and response allocation, preference and treatment efficacy, and skill acquisition.

RESULTS

Sixteen studies from six journals met criteria for inclusion in this synthesis. The results are summarized in Table 1 by (a) participant characteristics, (b) evaluation procedures, (c) dependent variables, and (d) results of evaluation.

Study	**Participant(s): (Age); Diagnosis**	**Evaluation Procedures**	**Evaluation Outcomes**
Functional Analysis			
Fisher et al. (1996)	1 male (11), ID	FA	As reinforcement intervals increase, the rates of problem behavior decrease, potentially explained by the reduced time spent in the EO.
Volkert et al. (2005)	2 females (7-9); ASD, DD, & VI 4 males (3, 7); ASD, DD, & VI	FA	The magnitudes of reinforcement provided did not influence behavioral outcomes, as long as the intervals were consistent across conditions.
Noncontingent Reinforcement			
Carr et al. (1998)	2 females (20-48); ID 3 males (20-48); ID	Multielement, reversal	Higher magnitudes of NCR created large and consistent reductions in response rates than the medium and lower magnitude schedules.
Ecott et al. (1999)	(18-53); ID	Multielement, reversal	Reduced response rates observed under both high and low magnitudes of NCR.
Wilder et al. (2001)	1 female (16); ID	Multielement, reversal	Response rates decreased slightly during the low magnitude NCR condition and decreased significantly during higher magnitudes of NCR.
Roscoe et al. (2003)	1 female; ID 3 males (23-39); ID	Multielement	When response rate was corrected for time spent consuming reinforcers, larger magnitudes of NCR produced lower response rates when compared to smaller magnitudes of NCR.
Extinction Procedures			
Lerman et al. (1999)	1 female (21); ID	FA, multielement	Strong response patterns of appropriate responding occurred across small and large magnitudes, however, much higher and more variable levels of inappropriate behavior occurred within the smaller reinforcement condition.

Table 1: Summary of Reviewed Studies

Lerman et al. (2002)	1 female (20); ID 2 males (4, 10); ID, ASD	FA, reversal	No difference was observed in the participants' response patterns during extinction following both the small and large magnitude conditions.
Davis et al. (2012)	1 female (8); ID, SEBD 3 males (12-18); ID, SEBD, ASD	FA, reversal	3/4 three of the four participants demonstrated dramatic increases in on-task behavior and their inappropriate behaviors were nearly eliminated. participants demonstrated dramatic increases in on-task behavior and their inappropriate behaviors were nearly eliminated.
Choice			
Hoch et al. (2002)	3 males (9-11); ASD	Reversal	Participants allocated more responses to an area containing a peer or sibling with higher reinforcement magnitudes than the alone area with lower reinforcement magnitudes. The outcomes for 2 participants maintained.
Reed et al. (2012)	10 males (7-11); ASD	Group design	No differences were observed in reinforcement sensitivity between the group of individuals with ASD and the control group. However, the group of participants with ASD showed greater levels of object bias, leading to a disruption of stimulus control.
Ward-Horner et al. (2014)	1 female (16); PDD-NOS, ADHD	Reversal	The continuous work schedule was exclusively chosen when equal reinforcement durations were provided. When the continuous condition produced 60% or 20% (6 min or 2 min) of the reinforcement provided by the discontinuous condition, the participant chose the discontinuous schedule.

Table 1 (Continued)

Preference & Treatment Efficacy			
Trosclair-Lasserre et al. (2008)	1 female (11); ASD 2 males (5); ASD	FA, multielement	All 3 participants preferred larger magnitudes of social reinforcement. More responses persisted under the larger magnitude for 2 participants, however, 1 participant allocated more responses to the smaller magnitude.
Fiske et al. (2014)	1 female (8); ASD 2 males (5, 7); ASD	Multielement	All participants signifying a preference for larger magnitudes of reinforcement via magnitude preference assessments and responding at higher rates under the larger magnitude during the reinforcer assessment.
Skill Acquisition			
Lerman et al. (2002)			Mixed outcomes (i.e., negative relation, positive relation, no relation) were observed across participants for the relation between reinforcement magnitude and duration of the PRP.
Fiske et al. (2014)	1 female (8); ASD 2 males (5, 7); ASD	Multielement	The total sessions required for mastery across participants with larger reinforcement magnitudes varied from 3 to 16.
Paden et al. (2015)	4 males (4-5); ASD	Multielement	All participants preferred the larger magnitudes of reinforcement, however, there was not a significant difference in the sessions required to reach mastery criterion between conditions.
Ferguson et al. (2019)	2 females (12, 13); ASD 2 males (3, 11); ASD	Multielement	Higher response variability occurred under higher magnitudes of reinforcement in comparison to smaller magnitudes.

Table 1 (Continued)

Participants

Reinforcer magnitude was evaluated with a total of 56 participants with developmental disabilities across the 16 included studies. Of the 56 participants, 16 (28%) were female and 40 (72%) were male. Participants' ages ranged from 3 to 53 years (*M* = 7.3 years). There was also a wide range of diagnoses among participants. Of the 56 included individuals, 34 (61%) participants were diagnosed with ASD; 22 (38%) participants were diagnosed with ID, ranging from mild to profound; and 4 (7%) participants were diagnosed with severe emotional and behavior disorders (SEBD). One participant had an additional diagnosis of ADHD, reactive attachment disorder, and neuropsychiatric syndrome (Ward-Horner et al., 2014); and one participant had an additional diagnosis of cerebral palsy (Davis, Fredrick, Alberto, & Gama, 2012). Some of these participants (22%) had multiple diagnoses, which accounts for the above-100% totals. Problem behaviors were reported for 19 (33%) participants, ranging from disruption, aggression, self-injurious behaviors (SIB), and destruction.

Evaluation Procedures and Experimental Designs

Six studies conducted functional analyses as part of their evaluation procedures. Four of these studies conducted the functional analyses as pre-experimental procedures (i.e., Lerman, Kelley, Van Camp, & Roane, 1999; Lerman et al., 2002; Trosclair-Lasserre et al., 2008; Davis et al., 2012), while two studies directly evaluated the effects of reinforcement magnitude on functional analysis outcomes (i.e., Fisher, Piazza, & Chiang, 1996; Volkert et al., 2005). Five studies implemented a multielement arrangement as their primary experimental design (i.e., Lerman et al., 1999; Roscoe et al, 2003; Fiske et al., 2014; Paden et al., 2015; Ferguson et al., 2019) and three studies implemented a reversal design as their primary experimental design (i.e., Lerman et al., 2002; Davis et al., 2012; Ward-Horner et al., 2014). Four studies employed a combined approach incorporating both multielement and reversal designs (i.e., Carr et al., 1998; Ecott, Foate, Taylor, & Critchfield, 1999, Wilder et al., 2001; Trosclair-Lasserre et al., 2008). Specifically, Trosclair-Lasserre et al. (2008) used a reversal design for one evaluation (i.e., preference assessment) and a multielement design for the second evaluation (i.e., reinforcer assessment). Hoch et al. (2002) implemented a reversal within a multiple baseline design across participants, and Reed et al. (2012) utilized a group design.

Dependent Variables

Functional Analyses

Two studies evaluated the effects of reinforcement magnitude on functional analysis outcomes. Fisher et al. (1996) first compared the effects of unequal and equal reinforcer durations used during a functional analysis on problem behavior rates with an 11-year-old boy with moderate ID. Unequal reinforcement intervals were provided across conditions (i.e., 3 s for attention and play, 30 s for demand and tangible) in the first and third functional analyses, whereas equal reinforcement intervals (i.e., 30 s) were provided across conditions in the second and fourth functional analyses. Volkert et al. (2005) extended Fisher et al. by conducting a set of three functional analyses varying in magnitudes of reinforcement with six children with ASD. The averages of reinforcement intervals provided across the conditions were 6 s for the small-magnitude functional analyses, 23 s for the medium-magnitude functional analyses, and 122 s for the large-magnitude functional analysis.

Noncontingent Reinforcement

Four studies assessed the effects of reinforcement magnitude on noncontingent reinforcement procedures. The first study, by Carr et al. (1998), examined response suppression associated with low, medium, and high magnitudes of noncontingent reinforcement in five individuals with severe to profound ID via a parametric analysis. Ecott et al. (1999) closely replicated Carr et al. (1998) by providing low and high magnitudes of contingent and noncontingent reinforcement to three adults with severe to profound ID. In both aforementioned studies, the arbitrary response of dropping poker chips into a cylinder was established for all participants.

Wilder et al. (2001) evaluated the effects of varying magnitudes and densities of NCR on the responding of a 16-year-old female with mild to moderate ID. With the aim to identify the responsible mechanisms for reduced response rates associated with NCR, Wilder et al. provided varying schedules of low and high magnitudes of contingent and noncontingent reinforcement across five conditions. To extend on the aforementioned study procedures, Roscoe et al. (2003) attempted to further explain the effects of NCR magnitude by adding controls and corrections for the time spent consuming reinforcers. In the first study, equal magnitudes of NCR were provided while the reinforcement consumption time was and was not corrected in overall session time. In the second study, response rate was measured while small, medium, and large magnitudes of NCR were provided across sessions.

Extinction Procedures

Lerman et al. (1999) evaluated the effects of reinforcement magnitude on spontaneous recovery through measurements of problem behavior during FCT and extinction procedures. A functional communicative response (i.e., hand clapping) was reinforced across small and large magnitude conditions where 10 or 60 s of access to preferred toys was provided contingent on hand clapping and screaming was placed on extinction. The percentage of intervals with appropriate communication and problem behavior were analyzed across the small and large magnitude conditions. Lerman et al. (2002) next evaluated the effects of reinforcement magnitude on resistance to extinction with three individuals exhibiting problem behavior. In experiment one, card touches were reinforced with two varying magnitudes of reinforcement through communication training and maintenance sessions (i.e., 20 or 60 s of access to tangibles or escape from instructions). Following the small and large maintenance conditions, two extinction phases were implemented until card touches dropped below 20% of the average rate during maintenance for three sessions or a maximum of 20 sessions.

Finally, Davis et al. (2012) evaluated the efficacy of using concurrent schedules of varying magnitudes of reinforcement in lieu of extinction during FCT with four participants diagnosed with SEBD and ID. As extinction may not be the best approach for treating particular behaviors, the concurrent schedule was arranged where appropriate behaviors produced a 30-s escape from tasks and the alternative response produced a 30-s escape from tasks and simultaneous access to preferred activities.

Choice and Response Allocation

Hoch et al. (2002) studied the effects of reinforcement magnitude and quality on choice responding in three boys with ASD during play activities with peers. The participants were provided a choice to play where a peer or sibling was located or to play alone. In one condition, the magnitude and quality of reinforcement were equal across choices, and in the other condition, the magnitude or quality of reinforcement was higher for choosing the location with a peer or sibling.

Ward-Horner et al. (2014) assessed the effects of reinforcement magnitude on an individual's choice between continuous and discontinuous work schedules across three experimental phases. A continuous work schedule was defined as completing five worksheets and gaining access to a predetermined reinforcement interval (2, 6, or 8 min across the three phases) and a discontinuous work schedule was defined as five cycles of completing one worksheet and gaining access to 2 minutes of reinforcement. As the reinforcement magnitude provided with the continuous schedule increased, the reinforcement magnitude with the discontinuous schedule was held constant to identify the point at which the participant would choose the discontinuous schedule over the continuous schedule.

Reed et al. (2012) assessed the effects of reinforcement magnitude on matching responses between two groups of participants. One group was comprised of 10 lower functioning individuals with ASD and the other group included 10 mental-aged matched participants. The authors tested the hypothesis that individuals with ASD display higher sensitivities to reinforcement across five concurrent schedules where each response was programmed to receive a different magnitude of reinforcement.

Preference and Treatment Efficacy

Lerman et al. (2002) completed a second experiment which evaluated the effects of reinforcement magnitude on responding and post-reinforcement pauses (PRP) during maintenance across small, medium, and large magnitude conditions. The procedures were identical to experiment one, where a card touch produced 20 s access to tangibles or escape from demands in the small magnitude condition, 60 s access in the medium magnitude condition, and 300 s in the large magnitude condition. Lerman et al. then calculated PRP and local response rates for analysis.

Trosclair-Lasserre et al. (2008) first studied the relation between preference for different magnitudes of reinforcement and reinforcer efficacy through a magnitude preference assessment and a magnitude reinforcer assessment with three children exhibiting problem behavior. The magnitude preference assessment utilized a concurrent schedule providing choice trials between three magnitudes of reinforcement (i.e., no reinforcement, small magnitude, and large magnitude). These values were 0 s, 10 s, 120 s in one condition and 0 s, 60 s, 120 s in the second condition for one participant. 105 s was used as an additional small magnitude choice for one participant, and one participant was only exposed to 10 s (rather than 60 s) as the medium magnitude choice. Next, Trosclair-Lasserre et al. delivered a progressive-ratio (PR) reinforcer assessment to evaluate the efficacy of the different magnitudes of reinforcement comparing the cumulative number of responses for each magnitude. Fiske et al. (2014) replicated and extended Trosclair-Lasserre et al. by using similar procedures to evaluate magnitude preference via preference assessments and reinforcer efficacy via PR analyses in three individuals with ASD.

Skill Acquisition

As part of a multi-procedure experiment, Fiske et al. (2014) evaluated the effects of reinforcer magnitude on skill acquisition following a magnitude preference assessment and a PR reinforcer efficacy analysis. As part of the treatment comparison for skill acquisition, participants were exposed to three different conditions. Responses emitted at the current prompt level were always reinforced with the larger magnitude of reinforcement, however, the amount of reinforcement provided for responses requiring the most intrusive prompt varied across the three conditions. Conditions were signaled via colored cards (i.e., no reinforcement in large/EXT, small magnitude in large/small, large magnitude in large/large). Comparisons of skill acquisition were made across conditions to test the hypothesis that more reinforcement would lead to quicker skill acquisition.

Paden et al. (2015) tested the effects of reinforcement magnitude on skill acquisition during DTT following a magnitude preference assessment in two boys with ASD. During DTT, unprompted and prompted correct responses were reinforced. Reinforcement included praise and 1/8 of an edible item in the small-magnitude condition, praise and two to three edible items in the large-magnitude condition, and praise in the praise only condition. Data were collected on the frequency of correct responses and the duration of sessions to show the time spent in each condition before mastery criterion was reached.

Ferguson et al. (2019) evaluated the effects of reinforcement magnitude on response variability in individuals with ASD. Participants alternated between small and large magnitude conditions under a Lag 1 schedule of reinforcement (i.e., the response must have differed from the previously emitted response to be reinforced). Reinforcement was 1/4 of a preferred edible in the small magnitude condition and 1 whole piece of a preferred edible in the large magnitude condition. Data were collected on percentage of responses that were variable and comparisons were made across the small and large magnitude conditions.

Evaluation Outcomes

Functional Analyses

Results from Fisher et al. (1996) suggested that as reinforcement intervals during functional analyses increase, the rates of problem behavior decrease, potentially explained by the reduced time spent in the establishing operation (EO). The findings from Volkert et al. (2005) extended Fisher et al by suggesting that the magnitude of reinforcement provided during functional analyses did not significantly influence behavioral outcomes, as long as the intervals were consistent across conditions. Functional analysis results were similar across the small, medium, and large magnitude conditions (6 s, 23 s, 122 s respectively).

Noncontingent Reinforcement

Through a parametric analysis on the effects of low, medium, and high magnitudes of NCR on response suppression, Carr et al. (1998) found that higher magnitudes of NCR created large and consistent reductions in response rates. In comparison, the medium-magnitude schedule created smaller and less consistent reductions, and the low-magnitude schedule did not have a significant effect on response rates. Ecott et al. (1999) replicated Carr et al.'s (1998) procedures, however, the authors did not replicate their findings to confirm a relation between reinforcement magnitude and response rate. Instead, Ecott et al. (1999) observed reduced response rates from NCR across the low and high magnitude conditions; however, the authors did not find evidence that differing magnitudes of NCR produced effects on response rates.

In Wilder et al.'s (2001) replication and extension, response rates decreased slightly during the low magnitude NCR condition and decreased significantly during the high magnitude condition. These outcomes replicate the findings of Carr et al. (1998). Roscoe et al. (2003) aimed to explain this through adding controls for reinforcement consumption time, while also replicating an evaluation of the relation between NCR magnitude and response rate. Roscoe et al. found that when response rate was corrected for time spent consuming reinforcers, larger magnitudes of NCR produced lower response rates when compared to smaller magnitudes of NCR.

Extinction Procedures

Lerman et al. (1999) examined the effects of reinforcement magnitude on the spontaneous recovery of screaming behavior through manipulating the duration of reinforcement intervals (10 s or 60 s) provided during FCT and extinction procedures. Their findings indicated strong response patterns of appropriate responding across the small and large magnitudes, however, much higher and more variable levels of screaming occurred within the smaller reinforcement condition. Lerman et al. (2002) conducted an additional study on the effects of reinforcement magnitude on resistance to extinction. An initial response burst occurred for one participant during both extinction phases, and the number of sessions spent in extinction varied from 11-20 across participants. No difference was observed in the participants' response patterns during extinction following both the small and large magnitude conditions.

Finally, Davis et al. (2012) assessed the utility of implementing concurrent schedules of varying magnitudes of reinforcement in lieu of extinction during FCT procedures. The authors report that three of the four participants demonstrated dramatic increases in on-task behavior and their inappropriate behaviors were nearly eliminated.

Choice and Response Allocation

Following exposure to higher magnitudes and quality of reinforcement associated with an area containing a peer or sibling, Hoch et al.'s (2002) assessment of reinforcement magnitude on choice responding demonstrated that participants allocated more responses to an area containing a peer or sibling than the alone area. The outcomes for two participants maintained as they continued to choose the area with a peer or sibling, regardless of the magnitude or quality of reinforcement provided. The authors offer the potential explanation that the peer or sibling became a conditioned reinforcer from being continually paired with higher magnitudes or qualities of reinforcement.

When equal reinforcement durations were provided for the choice between a continuous work schedule and discontinuous work schedule, or when a continuous work schedule produced 80% (8 min) of the reinforcement provided by the discontinuous work schedule (10 min), Ward-Horner et al. (2014) found the participant exclusively chose the continuous work schedule. However, when the continuous condition produced 60% or 20% (6 min or 2 min) of the reinforcement provided by the discontinuous condition, the participant chose the discontinuous schedule. The authors identified the 8 min continuous work schedule as the most efficient since the reinforcement interval was reduced by 2 min and the repeated time spent transitioning between work and reinforcement was eliminated.

When looking at sensitivity to reinforcement in individuals with ASD, Reed et al.'s (2012) findings suggest there were no differences in reinforcement sensitivity between the group of individuals with ASD and the control group. However, the group of participants with ASD showed greater levels of object bias, leading to a disruption of stimulus control and potentially explained by stimulus over-selectivity as manifested by individuals with ASD.

Preference and Treatment Efficacy

Results from Trosclair-Lasserre et al.'s (2008) magnitude preference assessment indicated that all three participants preferred larger magnitudes of social reinforcement when the difference in values was greatest (i.e., 10 s and 120 s), however, responses became more evenly allocated when the small magnitude choice increased to 50% or more of the larger value (e.g., 60 s). The magnitude reinforcer assessment found more responses persisted under the larger magnitude (i.e., 120 s) for two participants, however, one participant allocated more responses to the smaller magnitude (i.e., 10 s). Additionally, differences in responding between magnitudes were not observed until the schedule became more strenuous. Fiske et al. (2014) replicated the findings of Trosclair-Lasserre et al. (2008), with all participants signifying a preference for larger magnitudes of reinforcement via magnitude preference assessments and responding at higher rates under the larger magnitude during the reinforcer assessment.

Skill Acquisition

Lerman et al.'s (2002) second experiment had mixed outcomes for the relation between reinforcement magnitude and duration of the PRP, with one participant's data demonstrating a negative relationship (tangible sessions), one participant's data demonstrating a positive relationship (demand sessions), and two participants data showing no relation (tangible sessions). The differences in responding occurred when comparing the 20-s condition to the 300-s condition as there were not differences for the 60-s condition.

The results of Fiske et al.'s (2014) treatment comparison across magnitudes of reinforcement varied across participants. The quickest mastery of tasks across the conditions was five sessions in the large/large condition for the first participant, three sessions in the large/EXT condition for the second participant, and 16 sessions in the large/large condition for the third participant. The results from this assessment do not provide strong evidence for use of large magnitudes of reinforcement to achieve faster skill acquisition.

Paden et al.'s (2015) magnitude preference assessment showed that all participants preferred the larger magnitudes of reinforcement, however, there was not a significant difference in the sessions required to reach mastery criterion between conditions. The smaller magnitude of reinforcement was efficient in yielding relatively quick skill acquisition, and the duration of instructional time spent during the large-magnitude conditions was greater than small-magnitude conditions.

The results from Ferguson et al.'s (2019) evaluation on the effects of reinforcement magnitude on response variability demonstrated higher response variability in the large magnitude condition for all four participants in comparison to the small magnitude condition. Participants averaged 86% variable responding in the large magnitude condition and 61% variable responding in the small magnitude condition.

DISCUSSION

Several interesting outcomes have resulted from the research being conducted in the field of reinforcement magnitude. Studies on the effects of reinforcement magnitude in individuals with developmental disabilities span a wide range of dependent variables, including functional analyses, treatment of problem behavior, response allocation, skill acquisition, maintenance of skills, extinction procedures, and response variability. Beyond this scope, basic and applied research spanning decades has been conducted with additional populations. A number of clinical implications may be drawn from the studies identified in this synthesis.

Summary and Implications

First, Fisher et al. (1996) highlighted the importance of standardizing reinforcement intervals during functional analyses, and, potentially, the duration of exposure to the EO. Additionally, Volkert et al. (2005) showed that functional analyses outcomes were similar when small, medium, and large magnitudes of reinforcement were provided, which could imply that reinforcement intervals be selected based on specific concerns and appropriately tailored to the individual.

Four studies evaluated the effects of reinforcement magnitude and NCR. Carr et al.'s (1998) results demonstrated large and consistent response reductions with higher magnitudes of NCR. Ecott et al. (1999) aimed to replicate the findings of Carr et al.

however, their findings were inconsistent with Carr et al. Wilder et al. (2001) replicated the findings of Carr et al., suggesting that higher magnitudes of reinforcement in NCR reduce responding better than lower magnitudes of reinforcement. Wilder et al. offered the explanation that when using higher magnitudes of NCR, the participant spent a greater amount of time consuming the reinforcement, which may influence the reduced response rate. Roscoe et al. (2003) also replicated these findings, with the added correction for response rate and time spent in reinforcement. These results have potential clinical implications as the magnitude of reinforcement selected for NCR procedures may impact treatment efficacy.

The findings of Lerman et al. (1999) suggest that spontaneous recovery could be mitigated by utilizing higher magnitudes of reinforcement when behavioral treatments include extinction. Lerman et al.'s (2002) results also hold clinical significance as participants' responding maintained at similar levels with 20-s, 60-s, and 300-s reinforcement intervals. These outcomes suggest that clinicians could use shorter reinforcement intervals during interventions to achieve similar outcomes. Finally, Davis et al.'s (2012) findings provided evidence for the use of concurrent schedules of varying magnitudes of reinforcement as part of FCT when extinction may be undesirable. The participants from this study were diagnosed with SEBD and engaged in severe behaviors, so the potential clinical implications are positive for this population.

Through examining reinforcement magnitude and response allocation, Hoch et al.'s (2002) findings suggested that not only can the magnitude and quality of reinforcement influence an individual's choice to play near a peer or sibling, but the effects can maintain after treatment. Through an assessment on matching law, Reed et al.'s (2012) findings suggested that children with ASD demonstrate stimulus over-selectivity, leading to a disruption in stimulus control. These outcomes could have implications for developing interventions utilizing stimulus control for children with ASD. Lastly, the results of Warn-Horner et al. (2014) could have implications for clinicians who wish to improve the efficiency of training sessions through manipulating the schedule of reinforcement provided via continuous work schedules.

Trosclair-Lasserre et al.'s findings suggested that an individual's preference for reinforcer magnitude may influence relative reinforcer efficacy, and that magnitude may interact with schedule requirements. Fiske et al. (2014) replicated these results. Drawing on these outcomes, it seems plausible that choice between appropriate and inappropriate responding could be manipulated by varying the magnitudes of reinforcement provided in the treatment of problem behavior. It also appears that increasing the magnitude of reinforcement may increase overall treatment efficacy.

The findings of Paden et al. (2015) suggested that using smaller magnitudes of reinforcement may be desirable in DTT as it appears to reduce the time spent in sessions and produces the same level of mastery as larger magnitudes of reinforcement. Additionally, Ferguson et al.'s (2019) results suggest that larger magnitudes of reinforcement may strengthen variable behavior more effectively than smaller magnitudes of reinforcement. This could indicate potential implications for clinicians teaching individuals with ASD to vary responding.

Future Research

While a considerable body of research has been focused on studying the effects of reinforcement magnitude in basic and applied behavioral research, the outcomes have been fairly inconsistent, and with exception to NCR, lacking replication. The extent of which reinforcement magnitude influences behavioral mechanisms and intervention outcomes is still largely unknown, therefore future research should aim to replicate and extend previous studies to identify similar trends across dependent variables.

Conclusion

This synthesis evaluated sixteen studies that manipulated reinforcer magnitude in the treatment of developmental disabilities. Studies that met criteria were examined and summarized in terms of (a) participant characteristics, (b) evaluation procedures, (c) dependent variables, and (d) results of evaluation. From the body of studies, reinforcer magnitude was evaluated with a total of 56 participants with developmental disabilities. The effects of reinforcer magnitude were studied across a variety of dependent variables, including functional analyses, noncontingent reinforcement, extinction, response allocation, treatment efficacy, and skill acquisition. Results of this synthesis suggest additional research is warranted to develop a further understanding of how reinforcer magnitude influences behavior.

Chapter 3: Methods

PARTICIPANTS

Omar, Haley, and Allison were 13, 15, and 16 years old, respectively. All three participants attended a private school for children with developmental disabilities, had diagnoses of ASD, and were referred to the study for their limited communication skills and history of tangibly maintained problem behavior. Haley had an additional diagnosis of Down Syndrome and Allison was diagnosed with a rare chromosome anomaly. Haley and Allison had no vocal communicative responses and Omar had a small repertoire of 1- to 2-word vocal approximations for highly preferred items (e.g., iPad®, motor room). Each participant used an iPad®-based communication program (e.g., Proloquo2go™) to communicate and had a long history of making requests and answering questions with their iPad®-based programs. Caregivers reported that Omar had a long history of severe aggressive and destructive behaviors. Haley and Allison were reported to have a history of self-injurious behaviors (SIB) and aggression.

MATERIALS AND SETTING

Sessions were completed in the teacher workroom, conference room, or empty classroom of the participants' school. Sessions in the teacher workroom and empty classroom were conducted at a 2' by 4' wooden table with four chairs, and sessions in the conference room were conducted at a 3' by 8' table with six chairs. Other items were present in the rooms, but access was blocked if necessary (e.g., books, water machine, books, trash can). Materials required for the tangible pairwise functional analysis and baseline sessions included a high preference item identified via a multiple stimulus preference assessment (MSWO; DeLeon & Iwata, 1996) and a timer. Materials required for all subsequent sessions included five mand modalities (i.e., red microswitch, yellow microswitch, iPad® with MyTalkTools™, iPhone® with MyTalkTools™, laminated picture card) selected from the mand topography assessments (MTA; Ringdahl et al., 2009), an iPad® with access to videos and games, two laminated pieces of construction paper (i.e., purple and green), a timer, a video camera, tripod, data collection sheets, and pencils.

Response Measurement, Interobserver Agreement, and Treatment Fidelity

Doctoral students trained in direct observation and data collection used pencil and paper to collect data during sessions and laptop computers to collect data using videos of recorded sessions. Frequency data were collected on communicative responses emitted and problem behavior. Communicative responses included pressing a red microswitch, pressing a yellow microswitch, touching a communication button in the MyTalkTools™ application on an iPad®, touching a communication button in the MyTalkTools™ application on an iPhone®, emitting an appropriate vocal mand, or touching a laminated picture card. All responses emitted at least 1 s apart were recorded (i.e., rapid, repetitive pressing of a button counted as one response). A variable mand was defined as a response that differed from the previously emitted response. Percentage of variable communication was calculated for each session by dividing the number of variable mands by the total number of mands emitted and multiplying the resulting number by 100. Additional frequency data were collected on each participant's problem behaviors as identified through the functional analyses (e.g., scratching, hitting, pinching) and converted to responses per minute.

A second observer used a laptop computer to collect data for 44% of sessions. Interobserver agreement was collected trial-by-trial for the MTA and calculated based on percentage of total agreement (i.e., agreements divided by agreements plus disagreements, and then multiplied by 100). Interobserver agreement was calculated using an interval-by-interval procedure for the functional analyses, baseline sessions, and magnitude evaluations (i.e., sessions were divided into successive 10-s intervals, agreement was calculated by dividing the smaller number of responses recorded by the larger number of responses recorded in each interval, and the mean agreement across intervals was calculated). Total agreement for the MTA averaged 100% for all participants. Agreement for engagement in problem behavior during the FA and baseline sessions averaged 98.06% for Allison (range = 90.32%-100%), 89.79% for Haley (range = 80.65%-100%), and 100% for Omar. Agreement for the engagement in problem behavior during the magnitude evaluation averaged 100% for Allison and Haley, and 98.86% for Omar (range = 95.45%-100%). Agreement for communicative responses emitted during the small and large magnitudes averaged 98.75% for Allison (range = 95.66%-100%), 97.86% for Haley (range = 95.47%-99.48%), and 96.41% for Omar (range = 95%-98.63%).

Duration data were collected via laptop computers on time spent in reinforcement to calculate treatment fidelity. Each participant was programmed to spend 15 s in reinforcement for small magnitude sessions and 60 s in reinforcement for large magnitude sessions. Treatment fidelity for reinforcement intervals was defined as delivering the reinforcement within 5 s above or below the programmed time. Additional frequency data was collected to evaluate treatment fidelity for correct reinforcement delivery in accordance with the lag (i.e., reinforcement provided for variable mands only). Treatment fidelity was calculated for 100% of treatment sessions by dividing the total correct reinforcement deliveries by the total number of reinforcement deliveries. Fidelity averaged 94.54% for duration of reinforcement intervals and 97.27% for lag delivery. IOA for fidelity was collected for 44% of treatment sessions by a second observer and calculated based on a percentage of total agreement. Total agreement for treatment fidelity averaged 85%.

EXPERIMENTAL DESIGN

A nonconcurrent multiple baseline design with an embedded multielement design was implemented to evaluate the effects of reinforcement magnitude on response variability in the treatment of problem behavior. Outcomes from the tangible condition of the functional analysis served as the first five baseline data points for all participants. Two additional baseline sessions were conducted with Allison and three additional baseline sessions were completed with Omar using procedures identical to the tangible condition in the functional analysis. Using procedures similar to Ferguson et al. (2019), a multielement design with two experimental conditions (i.e., small magnitude and large magnitude) was utilized for the magnitude evaluation. Each set of small magnitude and large magnitude sessions was presented in a randomized order with a Lag 1 schedule of reinforcement in place and no programmed response for problem behavior. The purpose of the lag schedule was to establish a threshold of variable responding, similar to the frequency threshold utilized by Doughty et al. (2013) and Ferguson et al.

PRE-EXPERIMENTAL PROCEDURES

Childhood Autism Rating Scale

The Childhood Autism Rating Scale (CARS-2) was completed by each participant's lead teacher to confirm a diagnosis of ASD and assess symptom severity. All participants' assessments confirmed severe presentation of ASD symptoms, meaning their total raw scores were above 37 points. Raw scores totaled 46.5 for Allison, 46.5 for Haley, and 38 for Omar.

Preference Assessment

A multiple stimulus without replacement preference assessment (DeLeon & Iwata, 1996) was conducted with each participant to identify a hierarchy of preferred items. Four to six items recommended by teachers and therapists were included in three consecutive assessments. The iPad® was the highest preferred item for all three participants.

Pairwise Functional Analysis

A pairwise comparison including five randomized sets of tangible and control conditions was completed Allison and Omar. Due to the increase in the frequency and severity of Haley's self-injurious behaviors, only four sets of pairwise sessions were completed with Haley. In the tangible condition, the participant was provided 30-s access to a high preferred item contingent on problem behavior. In the control condition, the participant had unlimited access to the high preferred item.

Mand Topography Assessment

The MTA (Ringdahl et al., 2009) was completed following the functional analysis to select proficient mand modalities (i.e., communicative responses) for each participant's magnitude evaluation. Five communicative responses, relatively equal in response effort, were included for assessment with each participant (e.g., red microswitch, yellow microswitch, iPad® with MyTalkTools™, iPhone® with MyTalkTools™, picture card, vocal mand). The vocal mand was not included in Allison or Haley's assessments as they did not have vocal communicative responses. When pressed, each device emitted 1 of 2 vocal responses (i.e., "iPad please" or "I want iPad"). Each mand modality was presented for 10 trials with a four-step prompt procedure in place (i.e., time delay, vocal prompt, gestural prompt, physical guidance) and data were collected on the level of prompt required. 30 s of access to each participant's highest preferred item was provided as reinforcement for prompted and unprompted mands.

MAGNITUDE EVALUATION

Small Magnitude Condition

Each session included 11 trials, with the last ten trials scored as variable or invariable. During each trial, five communicative responses (i.e., mand modalities) were arranged approximately 1 inch apart on a plastic tray for Haley and Allison and four communicative responses were presented to Omar. Omar had a vocal approximation for iPad® in his repertoire ("oo-ped"), so the card touch was eliminated from his tray. A laminated sheet of green construction paper was present throughout all small magnitude sessions and the mand modalities were removed and rearranged during reinforcement intervals. Communicative responses were reinforced on a Lag 1 schedule and 15 s access to the iPad® was provided for variable responses. There was no programmed reinforcement for problem behavior.

Large Magnitude Condition

Procedures for the large magnitude condition were similar to those used during the small magnitude condition, however, 60 s of reinforcement was provided contingent on variable responding and a laminated sheet of purple construction paper was present to signal the large magnitude sessions.

DATA ANALYSIS

All data were graphed using Microsoft Excel©. For the mand topography assessment, 100% stacked bar graphs display the varying levels of prompts required to access reinforcement. The communicative responses are shown on the abscissa and percentage of trials are shown on the ordinate. For the pairwise functional analysis, two line graphs present occurrences of problem behavior across the tangible and control conditions. Sessions are shown on the abscissa and problem behavior per minute is shown on the ordinate.

For the magnitude evaluation, a phase line separates baseline data from the small and large magnitude sessions. Sessions from the magnitude evaluation are represented on two line graphs with different markers (i.e., open squares for small magnitude and open triangles for large magnitude). Rate of problem behavior is displayed with closed circle markers on a secondary axis for baseline sessions. Closed squares and closed triangles represent the rate of problem behavior during the small and large magnitude conditions, respectively. The left ordinate represents percentage of variable communicative responding and the right ordinate represents the rate of problem behavior per minute. Through visual analysis, the graphs were examined for similarities and differences in rates of variable responding and problem behavior across conditions.

Chapter 4: Results

PAIRWISE FUNCTIONAL ANALYSIS

Figure 1 depicts the outcomes of the pairwise functional analyses for Haley, Allison, and Omar. All participants engaged in elevated levels of problem behavior when compared to the control condition. Haley (see top panel of Figure 1) engaged in low levels of self-injurious behavior during the control condition (*M* = 0.4 RPM) and elevated levels of self-injurious behavior during the tangible condition (*M* = 1.6 RPM). Haley's results suggested a tangible and potential automatic function for aggression and self-injurious behavior. Allison (see middle panel of Figure 1) engaged in zero levels of aggressive behavior in the control condition and elevated levels of aggression in the tangible condition (*M* = 1.52 RPM). Omar (see bottom panel of Figure 1) engaged in zero levels of aggressive behavior in the control condition and elevated levels of aggression in the tangible condition (*M* = 1.4 RPM). The earliest instance of aggressive behavior was reinforced for Omar due to the intensity and severity of his behavior. Allison and Omar's results both suggested a tangible function for aggressive behavior.

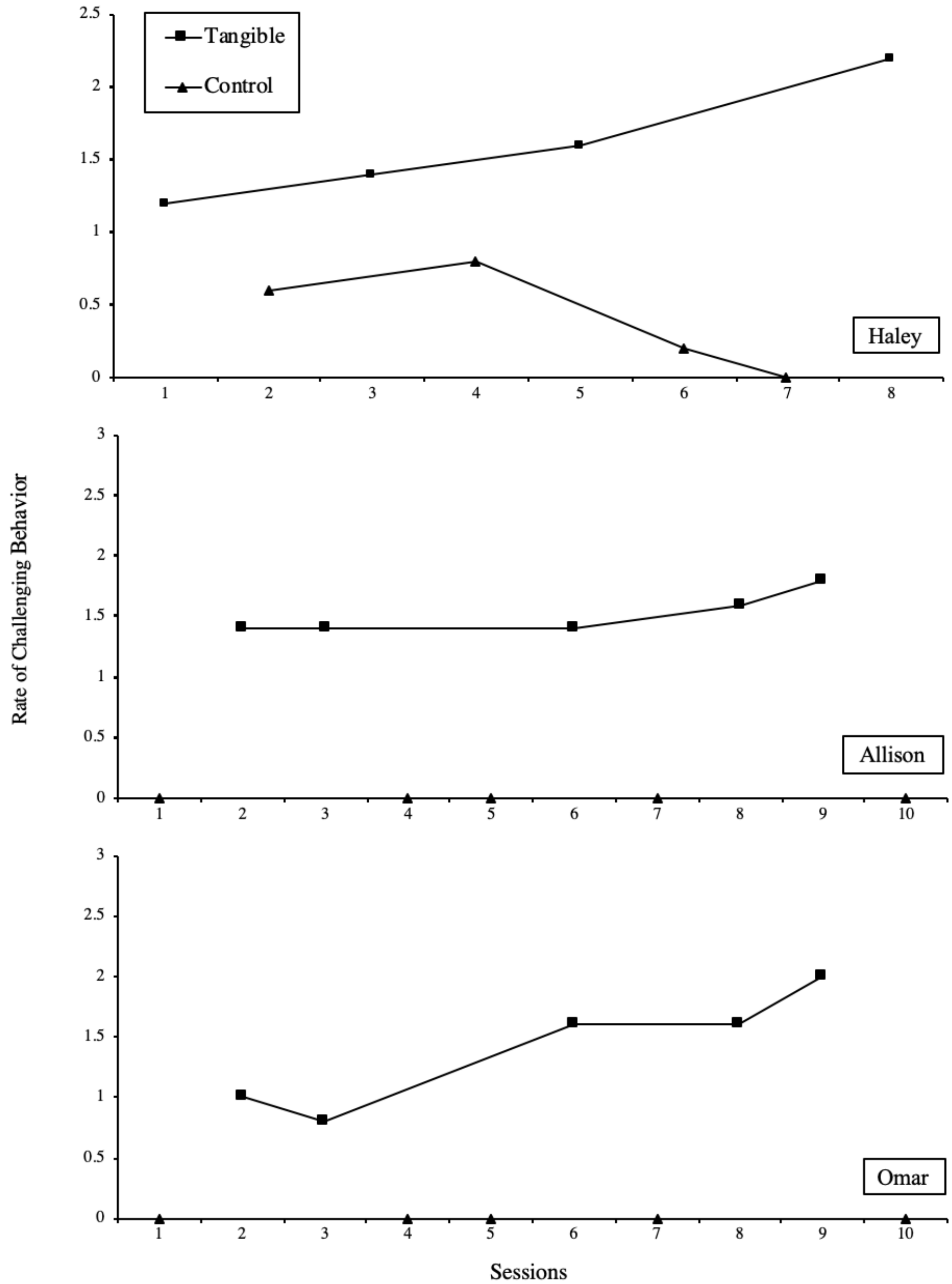

Figure 1: Rate of problem behavior per minute during the tangible and control conditions of the functional analyses for Haley (top panel), Allison (middle panel), and Omar (bottom panel).

MAND TOPOGRAPHY ASSESSMENT

Results from the MTA are depicted in Figure 2. Haley (see top panel of Figure 2) emitted 100% independent mands (i.e., response emitted before a prompt was delivered) in the yellow microswitch and iPhone® conditions. In the red microswitch and card exchange conditions, she emitted 90% independent mands following one trial requiring a vocal prompt. With the iPad®, Haley emitted 90% independent mands following one trial requiring a model prompt. Allison (see middle panel of Figure 2) emitted 100% independent mands in the yellow microswitch, iPhone®, and iPad® conditions. Allison emitted 90% independent mands with the red microswitch following one trial requiring a vocal prompt, and 60% independent mands with the card exchange. Omar (see bottom panel of Figure 2) emitted 100% independent mands in the yellow microswitch and iPhone® conditions. In the red microswitch and iPad® conditions, he emitted 90% independent mands following one trial requiring a vocal prompt. Omar had a vocal mand for iPad® in his repertoire (i.e., "oo-ped"), so this vocal approximation was used in place of the card exchange. For the vocal response condition, Omar emitted 80% independent mands following two trials requiring a vocal prompt.

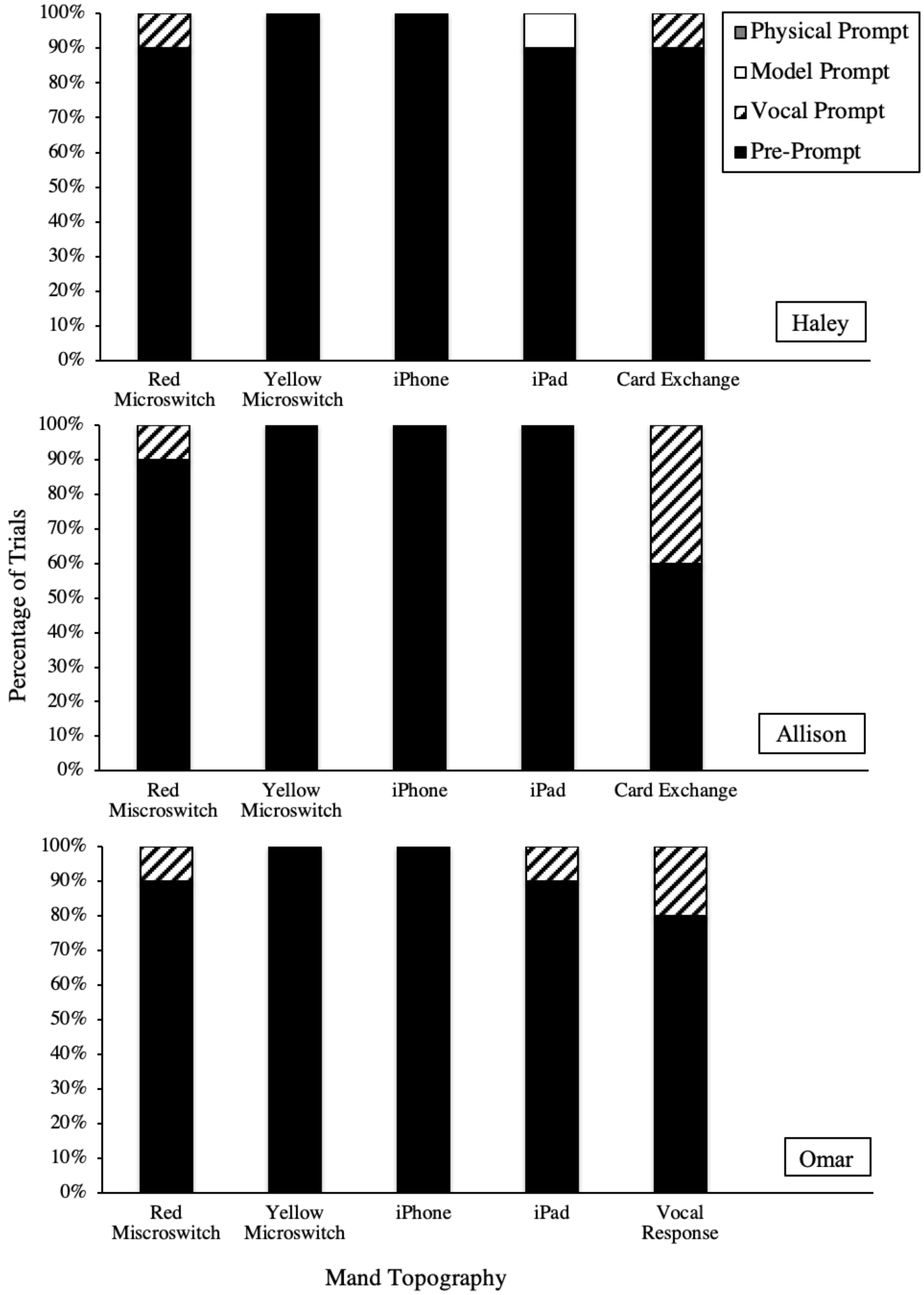

Figure 2: The prompt level required for Haley (top panel), Allison (middle panel), and Omar (bottom panel) to emit a response with each mand topography are displayed.

Magnitude Evaluation

The outcomes of the magnitude evaluation are depicted in Figure 3. The percentage of variable communicative responding during the treatment evaluation is displayed by open triangles for the large magnitude condition and open squares for the small magnitude condition. Problem behavior per minute (RPM) during baseline is displayed by the closed circles on a secondary axis, and problem behavior per minute during the small magnitude and large magnitude sessions are displayed by closed triangles and closed squares, respectively. Haley (see top panel of Figure 3) engaged in elevated levels of problem behavior during baseline (*M* = 1.6 RPM) and zero levels of problem behavior during the treatment evaluation. Overall, Haley exhibited higher levels of variable responding in the large magnitude condition (*M* = 69.66%) than the small magnitude condition (*M* = 58.57%). Overlap between the two data paths is observed at session 8 when her percentage of variable responding measured 66.66% for sessions 6 to 9. At session 10, the data paths divert and differentiation in variable responding in observed between the small and large magnitude conditions.

Allison (see middle panel of Figure 3) engaged in elevated levels of problem behavior during baseline sessions (*M* = 1.57 RPM) and near zero levels of problem behavior during the treatment evaluation (*M* = 0.008 RPM). Allison had one instance of aggression in her first treatment session, with problem behavior dropping to zero levels for the remaining sessions. In the treatment evaluation, Allison exhibited consistently higher levels of variable responding in the large magnitude condition (*M* =72.33 %) than the small magnitude condition (*M* = 61.58%). No overlap was witnessed between the two conditions with the exception of session 10 when her percentage of variable responding measured 62.5%.

Omar (see bottom panel of Figure 3) engaged in elevated levels of problem behavior during baseline sessions (*M* = 1.47 RPM) and exhibited significantly lower levels of problem behavior during the treatment evaluation (*M* = 0.35 RPM). Similar to Haley and Allison, Omar displayed consistently higher levels of variable responding in the large magnitude condition (*M* =69.22%) than the small magnitude condition (*M* = 59.86%). Overlap is seen in the large magnitude condition at session 12 when his percentage of variable responding measured 62.5%.

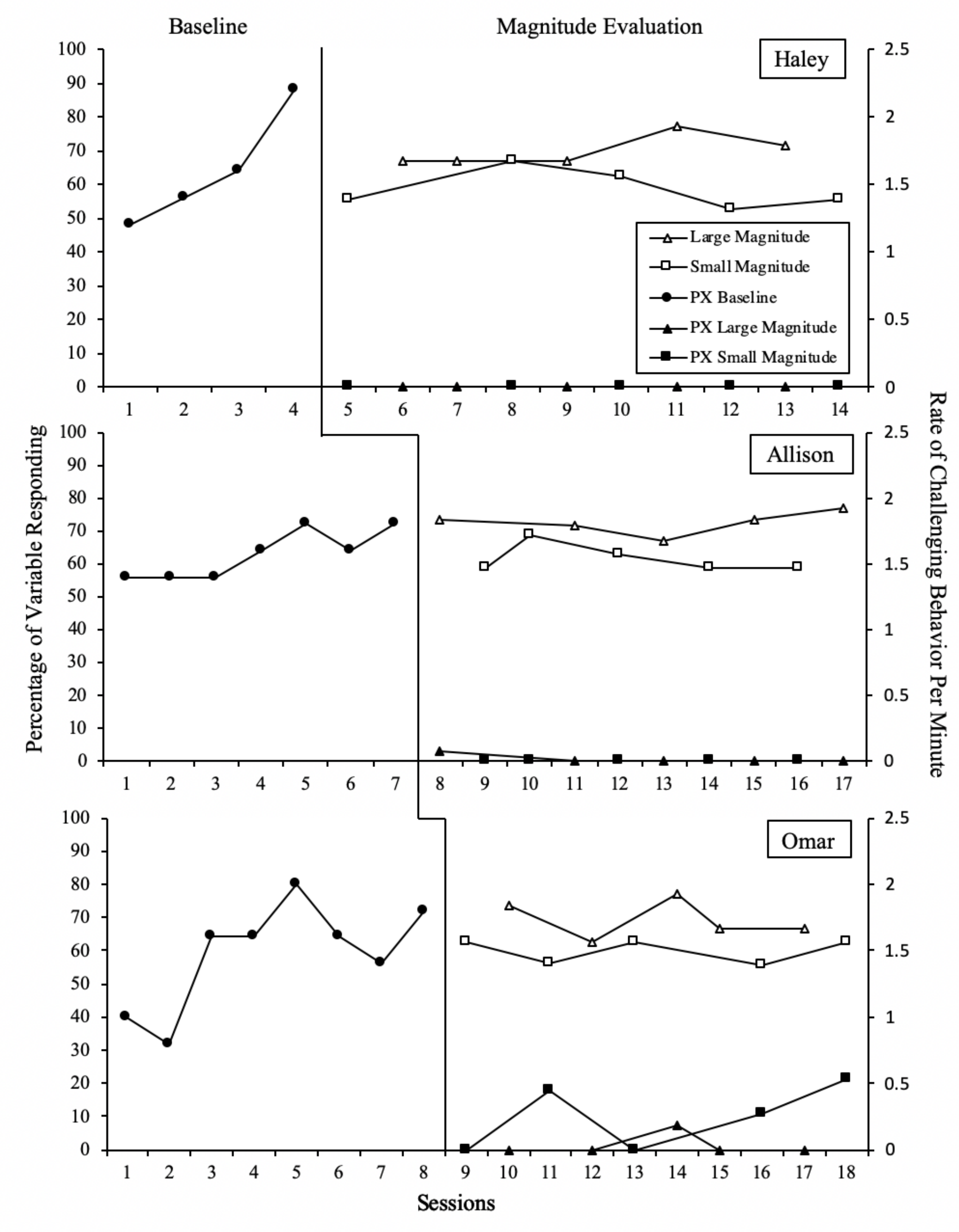

Figure 3: Percentage of variable communicative responding and rate of problem behavior per minute for Haley (top panel), Allison (middle panel), and Omar (bottom panel) during baseline and magnitude evaluation sessions are shown.

Chapter 5: Discussion

We evaluated the effects of reinforcement magnitude on response variability in the treatment of problem behavior. Similar to Ferguson et al. (2019), the results revealed that larger magnitudes of reinforcement increased response variability in all participants when compared to the small magnitude condition. All participants presented moderate levels of response variability in the small magnitude condition. Problem behavior was reduced to zero levels for Haley and Allison during the treatment evaluation and near zero levels for Omar.

The current study replicates and extends the previous literature in several ways. First, we replicated the previous work of Ferguson et al. (2019), providing a second demonstration that higher magnitudes of reinforcement can increase response variability. The present study also expanded on the experimental arrangements of Ferguson et al. through manipulations of the independent variable (i.e., the present study varied duration rather than quantity of reinforcement) and the inclusion of problem behavior as a dependent measure. The present outcomes also contribute to the growing body of research dedicated to identifying variables and procedures that influence response variability in individuals with ASD (e.g., lag schedules of reinforcement [e.g., Adami et al., 2017; Falcomata et al., 2018; Lee et al., 2002; Lee & Sturmey, 2006; Silbaugh et al., 2018], delays to reinforcement [e.g., Muething et al., 2018], application of extinction [e.g., Grow et al., 2008], and script training, reinforcement of novel responses, and the application of extinction [e.g., Betz et al., 2011]).

The current study also provides further evidence for the use of lag schedules during functional communication training (FCT) to increase variable responding and decrease problem behavior. Adami et al. (2017) and Falcomata et al. (2018) embedded lag schedules in FCT to successfully program multiple mands during treatment of problem behavior. Through programming multiple mands in variability training, potential clinical relapse could be mitigated (e.g., Hoffman & Falcomata, 2014) when faced with challenges to treatment (e.g., Wacker et al., 2011). Given the present results, the magnitude of reinforcement provided during such treatments may be a worthwhile consideration. Further, as clinicians select procedures to increase response variability in individuals with ASD, the current findings, in addition to Ferguson et al. (2019), suggest that attention be given to the magnitude of reinforcement provided during response variability training. Specifically, when lag schedules alone do not produce desired results, it may be useful to increase the magnitude of reinforcement provided for individuals exhibiting low-to-moderate levels of response variability.

Similar to Ferguson et al. (2019), the present findings contradict the findings of Doughty et al. (2013). Doughty et al. evaluated the effects of reinforcement magnitude on response variability in pigeons by varying the duration of feed access provided for four-peck sequences that met the relative frequency threshold contingencies. Doughty et al. found that larger magnitudes of reinforcement induced repetitive responding and smaller magnitudes of reinforcement were associated with more variable responding. One potential explanation for the pigeons' repetitive responding with the larger magnitudes of feed access could be explained by a reduction in the establishing operation (i.e., satiation). In the present study, all four participants maintained steady levels of variable responding in the large magnitude condition and did not appear to satiate when provided the longer duration of iPad® access (i.e., 60 s). Another possible reason for the discrepancy in outcomes could involve the procedures used to establish the response variability contingencies, though it is unknown how this would influence the outcomes. Doughty et al. found differences in response variability only when more stringent frequency thresholds were in place, requiring pigeons to greatly vary their responding. However, in the present study, a less stringent variability requirement was implemented (i.e., Lag 1 schedule of reinforcement) with differences in response variability clearly observed. Additionally, the present study measured a response as a single mand emission and a variable response as a single mand emission that differed from the previously emitted response; whereas, Doughty et al. measured a response as a four-peck sequence and a variable response as a four-peck sequence that met a relative frequency threshold. Lastly, rule-governed behavior may offer an explanation for the behavioral discrepancies between human and pigeon subjects.

LIMITATIONS

There are limitations in the current study worth noting. First, from a clinical standpoint, using large magnitudes of reinforcement is not always desirable or feasible. Although the 60 s selected for the large reinforcement interval would be manageable in most clinical settings, it is unknown whether the increased response variability associated with the large reinforcement interval would maintain if the reinforcement duration was slowly faded after training. However, based on the outcomes of the present study, we could hypothesize these results would not maintain with smaller magnitudes. It is also not known if the results of this study generalized outside of the research setting or maintained after completion of the study. Lastly, it is unknown whether the differences observed in response variability between the small and large magnitude conditions are socially or clinically significant.

FUTURE RESEARCH

The present study could be extended in several ways. First, future studies could extend on the present research with the inclusion of post-experimental procedures such as delay fading or schedule thinning. As demonstrated with previous research (Trosclair-Lasserre et al., 2008; Fiske et al., 2014), preference for reinforcement magnitude may influence reinforcer efficacy. A magnitude preference assessment could be included in future evaluations as a pre-experimental procedure. A measure of generalization and maintenance could also be incorporated in future studies to evaluate whether the magnitude of reinforcement provided during treatment has an effect on the generalization and maintenance of treatment outcomes. Another potential avenue of research could involve replicating the magnitude evaluation across environments (e.g., home, classroom, cafeteria) and interventionists (e.g., teacher, caregiver) to train for generalization of response variability. Finally, future experiments could assess the effects of reinforcement magnitude on clinical relapse when training multiple mands during FCT. Specifically, future studies could expand on the work of Hoffman & Falcomata (2014) to assess the effects of reinforcement magnitude on the resurgence of appropriate mands.

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