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An Evaluation of Delay to Reinforcement and Variant Responding

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# An Evaluation of Delay to Reinforcement and Variant Responding

by

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**An Evaluation of Delay to Reinforcement and Variant Responding**

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Children with Autism Spectrum Disorders and other developmental disabilities often exhibit invariant responding (i.e., restricted behavioral repertoires), deficits in communication, and challenging behavior. A variety of interventions have targeted increasing variant responding such as extinction, lag schedules of reinforcement, and percentile schedules of reinforcement. An additional variation studied in the basic literature entails the inclusion of a delay to reinforcement. Results of basic studies indicate that the inclusion of a delay to reinforcement leads to an increase in the variety of responses. The purpose of the current study was to evaluate the effects of a delay to reinforcement on the variability of communication responses during functional communication training with children with developmental disabilities with histories of engagement in challenging behavior. Results indicated that the delay to reinforcement increased variant communicative responding with all four participants.

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# Chapter 1: Introduction

Autism Spectrum Disorder (ASD) is a developmental disability that can impact individuals' ability to interact socially and regulate behavior (American Psychiatric Association, 2013). Individuals with ASD often engage in restricted and repetitive patterns of behavior such as stereotypy, interacting with a restricted number of items, or following strict routines. These patterns of behavior have been conceptualized as invariant behavior (Rodriguez & Thompson, 2015). Yet, to ensure success, behavior "must be sensitive to changes, both in physical environment and in contingencies of reinforcement, and thus must continually vary" (Neuringer, 2009, p. 320). Therefore, individuals with ASD or other developmental disabilities may contact obstacles during conditions when variant responding is advantageous such as extinction.

A variety of interventions aimed at increasing variant responding have been included within the basic literature and the applied literature with children with developmental disabilities. A lag schedule of reinforcement (Page & Neuringer, 1985) provides reinforcement for a response that differs from a specified number of previous responses. This schedule differentially reinforces varied responding and has been shown to increase individuals' with ASD responses to social questions (Lee, McComas, & Jawor, 2002) and tacts (Heldt & Schlinger, 2012). Additionally, periods of extinction for previously reinforced responses have been shown to increase the variety of lever sequences in rats (Neuringer, Kornell, & Olufs, 2001) and the variety of communicative gestures exhibited by children with ASD (Duker &

van Lent, 1991). Finally, percentile schedules of reinforcement reinforce operant variability based on an adapting criterion for reinforcement based on recent performance (Galbicka, 1994). For example, during a 30% percentile schedule of reinforcement, a specified response is reinforced if it is observed less than 30% of the previous specified number of responses. This procedure increased sequence variability in pigeons (Machado, 1989) as well as button pressing during a computer simulation (Miller & Neuringer, 2000) and task engagement (Athens, Vollmer, & St. Peter Pipkin, 2007) in individuals with ASD.

Within the basic literature, the effect of an alternative variable, a delay to reinforcement, on variant responding has been studied. Grunow and Neuringer (2002) found that as reinforcement rates decrease, not only did responding decrease across all groups, but the response variability increased in the group with initial low variability. Later, Wagner and Neuringer (2006) decreased reinforcement rates by varying the temporal delivery of reinforcement. Specifically, the timing of reinforcer delivery was manipulated by including a delay to reinforcement and measuring the effect on response variability in rats. Results showed that as the reinforcement rate decreased due to the inclusion of a delay to reinforcement, response variability increased in the group with low variability.

Odum, Ward, Barnes and Burke (2006) implemented a delayed reinforcement procedure with pigeons to determine the effects on sequence variability. Sessions alternated between a vary component where a sequence of pecks contacted reinforcement if it differed from a specified number of immediately preceding responses and a repeat component where reinforcement was contacted when a sequence was the same as the previous response. Next, delay time periods (i.e., 5, 15, 30 s) were included within both the vary and repeat components. Results suggested that when the delay period was included during the vary component, response variability was relatively unaffected. When the delay was implemented with the repeat component, response variability increased significantly. As the delay was increased during the repeat component, a corresponding increase in variability was observed. In other words, a delay to reinforcement increased the response variability of the group exhibiting low variability initially.

Stahlman and Blaisdell (2011) assessed the impact of a delay to reinforcement on the spatial variation of pecking behavior in pigeons. Specifically, a group of pigeons receiving immediate reinforcement was compared to a group who received reinforcement 4 s after the reinforced response. Data was collected on the spatial placement of pecks on the pecking device. Results suggested that when a delay to reinforcement was implemented, the spatial variation of pecks increased. Pigeons who were reinforced immediately did not produce comparable amounts of pecking spatial variation.

Wagner and Neuringer (2006) evaluated the effects of delayed reinforcement on the variability of response sequences produced by rats. The authors trained 3 groups of rats to respond at different levels of variability using percentile schedules of reinforcement. The groups were defined as: 1) high variability group (i.e., sequence reinforced when exhibited less than 20% of the previous 25 sequences),

2) middle variability group (i.e., sequence reinforced when exhibited less than 50% of the previous 25 sequences), and 3) low variability group (i.e., sequence reinforced when exhibited less than 75% of the previous 25 sequences). Next, a delay to reinforcement (i.e., 0.5, 2, 8, 16 s) was implemented. Results varied by variability group. Specifically, the group trained to exhibit high rates of sequence variability exhibited a significant decrease in sequence variability when reinforcement was delayed. The middle group's variability increased slightly with the inclusion of a delay to reinforcement, but the result was not statistically significant. Finally, the low variability group's sequence variability increased significantly when a delay to reinforcement was included. As the delay to reinforcement times increased, the low group exhibited a corresponding increase in sequence variability.

In addition to the presence of invariant behavior, children with developmental disabilities such as ASD also present with deficits in communication abilities, limiting their ability to request items and/or interact with others. Deficits in communicative abilities can result in the occurrence of challenging behavior (Carr & Durand, 1985) that come to serve various functions for the individuals. The challenging behavior may serve as the child's most efficient and effective way of requesting (i.e., manding) and obtaining his or her wants and needs as those behaviors contact reinforcement. One of the most effective and commonly used interventions for children with challenging behavior is functional communication training (FCT; Tiger, Hanley & Bruzek, 2008). During FCT, the child is taught an equivalent appropriate communication response that serves to replace the challenging behavior after the variable that maintains the challenging behavior is identified. Since its inception, numerous studies have evaluated the effectiveness of FCT for increasing socially acceptable communication responses and decreasing various types of challenging behavior including aggression (e.g., Wacker, Steege, Northup, Sasso, Berg, Reimers, …, Donn, 1990), self-injury (e.g., Fisher, Piazza, Cataldo, Harrell, Jefferson, & Conner, 1993), elopement (e.g., Falcomata, Roane, Feeney, & Stephenson, 2010), and access to rituals (e.g., Rispoli, Camargo, Machalicek, Lang, & Sigafoos, 2014). FCT has also been shown to be effective in treating behavior maintained by multiple functional reinforcers (e.g., Falcomata, White, Muething, & Fragale, 2012), in a variety of settings (e.g., Harding, Wacker, Berg, Lee, & Dolezal, 2009) and across implementers (e.g., parents; Suess, Romani, Wacker, Dyson, Kuhle, Lee, …, Waldron, 2014).

The purpose of the current study was to combine the use of the delay procedures as described in the basic literature and FCT for the treatment of challenging behavior. The problem of invariant behavior could be observed during FCT when the child exhibits a restricted preference for a certain communication response. This invariant responding may become problematic in that it could result in the re-emergence of challenging behavior during challenges to treatment (e.g., alteration of antecedent conditions; failure to reinforce appropriate communicative responses; Wacker et al., 2011). This study sought to evaluate if the inclusion of a delay to FCT would increase the communication response variability of participants with developmental disabilities using procedures similar to those described by Wagner & Neuringer (2006).

## Chapter 2: Method

### Participants

Participants were recruited from a school in the Central Texas area. Inclusion criteria for participation included a) diagnosis of a developmental disability, b) history of engagement in challenging behavior, and c) documented deficits in communication abilities. Participants were 3 males and 1 female ranging in age from 5 to 14 years (M = 10.5). Diagnoses included ASD and intellectual disability. Challenging behavior for each participant was aggression. Alex attended a public school whereas Patrick, Violet and Warren attended a private school for children with developmental disabilities (see Table 1 for individual participant characteristics).

### Settings and Materials

Sessions for Alex and Violet were conducted in the home. Sessions for Patrick and Warren were conducted in an empty classroom at their respective schools. Materials used in the study included work materials for the demand condition of the functional analysis (FA), leisure items (high and/or low preferred depending on the condition in place), and communication-based items. Leisure items were identified via an initial free operant preference assessment (Roane, Vollmer, Ringdahl, & Marcus, 1998; data available upon request) and interview of caregivers and/or school personnel. For each participant, communicative materials were individually selected based on results of the mand topography assessment (see Table 2). Communicative materials included a two-button BIGmack™ device, a one-button BIGmack™ device, a card for exchange, an iPad, and an iPhone. The buttons on the two-button BIGmack™ were differentiated by color (red versus yellow), by different pictures pasted on the button (e.g., a picture of a stop sign versus the word break), and vocal output (e.g., 'break please' versus 'I want a break'). The one-button BIGmack™ also included a vocal output but did not require a picture to differentiate it from other topographies. The laminated card for exchange had the word 'break' written on it. The iPad and iPhone each were equipped with an application (i.e., MyTalk Tools Lite) that allowed for vocal output and a visual representation of the functional reinforcer.

**Dependent Variables**

Variant mands served as the primary dependent variable. A variant mand was defined as a mand that was different from the immediately preceding mand. Target mands included a vocal response (i.e., asking for a break; Patrick only), BIGmack™ button activation (i.e., pressing the button with the hand), card exchange (i.e., handing the card to the communication partner) and activation of the iPad or iPhone (i.e., physical contact between the device and the hand).

Challenging behavior also served as a dependent variable. For Alex, challenging behavior was defined as aggression (e.g., hitting, pinching). For Patrick, challenging behavior was defined as aggression (e.g., hitting, pinching, moving hand within 6 inches of another person's face). For Violet, challenging behavior was defined as aggression (i.e., forcefully grabbing items away from another person's possession). For Warren, challenging behavior was defined as aggression (e.g., hitting, scratching, biting, forcefully grabbing items away from another person's possession).

**Data Collection and Interobserver Agreement**

All sessions were video recorded for subsequent data collection. A computer-based data collection system, Instant Data Analyzer, was used to code data on challenging behavior and mands for Patrick, Violet and Warren. Paper and pencil data collection was used for Alex. Frequency data were collected on mands and challenging behavior during both the FA and delay evaluation and subsequently converted to responses per minute (RPM) for analysis. Frequency data from the mand topography assessment (MTA) were converted to percentage of trials.

Trained observers independently scored at least 30% of all sessions from each assessment and condition for each participant. Interobserver agreement (IOA) was calculated for the MTA using a trial-by-trial method. The total number of agreements was divided by the total number of agreements plus disagreements and the resulting number was multiplied by 100. For each participant, IOA was 100% for the MTA. IOA was calculated for Alex's FA and delay evaluation using the total IOA method. The smaller number of mands was divided by the larger number of mands and the resulting number was multiplied by 100. For Alex, IOA was collected for 31.3% of sessions and was 100% for the FA. IOA was collected for 31% of sessions of the delay evaluation and averaged 97.8% (range = 75-100). IOA for the FA and delay evaluation was calculated using an interval-by-interval method. Specifically, sessions were divided into 10 s intervals. Exact agreement was calculated for each

10 s interval (i.e., the same number of responses recorded in a given 10 s interval). The total number of intervals with exact agreement was then divided by the total number of intervals and the resulting number was multiplied by 100. For Patrick, IOA was collected for 31.2% of sessions and averaged 99.3% (range = 96.7-100) for the FA.  For the delay evaluation, IOA was collected for 34.5% of sessions and averaged 98.1% (range = 80.6-100) for challenging behavior and 94.8% (range = 74.2-100) for mands. For Violet, IOA was collected for 35% of sessions and averaged 100% for the FA.  For the delay evaluation, IOA was collected for 31.8% of sessions and averaged 96.5% (range = 80.6-100) for challenging behavior and 94.8% (range = 61.3-100) for mands. For Warren, IOA was collected for 31.3% of sessions and averaged 97.4% (range = 93.5-100) during the FA.  For the delay evaluation, IOA was collected for 32.5% of sessions and averaged 93.3% (range = 77.4-100) for challenging behavior and 96.7% (range = 87.1-100) for mands.

**Experimental Design**

The FA was conducted within a multielement design and included three test conditions; attention, tangible, and escape; and a control condition (i.e., free play). The delay evaluation was conducted within a concurrent multiple baseline across three participants with an embedded ABAB reversal design.  The fourth participant, Alex, was not included in the multiple baseline due to scheduling conflicts.  Alex completed the same conditions as the other participants within an ABAB reversal design.

The first condition of the delay evaluation served as a baseline for the purpose of comparing levels of challenging behavior during the subsequent treatment conditions. Baseline sessions were identical to the test condition of the FA in which the highest rates of challenging behavior were observed. Next, a condition was implemented in which all mands were reinforced immediately and challenging behavior was ignored. This condition served as the A condition for the reversal and as an additional baseline for the purpose of comparing levels of variant responding during the subsequent condition. Finally, a condition was implemented in which reinforcement was provided 10 s after the first emitted mand. This condition served as the B condition of the reversal.

**Procedure**

**Functional Analysis**

First, a FA was conducted based on the procedures described by Iwata et al. (1982/1994) with the addition of a tangible condition (e.g., Marcus & Vollmer, 1996). This analysis was used to identify the possible function(s) of the challenging behavior (i.e., the antecedents and consequences that occasioned and maintained the behavior). Conditions included attention, tangible, escape, and control/free play. The tangible condition was not implemented with Alex based on initial descriptive analysis and interview. All sessions were randomly implemented and were 5 min in length. For Alex, an additional pairwise comparison was conducted to compare the free play condition to the attention condition. This comparison was used to isolate the attention condition from the demand condition.

**Attention**. The purpose of the attention condition was to test if challenging behavior was maintained by access to attention. During sessions, the participant was given access to low-preferred items (determined from the preference assessment). Before the session began, the experimenter provided the participant with approximately 30 s of high quality attention. When the session began, the experimenter removed all attention and engaged in a different activity. A fixed ratio (FR) 1 schedule of reinforcement was implemented in which attention was provided for 30 s contingent on challenging behavior. Following 30 s of attention from the experimenter, attention was removed and challenging behavior was again reinforced.

**Tangible**. The purpose of the tangible condition was to test if challenging behavior was maintained by access to high-preferred items/activities. During sessions, the participant had access to low preferred items. Before the session began, the participant was provided with approximately 30 s access to high-preferred items (determined from the preference assessment). When the session began, the experimenter removed the high-preferred items. A FR 1 schedule of reinforcement was implemented in which access to the high-preferred items was provided for 30 s contingent on challenging behavior. Following 30 s of access to high-preferred items, the items were removed and challenging behavior was again reinforced.

**Escape**. The purpose of the escape condition was to test if challenging behavior was maintained by escape from demands. When the session began, the experimenter presented a demand (e.g., academic work task) to the participant. Demands were determined by teacher and parent interview. Demands were presented using a 3-step prompting procedure. First, a vocal prompt was given. If the participant did not comply within 5 s, a gesture prompt was provided. If the participant did not comply within 5 s of the gesture prompt, a physical prompt was provided to achieve compliance. A FR 1 schedule of reinforcement was implemented in which demands were removed for 30 s contingent on challenging behavior. Following the 30 s break, the demand was presented and challenging behavior was available for reinforcement.

**Free play.** The free play condition served as a control condition with which the results of the test conditions were compared. During free play sessions, the participant had noncontingent access to high-preferred items and experimenter attention. No demands were placed on the participant. All challenging behavior was ignored.

## Mand Topography Assessment

Following the FA, a MTA was conducted based on the procedures described by Ringdahl et al. (2009). This assessment was used to confirm each participant's ability to independently emit the mand topographies (e.g., iPad, iPhone, BIGmack™, vocal) to be targeted during the delay evaluation. Sessions consisted of 10 trials in which the experimenter implemented the putative establishing operation (EO) associated with the reinforcer determined via the FA to be maintaining challenging behavior (e.g., if an escape function was identified, demands were implemented during trials). During each trial, a four-step prompting sequence was implemented. The prompting sequence included no prompt, a vocal prompt, a vocal + gesture prompt, and a physical prompt. For example, if the suggested function was escape from demands, a demand was presented to the participant. If the participant did not exhibit a mand for a break using the target modality within 5 s, a vocal prompt was provided. If the participant dis not exhibit a mand for break using the target modality within 5 s of the vocal prompt, a vocal and gesture prompt was provided. If the participant did not exhibit a mand for break using the target modality within 5 s of the vocal and gesture prompt, a physical prompt was provided. Contingent on the occurrence of a mand at any prompt level, the participant was provided with 30 s access to the identified reinforcer (e.g., access to attention or high preferred items; escape from demands). Data were collected and analyzed in terms of prompt level required per trial to produce mands per modality.

**Delay Evaluation**

**Baseline.** Procedures for Baseline were the same as the FA condition associated with the highest levels of challenging behavior relative to the free play condition for each participant. For Patrick and Alex, the procedures for Baseline were identical to the escape condition during the FA. For Warren and Violet, the procedures for Baseline were identical to the tangible condition during the FA. Communicative materials and devices were not present during the Baseline Condition.

**FCT.** During the FCT condition, all mands were reinforced on a concurrent FR 1/ FR 1/ FR 1 schedule of reinforcement. Specifically, the EO identified during the FA as being associated with challenging behavior was presented (i.e., high preferred activities were restricted; demands were presented) and the array of mand topographies were made available to the participant simultaneously. Specifically, for Warren and Violet, the high preferred items were removed and the topographies were presented. For Alex and Patrick, the demand was presented and the topographies were presented. Communicative materials and devices were presented together on a board so that all were presented simultaneously when the reinforcer was removed. Communicative device position was randomized between EO presentations. The first mand emitted was reinforced with immediate access to the identified reinforcer for 30 s, and the topographies were removed. All occurrences of challenging behavior were ignored (i.e., on extinction). Sessions were 5 min in length.

**FCT + Delay.** Next, the FCT + delay condition was implemented. This condition was identical to the FCT condition except that a tandem concurrent FR1/ FR1/ FR 1/ Fixed interval (FI) 10 s schedule of reinforcement was implemented. Contingent on the first mand emitted following the implementation of the EO, the second component of the sequential schedule of reinforcement, the FI 10 s, was initiated. Specifically, when the first mand was emitted, a 10 s delay to reinforcement was initiated. No signals were provided during either component of the sequential schedule of reinforcement. The topographies remained available and the participant was free to mand during the delay. No instructions were provided. The EO (i.e., restricted access to high preferred items for Warren and Violet; task demands for Patrick and Alex) continued to be programmed during the 10 s delay. After 10 s, the participant was given access to the identified reinforcer for 30 s.

# Chapter 3: Results

## Functional Analysis

Figure 1 displays the functional analysis results for all participants. Patrick (see top panel of Figure 1) engaged in low levels of challenging behavior during the control condition (i.e., free play; M = 0.05 RPM). He engaged in higher levels of challenging behavior during all test conditions when compared to free play including attention (M = 0.4 RPM), tangible (M = 0.6 RPM) and escape (M = 1.35 RPM) conditions. These results suggest that challenging behavior for Patrick served multiple functions. The condition with the highest overall level of challenging behavior, the escape condition, was used as the programmed EO during subsequent sessions. Warren (see middle panel of Figure 1) engaged in low levels of challenging behavior during the free play (M = 0.1 RPM) and the escape (M = 0.05 RPM) conditions. Higher levels of challenging behavior were observed during both the attention (M = 1.15 RPM) and tangible (M = 0.95 RPM) conditions. The tangible condition was selected to serve as the programmed EO during subsequent sessions with Warren. Violet (see bottom panel of Figure 1) engaged in zero levels of challenging behavior during free play (M = 0.0 RPM), escape (M = 0.0 RPM), and attention (M = 0.0 RPM) conditions. Challenging behavior was observed only during the tangible condition (M = 0.56 RPM) and therefore served as the programmed EO during subsequent sessions.

Figure 2 displays the functional analysis and pairwise comparison results for Alex. Zero levels of challenging behavior were observed during the initial functional analysis in the free play condition. Elevated levels of challenging behavior were observed during the attention (M = 0.28 RPM) and demand (M = 0.74 RPM) conditions. During the last two sessions of the attention condition of the initial functional analysis, no challenging behavior was observed. For this reason, an additional pairwise comparison of free play and attention was conducted. During these sessions, challenging behavior was observed at low levels during the free play (M = 0.48 RPM) and attention (M = 0.13 RPM) conditions; therefore, demands served as the programmed EO during subsequent sessions. Additionally, with the exception of one free play session, challenging behavior was observed at low levels during all pairwise comparison conditions.

**Mand Topography Assessment**

Figure 3 displays the results of the MTA. Patrick (see top panel of Figure 3) manded independently with each of the mand topographies including the yellow BIGmack™ button (80% independent), the iPhone (100% independent), the red BIGmack™ button (100% independent), and vocal mands (80% independent). Warren (see middle panel of Figure 3) independently manded the majority of trials with each mand topography including the yellow BIGmack™ button (100% independent), the iPhone (80% independent), the red BIGmack™ button (60% independent), and the iPad (100% independent). Violet (see bottom panel of Figure 3) manded independently with each mand topography including the iPad (80% independent), the iPhone (90% independent), the yellow BIGmack™ button (100% independent), and the red BIGmack™ button (100% independent). Figure 4 displays the results of the MTA for Alex. Alex manded independently with each of his mand topographies including the BIGmack™ (60% independent), a card exchange (60% independent), the iPad (50% independent), and the iPod (90% independent).

**Delay Evaluation**

The results of the delay evaluation are displayed in Figure 5 and Figure 6. Patrick (see top panel of Figure 5) engaged in high levels of challenging behavior during baseline (M = 2.0 RPM). When the FCT condition was implemented, challenging behavior decreased to the zero levels across all sessions and high levels of total manding (M = 1.76 RPM) were observed. During FCT sessions, low levels of variant manding were observed (M = 0.08 RPM; i.e., Patrick manded with the same modality during the majority of trials). When the FCT + delay condition was implemented, challenging behavior remained at low levels (M = 0.11 RPM). Total mand levels increased considerably (M = 6.17 RPM). In addition, variant mand levels also increased considerably (M = 3.03 RPM) when compared to the previous FCT condition. Upon the reversal to the FCT condition without the delay, total mand levels decreased to those observed during the first FCT condition (M = 1.7 RPM) and zero levels of challenging behavior were observed across all sessions. Variant mand levels also decreased (M = 0.37 RPM) when compared to the FCT + delay condition, but occurred at a higher levels when compared to the first FCT condition. When the FCT + delay condition was again implemented, challenging behavior was not observed while total and variant mand levels increased considerably (M = 8.48 RPM; M = 2.4 RPM) similar to the first delay implementation sessions.

Warren (see middle panel of Figure 5) engaged in high levels of challenging behavior during baseline sessions (M = 3.78 RPM). When the FCT sessions were implemented, challenging behavior decreased (M = 0.94 RPM) across sessions. Elevated levels of total manding (M = 1.66 RPM) and low levels of variant mands were observed (M = 0.68 RPM) during the initial FCT condition. When the FCT + delay procedures were implemented, challenging behavior increased (M = 1.69 RPM), but decreased during the course of the condition. High levels of total mands (M = 4.26 RPM) and variant mands (M = 1.97 RPM) were observed during the FCT + delay condition. During the reversal to the FCT condition, challenging behavior (M = 0.31 RPM), total mands (M = 1.91 RPM) and variant mands (M = 0.55 RPM) occurred at relatively lower levels. During the final FCT + delay condition, challenging behavior increased slightly (M = 0.45 RPM), while total mand (M = 4.25 RPM) and variant mand (M = 1.43 RPM) levels both increased considerably.

Violet (see bottom panel of Figure 5) engaged in high levels of challenging behavior during baseline sessions (M = 1.7 RPM). When the FCT condition was implemented, challenging behavior was not observed. Elevated levels of total manding (M = 1.78 RPM) and low levels of variant mands (M = 0.71 RPM) were observed. When the FCT + delay condition was implemented, challenging behavior increased initially (M = 0.34 RPM), but decreased during the course of the condition. High levels of total mands (M = 6.84 RPM) and variant mands (M = 1.84 RPM) were observed. Upon returning to the FCT condition, challenging behavior was not observed whereas total mand rate (M = 1.83 RPM) and variant mand rate (M = 0.97

RPM) both decreased to similar levels observed during the previous FCT condition. During the final FCT + delay condition, challenging behavior increased slightly (M = 0.02 RPM), while total mand rate (M = 8.02 RPM) and variant mand rate (M = 1.92 RPM) both increased considerably.

Alex (see Figure 6) engaged in high levels of challenging behavior during baseline sessions (M = 0.57 RPM). When the FCT condition was implemented, challenging behavior increased initially, but reduced to zero levels across the condition (M = 0.6 RPM). Elevated levels of total manding (M = 1.0 RPM) whereas zero levels of variant mands were observed. When the FCT + delay condition was implemented, challenging behavior was observed at low levels (M = 0.16 RPM). Total mands decreased (M = 0.63 RPM) and variant mands (M = 0.24 RPM) increased. Upon returning to the FCT condition, challenging behavior remained at low levels (M = 0.15 RPM) whereas levels of total mands (M = 1.49 RPM) increased and variant mands (M = 0.14 RPM) decreased. During the final FCT + delay condition, levels of challenging behavior (M = 0.03 RPM) and total mands (M = 1.07 RPM) decreased while variant mands (M = 0.26 RPM) increased.

Table 3 depicts the mean comparisons between the FCT and FCT + delay conditions for each participant. Each participant's variant mand rate increased when the FCT + delay condition was implemented. For Alex, an increase in variant mand rate was observed between the FCT (M = 0.07 RPM) and FCT + delay (M = 0.25 RPM) conditions. For Patrick, a considerable increase was observed between the FCT (M = 0.22 RPM) and FCT + delay (M = 2.85 RPM) conditions. For Violet, an increase in variant mand rate was observed between the FCT (M = 0.84 RPM) and FCT + delay (M = 1.90 RPM) conditions. Finally, for Warren and increase in variant mand rate was observed between the FCT (M = 0.61 RPM) and FCT + delay (M = 1.69 RPM) conditions.

## Chapter 4: Discussion

This study sought to evaluate the effects of a delay to reinforcement preparation previously described in the basic literature on response variability during FCT. First, a FA was conducted with each participant. A tangible function was identified for two participants whereas an escape function was identified for the remaining two participants. Next, a MTA was conducted during which each participant exhibited independence with the individually selected communication topographies. Finally, within a multiple baseline with an embedded ABAB reversal for 3 participants and an ABAB reversal design for the final participant, the delay to reinforcement was evaluated. Results for 3 of 4 participants (i.e., Patrick, Violet, and Warren) indicated that a delay to reinforcement considerably increased the response variability. For Alex, variant responding increased slightly when the delay to reinforcement was included. When FCT was implemented on a FR1 schedule of reinforcement without a delay, all participants tended to select the same topography. When a delay to reinforcement was included following the first mand, participants tended to sample other topographies.

There are several potential behavioral mechanisms that may have been responsible for the observed effects on response variability including adventitious reinforcement (e.g., Roane, Fisher, & Sgro, 2001) and extinction induced variability (e.g., Duker & van Lent, 1991; Grow, Kelley, Roane & Shillingsburg, 2008). The response patterns of the current study indicated the increase in variability is most likely attributed to extinction induced variability. If adventitious reinforcement was responsible for the increase in variability, we would expect the first mand following reintroduction of the EO to be the same as the last mand after the previous 10-s delay. This was not the pattern observed for any of the participants. While extinction was not actually implemented for appropriate mands, it is likely that the 10-s delay approximated a short extinction-like condition that led to the emergence of other responses in the same response class. This finding replicates other studies that found when appropriate behaviors were placed on extinction, other desirable behaviors emerged (e.g., Duker & van Lent, 1991; Harding, Wacker, Berg, Rick, & Lee, 2004; Lalli, Zanoli, & Wohn, 1994). Challenging behavior did not significantly increase during the 10-s delay condition even as it was in the same response class. For example, during the delay, Warren displayed some challenging behavior, but engaged in more manding and sampled various topographies. There were some carryover effects during initial delay sessions, but challenging behavior did not reemerge to baseline levels likely due to these behaviors being placed on extinction.

The response variability of each participant did not result in considerable carryover when the delay was removed and every mand was reinforced. The finding indicates that this procedure has short-term effects on mand variability during FCT. However, these results still have important implications for work in applied settings with individuals with challenging behavior. Namely, in the natural environment, interventions for children with communication deficits may contact barriers to effective treatment. Examples of barriers to treatment include failure to reinforce appropriate communication (i.e., extinction) and alterations of antecedent conditions (e.g., device malfunction and/or device unavailability). During these barriers, challenging behavior may re-emerge. In a recent study, extinction of appropriate communication responses led to a resurgence of destructive behavior when the appropriate topography was either present or not present (Wacker et al., 2013). The findings of the current study suggest that the presence of multiple topographies may have decreased the likelihood that challenging behavior re-emerged. Future studies should evaluate the use of multiple communication topographies during communication training and maintenance as a possible strategy to prevent re-emergence of challenging behavior.

Additionally, the inclusion of a delay to reinforcement could be a viable intervention strategy aimed at increasing response variability pertaining to mands during FCT. Thus, delay implementation may provide individuals in an applied setting with an easy strategy to increase the variability of communication responses. Future studies should evaluate use of delay implementation to teach new, appropriate alternative responses during FCT as well as the ideal delay time period to observe positive results.

There are several limitations of the current study that should be discussed. First, mand topographies were selected before the delay evaluation. Therefore, data were not collected on the gestures or vocal approximations that were observed because they were not assessed during the MTA. It is unclear if extinction of these responses led to the observed increase in response variability. Future studies could include additional observations or descriptive assessments prior to or in lieu of the

MTA to identify other possible members of the response class. Second, a return to the original baseline condition was not conducted. It is therefore unknown if the increases in response variability during the delay condition would be different following sessions in which challenging behavior was reinforced. Third, challenging behavior was on extinction in all conditions other than baseline even as it was part of the same response class as the mand topographies. Future studies could evaluate the impact of delay implementation on response variability when challenging behavior is available for reinforcement.

The results of the current study add to the literature on response variability by demonstrating a possible procedure for increasing the variability of appropriate responses while producing low rates of challenging behavior. Future studies should continue to assess response variability with this population who often exhibit very repetitive behaviors.

**Tables and Figures**

Table 1. *Participant Characteristics and Settings.*

| Participant | Gender/ Age | Diagnosis | Challenging Behavior/Definition | Setting |
|---|---|---|---|---|
| Alex | Male 5 years old | Autism | *Aggression*: hitting or pinching others | Home |
| Patrick | Male 12 years old | Autism, Intellectual Disability | *Aggression*: hitting or pinching others; hands within 6 inches of another's face | School |
| Violet | Female 11 years old | Intellectual Disability | *Aggression*: forcefully grabbing items away from another's possession | Home |
| Warren | Male 14 years old | Autism, Intellectual Disability | *Aggression*: hitting, scratching, biting others; forcefully grabbing items away from another's possession | School |

Table 2. *Participant Mand Topographies.*

| Participant | Red BIGmack™ Button | Yellow BIGmack™ Button | iPad | iPhone | Vocal | Card |
|---|---|---|---|---|---|---|
| Alex | X | | X | X | | X |
| Patrick | X | X | | X | X | |
| Violet | X | X | X | X | | |
| Warren | X | X | X | X | | |

Table 3. *Mean Comparison between Conditions.*

| | Mean Variant Mand Rate |
|---|---|
| Alex | |
| FCT | M = 0.07 RPM |
| FCT + delay | M = 0.25 RPM |
| Patrick | |
| FCT | M = 0.22 RPM |
| FCT + delay | M = 2.85 RPM |
| Violet | |
| FCT | M = 0.84 RPM |
| FCT + delay | M = 1.90 RPM |
| Warren | |
| FCT | M = 0.61 RPM |
| FCT + delay | M = 1.69 RPM |

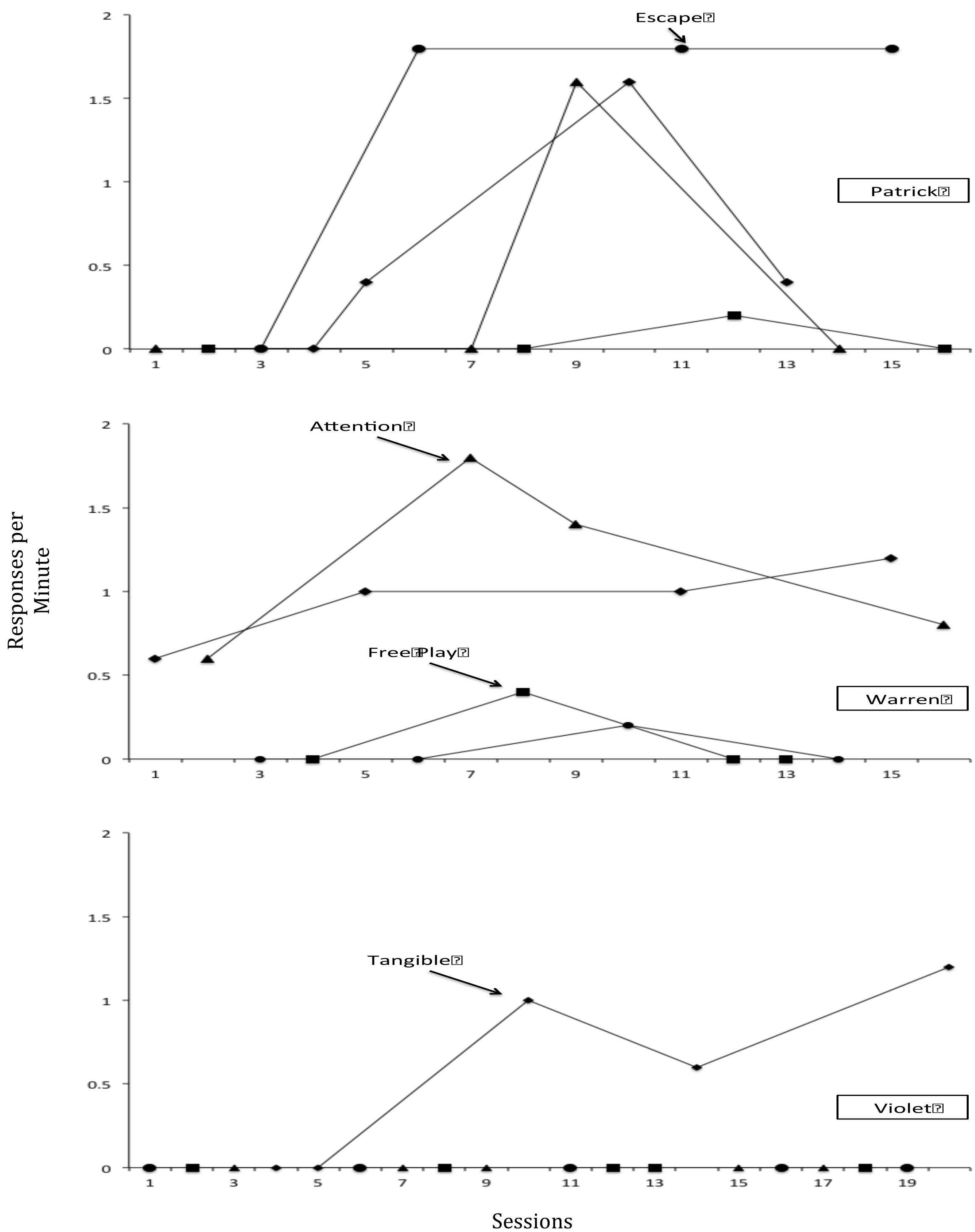


*Figure 1.* Functional Analysis Results for Patrick (top panel), Warren (middle panel) and Violet (bottom panel).

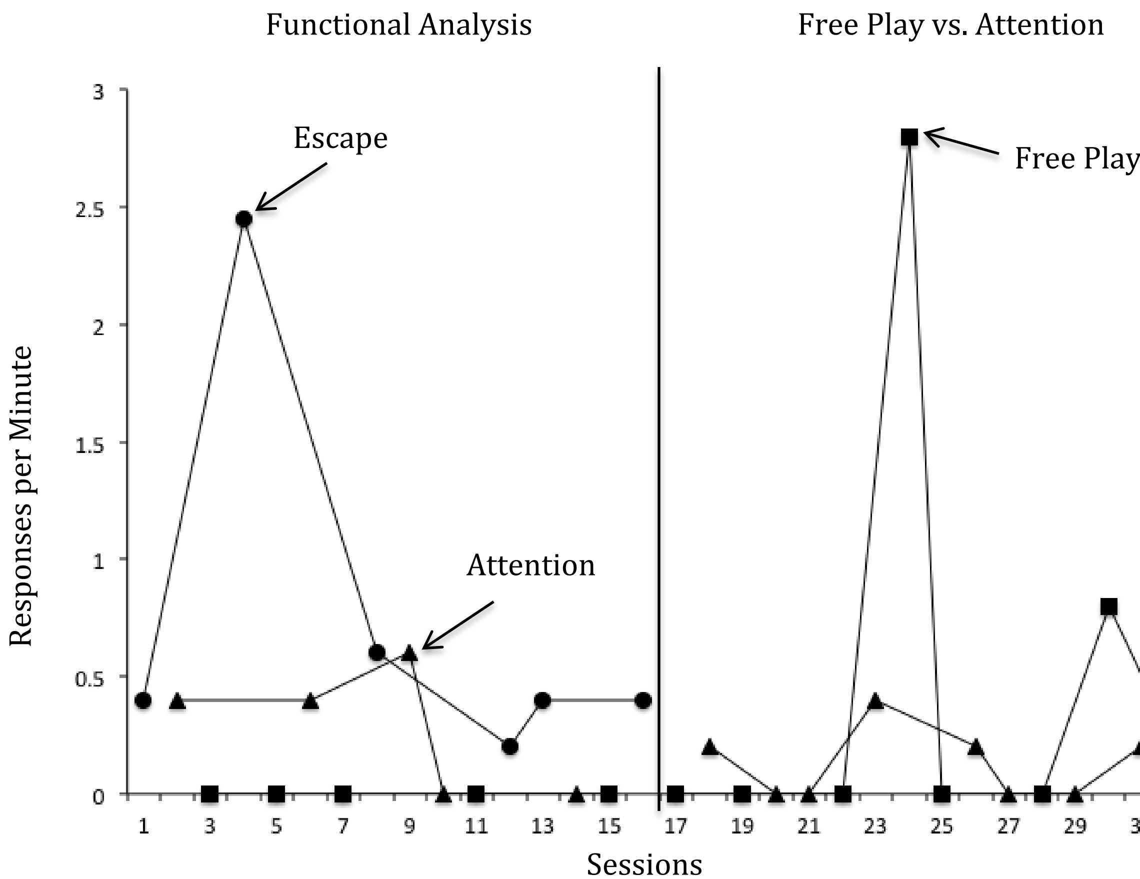


*Figure 2.* Functional Analysis and Free Play vs. Attention Pairwise Comparison Results for Alex.

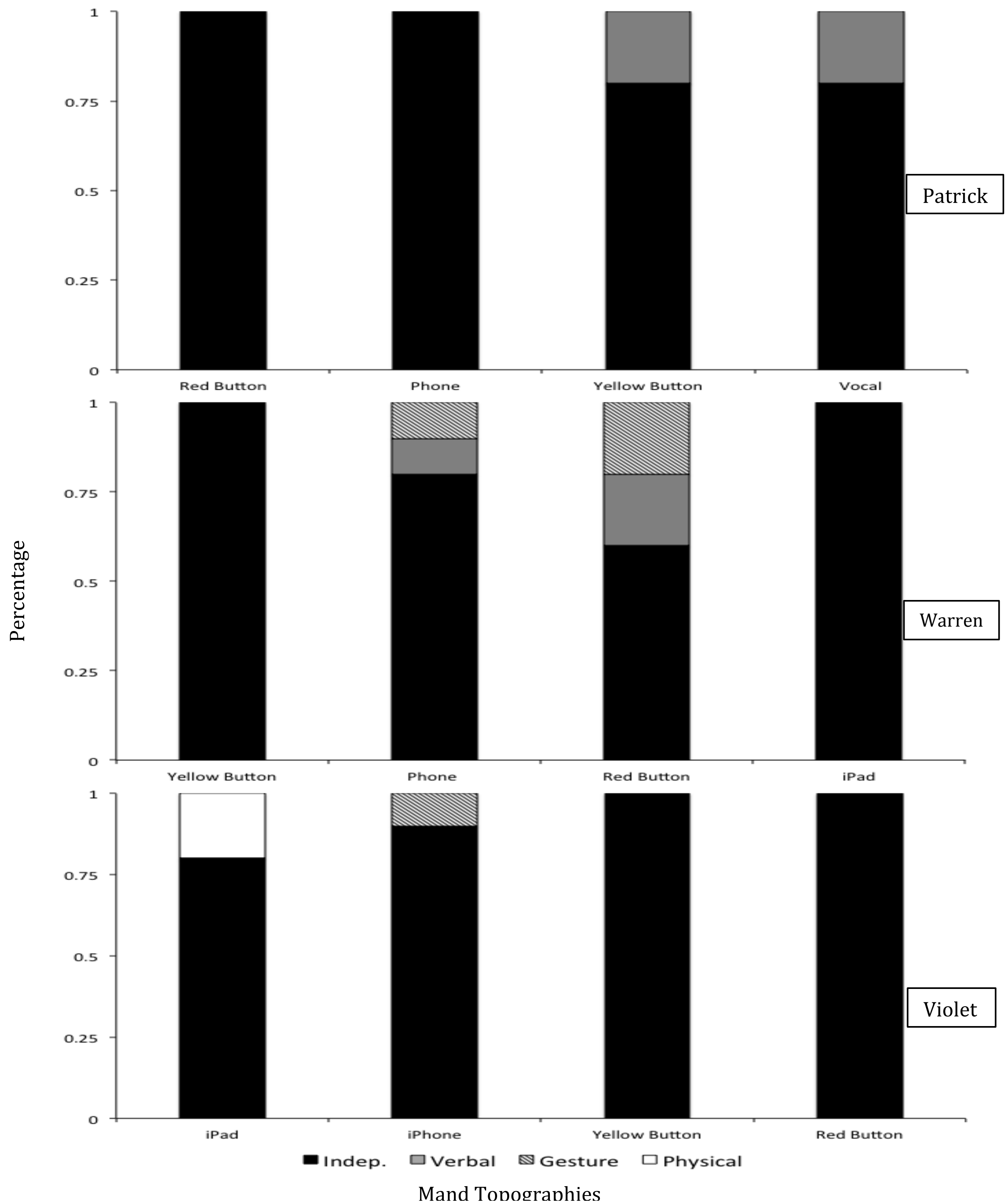


*Figure 3.* Mand Topography Assessment Results for Patrick (top panel), Warren (middle panel) and Violet (bottom panel). See Legend at bottom for prompt level.

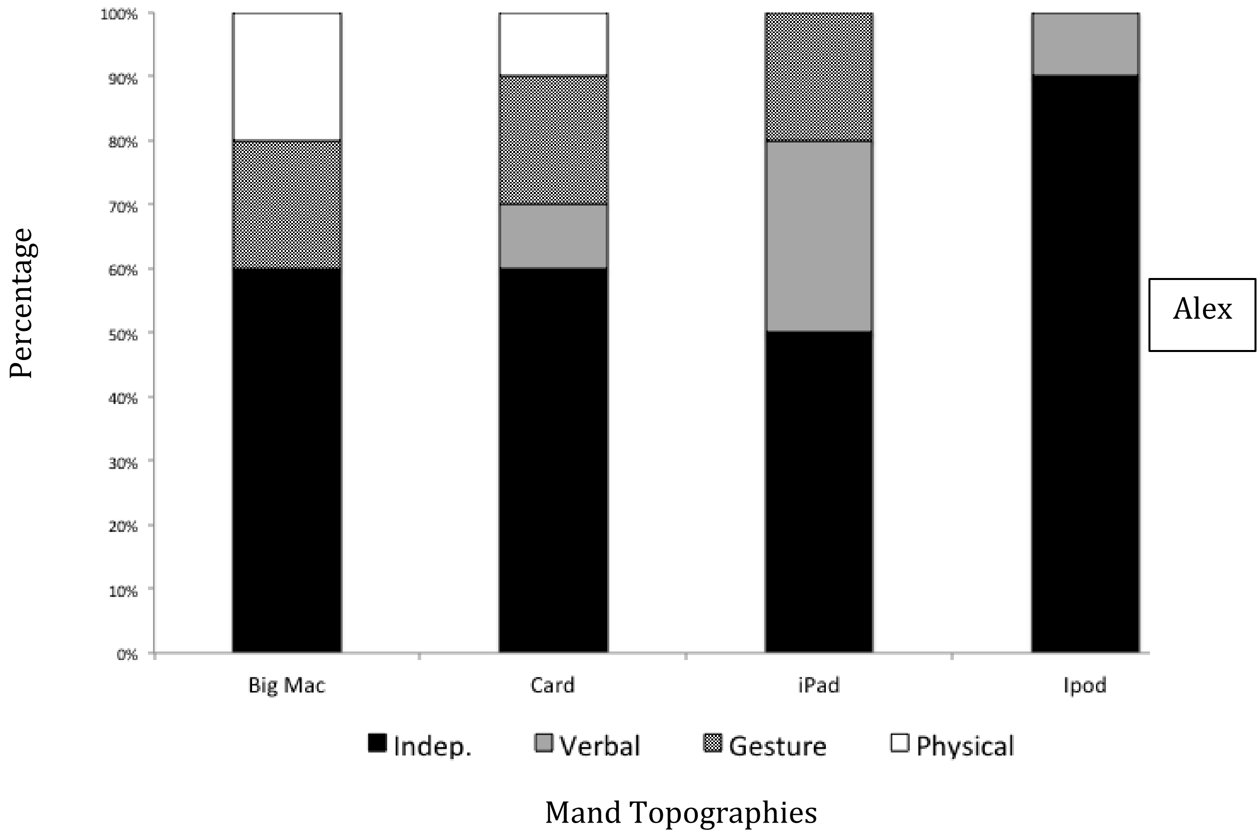


*Figure 4.* Mand Topography Assessment Results for Alex. See legend at bottom for prompt level.

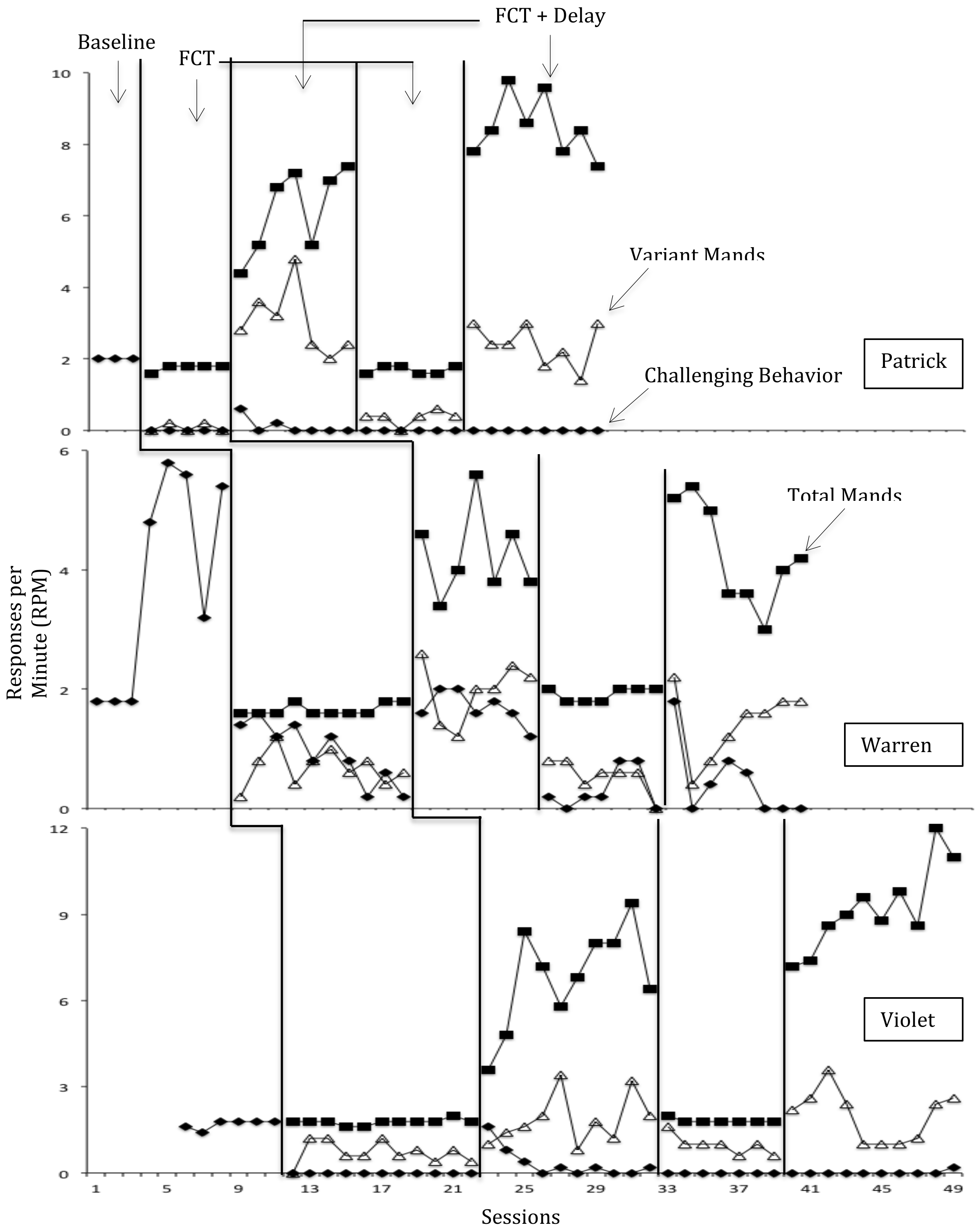


*Figure 5.* Delay Evaluation Results for Patrick (top panel), Warren (middle panel) and Violet (bottom panel). Challenging behavior RPM represented by closed diamonds, total mand RPM represented by closed squares, and variant mand RPM represented by open triangles.

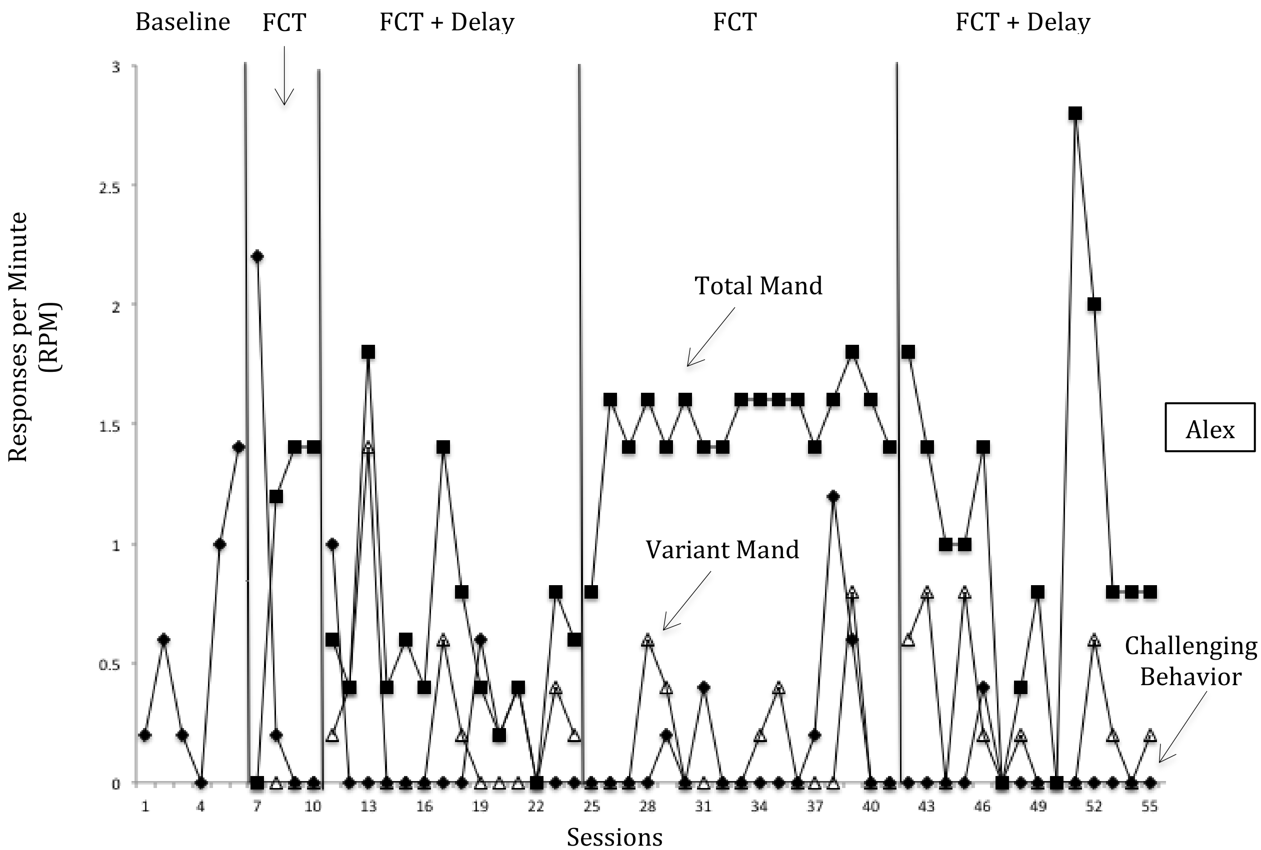


*Figure 6.* Delay Evaluation Results for Alex. Challenging behavior RPM represented by closed diamonds, total mand RPM represented by closed squares, and variant mand RPM represented by open triangles.

## Appendix A

## Literature Review: Use of Multiple Modalities of Communication during FCT

### Introduction

Individuals with developmental disabilities (e.g., autism spectrum disorder) often engage in challenging behavior (e.g., aggression, self-injurious behavior, disruptive behavior, non-compliance). Challenging behavior is often related to deficits in communication abilities (Carr & Durand, 1985). Thus, challenging behavior may serve as the child's most effective way of requesting his or her wants and needs. For example, a child may be unable to vocally request high-preferred items and instead will engage in challenging behavior, which is reinforced with access to the items. One of the most common interventions for children with challenging behavior is functional communication training (FCT; Tiger, Hanley & Bruzek, 2008). During FCT, the child is trained to emit an appropriate communication response (i.e., mand) to replace the challenging behavior.

FCT treatment often involves three phases (Tiger, Hanley & Bruzek, 2008). First, a functional analysis (FA; Iwata, Dorsey, Slifer, Bauman & Richman, 1982/1994) is conducted to identify the antecedents that occasion challenging behavior (i.e., removal of high-preferred items or attention; introduction of task demands) and the consequences that maintain the challenging behavior (i.e., access to high-preferred items or attention; removal of task demands). Next, an appropriate communication response (i.e., mand) is selected, and the individual is taught to use the response. This is often achieved by delivering the identified functional reinforcer following engagement in the appropriate mand while the challenging behavior no longer results in reinforcement (i.e., extinction is applied to challenging behavior). Finally, the appropriate mand is generalized across environments and individuals.

Tiger et al., (2008) provided several recommendations for selecting the mand modality to be used during FCT following the identification of the function(s) of challenging behavior. First, the effort needed to emit the mand should be considered. Specifically, if a mand requires more effort than challenging behavior, allocation of responding may favor challenging behavior and decrease the effectiveness of the treatment (e.g., Horner & Day, 1991). Second, how recognizable the mand is in the participant's environment should be considered. For example, a child who is taught to lift his arms in the air to request a hug may not receive the desired reinforcement from an unfamiliar adult. Third, acquisition time should be considered. For example, a child with a limited vocal repertoire will likely require extended training to emit a vocal mand or may never engage in vocal manding. In contrast, relatively less time may be required to train the child to emit a motor response or picture exchange response.

Given the above considerations, individualized selection of a mand(s) for use during FCT may be difficult. In addition, instruction of a single mand modality may not be sufficient. For example, within the natural environment, FCT may contact significant barriers to effective treatment including alterations of the appropriate antecedent conditions (e.g., device malfunction and/or device unavailability), failure to reinforcement appropriate communication (i.e., extinction), and introduction of novel tasks.  Wacker et al. (2011) evaluated the persistence of FCT treatment when challenges to treatment were included after training.  Results showed that for some participants, challenging behavior re-emerged when challenges to treatment were introduced.  Challenging behavior did not reach levels observed during baseline, but increased significantly when compared to correct implementation of FCT.  It is possible that instruction of multiple mand modalities during FCT would ameliorate the detrimental effects observed during challenges to treatment.  For example, if multiple devices are present and one malfunctions, the remaining functioning device may be emitted before challenging behavior re-emerges.

The purpose of the current literature review was to examine the use of multiple mand modalities within a FCT intervention to treat challenging behavior and their effects on response allocation.  This review differs from previous reviews of comparing mand modalities (e.g., van der Meer, Sigafoos, O'Reilly & Lancioni, 2011) by reviewing studies using multiple mand modalities specifically within the context of FCT and the treatment of challenging behavior.

## Method

To identify studies incorporating FCT and multiple mand modalities, a search of PsychINFO, Educational Resources Information Center (ERIC) and Google Scholar was conducted using keywords or combinations of keywords including: FCT, mand modalities, and multiple.  Ancestral searches of relevant articles were also conducted to identify any additional studies.  To be included in this literature review, studies had to focus on inclusion of multiple mand modalities within a FCT intervention package. For the purposes of this review, only peer-reviewed journal articles in English were included.

## Results

The literature search identified 15 total studies for inclusion in this review of multiple mand modalities within FCT. This section of the review describes the variables manipulated across multiple mand modalities in the identified studies including: effort, novelty, schedule manipulation, proficiency, and language. Table 1 summarizes the studies reviewed.

Table 4. *Summary of Reviewed Studies*

| Study | Participant(s): (Age), Disability | Modalities | Analysis | Results |
|---|---|---|---|---|
| **Effort** | | | | |
| Bailey et al. (2002) | 1 male (24), ID[a] | HE[b]: spelling; LE[c]: pointing | Isolation | HE = 0 mand rate; HE = ↑ challenging behavior |
| Buckley & Newchok (2005) | 1 male (7), autism | HE: travel 4.5 ft to card; LE: card exchange | Isolation | LE = ↑ mand rate; HE = ↑ challenging behavior |
| Danov et al. (2010) | 1 male (3), autism | HE: picture exchange; LE: vocal | Isolation | HE = ↑ mand rate, LE = ↑ challenging behavior during 1st 2 sessions |
| Horner & Day (1991) | 2 males (12, 14), 1 female (27); ID | HE: manual sign sentence; LE: manual sign word | Isolation | HE = ↓ mand rate; HE = ↑ challenging behavior; LE = ↑ task completion |
| Richman et al. (2001) | 1 male (3); autism | HE: picture exchange; LE: manual sign word | Choice | HE = ↓ mand rate; HE not observed after 2 sessions |
| **Novelty** | | | | |
| Derby et al. (1998) | 1 female: (12), Severe ID | EM[d]: babbling; NM[e]: picture touch | Choice | R+ for EM = ↑ challenging behavior; R+ for NM = ↓ challenging behavior |
| Harding et al. (2009) | 3 males (1-3), DD[f]/no diagnosis | EM: vocal; NM: microswitch | Choice | EM: ↑ mand rate |
| Winborn et al. (2002) | 1 male (2), 1 female (2); DD | EM: previously observed; NM: not observed | Choice | EM: ↑ mand rate; for 1 participant, EM = ↑ challenging behavior |
| Winborn-Kemmerer et al. (2009) | 1 male (7), DD; 1 female (20), ID | 2 NM: picture touch; card touch | Choice | Allocation differed by participant |

| | | | | |
|---|---|---|---|---|
| **Schedule Manipulation** | | | | |
| Falcomata et al. (2010) | 1 female (34), autism & ID | Vocal, Microswitch, Picture exchange | Isolation & Choice | Allocation to ↑ R+ modality (isolation); Allocation primarily to microswitch (choice) |
| Peck et al. (1996) | 4 males, 1 female (1-4), DD | Varied across participants; equal effort | Choice | Allocation to ↑ R+ modality |
| Peterson et al. (2009) | 5 males, 2 females (7-10), autism & ID | 2 card touches; break vs. work (no work task) | Choice | Allocation to ↑ R+ modality |
| Peterson et al (2010) | 2 males (4, 9), DD & ID | 2 card touches; break vs. work (with work task) | Choice | Allocation to ↑ R+ modality even with addition of work task before break |
| **Language** | | | | |
| Padilla et al. (2011) | 1 male (6), autism & ID; 1 female (5), DD | 2 microswitch (Spanish vs. English output) | Choice | No clear majority allocation (approx. 50% per modality) |
| **Assessment** | | | | |
| Ringdahl et al. (2009) | 3 males (4-24), DD | Microswitch, picture touch, sign, typing | Isolation | High proficiency mand = ↓ challenging behavior; low proficiency mand = ↑ challenging behavior |

*Note*: Isolation: modality allocation analyzed with 1 modality at a time; Choice: modality allocation analyzed with multiple modalities present
[a]ID: Intellectual Disability; HE: [b]High Effort; [c]LE: Low Effort; EM[d]: Existing Mand; NM[e]: Novel Mand; DD[f]: Developmental Delay

**Effort**

The majority of studies involving FCT and the use of multiple mand modalities assessed response allocation based on the effort required to complete each response. For example, several studies evaluated allocation to modalities and the effect on challenging behavior when a mand requiring high effort was compared to a mand requiring low effort. Five total studies involving FCT and assessment of allocation with mand modality based on effort were identified during the literature search.

In the first of a series of studies, Horner and Day (1991) evaluated the use of two mand modalities with differing effort parameters. Specifically, the high effort modality was defined as using sign language for an entire sentence (e.g., "I want a break"), while the low effort mand was defined as signing only a single word (e.g., 'break'). After evaluation of the challenging behavior, both mands were trained. First, the high effort mand was trained followed by the low effort mand. Challenging behavior also resulted in the same reinforcement as the mands (i.e., break from work tasks). The participant exhibited higher rates of challenging behavior during sessions with the high effort mand relative to sessions in which the low effort mand was targeted. The higher levels of challenging behavior during the high effort mand sessions may be attributed to the lower effort associated with the challenging behavior relative to the high effort mand. In addition, during sessions with the word sign (i.e., low effort mand), the participant engaged in more attempts to complete the work task. During the high effort mand sessions, the participant attempted the work task during initial sessions, but attempts eventually decreased to almost zero levels during the final sessions. Overall, the participant allocated the majority of his mands in each phase to the member of the response class that required the least amount of effort.

In a similar experiment, Buckley and Newchok (2004) trained a participant to use high and low effort mands after assessing challenging behavior. The low effort mand was a card exchange response. Specifically, the card was placed immediately in front of the participant following restriction of the functional reinforcer. The participant was required to place the card in the experimenter's hand. The high effort mand was also a card exchange response but the participant was required to travel 4.5 feet to the card, remove it from a communication board, travel to the experimenter, and place the card in his or her hand. The reinforcement delivered was equal for each mand. During sessions with the low effort mand, the participant engaged in low rates of challenging behavior and high rates of card exchange. During sessions with the high effort mand, the participant engaged in high levels of challenging behavior, and the high effort mand was not observed at all during the evaluation. The authors suggest that when selecting a mand for FCT, the response chain required for completion of the mand should be assessed. The high effort mand in this study required many more steps to complete when compared to the low effort mand. Thus, it is likely the participant allocated his responses exclusively to challenging behavior during sessions with the high effort modality as a result of the effort associated with the mand.

Richman, Wacker, and Winborn (2001) also assessed response allocation with mands during FCT based on the effort required. Specifically, the low effort mand that was trained was the sign 'please,' while the high effort mand was a picture exchange response. The two mand modalities were differentiated based on the number of steps in the response chain. The low effort mand only required manipulation of the participant's hands. The high effort mand required orientation to the card, removal of the card from the table, travel to the communication partner, and placement of the card in the partner's hand. Each mand modality resulted in equal amounts of reinforcement. First, the card exchange was trained and compared to challenging behavior when both resulted in the functional reinforcer. During these sessions, the participant allocated the majority of his responses to the picture exchange and engaged in low levels of challenging behavior. Next, the two mand modalities (i.e., sign "please" versus picture exchange) were compared. The participant initially engaged in both modalities equally and zero levels of challenging behavior. After two sessions, the sign "please" occurred at elevated levels and the card exchange occurred at zero levels. During the remainder of sessions, the participant only responded with the sign "please." The additional steps in the response chain for the picture exchange resulted in allocation to the mand with fewer steps, the single word sign.

In a similar experiment, Bailey, McComas, Benavidas and Lovascz (2002) evaluated allocation with mand modalities in isolation relative to challenging behavior. Following assessment of the challenging behavior, the modalities were taught in isolation.  The first mand required the participant to point to a picture. The second mand entailed having the participant spell a word on a board. Challenging behavior resulted in the same programmed consequences as each modality (i.e., 20 s interaction with functional reinforcer).  The modalities were presented in isolation and alternated between sessions.  Thus, only one mand was available for reinforcement during each trial.  Results for the participant suggested the low effort mand (i.e., pointing) was associated with higher levels of communication and lower levels of challenging behavior relative to the high effort mand (i.e., spelling).  In addition, the spelling mand was not observed independently during any session.

Danov, Hartman, McComas and Symons (2010) also assessed mand allocation with two mand modalities.  A vocal mand was compared to a picture exchange mand.  The participant was allowed to mand vocally for a variety of items. These items were also on the picture board and were available for picture exchange. Following a FA suggesting a possible tangible function, the mand modalities were presented in isolation.  During FCT sessions, a specific modality was available for reinforcement and challenging behavior was on extinction.  During the initial sessions with the vocal mand, high rates of challenging behavior were observed and no independent vocal mands were observed.  When the picture board was introduced, challenging behavior immediately decreased to zero levels and picture exchanges occurred at high rates.  During the remaining sessions when the vocal mand was available for reinforcement, no independent requests were observed.

However, challenging behavior did not occur during all remaining sessions. During a final phase, the picture exchange was placed on extinction but still available and vocal mands resulted in reinforcement. During these sessions, picture mands continued to occur at high rates while the vocal mand and challenging behavior were never observed. While vocal mands may theoretically require less effort and fewer steps when compared to a picture exchange response, the authors noted that for this participant, it was possible that the picture exchange response was the more efficient mand alternative.

Results of all the studies assessing mand allocation based on the effort associated with the mand demonstrated that effort is a crucial variable to consider when selecting a mand to replace challenging behavior. When the reinforcement remains equal for multiple mand modalities, the properties of the mand (e.g., response chain) likely influence allocation to specific modalities.

**Novelty**

Studies evaluating FCT with multiple mand modalities also assessed allocation when novel mands were taught and compared to existing mands in the participant's repertoires. Four studies evaluating mand allocation between novel and existing mand modalities were identified during the literature search and are described below.

Harding et al. (2009) assessed mand allocation for an existing mand and novel mands trained to the participant. The novel mands were trained in the home by parents after parent training with the experimenters. During baseline sessions where challenging behavior resulted in reinforcement, the participants engaged in high levels of challenging behavior and also exhibited variable levels of the existing mand modality (i.e., a vocal mand). During FCT sessions, challenging behavior was placed on extinction and only appropriate mands resulted in access to the functional reinforcer. Challenging behavior immediately decreased to low levels for each participant. During the next FCT sessions for two of the three participants, the functional reinforcer was restricted and the novel mand modality (i.e., microswitch) was presented to the participants. Both the existing mand (i.e., vocal) and the novel mand (i.e., microswitch press) were available for reinforcement. For the third participant, the functional reinforcer was restricted. This participant could engage in the existing mand modality (i.e., vocal) or one of two novel mand modalities: a card exchange or a single word sign. During these FCT choice sessions, each participant initially exhibited both novel and existing mand modalities. During final treatment sessions, each of the three participants allocated the majority of his or her responses to the existing, vocal mand. The participants allocated the majority of responses to the existing mand modality rather than the novel modality(s). The use of novel augmentative communication modalities did not interfere with the participant's use of vocal mands. In addition, in contrast to the baseline condition, the use of the existing mand modality did not result in increased engagement in challenging behavior.

In a similar study, Winborn, Wacker, Richman, Asmus and Geier (2002) evaluated mand modality allocation during FCT for novel and existing mands. Each mand was trained during the FCT intervention in isolation and each resulted in equal interaction with the functional reinforcer while challenging behavior resulted in no programmed consequences (i.e., extinction). A novel mand was defined as any mand that had not been previously observed while the existing mand modality was previously observed during assessment sessions. During training, the first participant exhibited elevated, variable rates of challenging behavior during the existing mand modality training and low to zero rates of challenging behavior during novel mand modality training. The second participant exhibited decreasing rates of challenging behavior during both existing and novel mand modality training. After training in isolation, a choice analysis was conducted. During choice sessions, the participant was free to use either modality. Both participants allocated the majority of their responses to the existing mand modality. However, the second participant engaged in higher levels of challenging behavior when the existing mand was selected. Both mand modalities served as quality replacements for the challenging behavior during training. However, when given the choice of modalities, participants gravitated to the existing mand modality. The authors note that if the assessment had ended after training, results would indicate that use of the novel mand would be most effective. However, when the modalities were evaluated together during the choice analysis, the use of novel mands decreased significantly. In addition, for the second participant, even though the majority of responses were allocated to the existing modality, higher rates of challenging behavior occurred in conjunction with this modality. Therefore, for this participant, continued use of the novel mand modality may result in lower levels of challenging behavior regardless of previous mand allocation. Overall, the results suggested that existing mands may be preferred over novel mands, but may result in corresponding increases in challenging behavior related to the existing modality.

Derby, Fisher, Piazza, Wilke and Johnson (1998) evaluated the effects of noncontingent reinforcement and contingent reinforcement on challenging behavior, existing mands and novel mand modalities. Existing mands were defined as mands observed during the initial assessment of challenging behavior and novel mands were any mands that were not observed during this assessment. First, noncontingent reinforcement was provided to the participant. Challenging behavior decreased during these sessions and low rates of manding (novel and existing) were observed. When reinforcement was provided contingent on challenging behavior, a significant increase co-occurred in existing mand modalities while novel mands were observed at low rates. When reinforcement was contingent on existing mands, challenging behavior continued to occur at elevated levels. In contrast, when reinforcement was contingent on novel mands, challenging behavior occurred at low to zero rates. The results for this specific participant indicated that use of the novel mands for FCT would be most effective. Challenging behavior occurred often in conjunction with existing mand modalities and therefore may have belonged to the same response class as the challenging behavior. These results were similar to results from Winborn et al. (2002) but discrepant from results of Harding et al. (2009).

Winborn-Kemmerer, Ringdahl, Wacker and Kitsukawa (2009) assessed mand modality allocation when two novel mands were trained to two participants. Each modality resulted in the same amount of reinforcement, had the same history of reinforcement (i.e., were novel) and required equal effort. The modalities trained were a picture touch and a microswitch touch. The motor responses for each modality were identical. After initial analyses, challenging behavior resulted in no programmed consequences (i.e., extinction). Next, each mand was taught in isolation within a reversal design and resulted in an immediate decrease in challenging behavior. During the choice analysis, both modalities were presented simultaneously to the participant after removal of the functional reinforcer. Results showed participants allocated the majority of responses to specific mand modalities, although allocation differed across participants. The first participant allocated the majority of mands to the picture card touch while the second participant allocated the majority of mands to the microswitch touch. The number of response-reinforcer pairings did not determine mand allocation as both participants preferred the mand modality that resulted in fewer reinforcement pairings. Overall results suggested that participants allocated the majority of responses to an individual mand modality even though both required equal effort. In addition, during FCT, it was important to individualize treatment and mand selection as mand allocation varied across individuals.

Overall, results of the above studies indicated that children allocate a majority of responses to specific mand modalities. Results differed between studies as response allocation was observed for novel mands (Derby et al., 1998; Winborn et al., 2002) or for mands already in the child's repertoire (Harding et al., 2009). Children also allocated the majority of responses to an individual mand modality even when both were novel (Winborn-Kemmerer et al., 2009). In addition, results from two studies showed corresponding increases in challenging behavior during use of the existing mand modality (Derby et al., 1998; Winborn et al., 2002) while one study did not (Harding et al., 2009). In summary, given the differing results based on novelty of mands, assessment of the mand modality(s) selected for FCT should be conducted to ensure positive treatment outcomes. The mand rate and the rate of challenging behavior should be evaluated during use with each mand modality before making a selection.

**Schedule Manipulation**

Another group of studies that incorporated multiple mand modalities into FCT evaluated the effects of the manipulation of the reinforcement or prompting schedule on mand allocation for specific modalities. Four studies were identified in the literature search as manipulating a schedule within FCT with multiple mand modalities.

Falcomata, Ringdahl, Christensen and Boelter (2010) evaluated the effects of prompt schedules on multiple mand modalities within a FCT evaluation. Three modalities were used during the series of evaluations including a vocal mand, microswitch touch and picture exchange. Each modality was already in the participant's repertoire before the evaluation. During the first phase, the functional reinforcer was removed and all three mand modalities were available. However, during the first condition of this phase, only vocal mands resulted in reinforcement. The microswitch and picture exchange had no programmed consequences (i.e., extinction). In the next condition, the picture exchange was the only modality available for reinforcement, and in the last condition, only the microswitch was available for reinforcement. Results of this phase indicated the participant allocated responses primarily to the mand modality that resulted in reinforcement. The remaining modalities on extinction occurred only one time during sessions respectively. Each mand modality served as a functional replacement for challenging behavior. This result suggested multiple mand modalities could be taught to participants as replacements for challenging behavior.

During the second phase of the study, the experimenters manipulated the prompting schedules for each modality in isolation. Specifically, both dense and lean prompt schedules were evaluated for each mand modality. The lean schedule was defined as 0.2 prompts per minute while the dense prompting schedule was defined as 2.0 prompts per minute. The prompt was the same across schedules and each mand resulted in the same amount of reinforcement. During the first condition of this phase, the microswitch was presented in isolation across each prompting schedule followed by the vocal mand and finally the picture exchange in subsequent conditions. Results indicated that the prompting schedule in place significantly impacted the rate of mands exhibited. Specifically, during the lean prompting schedule, the vocal mand and picture exchange were never observed across three sessions of each modality while the microswitch was observed twice across three sessions. Conversely, during the dense prompting condition, rate of manding for each modality available for reinforcement increased considerably.

During the final phase of the study from Falcomata et al. (2010), the prompting schedule was again manipulated, but all modalities were presented simultaneously. This condition was used to evaluate mand allocation in the presence of different prompting schedules. Specifically, in the first condition, the dense prompting schedule (i.e., 2.0 prompts per min) was implemented when all three modalities were present. Each modality was available for the same amount of reinforcement. The lean prompting schedule (i.e., 0.2 prompts per min) was implemented in the next condition followed by a return to the dense prompting schedule. Results of this phase indicated again that the prompting schedule impacted the rate of manding as considerably fewer mands occurred during the lean prompting schedule when compared to the dense prompting schedule. However, when each mand modality was available for reinforcement and presented simultaneously, the participant allocated responding primarily to the microswitch. The results of each phase indicated that for this participant, FCT should involve the use of frequent prompts (i.e., dense prompting schedule) and the microswitch.

Peck et al. (1996) evaluated mand allocation when the reinforcement for each modality was manipulated. Mand modalities required equal effort. For example, for one of the five participants, the mand modalities were touching a toy and a microswitch touch. Both modalities involved identical physical movements and therefore required equal effort. Following FCT that resulted in a significant decrease in challenging behavior, the choice analysis was conducted. During the choice analysis, each mand modality resulted in different amounts of reinforcement. For example, for one participant, the assessment of challenging behavior indicated an attention function. One of the mands resulted in 1 min of high quality attention (i.e., high reinforcement) while the other mand resulted in 10 s of attention followed by 50 s of ignoring (i.e., low reinforcement). Across three conditions, the reinforcement schedules were alternated. For example, for one participant in the first condition, the microswitch touch resulted in access to high reinforcement while the toy touch resulted in access to low reinforcement. In the next condition, the toy touch resulted in high reinforcement and the microswitch resulted in low reinforcement. In the last condition, the reinforcement schedules were again reversed. Results indicated each participant allocated the majority of responses to the mand modality resulting in high quality reinforcement while challenging behavior occurred at low levels.

In a subsequent study, Peterson, Frieder, Smith, Quigley and Van Norman (2009) again manipulated the reinforcement quality across mands. Specifically, following a FA and identification of a function, FCT was conducted with one mand modality, a card touch. During this condition, challenging behavior resulted in a 10 s break from work demands while the mand (i.e., card touch) resulted in a 1 min break from work demands. Results indicated challenging behavior decreased to low levels and mands occurred during 100% of trials. During the next condition, an additional mand was included. Challenging behavior resulted in the same 10 s break, the card touch resulted in a 30 s break and the additional mand, a separate card touch, resulted in a 1 min break. The additional card touch mand was differentiated from the original card touch by the word written on the card. The original card had the word 'break' written on it while the new card had the word 'work' written on it. However, while the participant was instructed that the new card touch was a mand for work, a work task was not included in this study. In the next condition, the reinforcement schedules for the card touches were reversed. Therefore, challenging behavior continued to result in a 10 s break, the break card touch resulted in a 1 min break, and finally, the work card touch resulted in a 30 s break. The final condition reversed the reinforcement schedules an additional time. Similar to results from Peck et al. (1996), each participant allocated the majority of his or her mands to the mand modality resulting in the most reinforcement. When selection of the work task resulted in the most reinforcement, this mand was selected most often and challenging behavior remained at low levels.

In a follow-up study, Peck Peterson et al. (2010) again manipulated the reinforcement schedules of multiple mand modalities. The mand modalities were identical to the previous study described above (i.e., card touches). However, a work task was included in this evaluation following a mand for work. Following a FA and FCT training which resulted in a significant decrease in challenging behavior, the reinforcement schedules were manipulated within a choice analysis. During the first phase of the choice analysis, the participants were told that they could either mand for a break, which resulted in a 15 s break from task demands, or mand for work, which resulted in 15-30 s of task demands followed by a 2 min break. Thus, the mand for work resulted in a greater amount of reinforcement even though task demands were presented. During the next phase, the reinforcement schedules were reversed. A mand for break resulted in a 2 min break from task demands while a mand for work resulted in 15-30 s of a work task followed by a 15 s break. Therefore, the mand for break resulted in a greater amount of reinforcement in this phase. Results showed that each participant allocated the majority of his or her responses to the mand modality that resulted in the most reinforcement, even when a mand for work resulted in a task demand. Thus, when the work task resulted in more reinforcement, the participants manded for work and engaged with the task before receiving a break. Conversely, when the mand for break resulted in more reinforcement, responses were allocated to this mand only. These results indicated an individual's mand allocation could be biased towards a work task when it results in higher quality reinforcement.

While results from Falcomata et al. (2010) suggested that rate of manding was impacted by prompting schedules, results from Peck et al. (1996), Peterson et al. (2009) and Peck Peterson et al. (2010) suggested that rate of manding was also impacted by reinforcement schedules. Specifically, a dense prompting schedule and an increase in reinforcement quality (i.e., high reinforcement) increased use of the corresponding mand modality. Each of these studies have specific implications for FCT implementation. For example, during initial communication training, dense prompting schedules and high quality reinforcement could be used to increase the rate of appropriate mands and differentiate mands from challenging behavior. In addition, mands for work tasks can be included to avoid access to continuous reinforcement.

**Proficiency**

A single study was identified that conducted an individualized assessment for selecting mand modalities before treatment (Ringdahl et al., 2009). Specifically, the experimenter implemented a mand topography assessment (MTA) to evaluate each participant's proficiency with a variety of mand modalities including microswitch, picture card touch, manual sign language and a typing mand. Before FCT was implemented, ten trials were conducted with each participant with each of three or four mand modalities. Within each trial, a three-step prompting procedure was implemented. Specifically, the functional reinforcer was restricted and the participant was given a verbal prompt (e.g., "If you want a break, press the switch."). If the participant did not mand (i.e., press the switch) within 5 s, a model prompt was provided followed by a physical prompt if the mand was not exhibited within 5 s after the model prompt. Regardless of prompting level, the functional reinforcer was provided following each mand. Data was taken on the prompting level required for each participant to mand. Next, FCT was implemented with two of the mands from the MTA. Mands were selected based on proficiency. Specifically, a high proficiency mand was defined as the mand that was exhibited with the fewest prompts during the MTA compared to the remaining modalities. The low proficiency mand was defined as the mand that required the most prompts across ten trials. The high proficiency and low proficiency mands were presented in isolation. For example, for one participant, the high proficiency mand (e.g., the microswitch) was presented to the participant following removal of the functional reinforcer. During the next phase, only the low proficiency mand (e.g., manual sign) was available for reinforcement following removal of the reinforcer.

Results were consistent across participants. During sessions with the high proficiency mand modality, challenging behavior was exhibited at low rates. During sessions with the low proficiency mand modality, challenging behavior was observed at higher levels. Therefore, results of the FCT intervention depended on the mand modality. The results of the MTA (i.e., proficiency level) successfully predicted the results of the FCT intervention. Yet, the authors point out that mand proficiency may not be related to the outcomes observed. The results could be related to variables described earlier in this review such as response-reinforcer pairings and/or effort.

**Language**

One study was identified that assessed mand modality allocation when modalities differed by language (Padilla et al., 2011). Specifically, one mand modality was defined as a microswitch touch that resulted in English language output and attention from caregivers also in English. The second mand modality was defined as a microswitch touch that resulted in Spanish language output and attention from caregivers also in Spanish. Following a FA, FCT treatment sessions were conducted with the microswitches. Specifically, work tasks were presented to the participant. Initially, five work tasks were completed before the microswitches were presented simultaneously. The language during the work tasks was alternated across sessions. The caregiver spoke in Spanish during work tasks during the first session and in English during the second session. The language of sessions continued to be alternated throughout the evaluation. Both microswitches were available for reinforcement in the form of break from work tasks for equal amounts of time and attention in the mand language. The work task requirement was increased to 10 and 20 tasks as the participant was successful (i.e., engaged in low levels of challenging behavior). Results showed that the participants chose both mand modalities around 50% of trials. Mand allocation was not based on the language of the mand modality. While FCT was effective in decreasing challenging behavior, increasing independent mand use and increasing task engagement, the language output from the device and language spoke during the break had no effect on mand allocation. This result could be attributed to the fact that the function of the challenging behavior identified during the FA was escape from task demands. Both mand modalities resulted in equal amounts of break time, but the language in which attention was provided was manipulated. Attention may not have maintained the challenging behavior and therefore, the participant did not allocate responding to a specific mand modality because both modalities resulted in the desired break from task demands.

## Discussion

A systematic literature search resulted in 15 identified studies that incorporated multiple mand modalities within a FCT intervention to decrease challenging behavior. Studies were grouped according to the relevant variable manipulated (e.g., effort, novelty). Results have implications for the use of FCT and selection of mand modalities.

**Summary**

The majority of identified studies manipulated the effort of mands, the reinforcement schedule associated with multiple mands, or compared use of novel mands to other novel mands and/or mands that were already in individuals' repertoires. Most of the identified studies manipulated the effort of mand modalities (Bailey et al., 2002; Buckley & Newchok, 2005; Danov et al., 2010; Horner & Day, 1991; Richman et al., 2001). Results were consistent across studies. Not surprisingly, a mand requiring high effort (i.e., more steps in response chain) was observed less frequently than a low effort mand. In addition, the high effort mand was related to a corresponding increase in challenging behavior.

The impact of novel mands on mand allocation has also been evaluated (Derby et al., 1998; Harding et al., 2009; Winborn et al., 2002; Winborn-Kemmerer et al., 2009). Results differed across studies. When mand modality allocation was assessed by comparing existing mands to novel mands, one study found the participant primarily allocated responding to the existing mand modality (Harding et al., 2009) while other studies suggested allocation to the novel mand modality (Derby et al., 1998; Winborn et al., 2002). The final study results suggested that individuals taught multiple novel mands allocated the majority of responses to a specific modality (Winborn-Kemmerer et al., 2009). In addition, challenging behavior was observed more often in the presence of the existing mand modality in two studies (Derby et al., 1998; Winborn et al., 2002) but not in a third study (Harding et al., 2009).

The next group of studies assessed mand allocation when a schedule associated with specific modalities was manipulated (Falcomata et al., 2010; Peck et al., 1996; Peterson et al., 2009; Peck Peterson et al., 2010). Schedule manipulation in each study impacted response allocation during FCT. A high prompting schedule during sessions (Falcomata et al., 2010) and/or high quality reinforcement (Peck et al., 1996; Peterson et al., 2009; Peck Peterson et al., 2010) impacted both response rate and/or response allocation. Participants engaged in higher rates of manding when the modality was associated with high quality reinforcement, even in the presence of work tasks (Peterson et al., 2010).

Individual studies were identified that incorporated multiple mand modalities and involved manipulation of a different variable. The language of the output device and resulting attention was manipulated across mand modalities (Padilla et al., 2011). Results showed that participants did not allocate the majority of mands to a specific language output. Another study implemented a pre-intervention assessment (i.e., MTA) to evaluate mand proficiency for a variety of mand modalities (Ringdahl et al., 2009). During FCT sessions after the MTA, the mand modality exhibited at the highest proficiency level was associated with better treatment outcomes (i.e., lower rates of challenging behavior).

**Implications For Practice**

Overall, results of each study identified have implications for selection of mand modalities during FCT. Mand modalities requiring less effort may be more efficient and result in less challenging behavior when compared to mands requiring more steps in the response chain. Each individual may allocate the majority of his or her responses to certain modalities of communication. Allocation of manding is individualized and is likely to differ across individuals. Given the results from Ringdahl et al. (2009), assessment of modality proficiency with multiple mand modalities should occur before treatment implementation. Every child in a classroom may not prefer to use a microswitch. Rate of challenging behavior during assessment of multiple mand modalities is an important factor to consider. Given the discrepant results that challenging behavior was and was not observed at increased levels when the existing modality was present, data on the challenging behavior exhibited during FCT sessions should be collected and used to determine changes to treatment.

Individual characteristics such as vocal and/or motor ability should be taken into consideration. Children may have the ability to mand for an item vocally, but these mands may be observed at very low rates. In this situation, a mand requiring a motor action may be more efficient and result in better treatment outcomes. In addition, children learned to use the mand modality that resulted in the highest quality reinforcement even when a work task was included before the higher quality reinforcement is delivered. Manipulation of the reinforcement schedule can result in increases in other adaptive behaviors such as task engagement. In summary, the studies identified offer suggestions and solutions for the selection of a mand modality or modalities during FCT.

**Future Studies**

Future studies should evaluate the use of multiple mand modalities within FCT in the context of prevention of clinical relapse. Results from Wacker et al. (2011) suggested that for one participant, when the original mand modality was removed from the environment and other untrained modalities were available for reinforcement, an increase in other appropriate mands was observed while for the remaining participants, challenging behavior re-emerged. Future studies could evaluate this result with more than two mand modalities. If challenging behavior does not re-emerge when a mand modality is placed on extinction and responding is allocated to other mand modalities, phase two of FCT from Tiger et al. may be adapted to include instruction of multiple modalities rather than a single mand modality.

## Appendix B: Statistical Testing Results

Results of the delay evaluation were also analyzed using t-tests. Means and standard deviations for challenging behavior RPM, total mand RPM and variant mand RPM were calculated for the FCT and FCT + delay conditions for each participant. The means of each condition were compared for each participant. For Patrick, the rate of challenging behavior during the FCT condition was zero ($M = 0$, $SD = 0$) and slightly increased during the FCT + delay condition ($M = 0.06$, $SD = 0.16$). There was not a significant effect for challenging behavior, $t(14) = 1.10$, $p = 0.14$, suggesting that the inclusion of a delay to reinforcement did not increase challenging behavior. The total mand RPM increased between the FCT condition ($M = 1.73$, $SD = 0.10$) and the FCT + delay condition ($M = 7.32$, $SD = 1.55$). This was a significant effect for total mand RPM, $t(14) = 12.06$, $p < 0.001$, suggesting that the inclusion of a delay to reinforcement increased the total mand responses. Patrick's variant mand RPM also increased between the FCT condition ($M = 0.22$, $SD = 0.21$) and the FCT + delay condition ($M = 2.71$, $SD = 0.81$). This increase was a significant effect, $t(16) = 9.68$, $p < 0.001$, suggesting that the inclusion of a delay to reinforcement significantly increased the variability of mands.

For Warren, challenging behavior increased between the FCT condition ($M = 0.63$, $SD = 0.53$) and the FCT + delay condition ($M = 1.07$, $SD = 0.80$). This increase was not a significant effect, $t(24) = 1.45$, $p = 0.08$, indicating that the inclusion of a delay to reinforcement did not significantly increase challenging behavior. The total mand RPM increased between the FCT condition ($M = 1.79$, $SD = 0.16$) and the FCT +

delay condition ($M = 4.25$, $SD = 0.78$). This increase was a significant effect, $t(15) = 12.87$, $p < 0.001$, suggesting that the inclusion of a delay to reinforcement during FCT significantly increased the total mand RPM. The variant mand RPM increased between the FCT condition ($M = 0.61$, $SD = 0.29$) and the FCT + delay condition ($M = 1.70$, $SD = 0.60$). This increase was a significant effect, $t(19) = 6.43$, $p < 0.001$, suggesting that the inclusion of a delay to reinforcement during FCT significantly increased the variant mand RPM.

For Violet, challenging behavior increased between the FCT condition ($M = 0.0$, $SD = 0.0$) and the FCT + delay condition ($M = 0.18$, $SD = 0.39$). This increase was a significant effect, $t(19) = 1.96$, $p < 0.05$, indicating that the inclusion of a delay to reinforcement significantly increased challenging behavior. The total mand RPM increased between the FCT condition ($M = 1.80$, $SD = 0.10$) and the FCT + delay condition ($M = 8.02$, $SD = 1.99$). This increase was a significant effect, $t(19) = 13.53$, $p < 0.001$, suggesting that the inclusion of a delay to reinforcement during FCT significantly increased the total mand RPM. The variant mand RPM increased between the FCT condition ($M = 0.84$, $SD = 0.38$) and the FCT + delay condition ($M = 1.92$, $SD = 0.86$). This increase was a significant effect, $t(27) = 4.83$, $p < 0.001$, suggesting that the inclusion of a delay to reinforcement during FCT significantly increased the variant mand RPM.

For Alex, challenging behavior decreased between the FCT condition ($M = 0.38$, $SD = 0.54$) and the FCT + delay condition ($M = 0.09$, $SD = 0.23$). This increase was not a significant effect, $t(25) = 1.28$, $p = 0.10$, indicating that the inclusion of a delay to reinforcement did not significantly decrease challenging behavior. The total mand RPM decreased between the FCT condition ($M = 1.25$, $SD = 0.38$) and the FCT + delay condition ($M = 0.85$, $SD = 0.66$). This increase was a significant effect, $t(44) = 3.40$, $p < 0.01$, suggesting that the inclusion of a delay to reinforcement during FCT significantly decreased the total mand RPM. The variant mand RPM increased between the FCT condition ($M = 0.07$, $SD = 0.23$) and the FCT + delay condition ($M = 0.25$, $SD = 0.34$). This increase was not a significant effect, $t(46) = 1.56$, $p = 0.06$, suggesting that the inclusion of a delay to reinforcement during FCT did not significantly increase the variant mand RPM.

Table 5. *Challenging Behavior RPM T-Test Results*

| | M | SD | T-value | p |
|---|---|---|---|---|
| **Patrick** | | | | |
| FCT | 0 | 0 | 1.10 | 0.14 |
| FCT + Delay | 0.06 | 0.16 | | |
| **Warren** | | | | |
| FCT | 0.63 | 0.53 | 1.45 | 0.08 |
| FCT + Delay | 1.07 | 0.80 | | |
| **Violet** | | | | |
| FCT | 0 | 0 | **1.96*** | **.029** |
| FCT + Delay | 0.18 | 0.39 | | |
| **Alex** | | | | |
| FCT | 0.38 | 0.54 | 1.28 | 0.10 |
| FCT + Delay | 0.09 | 0.23 | | |

* $p<.05$
*Note*. M = Mean. SD = Standard Deviation.

Table 6. *Total Mand RPM T-Test Results*

| | M | SD | T-value | p |
|---|---|---|---|---|
| **Patrick** | | | | |
| FCT | 1.73 | 0.10 | **12.06*** | **<.001** |
| FCT + Delay | 7.32 | 1.55 | | |
| **Warren** | | | | |
| FCT | 1.79 | 0.16 | **12.87*** | **<.001** |
| FCT + Delay | 4.25 | 0.78 | | |
| **Violet** | | | | |
| FCT | 1.80 | 0.10 | **13.53*** | **<.001** |
| FCT + Delay | 8.02 | 1.99 | | |
| **Alex** | | | | |
| FCT | 1.25 | 0.38 | **3.40*** | **<.01** |
| FCT + Delay | 0.85 | 0.66 | | |

* p<.05
*Note*. M = Mean. SD = Standard Deviation.

Table 7. *Variant Mand RPM T-Test Results*

| | M | SD | T-value | p |
|---|---|---|---|---|
| **Patrick** | | | | |
| FCT | 0.22 | 0.21 | **9.68*** | **<.001** |
| FCT + Delay | 2.71 | 0.81 | | |
| **Warren** | | | | |
| FCT | 0.61 | 0.29 | **6.43*** | **<.001** |
| FCT + Delay | 1.70 | 0.60 | | |
| **Violet** | | | | |
| FCT | 0.84 | 0.38 | **4.83*** | **<.001** |
| FCT + Delay | 1.92 | 0.86 | | |
| **Alex** | | | | |
| FCT | 0.07 | 0.23 | 1.56 | .06 |
| FCT + Delay | 0.25 | 0.34 | | |

* p<.05
*Note*. M = Mean. SD = Standard Deviation.

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