Lag Schedules and Functional Communication Training: A Replication

By

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CHAPTER I

INTRODUCTION

Individuals with disabilities are three to five times more likely to display challenging behaviors (CBs) than their typically-developing peers (Poppes, van der Putten, & Vlaskamp, 2010). CB can be minor, but in more severe cases might manifest as elopement, property destruction, aggression, or self-injurious behavior (SIB). Unfortunately, CB can result in significant repercussions for children exhibiting the behavior and for their caregivers. For example, children with CB might have limited access to educational and social experiences—as CB regularly interferes with the acquisition and practice of these skills—and are at an increased risk for school suspension, expulsion, and highly-restrictive placements (Dunlap et al., 2006). For their part, caregivers of these individuals—including parents, teachers, therapists, and support staff—might be faced with an increased level of stress (i.e., physical, mental, or emotional), which is positively correlated with both the severity of CB and precursors to burnout (Gallagher & Whiteley, 2013; Hastings & Brown, 2002). Although not limited to any specific age group or diagnosis, CB might be more prevalent for individuals with less-developed communication skills, including those with severe disabilities and young children (Poppes et al., 2010). For these individuals, CB can be a result of an inability to appropriately express their wants or needs (or have appropriate attempts reinforced), and might be the only method through which they have successfully attained them. In particular, young children with disabilities might be more susceptible to CB, given communication is less developed for this age group regardless of disability status. For this reason, functional communication training (FCT) is often used with young children to teach and reinforce appropriate communication while placing CB on extinction (Durand & Moskowitz, 2015).

Functional Communication Training

FCT is an evidence-based method (Odom, Collet-Klingenberg, Rogers, & Hatton, 2010; Wong et al., 2015) that relies on multiple techniques based on principles of applied behavior analysis (ABA), primarily functional behavior assessment (FBA) or functional analysis (FA), differential reinforcement of alternative behavior (DRA), and extinction. FCT has been widely applied since its development in 1985 by Carr & Durand, and has since become one of the most common interventions for addressing CB (Tiger, Hanley, & Bruzek, 2008). FCT has demonstrated positive effects across diverse populations, behaviors, functions, and communication modalities (Chezan, Wolfe, & Drasgow, 2017; Heath, Ganz, Parker, Burke, & Ninci, 2015; Kurtz, Boelter, Jarmolowicz, Chin, & Hagopian, 2011). Of importance, FCT is effective for young children with disabilities (Heath et al., 2015; Kurtz et al., 2011), when implemented by indigenous implementers (Chezan et al., 2017; Kurtz et al., 2011), and is rated as having high social validity by teachers, parents, and school administrators (Callahan, Henson, & Cowan, 2008).

FCT is traditionally conducted by teaching a single replacement response (i.e., a mand), and providing function-based reinforcement for each use of that response (i.e., FR-1 schedule, or continuous reinforcement; Tiger et al., 2008). Although this method is often extremely effective in replacing CB with appropriate manding, it also has notable limitations. Specifically, (a) reinforcing a single mand can result in rote responding (Rodriguez & Tumaspson, 2015), (b) a single mand or mand typography might not be appropriate for all communication partners or settings (Ringdahl & St. Peter, 2017; Rodriguez & Tumaspson, 2015; Tiger et al., 2008), reducing generalizability (Falcomata & Wacker, 2013); and (c) if reinforcement is not provided on a FR-1 schedule for the replacement mand it often fails to persist while CB resurges (Ringdahl & St. Peter, 2017; Wacker et al., 2011), impacting maintenance (Schieltz, Wacker, Ringdahl, & Berg, 2017). Taken together, these factors might result in less robust FCT outcomes, as demonstrated in a meta-analysis conducted by Chezan and colleagues (2017). Consequently, multiple FCT variations have been explored to make the intervention more effective for long-term use, including reinforcement thinning, incorporation of generalization strategies, delay tolerance training, punishment of resurgent CB, and the lag schedule of reinforcement, a variation of particular promise.

Lag Reinforcement Schedules

Lag reinforcement schedules are those in which reinforcement is contingent on a response differing from a predetermined number of previous responses (i.e., the response for trial x must differed from trials $x - 1$; Page & Neuringer, 1985), the number of which is denoted in the schedule name, "Lag *X*." They can be applied as individual interventions (e.g., Baruni, Rapp, Lipe, & Novotny, 2014; Lee, McComas & Jawor, 2002) or with additional interventions (e.g., FCT [e.g., Falcomata et al., 2018]; group contingencies [Wiskow & Donaldson, 2016]; response blocking [Silbaugh, Wingate, & Falcomata, (2017]). Although this technique has been used to increase response variability in basic and translational research for nearly 20 years, lag schedules of reinforcement remain minimally-researched (Ringdahl & St. Peter, 2017) and almost certainly minimally-utilized in the applied setting. Nonetheless, extant studies have demonstrated that reinforcing multiple responses addresses all of the aforementioned limitations of continuous reinforcement (i.e., increased response variability, generalizability, persistence of target responding, and reduced resurgence of undesired responding).

Response Variability

First, lag reinforcement typically results in increased response variability. Numerous studies have demonstrated when reinforcement is provided contingent on variable responding—either variable topographies (e.g., various ways to greet a friend) or modalities (e.g., vocal, sign language, picture exchange, voice-output device)—future responding tends to be more diverse than when a single response is consistently reinforced. This response variability has occurred outside the context of FCT across age, ability, and target behavior. For example, following Lee and colleagues' seminal study (2002), numerous researchers have applied a lag schedule to increase the diversity of verbal responding for individuals with autism (e.g., Esch, Esch, & Love, 2009; Susa & Schlinger, 2012). In addition, lag schedules have increased toy play variability (e.g., Baruni et al., 2014) and food consumption (Silbaugh & Falcomata, 2017; Silbaugh, Wingate, & Falcomata, 2017), among others, and reduced topic perseveration (Lepper, Devine, & Petursdottir, 2017). Importantly, researchers have also explored the use of lag reinforcement during FCT (i.e., Adami, Falcomata, Muething, & Hoffman, 2017; Falcomata et al., 2018).

Increased Generalizability

Second, the response variability required when establishing the lag schedule ensures a variety of responses will be taught and reinforced. This is important, given different responses are often more appropriate or useful in different contexts. For example, while a parent will understand when a child signs “movie please,” a babysitter might not (but she might understand when a picture of a favorite movie is presented). Consequently, reinforcing a single response reduces generalizability and can result in a context-bound intervention (Yoder, Lloyd, & Symons, 2018b). Lag schedules address this to some extent by reinforcing response variability, although programming diverse environmental variables might still be required for contextual generalization (Falcomata & Wacker, 2013; Tiger et al., 2008).

Behavioral Persistence and Resurgence

Third, lag schedules have demonstrated positive outcomes in maintaining functional responding (i.e., persistence) while postponing resurgence of the originally-reinforced behavior following lapses in treatment. In natural settings these lapses might be due to contextual changes (e.g., different communication partners, unavailability of primary communication device; Ringdahl & St. Peter, 2017) or to errors of omission (St. Peter Pipkin, Vollmer, & Sloman, 2010). Considerable basic and translational research has been conducted on the subject, exploring a wide variety of variables affecting behavioral persistence and resurgence, including topographical similarity between the original and replacement responses, the strength of the response class, and the duration, magnitude, and schedule of reinforcement for both responses (e.g., Lambert, Bloom, Samaha, Dayton, & Rodewald, 2015; Lattal & St. Peter, 2009; Ringdahl & St. Peter, 2017). Although behavioral persistence and resurgence are important to consider across behavior targets, they might be especially pertinent to FCT, given the significant impact of CB on both the individual exhibiting it and the surrounding environment.

Lag Schedules and FCT

Only two applied studies have been conducted in which lag reinforcement was used during FCT (i.e., Adami, Falcomata, Muething, & Hoffman, 2017; Falcomata et al., 2018); both were conducted by the same research group.

Adami and colleagues (2017) analyzed the rate of mands, variable mands, and CB with two participants with autism across two reinforcement schedules (i.e., Lag 0 and Lag 1). After conducting an FA and conducting a mand modality assessment (to ensure the selected mands were in the participants’ functional repertoire), they manipulated the schedules using a multi-treatment design (i.e., A-B-C-B-C-A-C). The authors found little deviation in the rate of mands (which were consistently high) or the rate of CB (which was consistently well below baseline levels) between the FCT/Lag 0 and FCT/Lag 1 schedules. However, the variability of mands were notably different between the schedules, with a much greater percentage in the Lag 1 schedule than in the Lag 0 schedule (in which minimal variable manding occurred). This study provided two valuable insights. First, when given an option, individuals might display rote responding; however, when required to use diverse mands to obtain reinforcement they may do so. Unfortunately, Adami and colleagues did not analyze the frequency of manding across the four available mand modalities, precluding a thorough analysis of how the schedules affected mand variability. In addition, given mand materials were not made available during the baseline condition, persistence of manding during this condition (when reinforcement was available for engaging in CB) could not be assessed. As the authors noted, the results of this study highlighted the need for additional replications to address several limitations and unanswered questions.

Falcomata and colleagues’ (2018) conducted a follow-up study addressing several of the aforementioned limitations and areas of future research. They manipulated sequentially-increasing lag schedules (i.e., Lag 0, Lag 1, Lag 2…) within FCT to investigate the effects on mand variability and CB with two children with autism. Similar to Adami et al. (2017), Falcomata and colleagues first conducted an FA to determine the maintaining reinforcer(s) for CB, followed by a mand modality assessment. They then analyzed the various lag schedules using A-B-A-B and A-B-A-B-A-B designs, sequentially increasing the lag requirement (within condition) when participants demonstrated appreciable changes in variable responding. Results indicated that FCT/Lags 1-5 resulted in a greater number of mands and greater variability of mands than FCT/Lag 0 for both participants, while CB remained at or near zero. The total number and variability of mands increased with each lag up to Lag 3—with minimal differences between Lags 3 and 4—with the rate of total manding peaking at Lag 3/Lag 4 for one participant and Lag 5 for the other. In addition, they found that the probability of a subsequent mand given an unreinforced mand was consistently high across lag schedule increases; mands remained at ceiling levels for one participant and over 95% for the other (for all but Lag 5). The probability of CB following an unreinforced mand was 0% for both participants for all schedules except for Lag 5 (for which it was 1%). These results provide additional support for Adami and colleagues' findings on the effectiveness of lag schedules in increasing mand variability. They also raise questions regarding the possibility of ceiling effects (i.e., mand variability will only increase to a certain degree, regardless of reinforcement schedule) and the possibility that lag schedules might result in maintenance of variable manding during returns to baseline (i.e., conditions analogous treatment lapses). However, their study had limitations similar to those of Adami and colleagues'—specifically the absence of mand materials during baseline—precluding an analysis of the intervention's effect on total and variable manding during this condition.

The results of these studies are promising, demonstrating the ability of FCT with lag reinforcement to increase mand variability. Nevertheless, given the paucity of research, its limitations, and the resulting unresolved questions, continued investigation into the effectiveness of lag schedules of reinforcement in (a) increasing mand variability, and (b) increasing mand persistence and postponing resurgence of CB during baseline is needed.

Current Study

The purpose of the current study was to advance the research on lag reinforcement within FCT through a conceptual replication of Falcomata and colleagues' (2018) study. Unlike direct replications, which aim to duplicate the original study across all variables, conceptual replications are those that are conceptually similar to the previous study with purposeful variations. Consequently, the current study will utilize the majority of the methods and analyses of Falcomata and colleagues while systematically varying in others, as will be discussed.

Importance of Replication

Replication studies are arguably of equal importance as those exploring original topics, given they can (a) provide an additional level of internal validity to previous studies, (b) extend the implications of previous studies to unique variables (thus increasing external validity or generalizability), and (c) allow for the systematic accumulation of evidence on a subject, as is required for identifying evidence-based practices (Travers, Cook, Therrien, & Coyne, 2016). Despite these benefits, replication studies are not commonly reported in special education research, even as they may be commonly conducted (Cook, Collins, Cook, & Cook, 2016). Given a large proportion of studies are replications to some extent, a majority of special education research might be considered a continuum of conceptual replication studies, from those closely aligned with preceding studies to those more distally related (Coyne, Cook, & Therrien, 2016). For this reason, it is critical these studies be conducted, identified as replications, and given due consideration in publication.

Multiple recommendations have been made regarding replication studies. First, researchers should ensure they identify their study as a replication—whether it be a direct or conceptual replication; this will clarify the study's purpose and method and might provide support for replication research in the field (Coyne et al., 2016). Second, replications should be considered in which there is limited author overlap. Because studies conducted by the same authors or research groups (a) might be more likely to result in replicated effects (Makel et al., 2016) and (b) might be subject to researcher and publication bias (Cook et al., 2016), studies conducted by different authors can provide unique contributions to special education research. Finally, Coyne and colleagues (2016) suggest replication studies state which components are and are not duplicated across studies and explain the theoretical rationale for any changes.

Scope of Current Study

The current study was a systematic, conceptual replication of Falcomata et al., 2018 (itself a conceptual replication of Adami et al., 2017). It was designed to meet suggested guidelines for high-quality replication studies put forth by Brandt and colleagues (2014) and Coyne and colleagues (2016). As such, specific components—determined *a priori*—differed from the original study; all other components were conducted following the methods of the original authors to the greatest extent possible, which was facilitated by direct collaboration with the first author.

Variations from Falcomata et al., 2018.

In the current study, I altered three specific components: (a) the age of participants, (b) the presence of mand materials during baseline conditions, and (c) the number of lag schedule increases.

Neither Adami et al., (2017) nor Falcomata et al., (2018) included participants of preschool age (i.e., 2–5 yrs). Although a total of three elementary-aged participants (aged 8–10 yrs) were included in their studies, the field lacks evidence on whether similar effects will generalize to young children, who have distinctly different learning histories and who might receive intervention in disparate contexts. Further, because CB is prevalent in this population—and FCT is used frequently to manage it—it is important to investigate the effects of the lag reinforcement model within FCT with this age group.

Second, neither aforementioned study included mand materials during the baseline condition, precluding an analysis of how the FCT/Lag intervention effected manding (both total and variable) during removal of the intervention. As one of the primary potential benefits of this intervention is to increase persistence of appropriate behavior (while CB ideally remains low) during lapses in treatment, this question requires investigation. Previous research suggests that CB is likely to increase during baseline conditions (when it will be reinforced); however, this study tests the hypothesis that a period of sustained mand persistence and variability, with levels of challenging behavior similar to those of the previous treatment condition, would directly follow returns to baseline. Thus, I hypothesized that there would not be an immediate change in target behaviors upon condition changes, but rather that levels would reverse after continued exposure to the new contingency.

Finally, rather than sequentially increasing the lag schedule from Lag 0 to Lag 5 (as was done in Falcomata et al., 2018), I increased the schedule to a maximum of Lag 3 for two reasons. First, young children have had less communicative experience than older children, such that competence with each new mand might require substantial training (and thus, time). Further, at this age many children utilize a limited number of mands, regardless of developmental ability; this indicates the manipulation of four unique mands is socially-valid within this population. Second, the original authors saw relatively few increases in either total mands or their variability with schedules higher than Lag 3.

Research Questions

The following research questions (RQs) guided this study.

(1) When compared to baseline, will an FCT/Lag schedule applied with young children with disabilities and CB result in:
  a. greater mand variability?
  b. increased mand persistence (i.e., frequency)?
  c. a reduced level of CB?

(2) As the lag schedule increases from FCT/Lag 0 to FCT/Lag 3:
  a. will the variability of mands increase?
  b. will the persistence of mands increase?
  c. will CB decrease?

(3) Will parents:
  a. rate the intervention goals, procedures, and outcomes as highly acceptable?

(4) Will masked raters:
  a. rate the intervention procedures as highly acceptable?
  b. identify socially-significant changes in the children's communication and CB?

CHAPTER II

METHOD

Participants

Children

Study participants were three children with autism, aged 3-5: Bowie, Tumas, and Fawn. Inclusion criteria for children were: (a) 36 to 71 months old at start of study; (b) diagnosis of a disability; (c) inconsistent use of appropriate mands to obtain wants and needs; and (d) presence of CB considered severe enough to be disruptive to daily living, as indicated by parent interview. Exclusion criteria included: (a) concurrent participation in any intervention that included FCT or alternate systematic mand instruction; (b) CB that resulted in serious physical harm to self or others in the previous six months (e.g., eye-gouging) and for which appropriate safety precautions could not feasibly be undertaken, or CB that was automatically-maintained; (c) physical limitations severe enough to preclude engagement with at least four mand modalities, per parent report or direct assessment; and (d) lack of availability of at least 1 hour, three times per week to devote to one-on-one intervention.

Seven participants were consented for the study. However, for four of these CB could not be reliably evoked by the implementers; thus, these participants were not ultimately included in the study. Bowie, a 42-month old White boy, engaged in some independent vocal functional communication (primarily one to two-word utterances) and would echo mands when modeled, but did not consistently mand to obtain his wants and needs. At these times—and when denied requests—he engaged in a variety of CB typographies, including yelling, aggression towards others (e.g., hitting, pulling hair), property destruction (e.g., throwing objects), and SIB (i.e., banging head on wall, floor, or table). In addition, Bowie engaged in self-stimulatory behavior, which generally consisted of dangling strings or cords in front of his visual field. Tumas was a 56-month old boy of Middle Eastern descent. Like Bowie, he engaged in some independent functional vocal communication but it was not consistent. He also engaged in scripted speech during conversations and play. Tumas's CB were similar to Bowie's (e.g., aggression, property destruction). Fawn, who was a 55-month old White girl**,** displayed similar vocal communications as Bowie and Tumas, but would also emit occasional one- to three-word vocalizations via a voice-output alternative and augmentative communication (AAC) device programed with Proloquo2Go. Her CB was typically vocal: yelling/screaming abruptly and loudly. In addition, she would sometimes display aggression toward self or others, including hitting her head with fisted hands and grabbing at or hitting others. During the study all participants attended different self-contained preschool classrooms and were receiving speech and language therapy, but none were receiving FCT or systematic instruction with non-vocal modalities. Fawn also received ABA-based therapy in her home at the time of the study.

Parents

Parent participants were mothers of identified children. Mothers of Bowie and Fawn were both White and 34 years old and Tumas's mother was 37 years old and of Middle Eastern descent.

Masked Raters

Twenty-three individuals aged 22 to 42 years (*mean* = 31.6 years) participated as social validity masked raters. The majority of raters were White non-Hispanic (21 of 23); one participant was White/Hispanic and one was of Asian descent. Raters were predominantly female (21 of 23) with a master's degree in an educational field (18 of 23); two participants had a doctoral degree and three a bachelor's degree. Six of 23 participants were current or former special teachers (2 had special education experience only, 2 had general education experience only, and 2 held both certifications) with no behavioral training; 1 participant was a preschool coach with no background in behavior. Fourteen participants had behavior training (12 were Board Certified Behavior Analysts [BCBAs] and 2 were Registered Behavioral Technicians [RBTs]), 6 of whom also held education licenses. All but one participant indicated they had professional experience with young children with disabilities—and autism specifically—and severe challenging behavior.

Setting

The study occurred primarily in participants' homes. For Bowie, all sessions occurred at the kitchen table, and for Tumas and Fawn sessions took place in the family room. In addition, per parent request due to scheduling, Fawn participated in one to two sessions weekly in a clinical observation room at Vanderbilt University. In all cases, the surrounding area was clear of toys and other competing stimuli, and, for all sessions but generalization, no other children or adults outside of implementers or parents were present. We conducted all sessions in the afternoon, following the children's school day. Sessions occurred three to five times per week for approximately 30 minutes, across a 5 to 7-week period for each child.

Materials

Materials required for the intervention fell into two categories: (1) assessment and intervention implementation, and (2) data collection.

Assessment and Intervention

The materials required for assessment included a copy of the Open-Ended Functional Assessment Interview (Open-Ended FAI; Hanley, 2009) for each child and tangible items that maintained each child's CB (i.e., preferred snacks for Bowie, an iPad with favorite apps for Tumas, and an iPad with apps and animal figurines for Fawn). Intervention sessions also required three AAC devices: a simple switch communicator (similar to a BIGmack), an iPad programmed with Tobi Dynavox Compass Connect, and picture communication cards depicting each child's specific mand.

Data Collection

All sessions were recorded using a Canon VIXIA digital camera and tripod, and coded using Procoder for Digital Video software (ProcoderDV; Tapp, 2003). To permit immediate data-based decisions, (a) during the FA a simple data sheet was used to track responses to various contingencies, and (b) during the intervention a data sheet was used to track mands and CB. We assessed procedural fidelity of both the FA and the intervention via video review using ProcoderDV. All data was managed using Microsoft Excel software. We measured social validity as rated by parents both pre- and post-treatment using modified versions of the

Treatment Acceptability Form–Revised (TARF-R; Reimers & Wacker, 1988); social validity as rated by masked raters was assessed via video review using a paper-and-pencil form.

Measurement

Dependent Variables

Dependent variables included the frequency (or estimated frequency, for Bowie) of target mands, variable mands, and target CB. These were individually selected and operationally-defined based on the unique behavioral repertoire of each child (Table 1). *Target mands* were the four mands selected via the mand modality assessment. For Bowie and Tumas these included a vocal mand, switch mand, iPad mand, and picture exchange mand, with the vocal mand being a unique word or phrase compared to the electronic output of the mand devices (to prevent a switch or iPad mand from prompting a vocal mand). Fawn's four target mands consisted of a sign mand, switch mand, iPad mand, and picture exchange mand. *Variable mands* were target mands that utilized a mand modality different from the modality emitted immediately prior (invariable mands were identical to the previous mand). *Target CB* was selected via the parent interview and child observation. Because target CB for all children consisted of a variety of behavioral topographies (e.g., yelling, hitting, property destruction) that was believed to comprise a behavior class, it was measured as an aggregate variable (i.e., "CB") across participants. Please see Table 1 for definitions of dependent variables and their coding requirements by participant.

Measurement System

We measured the frequency or estimated frequency of all target behaviors throughout each 5-min session. Data were coded using ProcoderDV using code files created for this study. For Tumas and Fawn, the frequency of target behaviors was measured via event recording. Each time a target behavior occurred that met an operational definition and its coding requirement, the video was time-stamped and the type of response (i.e., mand or CB) was marked. Each time a target mand was emitted, the mand modality and whether the mand was variable or invariable was also coded; the first mand of each session was not marked as either variable or invariable. Target mands were considered mutually-exclusive from CB. Thus, if CB was occurring concurrent with a target mand, that mand would not be coded but CB would be. If multiple mand modalities (e.g., vocal and picture) co-occurred these were both coded (to capture all emitted mands), with variability of each dependent on which began first.

For Bowie—who engaged in rapid rates of short-duration behavior that made accurate event recording unachievable—we estimated the frequency of target behaviors using 2-s partial-interval recording (PIR). PIR was selected rather than momentary time sampling or whole interval recording because it was hypothesized to be the interval system most likely to accurately estimate Bowie's behavior given previous research (e.g., Ledford, Ayres, Lane, & Lam, 2015) and his unique behavioral modality (i.e., many temporarily close instances of short duration). I corrected all behaviors using a Poisson transformation (Mann, Ten Have, Plunkett, & Meisels, 1991; Yoder, Ledford, Harbison, & Tapp, 2018a) and converted each to a percentage of intervals, resulting in the estimated percentage of intervals in which target behaviors were estimated to have occurred. Given data were binned into 2-s intervals rather than marked at their exact occurrence, mands and CB were not mutually-exclusive as they were for Tumas and Fawn.

Table 1
Dependent Variables: Operational Definitions, Examples, and Coding Rules

Behavior	Operational Definition	Examples	Coding Rules
Mands			
Vocal	Any vocal output including "poof" (Bowie) or "iPad please" (Tumas) emitted at a conversational volume	• "More poof"; "I want poof" • "More iPad please"; "I want the iPad please"	• Mark the behavior at the beginning of the vocal output • Do not code a second vocal mand within 2-s of the end of the first
Switch	A physical push and release of the button that (typically) results in the output of "Eat" (Bowie), "I want the iPad" (Tumas), or "My turn," (Fawn)	• Pushing the switch and immediately releasing, resulting in phrase emission • Holding the switch down for 2 s prior to releasing • Pushing the switch and releasing, resulting in no output	• Code when the output begins • Do not code if hand rests on switch but is not removed to create the output • Do not code a second switch mand within 2-s of the final output
iPad	A physical press/tap and release on the iPad that (typically) results in the output of "Eat" (Bowie), "I want the iPad" (Tumas), or "My turn," (Fawn)	• Tapping the iPad and immediately releasing, resulting in phrase emission • Holding the iPad down for 2 s prior to releasing • Tapping the iPad and releasing, resulting in no output	• Code when the output begins • Do not code if hand rests on i{ad but is not removed to create the output • Do not code a second iPad mand within 2-s of the final output
Picture	A physical transfer of the picture card from the board/floor towards the implementer's body	• Picking up the picture and holding it toward implementer, with implementer accepting it • Picking up the picture and holding it toward implementer, without it being accepted	• Mark the behavior at the moment the hand holding the picture extends furthest from the body toward the implementer • Do not code a second picture mand until the picture has been returned to the board/floor or back to the body for at least 1 s
Sign	A physical movement of an open hand to touch the child's chest at least one time	• Touching the chest with an open hand and removing it quickly, repeating two times • Touching the chest with an open hand and leaving on for 2 s prior to removal	• Mark the behavior the moment the hand first touches the child's chest • Do not code a second sign mand until 2 s have passed without hand touching chest

Table 1, cont.
Dependent Variables: Operational Definitions, Examples, and Coding Rules

Behavior	Operational Definition	Examples	Coding Rules
Challenging Behavior			
Bowie	• **Hitting, slapping:** forceful physical contact or attempted contact with hand/arm toward a person or an object • **Property destruction:** biting or throwing objects not intended for this use • **Yelling:** vocal output that is louder and higher in pitch than conversational volume	• Making a hitting motion toward implementer but no contact is made • Chewing and tearing at the mand picture • Forcefully slapping table with an open hand	• Code an interval as having challenging behavior if such behavior occurs at any point during the interval
Tumas	• **Hitting, kicking, slapping:** forceful physical contact or attempted contact with hand/arm/foot toward a person or an object • **Scratching**: forceful raking of fingernails across the body or clothing of another • **Property destruction:** Throwing objects not intended for this use	• Making a hitting motion toward implementer but no contact is made • Rapidly raising and lowering heels towards floor • Throwing iPad across room	• Mark the moment the child's body part makes contact with the person/object that is impacted; if no impact is made mark when behavior begins • Code a unique occurrence each time a challenging behavior occurs that is separated by the previous challenging behavior by at least 1 s
Fawn	• **Yelling**: vocal output that is louder and higher in pitch than conversational volume • **Self-injurious behavior:** forceful physical contact or attempted contact of child's hands/fists and head or head and object	• A 1-s, sharp vocal emission • Raising fists quickly toward head, without contact (i.e., blocked by implementer)	• Code a unique occurrence each time a challenging behavior occurs that is separated by the previous challenging behavior by at least 2 s

Thus, if any target behavior (i.e., mand or CB) or mand modality (i.e., vocal, switch, iPad, or picture) occurred within the 2-s interval it was marked. Finally, each *interval* was coded as variable or invariable. When an interval included a mand, the interval was coded as variable given either of the following circumstances: (a) the interval differed in *any* way from the previous mand interval (e.g., the previous mand interval included only a switch mand and the current interval included only an iPad mand; the previous mand interval included a vocal mand and the current interval included both a vocal mand and a picture mand); or (b) the interval included two or more mands and was identical to the previous mand interval. These coding rules were chosen to best reflect the true variability of Bowie's manding, as assessed by video review of the typical variability of multiple modalities occurring in consecutive intervals.

Interobserver Agreement

We assessed interobserver agreement (IOA) for >30% of randomly-selected (via a random number generator) sessions across participants, conditions, and behaviors (i.e., 35% for Bowie, 36% for Tumas, and 40% for Fawn). The primary coders—a master's student in special education for Bowie and a second master's student in special education for Tumas and Fawn—were blind to which videos were selected for IOA. Data coded by the primary coder and the reliability coder (myself) were compared using the point-by-point method of agreement (i.e., total number of agreements divided by number of agreements plus disagreements, multiplied by 100; Ledford, Lane, & Gast, 2018a). We calculated agreement for the three behavioral categories (i.e., response type [mand or CB], mand modality, and mand variability) individually to provide a percentage of agreement for each.

For Bowie, whose behavior was estimated via PIR, we assessed agreement of response type and mand modality across each 2-s interval. For Tumas and Fawn, whose behavior was recorded using event recording, we assessed agreement on response type and mand modality for all responses marked by at least one coder. Each behavior marked by one coder was required to have been marked by the other coder within a 2-s window in either direction for these to result in an agreement; if the time stamp or behavior marked by one coder was absent or different from the second coder, a disagreement was marked. Across participants we calculated mand variability only when both coders agreed a mand had occurred (as indicated by a consistent time stamp for event recording or the presence of any mand within an interval for PIR). We discussed all disagreements at weekly coding meetings and resolved these through consensus. However, to maintain consistency between videos that were and were not double coded, no data were changed based on these discussions. Following the conclusion of data collection, the average IOA by category was calculated for each participant, condition, and behavior to produce summative IOA estimates. In addition, we co-graphed the data (i.e., each coding variable individually) of both observers to discern potential observer drift or bias.

Code development and training. Due to the requirement of timely data analysis for single case research (Ledford, Lane, & Severini, 2018b), I initially coded all data to permit daily data-based decision making while agreement was achieved. Thus, following the beginning of data collection for each participant I trained the primary coder to fidelity using video footage, first of sessions simulating the conditions of the study (collected via previous, unrelated research) and then of actual sessions with study participants. No sessions that were used as practice were later used to assess IOA. The primary coders and I achieved agreement using three steps: (1) engaging in joint coding sessions; (2) independently coding sessions; and, once primary coders felt confident in the operational definitions and coding rules, (3) calculating agreement following coded videos. Three videos resulting in 90% or greater agreement for each behavioral category demonstrated IOA had been established. This commenced the re-coding of all sessions by the primary coder, with IOA checks occurring evenly throughout all phases of the study to ensure we maintained acceptable levels of agreement.

Procedural Fidelity

Procedural fidelity was assessed to ensure each child (a) was appropriately assessed (increasing the likelihood of an accurate identification of behavioral function), and (b) received the intended baseline and intervention procedures (increasing our confidence that any behavioral changes were due to the intervention being implemented as intended). Procedural fidelity was measured for both the FA (40% of sessions for Bowie, 50% of sessions for Tumas, and 75% of sessions for Fawn)and the intervention (35% of sessions for Bowie, 36% of sessions for Tumas, and 40% of sessions for Fawn); sessions were randomly-selected to include >30% of each condition and phase, per participant. Procedural fidelity measured the adherence to procedures and the dose of the intervention across all conditions, which allowed us to document consistency and differentiation across conditions. For the FA, we ensured the session length, response to CB, response to appropriate behavior, presence/absence of the EO, and presence/absence of control variables (e.g., preferred tangible items available in play condition) were appropriate for each condition. For intervention conditions, we tracked session length, availability of all mand materials, response to CB and response to mands (which were condition-specific), length of reinforcement, and appropriate reinstatement of the EO. For mands, we recorded errors of omission and commission, and for FCT/Lags 2 and 3 we assessed the appropriate reinforcement of pre-session mands. In all cases, fidelity was assessed by a coder who was not directly involved in the session (i.e., a master's student in special education) to reduce the potential for rater bias. In addition, to assess IOA I scored procedural fidelity for >30% of randomly-selected sessions across participants and conditions.

Social Validity

I evaluated the social validity of the study as rated by parents of included children and by masked raters. For parents, a modified version of the TARF-R (Reimers & Wacker, 1988) was used to measure the perceived social validity of the goals, intervention procedures, and child outcomes. Although subjective, this measure nonetheless provides important information regarding the impact of the intervention as rated by individuals directly impacted by child behavior and invested in child outcomes (i.e., parents; Strain, Barton, & Dunlap, 2012; Wolf, 1978). This measure was provided prior to the commencement of intervention and immediately after, to allow for comparison across time points.

For masked raters, I recruited current or former preschool teachers and individuals with a behavior credential to view randomly-selected video clips of baseline and intervention (i.e., FCT/Lag 2 or 2') sessions, following the conclusion of data collection for all participants. Raters were consented in person, after which they were sent an email with (a) a REDCap link to a researcher-created social validity questionnaire, and (b) a secure Box link to the two video clips of their selected child. Participants were asked to rate the change, if any, in child behavior and demeanor and the acceptability of implementer behavior across videos using a measure developed for this study (Appendix A). In addition, for intervention sessions participants rated the utility and feasibility of procedures. Because the children—but not necessarily myself—were unknown to the raters, raters were theoretically less likely to rate the change or procedures as positive due to social constraints (which were more likely for parents). Thus, this measure was hypothesized to serve as a more objective measure of the social significance of the intervention.

Experimental Design and Data Analysis

Two distinct experimental designs were used: a multi-element for the FA and an A–B–A-B for the intervention.

Functional Analysis

I determined the function of children's CB using a multi-element design. In this design, test conditions (i.e., sessions testing potential functions maintaining CB) were compared to a control condition (i.e., a condition unlikely to occasion CB). The number and type of conditions tested was determined from the results of the parent-completed Open-Ended FAI, which asked parents questions specifically targeting the potential function(s) of their child's CB. The number of sessions per condition was individualized and was dependent on (a) the severity of the CB and (b) the level and consistency of the data (with a minimum of three test and three control sessions per participant). We alternated conditions sequentially, beginning with a play session, such that each condition was presented a single time before the alternate condition was repeated.

Intervention

We used a variation of the A–B–A–B design to assess the effects of the intervention on the dependent variables. This design is one of the strongest single case research designs for demonstrating experimental control of reversible behaviors (which countless studies have demonstrated are properties of the dependent variables; Gast, Ledford, & Severini, 2018) and comparing between conditions during which the intervention is present and conditions in which it is not. Importantly, the A–B–A–B portion of the design in this study was a true reversal, during which one target behavior was reinforced during baseline (i.e., CB) and a contrasting behavior was reinforced during intervention (i.e., target mands; Gast et al., 2018), rather than a withdrawal.

The A–B–A–B–C variation included a baseline A condition (with reinforcement for CB but not for appropriate behavior), an intervention B condition (with reinforcement for mands meeting the current lag requirement, but no reinforcement for CB) with an increasing lag from FCT/Lag 0 to a culminating FCT/Lag 2 or 3, and a generalization C condition, in which mothers implemented the intervention with our support. In addition, for Tumas and Fawn we also implemented a B' condition (i.e., A–B–B'–A–B'–C) in which access to mand modalities was restricted for approximately 2 s following the reinforcement of any mand.

Data Analysis

Formative and summative analyses were conducted using the visual analysis guidelines outlined by Barton, Lloyd, Spriggs, & Gast (2018). The analysis of the FA was cross-conditional only. That is, I compared the level of data for each test condition to the control condition; if the test condition consisted of data consistently higher than data of the control condition it was identified as a function of the child's target CB. For the intervention, I conducted within- and across-condition analysis, analyzing the level, trend, variability, overlap, immediacy of change, and consistency of all data. Data were analyzed formatively to ensure the intervention resulted in positive changes in child behavior; if no changes or counter-productive changes occurred the intervention was modified in a manner hypothesized to produce therapeutic outcomes (as detailed below). Summative data analysis was used to answer the research questions. To evaluate if the FCT/Lag intervention resulted in increased mand persistence, increased mand variability, and a reduced level of CB when compared to baseline (RQs 1a-c), I compared data across conditions. To evaluate if an increase in the lag schedule resulted in an associated increase in mand persistence or variability and a decrease in CB (RQs 2a-c), within-condition comparisons of intervention phases were conducted.

CHAPTER III

PROCEDURE

Pre-Study

I consulted with members of my dissertation committee during the study's development and proposal defense, and with my advisor as needed during implementation and data analysis. After defending my proposal, I made any changes required or suggested by my committee; all changes made related specifically to the experimental design. Once IRB approval was obtained, I recruited dyads by contacting the directors of four programs—Susan Gray School, HOPE Autism and Behavioral Services, the Treatment and Research Institute for Autism Spectrum Disorders (TRIAD), and the Vanderbilt Behavior Analysis Clinic (BAC). However, all included participants were located via the Assistant Director of the preschool for children with Autism at the Vanderbilt Bill Wilkerson Center. I commenced study procedures following the consent of each dyad, such that each dyad was in a different intervention phase throughout the duration of the study, and only Bowie and Tumas overlapped temporarily.

Preliminary Assessment

A parent interview and child observation provided preliminary assessment information on each child, which was used to design the FA and intervention. I conducted the parent interview using the Open-Ended FAI, which allowed me to learn about the child's communication level, interests and preferences, and CB (i.e., typography, intensity, potential EOs, and potential maintaining variables). In addition, I collected demographic information (e.g., children's and parent's age and race/ethnicity, children's educational and therapeutic services) at this time. Concurrently, a research assistant engaged with the child with his or her favorite materials. This served to provide additional, anecdotal information regarding the child's developmental level, behavioral repertoire, and CB.

Study Overview

I next provided parents a 30-min PowerPoint presentation outlining study procedures and their behavioral foundations; during this time a research assistant engaged with the child. Presentations included general information about behavioral function, FA purpose and procedures, and baseline and FCT/Lag purpose and procedures, with hypothesized timelines and outcomes for each study component. During the presentation I stressed the importance of maintaining experimental control, and asked parents to refrain from utilizing any of the study procedures until the conclusion of all data collection. Specifically, I requested they continued to respond to challenging behavior and target mands as they normally would. In addition to this PowerPoint presentation, a short review of the purpose and procedures of each study component (e.g., FA, FCT/Lag) was provided prior to the commencement of that component.

Functional Analysis

Given FAs can be stressful for both implementers and recipients—and prolonged assessment delays the onset of a potentially critical intervention—we made every effort to identify a function that maintained each child's CB as efficiently as possible. Thus, because a single, dominant maintaining function—tangible—was indicated by parent interview and child observation for all children, we completed a single-function FA (Iwata & Dozier, 2008) with all participants. That is, a single test (tangible) condition was compared to a control (play) condition. The minimum number of sessions necessary to determine function while maintaining a high degree of confidence were conducted (i.e., three to five). Two implementers with experience conducting FAs (i.e., myself and a master's student in special education) were present for the duration of all sessions: I conducted all sessions and the second implementer video-recorded and graphed data (via pencil-and-paper data collection and data input into Excel). No other people were in the room, but Fawn's mother observed the FA sessions from the one-way mirror in the attached observation room.

Conditions

Conditions consisted of a tangible test condition and a play control condition. Sessions alternated between test and control, beginning with a control, such that one session of one condition was presented prior to the other being repeated. All sessions were 5 min long.

Tangible. This condition tested for behavior maintained by access to preferred items, specifically preferred snacks for Bowie, an iPad for Tumas, and an iPad or animal figurines for Fawn. Prior to each session, we provided each child with free access to their highly-preferred item for 30 s. At the start of the session, we removed access to the item and I began to interact with it. If a child emitted target CB the item was returned immediately—or for Bowie a single piece of snack was provided—concurrent with a verbal response from me (e.g., "Oh, you want the iPad;" "Ok, you can have it!"). For Tumas and Fawn, once the item was returned s/he was given 30 s to interact with it (after which it was removed again and the process was repeated); for Bowie the process was repeated after a single snack piece was provided. If a child appropriately bid for attention during the session I responded neutrally, but I did not provide access to the item if requested.

Play. This condition was used as a control, to determine if CB would occur when the child had free access to preferred items, activities, and forms of attention. For each child, preferred items included those present in tangible sessions in addition to other items identified as preferred via the Open-Ended FAI. We presented no demands during this condition, and attention was provided at least once every 15 s. If CB occurred, I ensured 5-10 s elapsed before reinstating attention.

Mand Modality Assessment

I selected potential mands via parent interview and child observation. During the interview, I asked parents what mand modalities were already in the child's repertoire. Child observations provided additional evidence on the physical strengths and constraints of participating children that might impact the ability to engage with certain modalities. I ultimately selected five potential modalities for assessment for Bowie and Tumas (i.e., vocal, switch, iPad, picture exchange, and sign) and four for Fawn (i.e., switch, iPad, picture exchange, and sign).

The mand modality assessment followed the procedures of Ringdahl and colleagues (2009). In summary, we assessed each mand modality individually for a total of 10 consecutive trials. Each trial began with the EO in place and free access to the required mand device (e.g., switch, picture card). A least-to-most prompting procedure (i.e., vocal prompt, model prompt, physical prompt) was used as needed during each trial. I first presented a vocal prompt: "If you want _____, press the button." If the child did so, s/he was provided with 30 s of access to the reinforcer (or a single snack piece for Bowie). If within 3 s s/he did not do so, I stated, "If you want _____, press the button like this," while modeling the action. If successful, reinforcement was provided. If not, the third prompt—"If you want _____, press the button like this" (while the second implementer provided a hand-over-hand prompt from behind)—was provided 3 s later (at which point the child received access to the reinforcer). Given the third prompt could not be provided for vocal mands, a 5-s pause occurred between each trial after which the procedure began again. A 1-min break with no access to the reinforcer separated the assessment of each mand modality.

If a child demonstrated any independent use (i.e., s/he emitted the mand following a verbal prompt alone) of exactly four mand modalities during the assessment, these were selected for the intervention, which occurred for Fawn (Table 2). If a child demonstrated success with more than four modalities—as was the case for Bowie and Tumas—modalities were selected based on (a) the level of proficiency achieved (i.e., the cumulative level of prompt required across trials), and (b) parent preference. For both Bowie and Tumas, the mand modalities selected were the switch, iPad, vocal, and picture.

Table 2
Percentage of Mands Emitted Following Vocal Prompt Alone During Mand Modality Assessment

Mand Modality	Bowie	Tumas	Fawn
Switch	90	100	100
iPad	100	100	100
Picture	60	100	100
Vocal	90	100	NA
Sign	20	100	100

Intervention

The intervention was provided using an A–B–A–B design framework, as previously discussed. I—a, 36-year-old White female with doctoral-level training in special education and credentialed as a BCBA—implemented all sessions; a second implementer—a 23-year-old, Mexican female graduate student in special education working towards behavior analysis certification—provided implementation support (signaling appropriate mands to reinforce) and recorded and graphed data (via pencil-and-paper data collection and data input into Excel).

Each 5-min session began with the participant-specific tangible EO in place. That is, I provided 30 s of pre-session free access to the tangible maintaining the CB and removed or restricted access as the session began. All devices required for target mands were readily-accessible on the table or floor and within easy reach of the participant across conditions. Bowie and Tumas's mother chose to be absent for all sessions but generalization. Fawn's mother was in the room in the home setting and either present in the room or watching through the observation window in the clinic for all sessions; in no instance did she intervene in procedures, but did smile at Fawn one time during the second baseline condition (i.e., Session 21).

Baseline (A)

Baseline procedures were identical to those of the tangible condition FA, with the exception of the addition of the mand materials. Thus, we reinforced CB but not appropriate mands.

FCT/Lag (B)

Prior to beginning each FCT/Lag session, I reviewed the contingency with the child, reminding them of the different mand modalities they could use to request the tangible item. During FCT/Lag 0, each independent mand of any modality was immediately reinforced. For Tumas and Fawn, this consisted of access to 30 s access of reinforcement (i.e., interacting with the iPad or animal figurines); for Bowie, each mand resulted in a single piece of an edible. All of Bowie's mand were reinforced save a few, isolated instances in which providing another edible might have resulted in choking. For Tumas and Fawn, if a mand occurred while the child already had access to the reinforcer it was ignored. In addition, if a mand occurred concurrent with CB, I said "I don't understand–try again," providing no additional consequence. If at any point there was 1 min in the EO with no manding, a single least-to-most prompt sequence was implemented; this occurred only with Bowie, during a single session. Finally, any instances of CB were ignored and blocked as necessary.

During FCT/Lag 1, procedures were identical to FCT/Lag 0 with the following exception: To receive reinforcement each mand modality was required to be different from the modality that occurred directly prior. In addition, each time reinforcement was provided I noted why the mand was reinforced (e.g., by stating, "Great! That was different."). If multiple mand modalities began at precisely the same time and one or both were variable, manding was reinforced; if neither were variable no reinforcement was provided.

During FCT/Lag 2 and FCT/Lag 3, procedures were identical to the FCT/Lag 1 condition, excepting: (a) to receive reinforcement during FCT/Lag 2 or FCT/Lag 3, each mand modality was required to be different from the *two* or *three* (respectively) modalities occurring directly prior; and (b) prior to the commencement of sessions, pre-session reinforcement was provided for a specific number of mands—two in the Lag 2 condition and three in the Lag 3 condition—regardless of variability (similar to the procedures of Heldt & Schlinger, 2012). Once the specific number of mands occurred and were reinforced we began the session. Due Bowie's undesirable response to FCT/Lag 3 (see Bowie's intervention results, pg. 21), Bowie was the only child with whom we implemented FCT/Lag 3.

FCT/Lag' (B')

For Tumas and Fawn, who began to engage in non-functional, repetitive responding (see pg. 33 for a discussion), an FCT/Lag' phase was introduced in which (a) mand devices were rotated following each reinforced mand, and (b) response interruption and redirection (RIR; Ahearn, Clark, & MacDonald, 2007) was implemented following the emission of a mand that met the reinforcement requirement of the current lag schedule. For Tumas this phase was introduced following FCT/Lag 1, and for Fawn after FCT/Lag 0.

Generalization (C)

This condition was identical to FCT/Lag 2 (or FCT/Lag 2', for Tumas and Fawn), with the exception that the intervention was implemented by the parent with researcher support (e.g., prompting to reinforce a mand, praise for correct implementation).

CHAPTER IV

RESULTS

We identified a functional relation between FCT with lag reinforcement and the frequency and variability of mands for all participants. That is, FCT with lag reinforcement—with and without modifications—resulted in a reliable increase in both the frequency and variability of mands when compared to a baseline condition. Further, the intervention resulted in a decreased level or increased variability of challenging behavior across all children. Importantly, increases in the lag requirement (up to Lag 2) resulted in concomitant increases in mand frequency and variability, demonstrating preschool children can fluently use a variety of mand modalities when required to do so. These results support Falcomata and colleagues' (2018) outcomes and indicate FCT with lag reinforcement might be an appropriate intervention for use with preschool-aged children with challenging behavior.

Bowie

Functional Analysis

The Open-Ended FAI and observation indicated that Bowie's CB was maintained by denied access to or removal of preferred tangible items—particularly snack foods—and denied access to or removal of his mother's undivided attention. However, given the intervention required non-parent manipulation of the reinforcer, we only tested a tangible condition during the FA. In the test condition, I placed Bowie's preferred snack item (cheese puffs) on the table, but out of reach, and blocked access when he reached for them. Upon each act of CB I provided a single edible and repeated the procedure. During the play condition Bowie had free access to the poofs as well as my attention and additional preferred tangible items (e.g., piece of string, musical toy).

As seen in Figure 1, we conducted five sessions each of play and test conditions, beginning with play. Bowie engaged in no instances of CB during the play condition, and engaged in CB in all test conditions except Session 6 (*range* = 0-10). Notwithstanding one overlapping datum point, the results of the FA indicated that denied access to preferred edibles was a function of Bowie's CB.

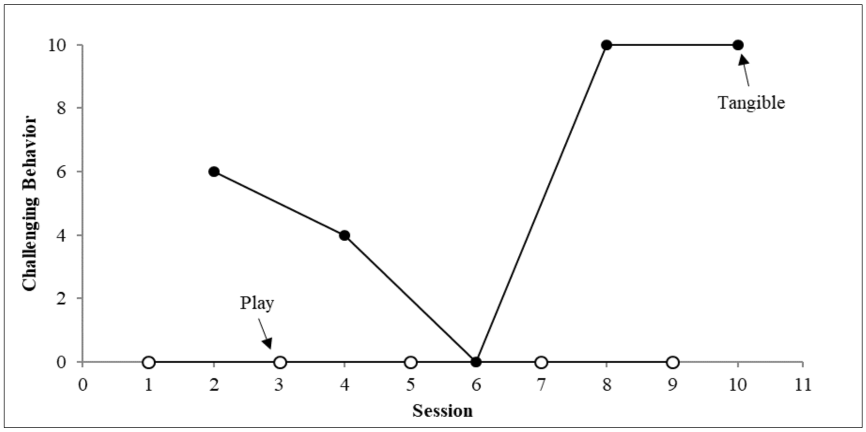

Figure 1. Bowie's functional analysis.

FCT/Lag

Mands. Bowie emitted mands in 27% of intervals in Session 1 (Figure 2), after which the frequency of mands exhibited a downward trend through Session 4, a small increase in Session 5, and a final decrease in Session 6. Variable manding demonstrated a decrease throughout the entire baseline condition, beginning with 11% of intervals and ending with a single variable mand per session.

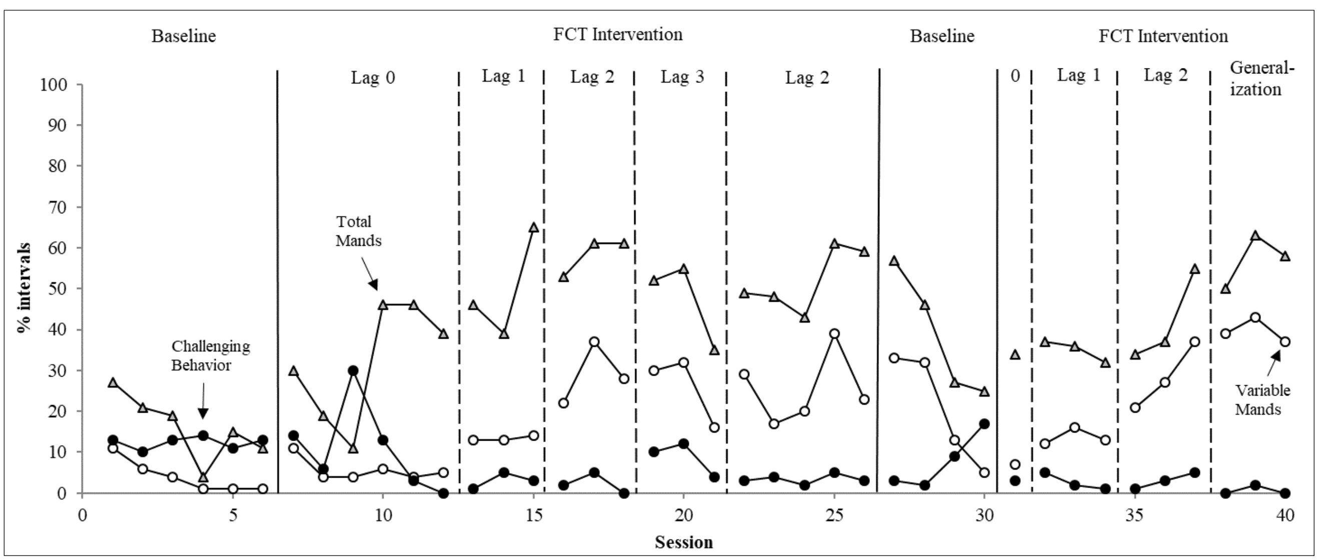

Figure 2. Percentage of intervals in which Bowie emitted a mand (closed triangles), variable mand (open circles), or challenging behavior (closed circles) during the FCT/Lag intervention.

There was an immediate increase in both the total (30%) and variable (11%) mands Bowie emitted in the first session of the FCT/Lag condition. While variable mands remained stable (range = 4%-11%) throughout the Lag 0 phase, total mands demonstrated less stability, with a decrease to 11% during Session 9 followed by a sharp increase to 46% in Session 10. When the lag was increased Session 13, there was an increase in both dependent variables, with a range of 39%-65% of intervals for total mands and 13%-14% of intervals for variable mands. The introduction of Lag 2 resulted in additional increases in total mands (*range* 53%-61%) and variable mands (*range* = 22-37%), with some variability. Data patterns changed, however, when Lag 3 commenced Session 19. Although both dependent variables remained relatively stable for the first two sessions, both dropped sharply during the third. Following this decrease, we returned to Lag 2 until data demonstrated patterns similar to those of the initial Lag 2 phase. Upon the reintroduction of baseline Session 27, Bowie maintained his level of both dependent variables for the first session, after which both sharply decreased to a low of 25% of intervals for total mands and 5% of intervals for variable mands Session 30. We attempted a fifth baseline session following this, but chose to stop data collection mid-session when Bowie began to engage in severe SIB (e.g., forcefully banging head on table), which had not been demonstrated during the study. Due to this extreme negative response, rather than return to Lag 2 immediately (as was proposed) we opted to return to Lag 0 and increase the response requirement when data were stable, as we did with the initial FCT/Lag condition. Following a single session of Lag 0 we moved to Lag 1, during which Bowie's level of total and variable mands approached those demonstrated in the original Lag 1 phase. We then moved to Lag 2 and saw an increasing trend in both variables, with the final session (Session 37) demonstrating levels similar to the initial Lag 2 (total mands = 55%; variable mands = 37%). During the generalization condition Bowie emitted a frequency and variability of mands similar to the previous Lag 2 phase (total mand *range* 50%-63%; variable mand *range* = 37-43%). During this condition he reached his highest level of both total and variable mands seen throughout intervention, emitting one or more mands during 63% of intervals and one or more variable mands during 43% of intervals in Session 39.

Challenging behavior. Bowie engaged in a stable level of CB during baseline, with CB occurring between 10% and 14% of intervals (Figure 2). CB remained stable during the first FCT/Lag session, after which variability increased prior to demonstrating a sharply decreasing trend, culminating in zero CB in Session 12. CB remained low, if somewhat variable, through the remainder of Lag 1 and Lag 2 (*range* = 1%-5%). When we introduced Lag 3, we saw an immediate increase in CB to baseline levels, which then decreased throughout the phase. The return to Lag 2 resulted in low levels of CB, similar to the initial lag phases (*range* = 2%-5%). Although these levels remained constant during the first two sessions of the second baseline condition, Bowie emitted a greater frequency of CB in Sessions 29 and 30, culminating with his highest level: 17% of intervals. We when reinstated the FCT/Lag intervention, Bowie's CB returned to levels similar to those of the initial Lags 1 and 2 (*range* = 1%-5%). Finally, Bowie emitted little CB during the generalization condition, with no CB Sessions 38 and 40 and CB in 2% of intervals Session 39.

Mand modality. Bowie's use of the four mand modalities varied across conditions and lag schedules (Figure 3). He manded with the switch most frequently across all conditions except the original baseline condition, employing this modality an average of 25% of intervals across conditions. He manded with the iPad second-most frequently (11%), followed by picture exchange (5%), and vocal communication (2%). While the switch and iPad were used regularly across conditions, picture exchange occurred more frequently as the study progressed, save the return to baseline and the second Lag 0 condition. His use of picture exchange peaked at 10% of intervals in the final Lag 2 and generalization conditions. Conversely, vocal manding peaked during Lag 3 (12%) before decreasing, and ultimately desisting, by the second Lag 1 condition.

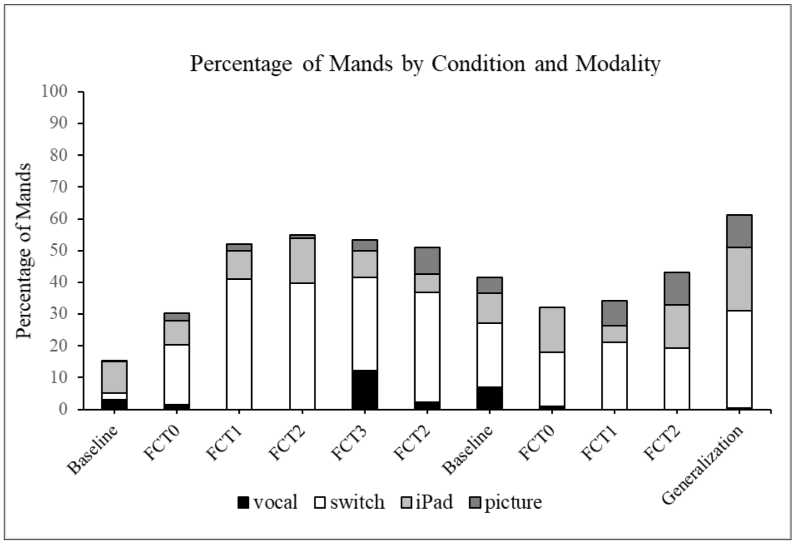

Figure 3. Percentage of mands emitted by Bowie, by condition and modality.

Summary. Bowie's data demonstrated a clear functional relation between the FCT/Lag intervention and (a) the frequency and variability of mands and (b) the frequency of CB. This was indicated by the immediate increase in both the frequency and variability of mands when the FCT/Lag intervention was introduced and a sharp decrease when baseline was reinstated, and the opposite pattern for CB. In addition, his data demonstrate a relation between the frequency and variability of mands and the lag schedule in place (up to Lag 2), as indicated by an immediate increase in both variables each time the lag was increased. Results between use of each modality and condition/phase were inconsistent.

Tumas

Functional Analysis

The results of the Open-Ended FAI and observation conducted with Tumas and his mother indicated multiple functions of his CB: attention, escape, and tangible. Ultimately, we decided to test tangible only, as Tumas's CB was reported as most prevalent and disruptive following denied requests for or removal of preferred items. Further, we observed that this behavior often appeared to set the occasion for continued, attention-maintained CB.

We conducted three test (i.e., tangible) and three control (i.e., play) sessions, beginning with control. Tumas engaged in zero instances of CB during the control condition, and 6-8 instances per test condition (Figure 4). Given this clear and continual separation of the two conditions we verified that Tumas's CB was maintained—at least in part—by tangible reinforcement.

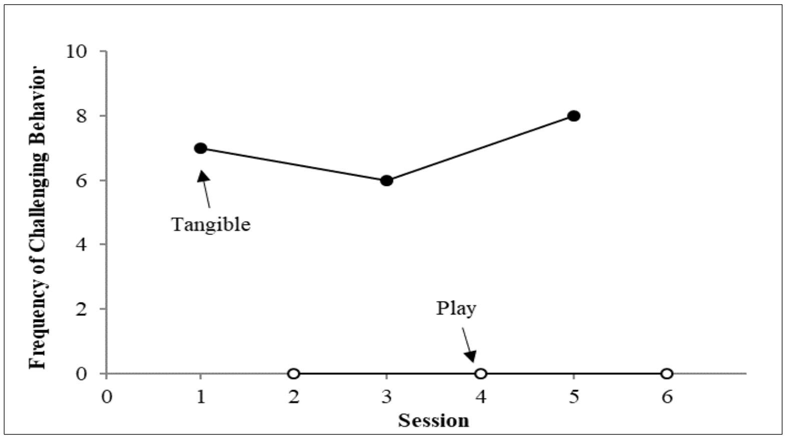

Figure 4. Tumas's functional analysis.

FCT/Lag

Mands. Tumas engaged in zero mands Session 1, followed by an increasing trend in total mand frequency for the next three sessions and a steep decline the final baseline session (Figure 5). Variable mands remained low and stable (*range* = 0-1). There was an immediate increase in level in total mands upon commencement of the intervention, and an increase in variable mands in the second intervention session. Both total and variable mands demonstrated an increasing trend for the remainder of the Lag 0 phase, with some variability. Although there was a notable increase in the number of total and variable mands in the Lag 1 (total mand *range* = 10-24; variable mand *range* = 6-22) data were quite variable and overlapped greatly with Lag 0 data. In addition, during Lag 1 Tumas began to display repetitive behavior, manding with more modalities than was necessary to receive reinforcement. Thus, Session 16 we introduced the Lag 1' phase. Once this modification was made, total and variable mands immediately stabilized, at a level lower than Lags 0 or 1 (total mand *range* = 11-12; variable mand *range* = 6-8). When Lag 2' began, Tumas's mands immediately increased and remained stable (total mand *range* = 9-21; variable mand *range* = 7-18) throughout the phase, excepting the single-session decline in both variables (Session 21). Upon the return to baseline, Tumas continued to emit a consistent level of mands the first session—17 total mands, 15 of which were variable—after which both total and variable mands demonstrated a sharp decrease, culminating with 0 of either Session 27. Once the intervention was reinstated Tumas's level of total and variable mands immediately increased to a level at or equal to the previous Lag 2' phase, and remained high and stable for the remainder of the phase. Finally, Tumas demonstrated a high and stable frequency of mands during the generalization condition. Similar to Bowie, during this condition he emitted his highest frequency of both total (26) and variable (23) mands.

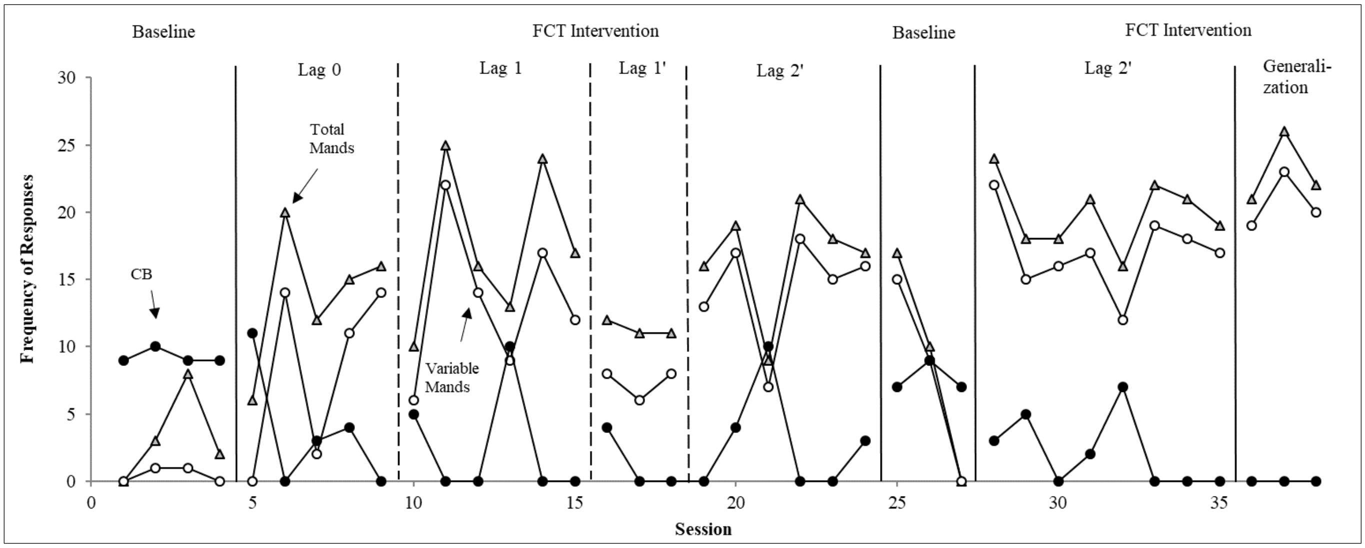

Figure 5. Number of mands (closed triangles), variable mands (open circles), or challenging behavior (closed circles) emitted by Tumas during the FCT/Lag intervention.

Challenging behavior. Tumas emitted a high, stable level of CB throughout the first baseline condition (*range* = 9-10; Figure 5). Upon the commencement of Lag 0, CB initially increased to 11 instances, after which behavior decreased and was somewhat variable for the remainder of the phase (*range* = 0-4). CB remained variable during Lags 1 and 1', with Tumas engaging in zero CB for two-thirds of sessions, but between 4 and 10 instances in the remaining sessions. Lag 2' began with an increasing trend in CB the first three sessions, from zero instances Session 19 to 10 instances Session 21. Following this, CB decreased—with some variability—for the remainder of the phase. With the return to baseline, Tumas engaged in a stable level of CB similar to the initial baseline condition (*range* = 7-9). His level of CB decreased immediately upon the return to Lag 2' and was variable for the next four sessions (*range* = 0-7). Following this, CB stabilized to zero instances per session for the remainder of the phase and throughout the generalization condition.

Mand modality. As seen in Figure 6, Tumas' primary communication modalities were consistently the switch and iPad, which were used approximately equally within each condition and phase. Upon commencement of Lag 1, Tumas began to mand using picture exchange, after which this modality was used to produce 9-26% of mands across all remaining conditions and phases. Vocal mands were rarely emitted but occurred a single time during Lag 1, the initial Lag 2', and generalization, and two times during the return to Lag 2'.

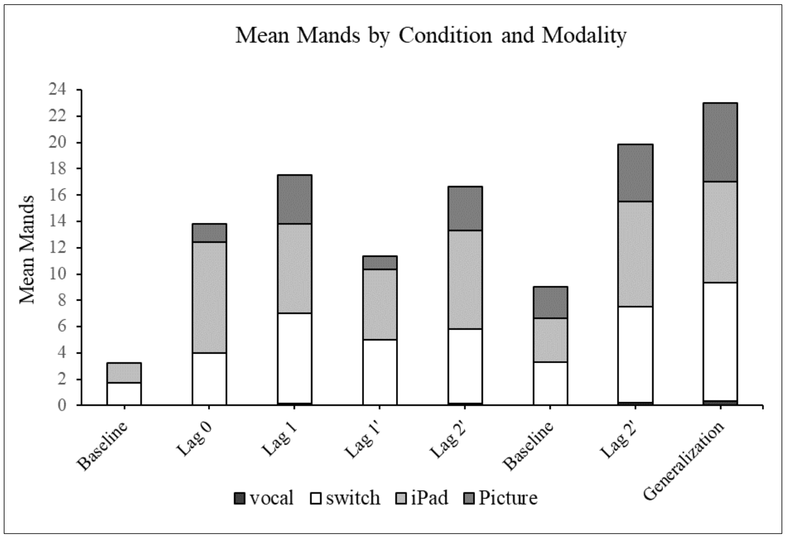

Figure 6. Mean number of mands emitted by Tumas, by condition and modality.

Summary. There was a functional relation between FCT/Lag intervention and the frequency and variability of mands for Tumas, as demonstrated by the increase in the frequency and variability of mands when the FCT/Lag intervention was introduced and the rapid decreasing trend when baseline was reinstated. In addition, although less distinctive, a functional relation between Tumas's CB and the intervention was demonstrated, as indicated by the overall decrease in level and increase in variability (which is indicative of a relation between the behavior and the contingency) of this behavior. Tumas's data also reveal a relation between the frequency and variability of mands and the lag schedule—following the addition of RIR in Lag 1'—as indicated by the increase in both variables with the increase from Lag 1' to Lag 2'. In addition, a relation was present—to some extent—between the use of certain mand modalities (i.e., picture exchange and vocal mands) and the lag schedule.

Fawn

Functional Analysis

The open-ended FAI was conducted with Fawn's mother. Along with our observations, the results indicated that Fawn engaged in CB in response to multiple situations (e.g., denied requests or to preferred items; personal frustrations, such as a tower falling over). Her mother noted that the CB typography that occurred most frequently was screaming, typically when preferred items were removed or denied. For this reason, we opted to perform a single-function FA with a tangible test condition and a play control condition. Because her mother reported she was especially fond of animals, both conditions included highly-preferred, animal-themed tangible items, including an iPad loaded with animal apps, animal figurines, and animal puzzles. We conducted six sessions, alternating between test and control.

Fawn engaged in variable levels of CB throughout the FA, as seen Figure 7. She emitted 0-3 CBs in play sessions and 1-13 CBs in test sessions, resulting in one overlapping datum point. Anecdotally, the variation in CB across sessions may have been due to the variability of included tangible items, some of which resulted in more (apparent) frustration for Fawn, either when they were removed or when they did not perform as desired (e.g., animal figurines wouldn't "stand up," but would instead fall over on their sides). Regardless, the relatively low CB emitted during the play condition and the overall separation between data paths indicated that a function of Fawn's CB was to gain or retain access to preferred tangible items. Further, the level of CB Fawn demonstrated during the test condition demonstrated her baseline level of CB given no implementer interference.

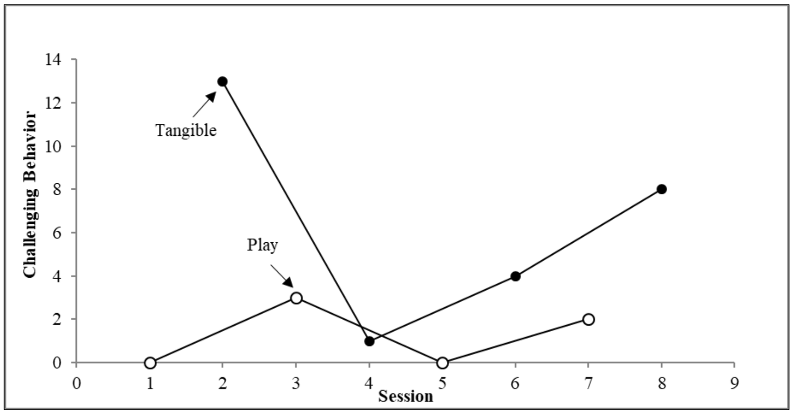

Figure 7. Fawn's functional analysis.

FCT/Lag

Mands. Fawn emitted six total mands and one variable mand during the first baseline session (Figure 8). Following this, total mands demonstrated a downward trend, hitting floor level Session 4; the level of variable mands was stable for three sessions before dropping to zero the final baseline session. Both total mands and variable mands demonstrated an immediate increase with the first FCT/Lag session, followed by an increasing trend in both variables for the remainder of the Lag 0 phase. However, given this rapid increase in level was in part due to the commencement of her repetitive manding, we introduced a Lag 0' phase Session 9. Upon introduction of this phase, Fawn's use of mands—both total and variable—decreased and stabilized (total mand *range* = 6-7; variable mand *range* = 0-3). Similar data patterns were seen in Lag 1', with an immediate and sizable increase in total and variable mands, followed by a slight downward trend in both, culminating in data stabilization (total mand *range* = 12-14; variable mand *range* = 7-10). Fawn emitted an increased frequency of total mands and variable mands during Lag 2', with both demonstrating an increasing trend throughout the phase. Her manding dropped considerably when baseline was reintroduced Session 20. However, this was followed by a sharp and sudden increase in both total and variable mands Session 22, then a decreasing trend in both for the remainder of baseline. With the reintroduction of Lag 2' came an immediate increase in total and variable mands—with some variability—to their highest levels yet (total mand *range* = 20-22; variable mand *range* = 16-19). Fawn's mands maintained during the first two sessions of generalization, with a notable increase in both (to their highest levels demonstrated) during the final session (total mands = 27; variable mands = 24).

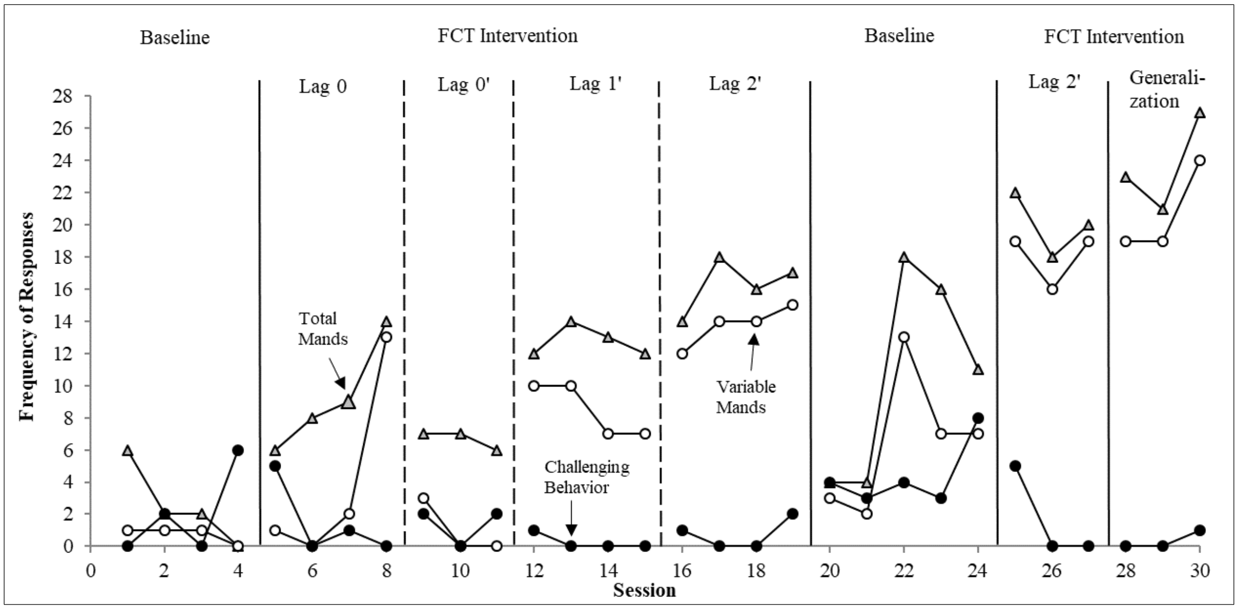

Figure 8. Number of mands (closed triangles), variable mands (open circles), or challenging behavior (closed circles) emitted by Fawn during the FCT/Lag intervention.

Challenging behavior. As seen in Figure 8, Fawn emitted a minimal number of CBs during the first three baseline sessions, followed by a sharp increase to six CB Session 4. Although data were not stable, because Fawn was engaging in increasingly severe SIB during this session, we chose to begin the FCT/Lag intervention Session 5. CB maintained the first Lag 0 session, after which it quickly dropped and stabilized for the remainder of the phase (*range* = 0-1). Fawn demonstrated an increased level of CB—with some variability—during the Lag 0' phase, followed by a reduction to zero occurrences per session for the final three sessions of the Lag 1' phase. When Lag 2' began there was again a minor increase in level with some data instability (range = 0-2). Upon the reintroduction of baseline, Fawn's CB immediately increased and stabilized at three to four occurrences per session, after which her level of CB spiked to eight occurrences Session 24. In the first session of the second Lag 2' phase, Fawn demonstrated some carryover from baseline—emitting five CBs—after which her CB dropped to floor levels. She engaged in no CB for the first two sessions of the generalization condition, and in one occurrence during the final session of the condition.

Mand modality. Fawn demonstrated clear changes in mand modality usage across conditions and phases (Figure 9). Like Bowie and Tumas, she began the intervention communicating primarily via the switch and iPad. She first manded via sign in Lag 0, but did not begin using this modality regularly until Lag 1'. By Lag 2' sign mand frequency had replaced that of switch mands, and Fawn began to use picture exchange as well. Although picture exchange mands were emitted for the remainder of conditions and phases, they occurred minimally, comprising just 3-13% of total mands across condition/phase.

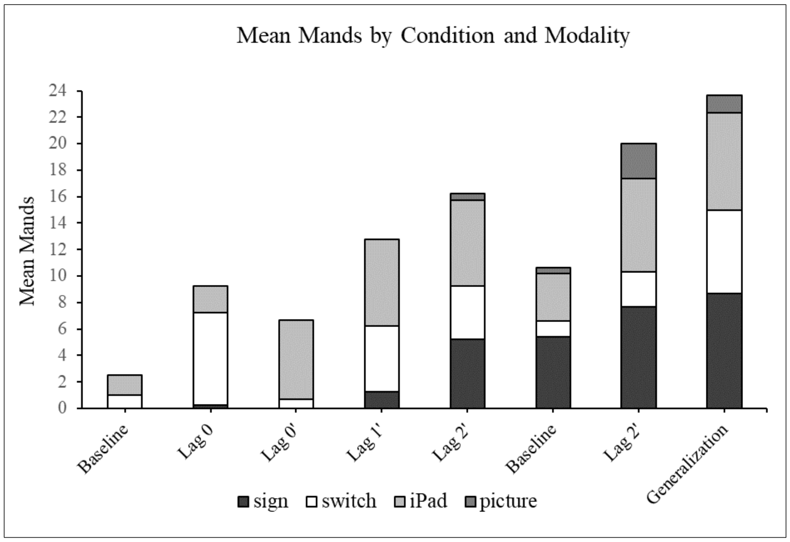

Figure 9. Mean number of mands emitted by Fawn, by condition and modality.

Summary. We identified a functional relation between the FCT/Lag intervention and the frequency and variability of mands for Fawn; furthermore, the strength of this relation appeared directly associated with the lag schedule in place. This can be seen in the immediate increase in the frequency and variability of mands when the FCT/Lag intervention was introduced and when the schedule was increased, and the subsequent data instability when baseline was reinstated. In addition, there appeared to be an association between Fawn's CB and the intervention. However, given the instability of her data and our inability to produce replicable effects, a functional relation was not demonstrated. Finally, we noted a relation between the use of both sign mands and picture exchange mands and the lag schedule, with the frequency of these mands increasing when the schedule required a greater level of variability to result in reinforcement.

Interobserver Agreement

Total IOA was high—with average IOA at or above 80%—across participants, phases, and conditions (Table 3), and across coding variables (Table 4). However, in one instance for Bowie, three instances for Tumas, and five instances for Fawn, a coding variable resulted in a single-session IOA of less than 80%. Typically, these low IOA values occurred early in the coding process (i.e., FA, FCT/Lag 0) and were related to low levels of behavior (i.e., two versus three CBs in a session). Although it is possible these low values indicate possible observer bias or drift, because (a) averages were generally well above acceptable levels across participants, conditions, and variables, and (b) the co-graphed data of both observers indicated no (discernible) observer bias or drift had occurred throughout the study, we feel our data are valid and can be considered accurate depictions of the behaviors as they occurred.

Table 3

Total Interobserver Agreement and Procedural Fidelity by Condition and Phase (in Percentages)

	Interobserver Agreement			Procedural Fidelity		
	Bowie	Tumas	Fawn	Bowie	Tumas	Fawn
FA Play	100	100	100	100	100	100
FA Tangible	86 (57-100)	86 (71-100)	100	100	100	90 (80-98)
Baseline	97 (96-99)	97 (97-100)	93 (79-100)	97 (95-100)	99	92 (75-100)
FCT/Lag 0	98 (97-99)	94 (93-95)	100	98 (96-100)	97 (96-97)	98
FCT/Lag 1	98 (97-99)	98 (97-99)	—	98 (97-99)	93 (92-95)	—
FCT/Lag 2	98 (98-99)	—	—	94 (83-98)	—	—
FCT/Lag 3	99	—	—	99	—	—
FCT/Lag 0’	—	—	94 (88-100)	—	—	90
FCT/Lag 1’	—	100	93 (78-100)	—	100	94 (89-100)
FCT/Lag 2’	—	98 (94-100)	100	—	93 (76-99)	95 (90-100)
Generalization	99	98	100	99	94	93

Table 4

Interobserver Agreement by Coding Variable (in Percentages)

	Bowie		Tumas		Fawn	
	Baseline	FCT/Lag*	Baseline	FCT/Lag*	Baseline	FCT/Lag*
Switch	99 (97-100)	96 (93-100)	100	98 (86-100)	100	95 (50-100)
iPad	97 (97-100)	98 (96-100)	96 (86-100)	95 (78-100)	100	99 (86-100)
Picture	99 (99-100)	99 (97-100)	100	98 (80-100)	100	91 (0-100)
Vocal	99 (98-99)	99 (96-100)	100	100	—	—
Sign	—	—	—	—	82 (50-100)	100
Total Mands	96 (91-99)	96 (95-97)	98 (94-100)	96 (90-100)	91 (75-100)	97 (80-100)
Variable Mands	99 (97-100)	97 (93-100)	100	99 (95-100)	100	98 (83-100)
Challenging Behavior	92 (91-94)	99 (97-100)	96 (89-100)	97 (67-100)	81 (25-100)	100

Procedural Fidelity

As seen in Table 3, procedural fidelity remained high (at or above 90% per condition and phase) for all participants. As with IOA, specific sessions resulted in procedural fidelity levels below 80% (one FCT/Lag 2' session for Tumas and one baseline session for Fawn). These low fidelity values resulted from failing to reinforce pre-session mands and several errors of omission and commission for Tumas, and from failing to reinforce all CB during baseline for Fawn. However, given that (a) these data points were consistent with the prior and subsequent sessions, and (b) the overall level of procedural fidelity (and IOA of procedural fidelity, as detailed below) was high, we do not believe these errors significantly impacted our data.

It is important to note that the fidelity with which additional mands were blocked following access to the reinforcer during the lag' sessions conducted with Tumas and Fawn (not included in the overall procedural fidelity assessment) was variable. On average, 1.3 (*range* = 0-5) mands that should have been blocked in the lag' phases for Fawn were not blocked (an average of 1.2 [*range* = 0-5] of which were variable), and an average of 1.8 (*range* = 0-4) mands that should have been blocked for Tumas were not (1.7 [*range* = 0-3] of which, on average, were variable). In both cases, the greatest number of mands that were not blocked occurred in the Lag 2' phase. For a discussion of the potential impact of these data see Limitations (pg. 35).

Interobserver Agreement

Interobserver agreement of procedural fidelity was well above contemporary research standards across participants, with an average IOA for the FA of 100% across children, and an average IOA for the intervention of 90% for Bowie (*range* = 78%-100%), 99% (*range* = 98%-100%) for Tumas and 97% (*range* = 87%-100%) for Fawn. This suggests the primary coder's assessment of the study's fidelity was valid, increasing our confidence the changes in children's behavior was due to the study procedures rather than confounding variables.

Social Validity

Parents

Overall, parents rated the intervention as having high social validity, as demonstrated by the results of the TARF-R pre and post-treatment questionnaires, with some exceptions (for average scores by question see Table 5). All parents found the intervention to be more acceptable than anticipated pre-treatment (Question 6), more or equally effective than anticipated (Question 5), and felt their child experienced less discomfort than anticipated (Question 9). Further, Bowie and Fawn's mothers rated their child's behavior as less severe post-treatment (Question 8), with Tumas's mother rating his behavior at the same level of severity. Similarly, Bowie and Fawn's mothers reported that the treatment resulted in fewer undesirable side effects than expected (Question 7), while Tumas' mother indicated it resulted in more undesirable side effects than anticipated. All parents liked the procedures (Question 10) as much or more at post-treatment than they had before the intervention. At post-treatment Bowie and Tumas's mothers had increased their belief that the procedures were likely to result in permanent improvements in their child's behavior (Question 2), were equally as willing to carry the treatment out independently (Question 11) as they were pre-treatment, and believed other family members would also be willing (Question 17). Fawn's mother thought the procedure was less likely to result in permanent improvements than anticipated at pre-test, was less willing to carry out the treatment, and believed other family members would be minimally-willing as well.

Table 5

Parent Social Validity (Treatment Acceptability Rating Form – Revised)

	Survey Question	Pre-Treatment Average	Post-Treatment Average
1	Compared to other children with behavioral difficulties, how serious are your child's problems? *(1 = Not at all serious → 5 = Very serious)*	3.3 (2-5)	3.3 (2-4)
2	How likely is this treatment to make permanent improvements in your child's behavior? *(1 = Unlikely → 5 = Very likely)*	4.3 (4-5)	4.3 (3-5)
3	How clear is your understanding of this treatment? *(1 = Not at all clear → 5 = Very clear)*	4.0 (3-5)	4.0 (3-5)
4	Given your child's behavioral problems, how reasonable do you find this treatment to be? *(1 = Not at all reasonable → 5 = Very reasonable)*	4.0 (3-5)	4.0
5	How confident are you this treatment will be/was effective for your child? *(1 = Not at all confident → 5 = Very confident)*	3.7 (3-4)	4.3 (4-5)
6	How acceptable is this treatment? *(1 = Unacceptable → 5 = Very acceptable)*	3.7 (3-4)	4.7 (4-5)
7	To what extent did undesirable side effects result from this treatment? *(1 = No side effects → 5 = Many side effects)*	2.7 (2-3)	2.0 (1-4)
8	How severe are your child's behavioral difficulties? *(1 = Not at all severe → 5 = Very severe)*	3.7 (3-4)	3.0 (2-4)
9	How much discomfort will/did your child experience during the course of this treatment? *(1 = Not at all → 5 = Very much)*	3.3 (3-4)	1.3 (1-2)
10	How much do you like the procedures used in this treatment? *(1 = Not at all → 5 = Very much)*	4.0 (3-5)	4.3 (3-5)
11	How willing are you to carry out this treatment? *(1 = Not at all willing → 5 = Very willing)*	4.7 (4-5)	4.0 (2-5)
12	How much time will be needed each day for you to carry out this treatment? *(1 = Little time → 5 = Much time)*	4.3 (4-5)	2.0 (1-4)
13	How well will carrying out this treatment fit into your family routine? *(1 = Not at all well → 5 = Very well)*	NA	3.0 (2-4)
14	How willing would you be to change your family routines to carry out this treatment? *(1 = Not at all willing → 5 = Very willing)*	NA	3.7 (2-5)
15	How affordable will continuing this treatment be for your family? *(1 = Not at all affordable → 5 = Very affordable)*	NA	4.0 (3-5)
16	How disruptive will it be to the family to continue this treatment? *(1 = Not at all disruptive → 5 = Very disruptive)*	NA	2.7 (2-4)
17	How willing are family members to help carry out this treatment? *(1 = Not at all willing → 5 = Very willing)*	NA	4.0 (2-5)

Masked Raters

Twenty-three participants were consented as social validity masked raters during the week of May 31st – June 6th, 2019. All raters completed the social validity assessment in its entirety. Eight raters viewed videos of Bowie, seven viewed videos of Tumas, and eight viewed videos of Fawn, with an approximately equal number viewing videos in an A-B (i.e., baseline-intervention; 12 raters) or B-A (i.e., intervention-baseline; 11 raters) order. Given there were no distinct patterns in ratings based on respondent's background, the child viewed, or the order in which videos were viewed, survey responses are provided as means (Table 6). However, when reviewing these values it is important to note that there was a wide range in responses—with all questions but one (Question 2) resulting in a rating of between 1 and 5 or 2 and 5—across all baseline and intervention videos.

On average, masked raters indicated that child behavior was more appropriate (Questions 2 & 4) and child affect was more positive (Question 1) during intervention than during baseline. They also indicated that children displayed fewer negative effects from procedures (Question 3) and appeared more motivated by procedures (Question 5) during intervention than during baseline. Further, raters indicated that implementer response to behavior was notably more appropriate (Question 6) and less upsetting (Question 8) during intervention sessions than in baseline, and that they were more likely to use the behaviors viewed in the intervention clip than those in the baseline clip under similar circumstances (Question 7). Finally, referring to the intervention alone, raters indicated the procedures were developmentally-appropriate for preschool children (Question 9; *mean* = 4.6, *range* = 2-5), would not be difficult to implement in a 1:1 setting (Question 10; *mean* = 4.8, *range* = 1-5), would result in positive behavior change within a short period (Question 12; *mean* = 4.5, *range* = 2-5), and could be used across children, behaviors, and settings (Question 13; *mean* = 4.4, *range* = 2-5). However, they did not feel as strongly that the procedures would be easy to implement in a group setting (Question 11; *mean* = 3.3, *range* = 1-5).

Table 6
Masked Rater Social Validity

	Survey Question	Baseline	Intervention
1	The child in the video appeared to have a happy or neutral affect. *(1 = Strongly disagree → 5 = Strongly agree)*	3.7 (2-5)	4.5 (2-5)
2	The child in the video appeared to demonstrate appropriate communication of their wants or needs *(1 = Strongly disagree → 5 = Strongly agree)*	2.4 (1-5)	4.7 (4-5)
3	The child in the video appeared to display no negative effects from the procedures. *(1 = Strongly disagree → 5 = Strongly agree)*	3.2 (1-5)	4.4 (2-5)
4	The child in the video appeared to demonstrate age-appropriate levels of challenging behavior. *(1 = Strongly disagree → 5 = Strongly agree)*	3.0 (1-5)	4.5 (2-5)
5	The child in the video appeared to be motivated by the procedures. *(1 = Strongly disagree → 5 = Strongly agree)*	3.9 (1-5)	4.8 (2-5)
6	The adult in the video responded appropriately to the child, given the child's behavior. *(1 = Strongly disagree → 5 = Strongly agree)*	1.9 (1-5)	4.6 (2-5)
7	The adult in the video used strategies I would use in similar circumstances. *(1 = Strongly disagree → 5 = Strongly agree)*	1.8 (1-5)	4.4 (2-5)
8	The adult in the video engaged in behavior that upset me. *(1 = Strongly disagree → 5 = Strongly agree)*	2.9 (1-5)	1.4 (1-4)
9	The adult behavior depicted in the video is developmentally appropriate for preschool children. *(1 = Strongly disagree → 5 = Strongly agree)*	NA	4.6 (2-5)
10	The adult behavior depicted in the video would not be difficult to implement in a 1:1 setting. *(1 = Strongly disagree → 5 = Strongly agree)*	NA	4.8 (1-5)
11	The adult behavior depicted in the video would not be difficult to implement in a group setting. *(1 = Strongly disagree → 5 = Strongly agree)*	NA	3.3 (1-5)
12	The adult behavior depicted in the video would result in positive behavior change within a short period. *(1 = Strongly disagree → 5 = Strongly agree)*	NA	4.5 (2-5)
13	The adult behavior depicted in the video could be used across children, behaviors, and settings. *(1 = Strongly disagree → 5 = Strongly agree)*	NA	4.4 (2-5)

CHAPTER V

DISCUSSION

We implemented FCT with lag reinforcement with three young children with autism and identified a functional relation between total and variable mands and the intervention—associated with the lag schedule in place—for all children. That is, all three participants were responsive to the intervention, with or without modifications, as indicated by increases in functional manding and decreases in or destabilization of CB. These outcomes support those of previous research, and demonstrate this intervention is effective for use with young children with autism and CB. Further, the results of this study indicate FCT with lag reinforcement might delay resurgence of CB during treatment lapses while temporarily maintaining appropriate manding, which no applied study has demonstrated.

Response to Intervention

FCT/Lag 2 vs. Lag 3

Bowie was the only participant with whom we conducted FCT/Lag 3 sessions. Upon implementing this phase with Bowie, we found that even though all four mand modalities were used repeatedly during the condition, as seen in Figure 3, he did not consistently engage in them sequentially, which—given he had only four available modalities—was required to result in reinforcement. Thus, although he regularly engaged in all modalities, he received reinforcement only a few times during each Lag 3 session. This rapid decrease in reinforcement appeared to result in ratio strain and eventual extinction, which is likely the reason his manding decreased rapidly Session 21. Thus, we returned to FCT/Lag 2 prior to withdrawing treatment in the second baseline condition to return manding to previous levels. For Tumas and Fawn, we chose to increase to a maximum schedule of Lag 2 rather than Lag 3. This was due to the undesirable outcomes of Bowie's intervention and because in neither case had either child emitted a mand in the initial Lag 0, 0', 1, or 1' sessions using their fourth mand modality (Figures 6 and 9). Although Bowie's results and those of Falcomata and colleagues (2018) indicate the fourth mand modality might become part of a the participant's repertoire only upon instating the Lag 3 schedule, we felt the potential risks for increasing the lag outweighed the research benefit.

Modifications

We provided modifications to the proposed intervention for all participants. For Bowie, in addition to returning to Lag 2 following Lag 3, as previously discussed, we also opted to return to Lag 0 rather than Lag 2 following the second baseline condition due to the severe CB that began to immediately follow unreinforced mands. This allowed us to reinforce all mands, and quickly reduce CB severity and level. Once behavior stabilized we felt comfortable increasing the lag schedule incrementally. Although this prevented a direct comparison with Tumas and Fawn and with the participants in Falcomata et al. (2018), it allowed us to retain the same basic experimental design and permitted the identification of a functional relation, similar to that of other participants.

For Tumas and Fawn, an FCT/Lag’ phase was introduced. This phase was an attempt to control the restricted, repetitive behavior (RRB) that arose for these two participants (see Repetitive Behavior, pg. 33), who began to emit multiple mand modalities in a row each time the EO was reintroduced, regardless of when reinforcement was provided. That is, when handed the highly-preferred tangible item as reinforcement they would emit some or all of the remaining mands in their repertoire prior to engaging with the item. The FCT/Lag’ phase was introduced directly upon identifying the non-functional patterning: For Tumas this occurred following FCT/Lag 1, and for Fawn after FCT/Lag 0. Similar to Bowie’s modification, this procedural change did not preclude an experimental analysis of the intervention. Unlike Bowie’s, however, the lag’ modification might have altered the contingency enough to be considered a distinct variation of the intervention (see Limitations, pg. 35).

Challenging Behavior

Bowie was the only participant who demonstrated a clear and consistent reduction in CB during the intervention and a reversal in CB upon the return to baseline. Although Tumas’s behavioral variability increased during the intervention, indicating some association between the intervention and CB, the amount of variability and overlap with baseline preclude an unequivocal functional relation. Similarly, although there was a notable increase in the level and trend of Fawn’s CB during the return to baseline, because her CB was rarely present during baseline, a functional relation cannot be stated. I present two hypotheses for this difference across participants.

The first is the type of tangible provided, either edible or iPad/toy. For Bowie, interacting with the reinforcer (i.e., a small snack item) appeared in no way frustrating—he would pick up the item and consume it with no difficulty. For Tumas and Fawn, at various times throughout the study the reinforcers were themselves apparently frustrating, occasioning CB (as demonstrated by the CB Fawn emitted during the play condition of her FA; Figure 7). For example, waiting for an app to load sometimes resulted in throwing the iPad for Tumas, and stacking animal figurines, followed by them falling over, could result in screaming from Fawn. Although these events were equally likely to occur during baseline and intervention conditions, because there were a greater number of intervention sessions than baseline sessions (i.e., 3.2 times more, on average across participants) there might have been a greater impact on the intervention condition, perhaps resulting in increased variability. The second possibility is related to the repetitive behavior of Tumas and Fawn. Although in no instance did CB directly follow the blocking of mand modalities in a lag’ phase for either participant, the RIR procedure might have impacted the behavior of the children. Given there is a significant correlation between insistence on sameness rituals and routines and parent-reported anxiety in children (Lidstone et al., 2014; Rodgers, Glod, Connolly, McConachie, 2012)—which is not the case for “lower-order” RRBs, such as the repetitive motor movements identified in Bowie—it is possible that Tumas and Fawn were attempting to engage in the repetitive behavior to manage anxiety associated with the intervention (Lidstone et al., 2014; Rodgers et al., 2012). Consequently, because the successful completion of the routine was blocked, there may have been an increased or unmanaged level of anxiety in these children, possibly resulting in increased levels of CB during this condition.

Resurgence of CB. The experimental design used in this study precludes a true analysis of resurgence, which requires the third condition put both behaviors (mands and CB, in this case) on extinction (Lattal & St. Peter Pipkin, 2009). However, because (a) mand materials were included during the baseline condition, and (b) the procedure during the return to baseline mimicked those of a resurgence test until the first mand was reinforced, this study provided preliminary evidence regarding the potential for the FCT/Lag intervention to prevent resurgence of CB during treatment lapses while (temporarily) maintaining manding. Unfortunately, our results were not unequivocal: Responding during the return to baseline was drastically different across the three participants, suggesting that—as many authors have detailed regarding resurgence (e.g., Lattal & St. Peter Pipkin, 2009; Ringdahl & St. Peter, 2017; Schieltz, Wacker, Ringdahl, & Berg, 2017)—many complex factors are at play.

Bowie's results demonstrate that the FCT/Lag intervention resulted in the persistence of appropriate behavior and the postponement of inappropriate behavior during brief reversals in treatment, as hypothesized. Bowie maintained his levels of both total and variable mands *with no increase in CB* for the first two sessions in the second baseline condition (Figure 2). That is, for two back-to-back 5 min sessions Bowie continued to mand rather than engage in CB to procure reinforcement. However, the results seen with Bowie were not replicated with either Tumas or Fawn, who demonstrated notably different data patterns.

For Tumas, although his total and variable mands maintained at Lag 2' levels for the first session upon the return to baseline (Figure 5), they dropped to Lag 1' levels during the second session and extinguished in the third; his CB returned to a level equal to the original baseline condition immediately. These results are not surprising given his CB—which was variable across conditions, and thus was not unanticipated in any session—was reinforced during the first return-to-baseline session while his mands were not. Thus, the fact that he continued to persist with mands at the level he did for the first two session speaks to the potential of this intervention to postpone resurgence, even if it does not directly demonstrate this to be the case.

Fawn demonstrated an immediate increase in CB similar to Tumas, but instead of maintaining her mand level her use of mands reduced immediately to that of the original baseline condition (Figure 8). Following this, her CB remained stable but her total and variable mands increased to Lag 1'/Lag 2' levels, possibly representing a resurgence in mands. This was unexpected, given (a) the response of the previous two participants, and (b) that she engaged in CB regularly, which was reinforced with fidelity. A possible reason for these data patterns is the fact that the first two sessions in the second baseline condition were the first in which Fawn's mother was in the clinic room during the session, rather than observing through the observation booth. Although she was in the room during home sessions, the intervention room in her home was approximately 20'x20'—with Fawn's mother on the opposite side working on her laptop—compared to the significantly smaller space of approximately 8' x 8' in the clinic, with Fawn's mother attending to sessions. This change, which was required due to changes in building protocols (and by our intent to allow parents to observe all procedures as desired) might have been consequential. Anecdotally, during these sessions Fawn left the table more often, and regularly walked over to and climbed on her mother. Although her mother generally ignored her, her presence may have impacted Fawn's behavior and should be considered a confounding variable.

There are multiple additional possibilities to account for the differences in baseline responding across participants, with the reinforcement history of mands and CB—both prior to and during the study—offering the most likely explanation. Regarding mands it is significant that although Bowie participated in an approximately equal number of intervention sessions prior to the return to baseline as did Tumas or Fawn (19, 19, and 14 sessions, respectively), in each session he received reinforcement at a notably greater rate than Tumas or Fawn, estimated at 5 reinforced mands/min, 1.5 reinforced mands/min, and 1.3 reinforced mands/min, respectively.

(Note: estimated rate is averaged from sessions in which procedural fidelity was coded). Given previous research on the impact of the rate of reinforcement—of both the original and the alternative behavior—on subsequent resurgence (Bruzek, Thompson, & Peters, 2009; Wacker et al., 2011), this seems the most parsimonious explanation.

Another explanation is the strength of the response class maintained by access to tangibles for each participant. Given Tumas and Fawn were 14 and 13 months (respectively) older than Bowie, and were more independently communicative via vocal or AAC mands prior to study commencement, it is possible their CB and mand repertoires constituted a more clearly-defined response class than was the case for Bowie. If this were so, it would follow that CB and mands to attain tangible items would occur less discriminately—potentially outside of the confines of implementer manipulations—resulting in reduced experimental control (Cooper et al., 2007). Similar differential effects across participants were demonstrated in a 1999 study of Richman and colleagues', in which reinforcement and extinction of individual, functionally-equivalent typographies of CB resulted in variable outcomes, with some participants responding sequentially within the response class (i.e., engaging in a specific sequence of behaviors). Further, if CB and mands were a single, cohesive response class for these participants they might have responded sequentially within this class based on response effort or reinforcement history (Lalli, Mace, Wohn, & Livezey, 1995; Richman et al., 1999; Ringdahl et al., 2009). This possibility is not unlikely given Tumas and Fawn were inclined to repetitive behavior, and thus might have been more likely to sequentially emit mands than Bowie. In addition, Schieltz and colleagues (2017), among others (e.g., Mace et al., 2010; Volkert, Lerman, Call, & Trosclair-Lasserre, 2009), found that while adding appropriate, functionally-similar mands to the response class, the FCT/Lag intervention might also actually strengthen CB rather than replace it, especially when FCT is conducted in the same environment in which CB was originally reinforced (as was the case in this study). If Tumas and Fawn had formed a stronger mand/CB response class than Bowie (either prior to or during the intervention), which could have resulted in the strengthening of their CB. In addition to accounting for the immediate increase in CB upon the return to baseline, this could help explain the variable level of CB both children engaged in throughout the study. These suppositions are among many potential explanations for the difference in responding across participants. Future studies that include mand materials during baseline conditions are warranted to continue to examine the effects of this intervention on mands and CB during conditions akin to treatment lapses.

Generalization

When the intervention was implemented by their mothers, all participants maintained their level of mands while engaging in no CB (Bowie and Tumas) or an equal level of CB (Fawn) compared to FCT/Lag 2 or FCT/Lag 2'. In fact, each child demonstrated his or her highest number of mands in this condition. Further, there was no decrease in the fidelity in which the intervention was provided by mothers (with *in vivo* coaching) for any child (Table 3). This demonstrates that (a) young children might perform better when FCT/Lag schedules are provided by known implementers rather than by researchers, and (b) that indigenous implementers are capable of providing FCT/Lag reinforcement to fidelity when implementation support is provided. These results are supported by countless studies demonstrating maintenance of effects with indigenous implementers following researcher-provided interventions, but are the first to demonstrate this related to FCT with lag reinforcement. Future research might consider the extent to which coaching and support are required for indigenous implementers to provide these interventions, as well as the level of fidelity that is needed to result in successful outcomes.

Mand Modality

We identified a relation between the percentage of mands emitted by modality and the lag schedule for Bowie (Figure 3). These results were consistent with Falcomata and colleagues' (2018) study, in which both participants consistently demonstrated a more even distribution across modalities as the lag schedule increased. However, we did not identify a similar relation for Tumas and Fawn (Figures 6 & 9). Although both children generally emitted a more balanced allocation of modalities as the intervention progressed, there did not appear to be a relation between mand allocation and the lag schedule. For example, beginning with Lag 0 Fawn began to emit three modalities consistently, with the level of each remaining relatively constant across lag increases; similar patterning was seen with Tumas. This might have been due to (a) the repetitive responding of both children (which was not a factor in the aforementioned study or for Bowie, and which might have confounded the analysis), or (b) the variables associated with each modality, including response effort, novelty, and preference.

Regarding the second hypothesis, certain modalities might have required a greater response effort to emit—due to any number of factors, such as an increased communicative demand (e.g., picture exchange, which required handing a picture to the implementer rather than a less-interactive switch press)—regardless of participants' demonstrated proficiency with each (as assessed via the mand modality assessment). Or, alternately, some modalities been more or less preferred, perhaps due to novelty or the unique characteristics of each (e.g., additional reinforcement via the voice output of the iPad or switch). It is also likely each participant had a unique reinforcement history associated with the selected modalities, possibly resulting in the variations in use. Any or all of these elements might have been at play across participants, but would manifest differently due to the idiosyncratic characteristics of each participant. This explanation, which is supported by previous research on the use of various mand modalities within FCT (Ringdahl et al., 2009; Winborn-Kemmerer, Ringdahl, Wacker, & Kitsukawa, 2009) is perhaps the most parsimonious interpretation for the results, especially given no data were collected on the effort, novelty, or preference of modalities across children. As suggested by previous authors, more research is necessary to determine which factors are contributing (and to what extent) to responding across various modalities within the context of FCT.

Repetitive Behavior

Tumas and Fawn both engaged in "higher-order" RRB (e.g., routine-oriented behavior, compulsions, insistence on sameness; Turner, 1999) during the FCT/Lag condition, which was not reported for any participants in Adami (2017) or Falcomata (2018) and colleagues' research. Tumas demosntrated this by sequentially manding in a specific order (i.e., switch, iPad, and picture) beginning Session 11. Although the reinforcer was provided with fidelity following the mand modality meeting the lag schedule, he would postpone interaction with the reinforcer until the chain was complete. Fawn began to demonstrate the same behavior beginning Session 8, but also insisted the mand materials remain in the same spot on the table/floor. Conversely, Bowie did not engage in any such behaviors. Upon questioning, both Tumas's and Fawn's mothers indicated they had seen similar behavior in their children at home, which Bowie's mother had not. For example, Tumas would engage in CB if his mother deviated from her normal course to school, and Fawn insisted all lights to be on and doors to be shut within her line of sight (and would correct any "anomalies"). Although there are a variety of hypotheses on why some individuals with autism might display higher-order RRBs (see Bauminger-Zviely, 2014), the findings of Bishop and colleagues (2006) indicate these behaviors might be more common in older children when compared to younger (e.g., Tumas and Fawn versus Bowie), who might display more "lower-order" RRBs (e.g., repetitive movements or manipulation of objects). Other possibilities, such as the potential relation between non-verbal IQ and various forms of RRBs (Boyd, McDonough, & Bodfish, 2012), while possible, are beyond the scope of this study.

It is hypothesized the repetitive behaviors emitted by Tumas and Fawn might have, in part, been originally occasioned by the contingency review that was provided at the start of each session. Unlike Adami (2017) and Falcomata (2018) and colleagues, we began each intervention session reminding children of the various ways in which they could mand, prompting them to engage in each. It is possible this review primed Tumas and Fawn to emit *all* mand modalities sequentially, regardless of need, given they were predisposed to higher-order RRB. However, because no attention—positive or negative—was provided contingent on the repetitive behavior and the behavior continued even after external reinforcement was provided for functional manding, it is probable it was maintained by automatic reinforcement via private stimuli (Cunningham & Schreibman, 2008). Given this behavior was non-functional, and when untreated RRB will often worsen over time (Richler, Huerta, Bishop, & Lord, 2010), our response was RIR and item rotation (i.e., rotating the order in which the mand devices were arranged on the table/ground prior to reinstating the EO).

RIR involves two processes critical to its success: (a) response blocking, and (b) redirection to an appropriate, functional task. It is commonly used with vocal stereotypy and has more recently been demonstrated successful with higher-order RRB (Boyd, McDonough, Rupp, Khan, & Bodfish, 2011). By preventing the children from completing the attempted sequence and redirecting them to the tangible reinforcer, we might have acted to block automatic reinforcement of the behavior, which was then replaced with socially-mediated reinforcement. Over time this appeared to weaken the response–automatic reinforcement relation for both children. Anecdotally, by the end of the study Tumas no longer attempted to engage in the repetitive behavior (potentially due to extinction; Ahearn et al., 2007) and Fawn had desisted chaining easily-blocked mand modalities (i.e., switch, iPad, picture), but still engaged in the iPad–sign chain (given the "my turn" sign was difficulty to block quickly and without disruption). Similar results were seen in Silbaugh and colleagues' (2017) study, in which researchers applied response blocking to prevent access to invariable behavior (i.e., food consumption). Our outcomes build on their findings and speak positively to the utility of RIR within FCT with lag reinforcement to address higher-order RRB. In addition, the FCT/Lag procedure itself, which requires variable responding for access to reinforcement, is a known intervention for such repetitive behavior (i.e., differential reinforcement of variability; DRV; Boyd, McDonough, & Bodfish, 2012). Thus, by incorporating RIR into the existing DRV procedures, we created a novel intervention to address Tumas and Fawn's repetitive behaviors within the context of FCT. This modification might warrant future research regarding: (a) its utility and efficacy, (b) identifying individuals who might require it prior to intervention onset, and (c) fading RIR procedures when blocking is no longer required.

Social Validity

Although previous research demonstrated that FCT with continuous reinforcement was rated as socially-valid (Callahan et al., 2008), the current study is the first to provide meaningful, quantitative data as to the social validity of the FCT/Lag intervention. Social validity data were provided by both significant others (i.e., parents of participants) and masked raters (i.e., professionals in ABA and special education, the two fields most likely to utilize these procedures in applied settings). Data from both analyses indicates that, on average, raters found the intervention to be meaningful, generally resulting in socially-significant changes in participants. However, there were mixed findings across individual raters, as demonstrated by some instances in which parents noted less than optimal results (e.g., more side effects than anticipated according to Tumas's mother) and masked raters provided widely variable responses (e.g., score of 1 versus 5 regarding whether the implementer's behavior was appropriate during baseline). Differences across raters could have occurred for a variety of reasons, including (a) the child the question pertained to, (b) the raters' personal experience and history with similar children, or (c) the raters' personal relationship with the study implementers. Future research should continue to assess the social validity of the FCT/Lag intervention with significant others (including the participants themselves) and masked raters to provide additional information regarding the effectiveness, acceptability, and feasibility of the procedures.

Although our study resulted in largely positive social validity outcomes as perceived by raters—and all forms of social validity are essential for a comprehensive assessment of an intervention (Strain et al., 2012)—we must be careful in overestimating the reliability of subjective data, given its inherent bias. Thus, it is notable that this is the first study implementing FCT with lag reinforcement (to my knowledge) that (a) occurred primarily in natural settings, (b) welcomed parent observation, and (c) included significant others as implementers. These procedural characteristics speak objectively to this procedure's social validity, given the intervention was effective under conditions that more closely resembled natural settings. This is important, considering interventions—no matter how effective—cannot be deemed socially valid unless they are effective and feasible in "real-world" settings when implemented by natural agents (Wolf, 1978). In addition, by measuring generalization of the intervention we provided an additional objective measure not captured by parent or masked rater surveys (Kennedy, 2002).

Limitations

Perhaps the most significant limitation of the study was how the RIR modification used with Tumas and Fawn affected data patterns, and thus might have impacted the validity of results. Following the introduction of the first lag' phase, procedures mandated that, following a mand that met the lag schedule (and thus resulted in access to the reinforcer), I restrict access to all additional mands until the participant began to engage with the reinforcer appropriately. However, this procedure was not conducted with one hundred percent fidelity for multiple reasons. First, it was impossible to restrict Tumas's vocal mands, and very difficult to restrict access to Fawn's sign mands without being overly intrusive (and we believed that preventing her from physical movement resulting in functional communication was not ethical). Thus, if an attempt to block a sign mand by quickly inserting a physical barrier between her hand and her chest was unsuccessful, we permitted the mand; this occurring following numerous iPad mands emitted during lag' phases. Second, the FCT/Lag procedure required a sophisticated chain of communication in which (a) the second implementer noted it was time to reinforce, given the child's mands, (b) the second implementer informed me to provide the reinforcer, and (c) I provided the reinforcer while attempting to block all further mands. Given the many steps required in this chain, it was often the case that by the time I was able to provide the reinforcer and begin blocking, the participant had already engaged in one or more additional, unrequired mands. Unfortunately, this occurred repeatedly (see Procedural Fidelity results, pg. 26), which resulted in the emission of multiple mands that should not have been emitted—per the modification—and thus impacted the data patterns for Tumas and Fawn within lag' phases. Notably, this procedural infidelity resulted in a greater frequency and variability of target mands during the FCT/Lag' phases *but not* during the baseline condition or previous FCT/Lag phases, which might be considered a threat to internal validity (Gast & Ledford, 2018). Due to this concern, in addition to graphing the original data for Tumas and Fawn, we also graphed their data after omitting mands that should have been blocked during lag' phases (Figures 10 & 11). These data demonstrate that while, in some cases, mand levels were affected (decreasing the degree of separation across lag increases, in some cases), data patterns were not, which speaks to the validity of the intervention. Future studies using the lag' modification should consider this possibility *a priori* and determine (a) how additional, unnecessary mands might be blocked successfully and unobtrusively, and (b) how to account for potential measurement error due to this modification during data collection and analysis (e.g., remove these mands from data analysis prior to making condition or phase-change decisions).

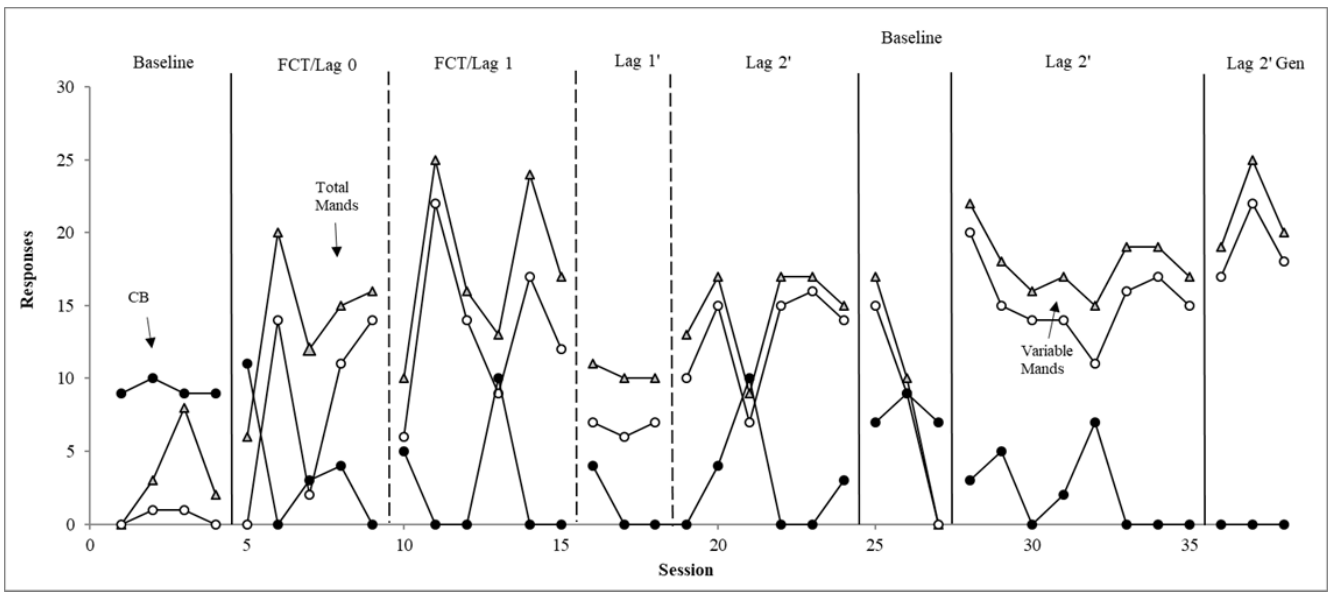

Figure 10. Tumas's data with unblocked mands removed.

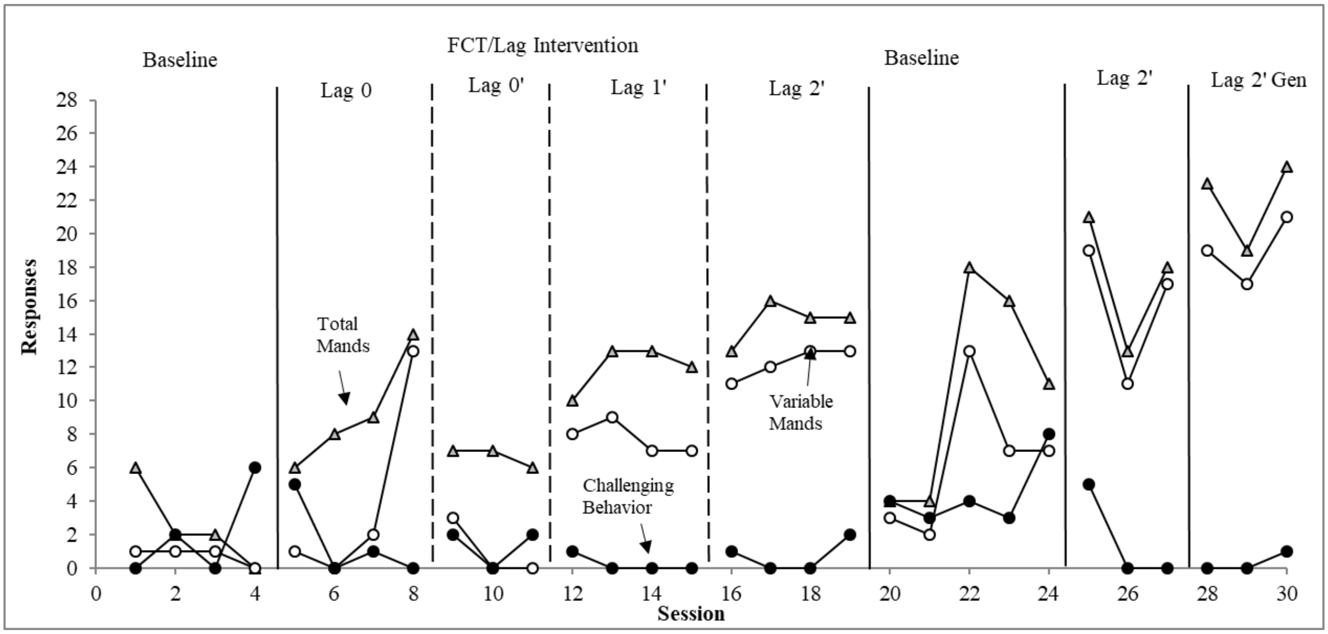

Figure 11. Fawn’s data with unblocked mands removed.

Another limitation was the use of PIR rather than event recording to code Bowie’s data. Although PIR has been demonstrated the most accurate interval system to measure rate (Yoder et al., 2018b), its use comes with compromise in data accuracy. For example, we know that PIR is likely to overestimate rate, particularly with long-duration behaviors, and might result in differentially-accurate estimates when comparing baseline and intervention conditions. While this might not impact the presence of a functional relation, it might result in an inflated effect (Ledford et al., 2015; Yoder et al., 2018). For this reason, we applied PIR using the best-known strategies for avoiding these pitfalls: (a) we applied to behaviors of short duration (<1 s per behavior); (b) chose 2-s intervals, given small intervals are recommended to improve data accuracy (Mann et al., 1991; Yoder et al., 2018a, 2018b); and (c) applied the Poisson correction, a probability distribution of the rate of occurrence that has resulted in increased data accuracy (Yoder et al., 2018a). Thus, given Bowie’s cross-conditional, replicated data changes, it is highly probable there was a true functional relation; however, it is possible the extent of the behavior change was over-estimated. In addition, when calculating IOA for Bowie we used the point-by-point method; however, when using PIR it is typically recommended that occurrence and non-occurrence agreement or Kappa be used to generate a more precise measure that takes into account the possibility of chance agreement (Ledford et al., 2018b). However, we opted to report behavior using a consistent method across participants, and—given the high IOA for all children—feel satisfied the point-by-point method produced as accurate a measure of IOA for Bowie’s data as it did for Tumas and Fawn (when applied to timed event recording).

My decision to have masked raters view a video from the baseline condition—rather than one from an FA test condition—to compare with the FCT/Lag 2 or 2’ session could also be considered a study limitation. This decision is important, given (a) no context was provided prior to viewing the videos, and (b) the survey questions asked about children’s behavior—both appropriate and challenging—in the videos and how I responded to it. Because mand materials were available during baseline and all children manded appropriately (as well as engaged in CB) during the video clips, it is probable there was less of distinction in (a) the child's behavior before and after the intervention than would have been the case if they had viewed a clip of an FA test condition. Thus, this may have weakened the perceived change in the social validity of the intervention and resulted in much greater heterogeneity in rating.

Finally, this study entailed a minimal level of ecological validity, which might be considered a limitation. Although we made an effort to extend the ecological relevance of previous studies by conducting sessions in natural settings and involving significant others in assessment and intervention, it can be argued the goals and outcomes were not overly socially-significant for participants or families, nor likely to maintain following the study's conclusion, and the procedures were generally unfeasible in real-world situations. However, given the current, relatively nascent state of research on FCT/Lag reinforcement, it might also be true that the current study had a notably higher level of ecological validity than that of the majority of previous studies, which, excepting Adami (2017) and Falcomata (2018) and colleagues, consisted of basic or translational research conducted in labs. Nonetheless, future research should focus on extending this intervention to natural settings and implementers and supporting children in their most pressing area of need.

Future Research

When considering future research related to FCT with lag reinforcement, there are two primary avenues with which to explore this meaningful intervention: (a) investigation of the variables related to study efficacy, including the various factors affecting responding across mand modalities and conditions, particularly as is related to resurgence; and (b) expanding the intervention to include more socially- and ecologically-valid procedures, such as the greater inclusion of indigenous implementers and identifying modifications appropriate to natural settings. Regarding the first avenue, although this study did explore the effect of retaining mand devices in the baseline condition—suggesting that in some cases FCT with lag reinforcement might prevent resurgence of CB—because reinforcement was provided for CB, this condition served only as a surrogate to that of a true resurgence condition (in which no reinforcement would be provided for mands or CB); future research might assess the true resurgence of CB following an FCT/Lag intervention in applied settings. In addition, further investigations as to how characteristics of the intervention (e.g., reinforcement history), response class, and mand modalities (e.g., novelty, response effort) affect the level and variability of mands and CB, both in the intervention and baseline conditions, are warranted. Research is also needed to determine how to identify the maximum lag schedule for each participant *prior* to the onset of undesired behavior changes (as was the case with Bowie), potentially in relation to participant characteristics such as age and response to schedule increases. Further work might also utilize the lag' modification used in this study, with a specific focus on (a) its utility and efficacy, (b) identifying individuals who might require this modification prior to intervention onset.

The second direction of research is expanding the social and ecological validity of the intervention. First, given all participants in the current and previous applied studies were diagnosed with autism, further assessment as to the effect of the FCT/Lag intervention with participants identified with other delays or disabilities might produce meaningful data regarding the widespread utility of this intervention. Researchers might also explore how to further incorporate this intervention into natural settings, and assess the effects when procedures are completed entirely by indigenous implementers, such as parents and teachers. This might require further analysis of the level of procedural fidelity required to produce viable outcomes, and the extent to which coaching and support is required for indigenous implementers to maintain this level. Finally, for this intervention to result in meaningful, long-term outcomes across children, implementers, and settings, future research should identify methods to increase the feasibility, generalizability, and maintenance of effects of the intervention.

Conclusion

This study applied FCT with lag reinforcement across three young children with autism, with the purpose of increasing the variability and persistence of appropriate responding while maintaining low levels of CB during treatment and treatment lapses. We identified a functional relation between total and variable mands and the intervention for all children. In addition, we applied a novel modification (i.e., combination of RIR and DRV) for two participants, which resulted in an increase in functional manding for both. Our results support and extend those of previous research, by demonstrating FCT with lag reinforcement might delay resurgence of CB during treatment lapses while temporarily maintaining appropriate manding. This research is significant, given the great impact CB has on the children who engage in it and on their significant others. Further research is needed to parse out the impact of various intervention and child characteristics on intervention efficacy.

Appendix A

Masked Rater Social Validity REDCap Survey

Confidential

FCT/Lag Social Validity AB

Please complete the survey below (for video order A-B).

Thank you!

Please complete the following demographic questions.	
What is your highest educational degree and in what field (e.g., MS in Applied Behavior Analysis, PhD in Special Education)?	________________________
How old are you (in years)?	________________________
What is your gender?	◯ Female ◯ Male ◯ Other ◯ Prefer not to say
What is your race/ethnicity? Choose all that apply.	☐ Black ☐ White ☐ Hispanic ☐ Asian descent ☐ Middle Eastern descent ☐ Other ☐ Prefer not to say
What other race/ethnicity do you identify with?	________________________

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Please complete the following questions related to your experience with young children (aged 0-5 yrs).	
What is/was your role working with young children (aged 0-5 yrs)? Choose all that apply.	☐ Special education teacher ☐ Regular education teacher ☐ BCBA ☐ RBT ☐ Other
What other role did you serve when working with preschool children?	________________________________
What population of young children have you had direct experience working with (in a professional capacity)? Choose all that apply.	☐ children with disabilities ☐ children without disabilities ☐ children with ASD ☐ children with severe challenging behavior

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Please select the following:	
Please select your video set.	○ Bowie ○ Tumas ○ Fawn
Please select which video you've been assigned to watch first.	○ A ○ B

STOP!

Please watch Video A before completing the next section.

Confidential

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Please answer the following questions in response to the child behavior in Video A.

The child in the video appeared to:

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Have a happy or neutral affect.	○	○	○	○	○
Demonstrate appropriate communication of their wants or needs.	○	○	○	○	○
Display no negative effects from the procedures.	○	○	○	○	○
Demonstrate age-appropriate levels of challenging behavior.	○	○	○	○	○
Be motivated by the procedures.	○	○	○	○	○

Please answer the following questions in response to the adult behavior in Video A.

The adult in the video:

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Responded appropriately to the child, given the child's behavior.	○	○	○	○	○
Used strategies I would use in similar circumstances.	○	○	○	○	○
Engaged in behavior that upset me.	○	○	○	○	○

STOP!

Please watch Video B before completing the survey.

Please answer the following questions in response to the child behavior in Video B.

The child in the video appeared to:

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Have a happy or neutral affect.	○	○	○	○	○
Demonstrate appropriate communication of their wants or needs.	○	○	○	○	○
Display no negative effects from the procedures.	○	○	○	○	○
Demonstrate age-appropriate levels of challenging behavior.	○	○	○	○	○
Be motivated by the procedures.	○	○	○	○	○

Please answer the following questions in response to the adult behavior in Video B.

The adult in the video:

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Responded appropriately to the child, given the child's behavior.	○	○	○	○	○
Used strategies I would use in similar circumstances.	○	○	○	○	○
Engaged in behavior that upset me.	○	○	○	○	○

Please answer the following questions in response to the adult behavior in Video B.

The adult behavior depicted in the video:

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Is developmentally appropriate for preschool children.	○	○	○	○	○
Would not be difficult to implement in a 1:1 setting.	○	○	○	○	○
Would not be difficult to implement in a group setting.	○	○	○	○	○
Would result in positive behavior change within a short period.	○	○	○	○	○
Could be used across children, behaviors, and settings.	○	○	○	○	○

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