EFFECTS OF A MULTIPLE SCHEDULE OF REINFORCEMENT FOLLOWING FUNCTIONAL COMMUNICATION TRAINING ON COMMUNICATION RESPONSES AND PROBLEM BEHAVIOR OF CHILDREN WITH AUTISM SPECTRUM DISORDER

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ABSTRACT

REEM MUHARIB. Effects of a multiple schedule of reinforcement following functional communication training on communication responses and problem behavior of children with autism spectrum disorder. (Under the direction of DR. CHARLES L. WOOD)

Researchers have found some children with autism spectrum disorder exhibit problem behavior (Emerson et al., 2001; Lowe et al., 2007). Additionally, research has shown problem behavior is likely to occur due to children's deficits in communication skills (Kaiser, Cai, Hancock, & Foster, 2002; Park, Yelland, Taffe, & Gray, 2012). One way to address problem behavior by increasing functional communication is functional communication training (FCT; Carr & Durand, 1985). The purpose of this study was to examine the effects of a multiple schedule of reinforcement following FCT on behaviors of two children with ASD who engaged in problem behavior. The specific dependent variables were functional communication responses (FCRs) during SD, FCRs during S-Delta and problem behavior. After the functional analysis (FA) results confirmed the function of each participant's problem behavior (access to tangibles), participants were taught to mand (i.e., request) for the functional reinforcer using FCT procedures. Then, the multiple schedule of reinforcement intervention began using a reversal design. The results demonstrated the effectiveness of a multiple schedule of reinforcement on discriminated FCRs and problem behavior for one child. For the second child, an alternative activity was necessary to enhance the effectiveness of the intervention. In addition, one child had variable results on generalization across teachers and a setting as well as maintenance whereas the second child demonstrated the ability to generalize and maintain discriminated FCRs and problem behavior. Social validity results showed that

teachers/paraprofessionals found the use of an alternative activity to be acceptable and feasible to implement. Teachers/paraprofessionals orally expressed that they would change the signaling stimuli to a single stimulus that is more feasible to use in the classroom.

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CHAPTER 1: INTRODUCTION

Children with autism spectrum disorder (ASD) often exhibit deficits in social, language, and communication skills (American Psychiatric Association, APA, 2013). According to a recent estimate, 1 in 59 children is diagnosed with ASD (Centers for Disease Control and Prevention, CDC, 2014). Of these children, 30% may never develop a functional spoken language (Wodka, Mathy, & Kalb, 2013). Research has shown problem behavior is likely to occur due to children's deficits in communication skills (Kaiser, Cai, Hancock, & Foster, 2002; Park, Yelland, Taffe, & Gray, 2012). That is, children who do not have functional communication skills are more likely to engage in problem behavior as means of communicating their needs and wants (Chiang, 2008).

Problem behavior has been defined as any repeated pattern of behavior that has one or two negative effects on the target child: (a) effects on the child's learning, and (b) effects on the child's social interactions with others (Smith & Fox, 2003). Research has estimated 10-15% of children with developmental disabilities (DD) exhibit problem behavior (Emerson et al., 2001; Lowe et al., 2007). Of those children, 7% engage in forms of aggression, 7-23% engage in self-injurious behavior (SIB), and 4-5% engage in destructive behavior (Beavers, Iwata, & Lerman, 2013; Emerson et al., 2001). DD is a large category that consists of different conditions such as ASD, intellectual disability (ID), and Down syndrome. Children who are diagnosed with ASD are often diagnosed with co-occurring ID (APA, 2013), and often display problem behavior (Dominick et al., 2007; Murphy, Healy, & Leader, 2009).

Problem behavior such as aggression, SIB, and destruction, puts the child and others (e.g., caregivers, teachers) in danger (Sigafoos, Arthur, & O'Reilly, 2003).

Problem behavior can also affect the child's academic success and social integration with other children in school and community (Koegel, Koegel, Hurley, & Frea, 1992; Sigafoos et al., 2003). Additionally, as the child develops without receiving an effective intervention, problem behavior is likely to continue to be present in adulthood (Murphy et al., 2005). As problem behavior worsens, the child becomes at an increased risk for long-term inpatient care (Emerson, 2000).

Children with ASD/DD who engage in problem behavior are often disciplined using punishment procedures in school settings (Scott et al., 2005). As indicated by the U.S. Department of Education Office of Civil Rights report, 58% of students with disabilities who received seclusion disciplinary, and 75% of students who were restrained were students with DD (U.S Department of Education, 2014).

Problem behavior can also impact the quality of life of caregivers. Numerous studies have found increased levels of stress associated with caregivers of children with ASD/DD who engage in problem behavior (Freeman, 1994; Hastings & Brown, 2002; Jenkins, Rose, & Lovell, 1997). Due to the negative effects of problem behavior, there is no doubt that treatment should be a priority and should be delivered as early as possible (Cooper, Heron, & Heward, 2007; O'Reilly et al., 2010).

One way to mitigate problem behavior in children with ASD/DD is functional communication training (FCT, Carr & Durand, 1985). FCT is a function-based behavioral intervention that relies on differential reinforcement of alternative behavior (DRA) procedures. FCT consists of two steps: (a) assessing the function(s) of the child's problem behavior(s) through functional behavior assessments (FBAs), and (b) teaching the child an appropriate communicative response that results in accessing the same functional reinforcer maintaining the problem behavior (Carr & Durand, 1985). For more robust effects, FCT typically involves placing the problem behavior on extinction; that is, the problem behavior no longer produces the putative reinforcer (Cooper et al., 2007). As found in a study, extinction of problem behavior was concurrently implemented with FCT in 79% of FCT studies (Hagopian, Boelter, & Jarmolowicz, 2011). This suggests that extinction of problem behavior during FCT may an important component of the treatment (Fisher, Thompson, Hagopian, Bowman, & Krug, 2000).

Cooper et al. (2007) describe the process of FBAs as indirect and direct assessments. Indirect assessments include interviewing caregivers/teachers or asking them to complete rating scales/checklists to potentially identify the environmental variables evoking and maintaining the child's problem behavior. Direct assessments include objective observations of the child in the natural environments using continuous recording or narrative recording (antecedent-behavior-consequence) methods to identify the environmental variables evoking and maintaining the problem behavior. Next, a hypothesis of the function(s) of problem behavior can be formulated and subsequently tested through experimental functional analyses (FA; Iwata, Dorsey, Slifer, Bauman, & Richman, 1982/1994). As explained by Cooper et al. (2007), the application of FBAs helps prevent reliance on punishment and exclusionary methods.

After the identification of the function(s) of problem behavior, a functionally equivalent communication response is chosen for the child. The new functional communication response (FCR) should require less response effort than the problem behavior. This is because response effort may influence response allocation during FCT. In other words, if the response effort of the new FCR is high, the child may be less likely to emit the new FCR and more likely to engage in problem behavior (Horner & Day, 1991). Additionally, the new FCR should be easily understood by communicative partners so that the child's FCR results in access to reinforcement from the listener/communicative partner (Cooper et al., 2007). Finally, the new FCR should be in the child's repertoire. For instance, if the child has some vocal abilities, then a vocal FCR could be chosen. If the child does not have vocal abilities but has fine motor skills, then a FCR could be a sign, a picture exchange (PE; e.g., Frea, Arnold, & Vittimberga, 2001), or an icon touch on a speech-generating device (SGD; e.g., Muharib, Correa, Wood, & Haughney, 2018).

Establishing operations (EO) should also be considered when using FCT. An EO is a motivating operation that alters the effectiveness of a certain stimulus/reinforcer; and thus, it alters the frequency of the behavior that has been reinforced by that stimulus/reinforcer (Laraway, Snycerski, Michael, & Poling, 2003). For example, if a child is presented with a highly preferred item out of reach, the child is likely to engage in behavior, whether appropriate or inappropriate, to access the highly preferred item. On the other hand, if the child has quit engaging with the highly preferred item after playing with it for a long duration of time, the child may be less likely to engage in behavior to access that item due to satiation (i.e., abolishing operation, AO).

Although FCT is an evidence-based practice (Kurtz, Boelter, Jarmolowicz, Chin, & Hagopian, 2011; Muharib & Wood, 2018, Wong et al., 2013) with numerous studies indicating its efficacy to suppress problem behavior and increase appropriate FCRs (Franco et al., 2009; Mancil, Conroy, & Nakao, 2006; Neidert, Iwata, & Dozier, 2005; O'Neill & Sweetland-Baker, 2001; Thomson, Fisher, Piazza, & Kuhn, 1998), FCT may be impractical in natural settings because it requires reinforcing the child's FCR on a dense fixed-ratio schedule (i.e., FR 1). This fact can result in reduced implementation fidelity by caregivers/teachers. In other words, when the child emits the FCR too often, the caregivers/teachers may not be able to reinforce every FCR. As a result, the child's FCR may undergo extinction; and as a consequence, resurgence of problem behavior may occur (Fisher et al., 2000; Hagopian et al., 2011; Lalli, Casey, & Kates, 1995).

To facilitate treatment transfer and maintenance effects in natural settings, researchers have investigated various procedures of thinning schedules of reinforcement to bring the FCR to a practical level without risking resurgence of problem behavior. Examples of those thin schedules of reinforcement include; delay-to-reinforcement (e.g., Hanley, Jin, Vanselow, & Hanratty, 2014), alternative activity (e.g., Hagopian, Contrucci, Kuhn, Long, & Rush, 2005), demand fading/ chained schedules of reinforcement (e.g., Berg et al., 2007; Falcomata , Roane, Muething, Stephenson, & Ing, 2012), response restriction (e.g., Roane, Fisher, Sgro, Falcomata, & Pabico, 2004), and multiple schedules of reinforcement (e.g., Greer et al., 2016).

Multiple schedules of reinforcement involve the use of two or more simple schedules (e.g., fixed interval, FI 60 s, FI 120 s) that involve two or more different contingencies (e.g., reinforcement on one schedule, and extinction on the other). Multiple schedules also involve the use of a stimulus correlated with each schedule (e.g., red card versus blue card); one of which is an SD that signals the availability of reinforcement for an FCR while the other stimulus signals the unavailability of reinforcement (i.e., S-Delta). These stimuli and contingencies are presented successively, not simultaneously. Thus, the FCR comes under stimulus control of the SD (Cooper et al., 2007).

Many studies have found multiple schedules of reinforcement following FCT to be effective in reducing FCRs to a manageable level while maintaining low to zero levels of problem behavior (Betz, Fisher, Roane, Mintz, & Owen, 2013; Fisher, Greer, Fuhrman, & Quirim, 2015; Fuhrman, Fisher, & Greer, 2016). However, as indicated by numerous literature reviews (Falcomata & Wacker, 2013; Heath, Ganz, Parker, Burke, & Ninci, 2015; Neely, Garcia, Bankston, & Green, 2018), FCT research, including studies that used multiple schedules of reinforcement, lack generalization and maintenance measures. Thus, this study addressed this gap by including generalization and maintenance measures.

Additionally, recent research indicated 76% of individuals, whose treatment involved thinning schedules of reinforcement following FCT, showed resurgence of problem behavior. Some of whom showed resurgence of problem behavior that exceeded the mean levels observed during baseline (Briggs, Fisher, Greer, & Kimball, 2018). As previous research on multiple schedules of reinforcement following FCT involved two components (e.g., SD 60 s, S-Delta 60 s), this study will examine a different approach to multiple schedules (Beth-Tung, Scheithauer, Muething, & Mevers, 2018) to determine if similar patterns of resurgence of problem behavior will occur. Instead of multiple S-Delta intervals interval, the method involved one S-Delta reinforcement interval (e.g., SD 30 s, S-Delta 60 s, SD 30 s).

Therefore, this study attempted to answer the following research questions:

1. What are the effects of FCT and a multiple schedule of reinforcement with one S-Delta on problem behavior and FCRs in children with ASD?

2. To what extent does rapidly thinning the schedule of reinforcement cause resurgence of problem behavior when the multiple schedules consist of one S-Delta component?
3. To what extent will the effects of FCT and a multiple schedule of reinforcement on problem behavior and FCRs in children with ASD generalize across the classroom teachers?
4. To what extent will the effects of FCT and a multiple schedule of reinforcement on problem behavior and FCRs in children with ASD generalize across school settings?
5. To what extent will the effects of FCT and a multiple schedule of reinforcement on problem behavior and FCRs maintain in children with ASD?
6. What are the teachers', paraprofessionals', and parents' perceptions of the intervention?

Significance of the Study

The current study may contribute to the FCT literature in several ways. First, it investigated the effects of two reinforcement intervals during a multiple schedule of reinforcement on communication responses and problem behavior of children with ASD. To date, there is no published peer-reviewed study that has examined the effects of such arrangement. Second, the current study added to the body of research on resurgence of problem behavior by investigating the effects of rapid thinning of reinforcement while using one S-Delta interval. Third, this study addressed the severe need in the FCT literature to examine the extent of generalization and maintenance. The current study programmed for generalization across teachers and settings as well as maintenance.

Finally, there is a lack of social validity in the FCT literature. The current study addressed that by collecting social validity data from teachers/ paraprofessionals after the conclusion of the experiments.

Delimitations

The results of this study should be interpreted in the context of the following delimitations. First, because this study employed a single-case design, the results of this study are limited in terms of external validity. The results should not be generalized to the broader population of children with ASD. Second, this study targeted children with ASD who engage in problem behavior such as aggression, SIB, and destruction. Thus, the current study did not aim to mitigate minor problem behavior such as off-task behaviors. Additionally, the problem behavior must be maintained by positive reinforcement (e.g., attention, tangible). The study did not target children whose problem behavior was maintained by negative or automatic reinforcement. In addition, this study targeted elementary aged children. Therefore, the current study should not be generalized to students in upper grades. Furthermore, the study was carried out in a self-contained classroom. That is, the study was not carried out in inclusive classrooms, home of the children, or community settings. Finally, in this study, the interventionist taught the participants one FCR only as an alternative of problem behavior. The study did not attempt to target complex communication skills.

Definition of Terms

Abolishing operation. "A motivating operation that decreases the reinforcing effectiveness of a stimulus, object, or even. For example, the reinforcing effectiveness of food is abolished as a result of food ingestion" (Cooper et al., 2007, p. 689).

Alternative activity. Providing a competing stimulus to the individual during the delay to reinforcement communication. The competing stimulus may function as an "alternative source of reinforcement" (Hagopian et al., 2005, p. 178).

Antecedent. "An environmental condition or stimulus change existing or occurring prior to a behavior of interest" (Cooper et al., 2007, p. 689)

Augmented and alternative communication. "An area of educational and clinical practice that aims to supplement or replace an individual's natural speech and/or handwriting through unaided approaches such as manual signing and gestures and/or aided approaches such as graphic symbols, communication boards, speech-generating devices (SGDs)" (Schlosser & Koul, 2015, p. 285).

Autism Spectrum Disorder. Autism spectrum disorder is a pervasive neurodevelopmental disorder that affects social-communication skills and is associated with repetitive and restricted patterns of behavior (APA, 2013).

Automatic reinforcement. "Reinforcement that occurs independent of the social mediation of others" (Cooper et al., 2007, p. 690).

Aversive stimulus. "In general, an unpleasant or noxious stimulus; more technically, a stimulus change or condition that functions (a) to evoke a behavior that has terminated it in the past; (b) as a punisher when presented following behaviors, and/or (c) as a reinforcer when withdrawn following a behavior" (Cooper et al., 2007, p. 691).

Behavior. "The activity of living organisms; human behavior includes everything people do" (Cooper et al., 2007, p. 690).

Brief functional analysis. A variation of a traditional functional analysis which "involves implementing one session each of the control condition and each of the test condition" (Cooper et al., 2007, p 512).

Chained schedule of reinforcement. "A schedule of reinforcement in which the response requirements of two or more basic schedules must be met in a specific sequence before reinforcement is delivered; a discriminative stimulus is correlated with each component of the schedule" (Cooper et al., 2007, p. 691).

Consequence. "A stimulus change that follows a behavior of interest" (Cooper et al., 2007, p. 692).

Delay-to-reinforcement. "Delaying delivery of the reinforcer following the communication response" (Hagopian et al., 2011, p. 5).

Demand fading. A procedure in which "the client is initially required to complete a single demand (e.g., fold one towel) before his or her request for a break (escape) is reinforced. Then, the number of demands the client must complete before the communication response is reinforced is gradually increased (faded)" (Fisher et al., 2000, p. 5).

Developmental disability. "A group of conditions due to an impairment in physical, learning, language, or behavior areas. These conditions begin during the developmental period, may affect day-to-day functioning, and usually last throughout a person's lifetime" (CDC, 2018).

Differential reinforcement. "Reinforcing only those responses within a response class that meet a specific criterion along some dimension(s) (i.e., frequency, topography, duration, latency, or magnitude) and placing all other responses in the class on extinction" (Cooper et al., 2007, p. 693).

Differential reinforcement of alternative behavior. "A procedure for decreasing problem behavior in which reinforcement is delivered for a behavior that serves as a desirable alternative to the behavior targeted for reduction and withheld following instances of the problem behavior" (Cooper et al., 2007, p. 693).

Direct assessment. Functional behavior assessment procedures that entail observations of the target behavior in a contrived or natural environment (Cooper et al., 2007).

Discriminative stimulus. "An antecedent stimulus correlated with the availability of reinforcement for a particular response class" (Cooper et al., 2007, p. 261).

Establishing operation. "A motivating operation that establishes (increases) the effectiveness of some stimulus, object, or event as a reinforcer. For example, food deprivation establishes food as an effective reinforcer" (Cooper et al., 2007, p. 695).

Extinction. "The discontinuing of a reinforcement of a previously reinforced behavior (i.e., responses no longer produce reinforcement); the primary effect is a decrease in the frequency of the behavior until it reaches a prereinforced level or ultimately ceases to occur" (Cooper et al., 2007, p. 695).

Fixed-interval schedule of reinforcement. "A schedule of reinforcement in which reinforcement is delivered for the first response emitted following the passage of a fixed duration of time since the last response was reinforced" (Cooper et al., 2007, p. 695).

Fixed-ratio schedule of reinforcement. "A schedule of reinforcement requiring a fixed number of responses for reinforcement" (Cooper et al., 2007, p. 696).

Functional analysis. "An analysis of the purposes (functions) of problem behavior, wherein antecedents and consequences representing those in the person's natural routines are arranged within an experimental design so that their separate effects on problem behavior can be observed and measured" (Cooper et al., 2007, p. 696).

Function-based intervention. "A strategy used to improve behavior by developing intervention components based on prior assessment of the function of a challenging, or target, behavior" (Janney, Umbreit, Ferro, Liaupsin, & Lane, 2013, p. 113).

Functional behavior assessment. "A systematic method of assessment for obtaining information about the purposes (functions) a problem behaviors serves for a person; results are used to guide the design of an intervention for decreasing the problem behavior and increasing appropriate behavior" (Cooper et al., 2007, p. 696).

Functional communication response. A communicative response that is functionally equivalent to the targeted problem behavior (Carr, Smith, Giacin, Whelan, & Pancari, 2003).

Functional communication training. "An antecedent intervention in which an appropriate communicative behavior is taught as a replacement behavior for problem behavior usually evoked by an establishing operation (EO); involves differential reinforcement of alternative behavior (DRA)" (Cooper et al., 2007, p. 696).

Indirect assessment. Functional behavior assessment methods that include interviews, checklists, and rating scales completed by people who are familiar with the target child to assess the conditions that correlate with the target problem behavior. (Cooper et al., 2007).

Intraverbal. A verbal operant that is controlled by a verbal stimulus that has no point-to-point correspondence and is reinforced by nonspecific social reinforcement such as praise (Cooper et al., 2007).

Intermittent schedules of reinforcement. "A contingency of reinforcement in which some, but not all, occurrences of behavior produce reinforcement" (Cooper et al., 2007, p. 698).

Mand. A verbal operant that is controlled by an establishing operation and is reinforced by the corresponding stimulus (Cooper et al., 2007).

Mixed schedule of reinforcement. "A compound schedule of reinforcement consisting of two or more basic schedules of reinforcement (elements) that occur in an alternating, usually random, sequence; no discriminative stimuli are correlated with the presence or absence of each element of the schedule, and reinforcement is delivered for meeting the response requirements of the element in effect at any time" (Cooper et al., 2007, p. 699).

Motivating operations. "An environmental variable that (a) alters (increases or decreases) the reinforcing or punishing effectiveness of some stimulus, object, or event; and (b) alters (increases or decreases) the current frequency of all behavior that has been reinforced or punished by that stimulus, object, or event" (Cooper et al., 2007, p. 699).

Multiple schedule of reinforcement. "Presents two or more basic schedules of reinforcement in an alternating, usually random, sequence. The basic schedules within the multiple schedule occur successively and independently. A discriminative stimulus is correlated with each basic schedule, and that stimulus is present as long as the schedule is in effect" (Cooper et al., 2007, p. 319).

Noncontingent reinforcement. "A procedure in which stimuli with known reinforcing properties are presented on fixed-time (FT) or variable-time (VT) schedules completely independent of behavior; often used as an antecedent intervention to reduce problem behavior" (Cooper et al., 2007, p. 700).

Picture exchange communication system. An augmented and alternative communication system that consists of six teaching phases (Frost & Bondy, 2002).

Punishment. "Occurs when stimulus change immediately follows a response and decreases the future frequency of that type of behavior in similar conditions" (Cooper et al., 2007, p. 702).

Response restriction. "Entails restricting access to a device needed to engage in the alternative response" (Hagopian et al., 2011, p. 10).

Resurgence. "The recurrence of a previously reinforced response (e.g., destructive behavior) when alternative reinforcement is challenged (e.g., extinction or schedule thinning" (Fuhrman et al., 2016, p. 884).

Schedule of reinforcement. "A rule specifying the environmental arrangements and responses requirements for reinforcement; a description of a contingency of reinforcement" (Cooper et al., 2007, p. 703).

Schedule thinning. "Changing a contingency of reinforcement by gradually increasing the response ratio or the extent of the time interval; it results in lower rate of reinforcement per responses, time, or both" (Cooper et al., 2007, p. 703-704).

Speech-generating devices. Communication devices that generate digitized or synthesized speech outputs (Rispoli, Franco, van der Meer, Lang, & Camargo, 2010).

Stimulus delta. “A stimulus in the presence of which a given behavior has not produced reinforcement in the past” (Cooper et al., 2007, p. 705).

Synthesized functional analysis. Open-ended “interview results used to design individualized and intimately matched test–control analyses that differ only in that the test condition includes the putative reinforcement contingency and the control condition does not” (Hanley et al., 2014, p. 17).

Tact. A verbal operant that is controlled by a nonverbal stimulus and is maintained by nonspecific social reinforcement such as praise (Cooper et al., 2007).

Variable-interval schedule of reinforcement. “A schedule of reinforcement that provides reinforcement for the first correct response following the elapse of variable durations of time occurring in a random or unpredictable order. The mean duration of the intervals is used to describe the schedule” (Cooper et al., 2007, p. 707).

Variable-ratio schedule of reinforcement. “A schedule of reinforcement requiring a varying number of responses for reinforcement. The number of responses required varies around a random number; the mean number of responses required for reinforcement is used to described the schedule (e.g., on a VR 10 schedule an average of 10 responses must be emitted for reinforcement, but the number of responses required following the last reinforced response might range from 1 to 30 or more” (Cooper et al., 2007, p. 708).

Verbal behavior. “Behavior that is reinforced through the mediation of other persons” (Skinner, 1957).

Verbal operant. A unit of verbal behavior that is controlled by motivating operations and discriminative stimuli and is maintained by consequences. (Skinner, 1957).

CHAPTER 2: REVIEW OF LITERATURE

This section will provide a comprehensive review of literature. This review will include seminal and recent research that targeted at least one child 8 years old or younger. The primary focus of the following literature review will be the analysis of verbal behavior based on Skinner's (1957) approach, the use of speech-generating devices to increase verbal behavior, the use of functional analysis to assess problem behavior, and the use of functional communication training. The following literature review will examine variables that influence the development of verbal behavior, how speech-generating devices can be used to increase communication skills, how functional analysis can assist in identifying the communicative function, and how functional communication training can be used to mitigate problem behavior of children with ASD/DD. Refer to Figure 1 for the logic model of this study.

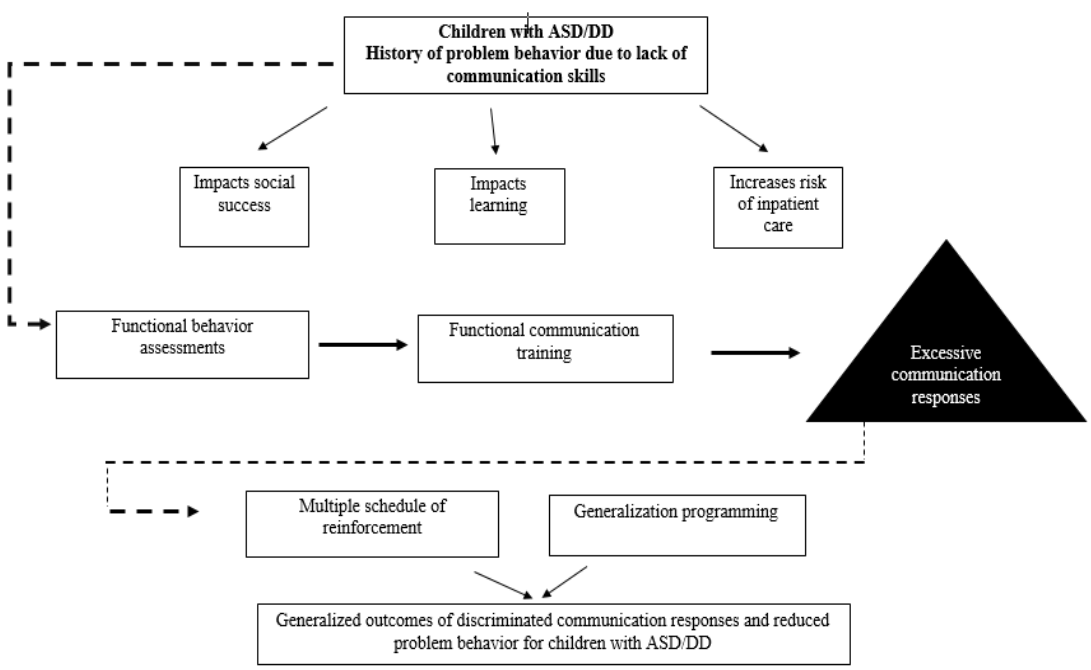

Figure 1. Logic model for the current study.

Verbal Behavior

This study builds on the theoretical framework of Skinner (1957). Skinner defined verbal behavior as behavior that is reinforced by the mediation of another person. In his analysis, verbal behavior is controlled by motivating operations (MO), other antecedent stimuli, and maintained by consequences. This functional behavioral unit is referred to as verbal operants. Skinner (1957) categorized verbal behavior into six verbal operants: mand (i.e., requesting), tact (i.e., naming), intraverbal (i.e., answering questions and commenting), echoic (i.e., repeating), textual (i.e., reading), and transcription (i.e., spelling). In Skinner's analysis of verbal behavior, mands are controlled by motivating operations and reinforced with a specific reinforcer. For example, when a child is hungry (an MO) and mands for a cookie, the reinforcer would be a cookie. Tacts are controlled by a nonverbal stimulus (e.g., smell, taste) and reinforced with generalized conditioned reinforcers. For example, when a child tastes a cookie and says "it's delicious", a reinforcer could be a verbal response from the mother such as saying "yes, it is." Echoic and intraverbal are controlled by a verbal stimulus (hearing someone say "ball") and reinforced with generalized conditioned reinforcers. Generalized conditioned reinforcers can be verbal (e.g., saying "good", "uhha", "yeah"), or nonverbal such as nodding and smiling (Kranser, 1958). Skinner's approach to verbal behavior includes teaching the child both speaker and listener skills using the operant-specific antecedent and consequence variables (Carr & Firth, 2005).

Because Skinner's approach to verbal behavior depends on the function of behavior rather than form, this approach can be more useful in teaching functional communication skills to children with ASD/DD (Bondy, Tincani, & Frost, 2004;

Sundberg & Michael, 2001). Additionally, when a child with ASD/DD can mand and tact many objects, for example, but cannot emit an intraverbal response, the behavioral approach does not attribute that to failure in auditory processing or to the child's diagnosis. Rather, the verbal behavior approach takes the responsibility to arrange the variables that control and maintain a specific verbal operants (Sundberg & Michael, 2001).

According to Skinner (1957) a pure verbal operant occurs when the verbal operant is solely controlled and maintained by the operant-specific antecedent and consequence variables. For example, a pure tact is when a child says "car" when she sees a car and then receives a generalized conditioned reinforcer (e.g., "that's right, it's a car"). Teaching a child with ASD/DD one verbal operant (e.g., mand) does not spontaneously transfer the stimulus control to other verbal operants without direct planning. For instance, if the child can mand for a cookie, that does not necessarily mean she can echo or tact "cookie" (Shafer, 1994; Sundberg & Michael, 2001). Impure verbal operants or multiply controlled verbal operants occur when there are multiple controlling and maintaining variables. For example, a mand-tact verbal operant is when a child is hungry, sees a cookie, says "cookie," and receives a cookie. Because of the presence of the nonverbal stimulus (i.e., the cookie), the mand is impure (Bondy et al., 2004; Cooper et al., 2007). Combining multiple verbal operants in teaching functional communication skills to children with ASD/DD may be beneficial (Cooper et al., 2007; Sundberg & Michael, 2001). For example, it may be more efficient to first teach the child to mand for a preferred item in the presence of the item than in its absence (i.e., mand-tact, Cooper et al., 2007). Subsequently, the stimulus control can be transferred from the nonverbal stimulus (i.e., the presence of the item) to the motivating operations by fading out the presence of the item (Cooper et al., 2007).

In the verbal behavior model, there is an emphasis on carefully organizing the environment so that it contains a variety of highly preferred items and activities to be delivered contingently and immediately to the child upon correct verbal responses. Verbal behavior training can be accomplished within a discrete-trial format or via Natural Environment Training (NET). The latter approach is typically used to facilitate response generalization across a variety of natural and contrived stimuli (Carr & Firth, 2005).

A plethora of studies support Skinner's approach to teach verbal behavior to children with ASD/DD (Bondy et al., 2004; Ganz et al., 2012; Millar, Light, & Schlosser, 2006, Shafer, 1994). Studies have used this approach to teach vocal-verbal behavior, or verbal behavior via augmented and alternative communication (AAC). AAC systems are communication systems that either supplement unintelligible speech or compensate for the absence of speech (Schlosser & Wendt, 2008). Examples of AAC include Picture Exchange Communication System (PECS; Bondy & Frost, 1994, 2002), picture exchange (PE; e.g., Frea, Arnold, & Vittimberga, 2001), manual sign (MS; e.g., Adkins & Axelrod, 2001), and speech generating devices (SGDs; e.g., Beck, Stoner, Bock, & Parton, 2008).

Vocal Verbal-Behavior

Earlier verbal behavior studies focused on teaching vocal verbal operants. For example, Drash, High, and Tutor (1999) used the verbal behavior approach to teach three children with ASD ages 2 and a half to 3 years vocal mand, tact, and echoic operants. Prior to intervention, children's language assessments revealed they functioned linguistically at ages 10 to 14 months. Training, which took place in an outpatient clinic, was conducted in a discrete-trial format. Training consisted of structuring the environment to be highly reinforcing, prompting, as well as shaping and reinforcing appropriate vocalizations. To structure a highly reinforcing environment, parents were asked to give a list of children's preferred edibles and items. A trial began with a vocal prompt (e.g., "would you like this?"). Contingent reinforcement was delivered upon any vocalization that was not inappropriate such as crying or yelling. Data were collected on percentages of vocal mands, tacts, and echoics. Baseline data were not collected. The treatment results suggested that all three children learned to use mands and echoics. Data were variable for tacts, and no functional relation was established due to the lack of experimental control.

Sundberg, Loeb, Hale, and Eigenheer (2002) taught two 5-and 6-year old children with ASD to mand for information (where). Both children had manifested strong vocal abilities to mand, tact, and emit intraverbal responses. However, neither child was able to mand for information using "where?" The intervention, which took place in an isolated area within children's classroom, consisted of echoic prompts and verbal information regarding the location of the requested item. Training started with giving the child a box that contained a preferred item to interact with. Next, the box and item were removed, and the child was given a neutral item to interact with. Then, the child was given back the box but without the preferred item. The child was required to ask "where?" No mands and incorrect mands were followed by an echoic prompt (e.g., say "where is…?"). Independent and prompted responses resulted in verbal information regarding the location of the missing item and an interaction with the item for 30 s. Data were collected on the percentage of correct mands. Using a multiple baseline across stimuli design, the results suggested a functional relation between the intervention and increased mand for information responses.

As suggested by previous studies (Drash et al., 1999; Sundberg et al., 2002), using the behavioral approach by arranging the antecedents and consequences can be effective in teaching children with ASD/DD to use verbal operants. Specifically, these studies showed positive effects on vocal mands and echoics. Variable results were found on vocal tacts in Darsh et al.'s (1999) study.

Picture Exchange Communication System

Since the development of Picture Exchange Communication System (PECS) by Bondy and Frost (1994), numerous studies have investigated its effects on communication for children with ASD/DD whether as a separate intervention (e.g., Ganz & Simpson, 2004) or in comparison to other AAC modalities (e.g., Adkins & Axelrod, 2001). PECS is a training protocol developed to teach children with ASD/DD to communicate using pictures. It consists of six phases which start with teaching the child to mand using a picture, and progresses to teaching the child to mand using multiple pictures, and to using pictures for a variety of other communicative functions (Bondy & Frost, 1994).

PECS alone. Several studies have investigated the effects of PECS alone on a variety of verbal behavior variables. For example, Charlop-Christy, Carpenter, Le, LeBlanc, and Kellet (2002) taught three children with ASD ages 3 to 12, who did not speak or rarely spoke, to communicate via PECS. Training took place in a clinic as well as the classrooms and homes of the participants. Charlop-Christy et al. followed the PECS protocol (Bondy & Frost, 1994) in teaching children the six PECS phases; "(a) physical exchange, (b) expanding spontaneity, (c) picture discrimination, (d) sentence structure, (e) ''What do you want?'' and (f) commenting" (Charlop-Christy et al., 2002, p. 218). Data were collected on several dependent variables. These included vocal spontaneous responses, vocal echoic responses, mean length of utterance, social-communication responses, and problem behavior. Using a multiple baseline across participants design, the results indicated two children showed substantial improvements in vocal spontaneous responses, vocal echoic responses, and mean length of utterance. Additionally, all children showed increases in social-communication responses (i.e., eye contact, joint attention, play). However, PECS had no effects on problem behavior for any child.

Similarly, Kravits, Kamps, Kemmerer, and Potucek (2002) taught a 6-year-old girl with ASD to communicate via PECS. The participant was able to vocally communicate using one to two-word utterances but she rarely initiated communication and her utterances were unintelligible. Training was conducted during snack and leisure periods at home as well as play and center periods in her kindergarten classroom. Kravits et al. taught the participant the first three phases of PECS using the PECS manual (Bondy & Frost, 1994). Data were collected on the frequency of spontaneous verbal responses (requests, comments, and expansions) using PECS. Using a multiple baseline across settings design, the findings suggested some increases in the spontaneous verbal responses with a lot of variability.

Four years later, Marckel, Neef, and Ferreri (2006) taught two 4-and 5-year-old boys with ASD, who had previously been taught to use PECS, to improvise communication. The purpose of this investigation was to teach children to make various requests with limited pictures based on the color, shape, and function of the item. Training was conducted in the participants' homes. Prior to training, Marckel et al. identified children's preferred items through interviews with parents and therapists. The training was conducted sequentially across three descriptors (color, shape, and function). During intervention, the therapist placed a preferred item in front of the child, and then physically prompted the child to use the correct descriptor. After fading out physical prompts, an error correction procedure was implemented. When a child made an incorrect response, the child was asked to try again. When the child made another incorrect response, the therapist prompted the child. Independent and prompted response resulted in praise and brief access to the item. Data were collected on the number of correct improvised mands using PECS. An improvised mand consisted of using one or more descriptors to mand for an item (e.g., "eat", "circle", or "black" for an Oreo). Using a multiple baseline across three descriptors, the data suggested a functional relation between the intervention and using a descriptor to mand for an item for both children. Additionally, both children were able to generalize the skill across different untrained items.

Further investigation of PECS was conducted by Angermeier, Schlosser, Luiselli, Harrington, and Carter (2008). The authors aimed to examine whether high vs. low resemblance of PECS symbols to the referents (e.g., items) affect the effectiveness and efficiency of PECS acquisition. Four children ages 6 to 9 years who were diagnosed with autism or Pervasive Developmental Disorder (PDD) participated in the study. The training was conducted in an isolated room in the participants' school. Angermeier et al. taught the participants the first three phases of PECS by following the PECS protocol

(Bondy & Frost, 1994). Sessions began with presenting a highly preferred item, and then physically prompting the child to exchange the correct symbol. Progressive time delay was implemented to gradually fade out the physical prompts. The authors randomly alternated between PECS and Blissymbols symbols (high vs. low resemblance) across PECS phases. Data were collected on the percentage of correct mands via PECS across the two conditions in phases I, II, and III of PECS. Using a multiple baseline with an embedded alternating design, the results indicated no difference between the conditions. Additionally, only one child mastered criterion on PECS phase III.

Two studies led by a research team aimed to examine the effects of PECS on speech (Ganz & Simpson, 2004; Ganz, Simpson, & Corbin-Newsome, 2008). Ganz and Simpson (2004) taught three children (one Asian, one Caucasian, and one African-American) with autism/ autistic characteristics, ages 3 to 7, to use PECS. Training took place in each participant's classroom. The intervention consisted of echoic prompting (e.g., "I want candy") in addition to following the PECS protocol to teach the first four phases of PECS (Bondy & Frost, 1994). Data were collected on the percentage of independent PECS exchanges, number of intelligible spoken words, and percentage of non-word vocalizations. Using a changing criterion design, the data indicated all children mastered criterion on independent PECS exchanges in all four phases. Additionally, all children's responses showed substantial increases of intelligible spoken words in the fourth phase of PECS. Variable results were obtained in terms of non-word vocalizations as one child's responses decreased, another child's responses increased, and the third child's responses showed no trend.

Four years later, Ganz et al. (2008) replicated the procedure from Ganz and Simpson's (2004) study. The participants included three 3 to 5-year-old children (two Latinos, and one Caucasian) diagnosed with autism/ autistic characteristics. Training took place in each participant's home. Data were collected on the percentage of independent PECS exchanges, number of intelligible spoken words, and percentage of word approximations (e.g., "ba" for "ball"). Using a multiple baseline across participants design, the results showed two children mastered criterion on PECS exchanges for all the four phases of PECS that had been taught. However, one child did not master any of the PECS phases. In terms of spoken words, two children showed little increases of spoken words with a lot of variability. Finally, only one child demonstrated an increase of word approximations in the fourth phase of PECS.

Overall, previous studies on PECS have shown some positive effects on PECS exchanges of children with ASD/DD (e.g., Ganz et al., 2008; Ganz & Simpson, 2004; Marckel et al., 2006). However, there appears to be mixed results in terms of PECS effects on speech. Some studies have suggested PECS produced increases in speech (Charlop-Christy et al., 2002; Ganz & Simpson, 2004) whereas others showed little or no increases in speech as an effect of PECS (Ganz et al., 2008; Kravits et al., 2002).

PECS in comparison to sign. In addition to investigating the effects of PECS on communication, a few studies have compared PECS and manual sign (e.g., American Sign Language). For example, Adkins and Axelrod (2001) taught a 7-year-old child with PDD and attention deficit hyperactivity disorder (ADHD) to mand using PECS and sign. The child was only able to vocally produce a few sounds. Training was conducted in the participant's classroom. The intervention consisted of following the PECS protocol for phase I (Bondy & Frost, 1994). A similar procedure to teach the child to mand via sign was implemented. This involved physical prompts and a 10-s time delay. Data were collected on the percentage of trials requiring physical prompts, and number of trials to criterion. Using an alternating design, the findings suggested that PECS was more effective as it required fewer physical prompts, and more efficient as it required a fewer number of trials.

Tincani (2004) extended Adkins and Axelrod's (2001) study by measuring vocal behavior in addition to acquisition of PECS and sign. Tincani included two 5-and 6-year old children (one Asian and one African-American) who had a diagnosis of ASD and intellectual disability (ID). Both children were able to imitate a few sounds vocally and communicate by gestures. Training took place in the participants' self-contained classroom. The intervention for sign involved presenting a preferred item, modeling the sign for the item, and providing a vocal model (e.g., saying "*cookie*"). If incorrect response or no sign occurred, a physical prompt was provided. Prompted and independent sign resulted in a brief access to the preferred item. The intervention for PECS consisted of following the PECS protocol for phases I, II, and III (Bondy & Frost, 2002). Data were collected on independent mands and word vocalizations. Using a multielement design with baseline and best treatment phases, the results suggested one child showed a higher percentage of independent mands using PECS. On the other hand, sign training produced a higher percentage of independent mands for the other child. In terms of vocalizations, both children demonstrated a higher percentage of vocalizations during sign training.

In short, studies that compared PECS and manual sign in terms of acquisition rate suggested that children with ASD/DD may differ as some may acquire PECS more rapidly (e.g., Adkins & Axelrod, 2001; Tincani, 2004) while others may learn to sign more rapidly (Tincani, 2004). A study that measured vocalizations demonstrated more increased vocal mands during sign training compared to PECS training (Tincani, 2004).

PECS in comparison to low-tech speech-generating devices. In addition to comparing PECS to manual sign, researchers have also compared PECS and low-tech speech generating devices (SGDs). An SGD is any communication device that generates a speech output (e.g., BIGmack). Low-tech SGDs have a few buttons in which an adult can pre-record a specific message in each one (e.g., "*I want water*") based on the needs of the user (e.g., child). Pressing a button on low-tech SGDs produces a static speech output (Rispoli, Franco, van der Meer, Lang, & Camargo, 2010).

To compare the acquisition rates of PECS and a low-tech SGD, Beck et al. (2008) included four Caucasian preschool children who had a diagnosis of ASD (one had speech and language impairment). All children had no vocal repertoire and did not have a history with any AAC. The materials included PECS and GoTalk device which had nine locations to record messages. The intervention in both conditions (PECS I, II, III, GoTalk I, II, III) were adapted from Bondy and Frost (2002) and consisted of physical prompts, prompt fading, and contingent access to the reinforcer upon independent and prompted mands. The only difference in these conditions was echoic prompts. In PECS training, after the child exchanged the correct symbol, the interventionist provided an echoic prompt ("*cookie*", "*I want a cookie*"). In GoTalk training, the device provided an echoic prompt when the child pressed the correct button. Data were collected on independent mands across both conditions. Using an alternating treatment design, the findings demonstrated PECS was mastered in shorter time compared to GoTalk. Specifically, two children mastered PECS (phases I, II, and III) and only mastered the first phase of GoTalk. The other two children only showed increases in mand via PECS in phase I and showed no increases in mand via GoTalk.

Finally, Boesch, Wendt, Subramanian, and Hsu (2013) compared PECS and a five-button Logan ProxTalker device in terms of manding acquisition rate. The participants included three 6-to-10-year-old children (one Latino and two Caucasians) with ASD who had no to minimal speech (eight spoken words). Training took place in a therapy room. The intervention consisted of following the PECS protocol (Bondy & Frost, 2002) for PECS phases I, II, and III. An adaptation of the PECS protocol was used for the device training. Data were collected on the number of independent correct mands across each modality (PECS; exchange a picture, SGD; evoke a button). Using a multiple baseline across participants with an embedded alternating treatments design, the findings did not demonstrate differences in acquisition rates between PECS and the SGD.

To summarize, prior studies that compared PECS and low-tech SGDs demonstrated variable results in terms of acquisition rate. One study showed children with ASD/DD learned to use PECS more rapidly (Beck et al., 2008) while the other study showed no differences in terms of acquisition rates (Boesch et al., 2013).

Summary

Skinner's analysis (1957) of verbal behavior has been applied in behavioral research to examine its efficacy to increase verbal behavior of children with ASD/DD. Specifically, earlier studies focused on manipulating the motivating operations, antecedents and consequences to increase vocal-verbal behavior of children with ASD/DD (Drash et al., 1999; Sundberg et al., 2002). Those studies suggested that using highly preferred items, prompting, and reinforcing can be effective in increasing vocal mands and echoics. However, Drash et al. (1999) showed variable results on vocal tacts.

Since the development of PECS (Bondy & Frost, 1994), an abundance of research has been conducted to evaluate its effects on verbal behavior of children with ASD/DD. Those studies have examined its efficacy as a stand-alone intervention (e.g., Ganz et al., 2008) or in comparison to other AAC modalities (e.g., Beck et al., 2008). Overall, prior investigations have shown children with ASD/DD can learn to communicate via PECS (e.g., Boesch et al., 2013; Ganz et al., 2008; Marckel et al., 2006). The effects of PECS on vocal verbal behavior has demonstrated variable results. Some studies have suggested PECS can improve vocal verbal behavior (Charlop-Christy et al., 2002; Ganz & Simpson, 2004) while others showed little or no increases in vocal verbal behavior as an effect of PECS (Ganz et al., 2008; Kravits et al., 2002).

Finally, based on previous research, children with ASD/DD may differ in acquisition rates of PECS compared to other AAC modalities. Some children with ASD/DD may learn to use PECS more rapidly compared to sign (e.g., Adkins & Axelrod, 2001) or low-tech SGDs (Beck et al., 2008) while others may show no differences (Boesch et al., 2013) or learn to sign more rapidly (Tincani, 2004).

High-Tech Speech-Generating Devices to Teach Verbal Behavior

High-tech SGDs are computer devices that allow for customization based on a child's needs and communication level and can be activated by the child to generate a synthesized or digitized speech outputs. Unlike low-tech SGDs which generate static speech outputs, high-tech SGDs (e.g., iPads, iPods) generate synthesized or digitized speech outputs; making speech outputs easier to understand by communicative partners

(Rispoli et al., 2010). High-tech SGDs are usually combined with visual cues such as photographs or line drawings (Mirenda, 2003; Ogletree & Oren 2006).

High-tech SGDs can be a viable option for children with ASD/DD who lack speech skills. Unlike manual sign, high-tech SGDs do not require complex fine motor skills. Additionally, speech outputs generated by those devices are easier to understand by communicative partners than manual sign (Lorah, Parnell, Whitby, & Hantula, 2015). High-tech SGDs also surpass the capabilities of picture cards as they have more capacity to store icons and speech outputs, are easier to carry (Lorah et al., 2015), and are more socially acceptable (Lorah et al., 2013). High-tech SGDs have been used in previous studies to teach several verbal operants. These include mands, tacts, and intraverbals.

High-Tech SGDs for Manding Skills

Manding (i.e., requesting) is a fundamental communication skill. Effective language programs typically begin with teaching the child to mand so that the child has control over his/her environment by having the ability to recruit reinforcement (Sundberg & Michael, 2001). Manding relies on an establishing operation (EO) to evoke a child's response (Skinner, 1957). For example, when a child has been deprived of a favorite type of food (e.g., candy), he/she is likely to mand for this type of food. Because teaching manding depends on an EO, it is crucial to identify the child's preferences through one or more preference assessments. These preference assessments can be indirect or direct. Indirect preference assessments can be accomplished through questionnaires or interviews with teachers and caregivers. Direct preference assessments can be accomplished through natural observations, or trial-based assessments (Cooper et al., 2007). Trial-based assessments involve manipulation of stimuli presented to the child.

Trial-based assessments include single-stimulus preference assessments (i.e., presenting one stimulus and measuring time of engagement with the stimulus; Pace, Ivancic, Edwards, Iwata, & Page, 1985), free-operant (i.e., presenting an array of stimuli and measuring time of engagement with the selected stimulus; Roane,Vollmer, Ringdahl, & Marcus, 1998) multiple-stimulus-with-replacement (i.e., presenting an array of stimuli, the child selects a stimulus, the stimulus is represented with the other stimuli; DeLeon & Iwata, 1996), multiple stimulus without replacement preference assessment (i.e., presenting an array of stimuli, the child selects a stimulus, the stimulus is removed from the array; DeLeon & Iwata, 1996), and forced choice/pairwise assessments (i.e., two stimuli are presented; Fisher et al., 1992).

A plethora of studies have investigated the use of high-tech SGDs to teach manding to children with ASD/DD. Manding via a high-tech SGD has been taught as a single-step (e.g., Gevarter et al., 2014), or multistep (e.g., Alzrayer, Muharib, & Wood, 2018; Muharib, Alzrayer, Wood, & Voggt, 2018). Additionally, manding via a high-tech SGD has been compared to manding via other modalities such as manual sign and picture exchange (e.g., Achmadi et al., 2014).

Single-step manding via high-tech SGDs. In single-step manding, the child is required to touch one icon/button representing the preferred stimulus to gain access to it. Schlosser et al. (2007) taught five children with autism, ages 8 to 10, who communicated by grabbing, reaching, and crying, to mand for preferred stimuli using Vantage (a high-tech SGD). The study took place in children's classroom. To identify preferred stimuli, Schlosser et al. conducted interviews with parents and teachers, a single-stimulus preference assessment (Pace et al., 1985), and a multiple stimulus without replacement assessment (DeLeon & Iwata, 1996). Intervention consisted of a 10-s constant time-delay (Striefel & Owens, 1980), modeling the correct response, and physical prompt when no response occurred after 5 s of modeling. Contingent on activating the correct button, the child was given a 5 s access to the requested stimulus. Using an alternating treatment design (speech output versus no speech output), the results showed that all children acquired the skill of manding via Vantage. No difference was notable between the two conditions in terms of manding via the SGD. However, high variability in vocalizations was evident in all children across both conditions (i.e., speech output versus no speech output).

A few years later, Dundon, McLaughlin, Neyman, and Clark (2013) investigated the effects of the Model-Lead-Test procedure (Marchand-Martella, Slocum, & Martella, 2004) to teach a 5-year-old child with autism to mand for preferred stimuli using two iPad applications (My Choice Board, and GoTalk Now Free). The experiments took place in an isolated area within the child's classroom. The procedure consisted of three steps: (a) pointing to the correct icon and labeling it, (b) hand-over-hand touching the correct icon, and (c) asking the child *"what do you want?"* In all steps, the researcher had the iPad application open. Each application consisted of four images of preferred stimuli. Whether manding via the iPad occurred with or without prompts, the child was given a 30-s access to the requested stimulus. Using a multiple baseline design across two iPad applications, the results showed that the child learned to mand for preferred stimuli independently. Nevertheless, as the study had only two demonstrations of effect, no functional relation was established.

Using a different iPad application called Proloquo2Go, Sigafoos et al. (2013) examined the impact of systematic instruction (i.e., least-to-most physical guidance, 10-s prompt delay) on children's ability to mand for the continuation of toy play. The children were two siblings, ages 4 and 5 years, diagnosed with autism. Both children communicated by reaching, pointing, or hitting. The experiments took place in a clinic. To identify their preferred stimuli, the researchers conducted preference assessment sessions in which each was divided into 10, 30-s intervals. Children were asked to pick a toy from a large box and their engagement with the toys was observed for the 30 s. During intervention, the iPad application displayed the correct page that showed a line drawing icon of *Toy Play*. The experimenter allowed the child to play with a preferred toy for 30 s. Then, the toy was retrieved with a vocal statement (e.g., "*my turn now, let me know if you want it back*"). The least amount of physical guidance was used when the child did not touch the icon within 10 s. Whether independent or prompted manding via the iPad occurred, the child was re-given the toy for 30 s. Using a multiple-baseline across participants design, the findings showed both children learned to mand for the continuation of toy play via Proloquo2Go and maintained the skill. Additionally, both children were able to generalize manding via Proloquo2Go across a different stimulus (i.e., a game for one child, and snack for the other child). However, the study did not establish a functional relation as it only showed two demonstrations of effect.

Three years later, Lorah (2016) also examined whether children with ASD/DD could mand via Proloquo2Go on an iPad and also discriminate between symbols. Three children, ages 3 to 4, who were diagnosed with autism and had limited to weak echoic and mand repertoires (Sundberg, 2008), participated in the study. The intervention took place in children's classroom. To identify children's preferred stimuli, a free operant (Roane et al., 1998) and a multiple stimulus without replacement (DeLeon & Iwata, 1996) were conducted. Lorah used a changing criterion design embedded in a multiple baseline across participants to teach children in four phases to discriminate between symbols to mand for preferred stimuli. In phase one, the Proloquo2Go page consisted of one symbol/icon which represented a preferred stimulus. In phase two, the page consisted of one symbol/icon which represented a preferred stimulus and three blank icons. In phase three, the page consisted of two symbols/icons which represented two preferred stimuli and two blank icons. In phase four, the page consisted of four symbols/icons which represented four preferred stimuli. In all phases, a 5-s time delay and physical prompts were used. Contingent on correct independent or prompted manding, the child was granted a 30-s access to the requested stimulus. The findings indicated a functional relation between the procedures and manding via Proloquo2Go. Additionally, all children were able to maintain the manding skill.

To examine whether PECS (Bondy & Frost, 1994; Frost & Bondy, 2002) can be used to expand children's manding skills, King et al. (2014) included three children ages 3 to 5 who were diagnosed with ASD and DD in the study. Children were either non-vocal-verbal or with limited unintelligible speech. Two out of the three children engaged in problem behavior such as crying, screaming, and hitting. The experiments took place in a hallway at the children's school. To identify children's preferred stimuli, interviews with teachers and parents were conducted. Subsequently, forced choice assessments (Fisher et al., 1992) were implemented. Intervention phases (phase 1 through phase 4) were adapted from PECS. In all phases, most-to-least physical guidance was used.

Contingent on correct independent or promoted manding, the child was given access to reinforcer for 5-15 s with a vocal statement from the interventionist ("*I want* [reinforcer]"). Using a multiple-probe across participants design, the results showed a functional relation between the adapted PECS procedure and manding via Proloquo2Go (phase 1 through phase 3b). Children, however, were not able to master phase 4 of PECS which required them to press "I want" icon in addition to the icon of a preferred stimulus. Furthermore, vocal manding (i.e., intelligible vocal approximation or single-word utterance) for the preferred stimuli was variable for one child, and near zero levels for two children.

Waddington, van der Meer, Carnett, and Sigafoos (2017) also used the PECS (phase 2) protocol to teach an 8-year-old boy with autism to approach communicative partners to mand for preferred stimuli using Proloquo2Go on an iPad. To identify the child's preferred stimuli, a multiple stimulus without replacement preference assessment was conducted (DeLeon & Iwata, 1996). Subsequently, 12 pages were created on the application. Each consisted of an image of the preferred stimulus, a distractor (paper), and two blank icons. During intervention, the application was open to the correct page. The communicative partner, standing at distance, held the preferred toy and paper and looked at the child expectantly. When the child did not approach the communicative partner or activate the correct icon within 10 s, the interventionist (another person) provided the least amount of physical guidance. Prompted or independent manding resulted in a 30 s access to the requested toy. Through a multiple-baseline across settings design, the study demonstrated a functional relation between the PECS (phase 2) protocol and manding via Proloquo2Go in school, clinic, and home. In addition, the child was able to generalize manding across settings within the main settings (i.e., office in clinic and school, and living room in home).

Researchers have also examined whether children with ASD/DD acquire manding skills more rapidly using certain iPad applications and display formats compered to others. Gevarter et al. (2014) taught three children (one African-American, and two Caucasian-Americans) with ASD and ID, ages 3 and 4, who mainly communicated by pointing and leading, to mand for preferred stimuli using two iPad applications in three formats (i.e., GoTalk 'a line drawing symbol', and Scene and Heard 'a photograph' and 'a photograph combined with a line drawing symbol'). The experiments took place in children's homes. Interviews with parents were conducted, followed by multiple stimulus without replacement assessments (DeLeon & Iwata, 1996) to identify children's preferred stimuli. In an alternating treatments design, the experimenter had the iPad application open (i.e., GoTalk, Heard and Scene with a photograph, or Heard and Scene with the combined feature), and presented three preferred stimuli and allowed the child to reach for one. A 6-s time delay was used before least-to-most physical guidance was implemented. Whether touching the icon occurred independently or prompted, the child was given access to the reinforcer. Acquisition results showed that two children mastered criterion on GoTalk and Heard and Scene with a photograph but acquisition was more rapid and sustained with the latter. The third child mastered criterion on all three formats but acquired manding skill more rapidly using GoTalk. The results suggest that for some children, the type of iPad applications as well as the configuration of the display format may influence manding acquisition.

Similarly, Gevarter et al. (2017) examined whether certain display configurations impact manding skills acquisition of children with autism. Five children ages 3 to 8 who were diagnosed with autism and had no prior history of using AutisMate application on an iPad participated in the study. The iPad application was presented in four display configurations: (a) photo image display presented four real images of preferred stimuli; (b) symbol grid presented four line drawing symbols of preferred stimuli; (c) hybrid display presented two real images of two preferred stimuli and two line drawing symbols of another two preferred stimuli; and (d) pop up symbol grid presented real images of preferred stimuli, upon touching the screen, it popped up presented four line drawing symbols of those preferred stimuli. Prior to alternating treatments, multiple stimulus without replacement assessments (DeLeon & Iwata, 1996) were conducted to identify children's preferred stimuli. In intervention, the child was presented with four preferred stimuli while the iPad was open to the correct page. Least-to-most physical guidance was used when the child did not respond within 6 s. Whether prompted or independent, a correspondence check (Frost & Bondy, 2002) was used by saying "*take it*". The child was given a 20 s access to the reinforcer if he/she reached for the corresponding item. The findings showed that only one child mastered criteria on all four formats. His acquisition was more rapid and stable in the photo image, and hybrid conditions. Two children mastered criteria on all formats but the hybrid. Their acquisition was more rapid and stable in the photo image condition. Two children did not master criteria on any format; thus the intervention required procedural modifications (i.e., one icon or a preferred stimulus, and a distractor icon). With the modification, one child mastered criteria on all formats but the hybrid. His acquisition was more rapid and stable in the photo image condition. The other child mastered criteria on all formats but the symbol grid. His acquisition was more rapid and stable in the photo image and pop-up symbol grid conditions. This study suggests that some children may be able to mand using a high-tech SGD with four icons on the page while others may need to start with fewer icons and require distractor training.

Finally, impact of single-step manding via high-tech SGDs on vocalizations was investigated. Gevarter et al. (2016) included four boys (one African-American, one Caucasian-American, and two Latino-Americans) with autism, ages 4 to 7, who had scored at Level 1 on the Early Echoic Skills Assessment (EESA; Esch, 2008) from the Verbal Behavior Milestones Assessment and Placement Program (VB-MAPP; Sundberg, 2008). Three out of the four children had a history of using iPad applications for communication (e.g., GoTalk, Heard and Scene). The experiments took place in children's homes. To identify each child's preferred stimuli, interviews with parents and therapist were conducted, followed by multiple stimulus-without-replacement assessments (DeLeon & Iwata, 1996). The dependent variables were (a) independent vocalization (i.e., full-word or approximation after the SGD's speech output but without a vocal model from the interventionist); and (b) vocal initiations (i.e., full-word or approximation before the SGD's speech output). The SGD was GoTalk Now application loaded on an iPad. During intervention, the child was presented with one preferred stimulus while the iPad was open to the correct page. A 5-s time delay was implemented for both vocalizations and SGD manding. When the child emitted the target vocalization but did not mand via the SGD, physical guidance was used. Likewise, when neither vocalizations nor SGD manding occurred within 5 s, physical guidance was used to activate the correct icon. In this case, a 5-s reinforcer delay was used. When the child emitted the target vocalizations during the 5-s interval, he/she was granted a 20-s access to the reinforcer. Otherwise, the child was presented with a simple distractor trial (e.g., "touch your nose") and was given access to a less preferred item. Using a multiple-baseline across participants design, the findings showed only two children demonstrated increased independent vocalizations. The other two children needed vocal model to increase the target vocalizations. The results suggest that applying additional echoic prompts in combination with SGDs may increase vocalizations of some children with autism and limited vocal imitation skills.

Overall, previous studies on single-step manding using high-tech SGDs have shown positive effects on increased manding via SGDs whether with systematic instruction (e.g., Lorah, 2016; Sigafoos et al., 2013) or the PECS protocol (e.g., Waddington et al., 2017). Nevertheless, studies have shown mixed results in terms of vocal manding (Gevarter et al., 2016; Schlosser et al., 2007). In addition, studies have suggested that children's acquisition rates of manding via iPad applications may greatly differ with various display configurations (Gevarter et al., 2014, 2017).

Multi-step manding via high-tech SGDs. In addition to single-step manding via high-tech SGDs, researchers have investigated whether children with ASD/DD can be taught to mand via SGDs in multi-steps. For instance, Carnett, Bravo, and Waddington (2017) examined the effects of behavior chain interruption strategy (BCIS) on multi-step manding for action (e.g., "*unlock the iPad*"). Participants were three nonvocal-verbal children with autism, ages 5 to 13, who had prior history of using SGDs for manding. Carnett et al. identified each child's preferred stimuli through interviews followed by forced choice assessments (Fisher et al., 1992). Using Proloquo2Go loaded on an iPad, one child was required to type in the targeted action mand, and then activate the speech output (e.g., "*unlock the iPad*"). The other two children were required to activate one symbol (out four) in each of four pages in the correct sequence (e.g., actions, unlock, watch video, iPad). In addition to BCIS, intervention included least-to-most prompting, a 5-s prompt delay, and differential reinforcement. Generalization probes were conducted across a different (untrained) locked device. Using a multiple-probe across participants design, the results showed one child mastered criterion and was able to generalize manding for action across the untrained locked device. The other two children required procedural modifications in which simultaneous prompting was used. They mastered criterion with the procedural modifications. Additionally, these two children were not able to generalize across the untrained locked device.

Similarly, Genc-Tosun and Kurt (2017) examined the effects of total task chaining and systematic instruction (i.e., time delay, graduated guidance, and reinforcement) on six-step manding via an iPad loaded with Dokun Konus (Touch and Speak) application. Participants were three 4-year-old children diagnosed with autism, two of whom had limited speech repertoire (10 to 15 words), and one was nonvocal-verbal. All children had no prior history of using an SGD. Interviews were conducted to identify children's preferred stimuli followed by single-stimulus (Pace et al., 1985) and multiple-stimulus-with-replacement (DeLeon & Iwata, 1996) assessments. Children were required to (a) press the home button of the iPad, (b) unlock the screen, (c) select the correct category of the desired item (snack or toys), (d) scroll the page, (e) touch the icon corresponding to the desired item, and (f) take the requested item. Using multiple-probe across participants design, the results demonstrated a functional relation between the intervention package and multi-step manding. Additionally, children were able to generalize multi-step manding across people and maintain the skill.

In addition, researchers have examined whether vocalizations can increase with using SGDs in multi-step manding. For example, Alzrayer et al. (2018) examined the impact of the mand-model approach on two-step SGD manding and vocalizations of three children (one African-American, one Caucasian-American, and one Latino) with ASD and DD. Children were 5 to 8 years old who scored at Level 1 on the Early Echoic Skills Assessment (EESA; Esch, 2008). None of the children had prior experience with any SGD. To identify children's preferred stimuli, interviews with teachers were conducted followed by multiple stimulus without replacement preference assessments (DeLeon & Iwata, 1996). The intervention consisted of progressive time-delay (Charlop, Schreibman, & Thibodeau, 1985), echoic prompts, least-to-most prompts, and differential reinforcement. The two-step SGD manding consisted of (a) touching the GoTalk Now application button on the iPad, and (b) touching and activating the speech output of the icon corresponding with the desired item. Children were also required to vocalize the word of the item before or after the speech output (e.g., "*candy*", "*car*"). Using a multiple-probe across participants design, the findings showed a functional relation between the intervention package and the two-step SGD manding and vocalizations. Additionally, all children maintained and generalized two-step SGD manding across teachers. However, vocalizations did not maintain or generalize for two children.

In addition to multistep manding via an SGD, researchers have combined manding with intraverbal training. For example, Strasberger and Ferreri (2014) recruited typically developing children to teach four children with ASD and ID, ages 5 to 12, to respond to two question (a) what do you want?; and (b) what is your name? To answer each question correctly, the child had to complete a two-step sequence on the Proloquo2Go application loaded on an iPod. Children's preferred stimuli were identified by interviews with teachers followed by a forced choice assessment (Fisher et al., 1992). The peer-assisted intervention consisted of graduated guidance, 2 to 5-s time delay, and access to edibles contingent on correct SGD responses. Using a multiple baseline across participants design, the findings showed two children mastered criterion on both two-step responses to *what do you want?,* and *what is your name?,* and also maintained and generalized the skill across snack time. However, two children did not respond to *what is your name?* in the two-step sequence. Additionally, generalization across snack time was low, and no data were collected on their maintenance.

Similarly, Waddington et al. (2014) examined the effects of systematic instruction (i.e., least-to-most prompting, time delay, error correction, and reinforcement) on children's ability to answer the question ("*would you like anything?*") via Proloquo2Go on an iPad. Three children with autism, ages 7 and 10, participated in the study. All children had received a manding intervention using Proloquo2go. To identify children's preferred stimuli, interviews with parents and therapists were conducted followed by multiple stimulus without replacement preference assessments (DeLeon & Iwata, 1996). In this three-step sequence, the Proloquo2go page contained four symbols (category, two toys, and thank you). Children were required to (a) touch and activate the symbol that represented the category of the desired item (e.g., toys), (b) touch and activate the symbol corresponding to the desired item, and (c) touch and activate a "*Thank You*" icon upon receiving the reinforcer. Using a multiple baseline across participants design, the findings showed only one child mastered criterion on the three-step manding and maintained the skill. The other two children had mixed results.

Four years later, Muharib et al. (2018) examined the effects of backward chaining on children's ability to answer the question ("*what do you want?*") via Proloquo2Go on an iPad. Three children (two African-Americans, and one Caucasian-American) with ASD and DD, ages 6 to 8, participated in the study. All children were able to vocally mand in one word (e.g., "*popcorn*"). Interviews with teachers were conducted followed by multiple stimulus without replacement preference assessments (DeLeon & Iwata, 1996) to identify children's preferred stimuli. In this experiment, children were required to perform a three-step sequence on the iPad: (a) touch and activate *I want to* icon, (b) touch and activate one out of three action icons (i.e., eat, play, or watch), and (c) touch and activate the icon corresponding with the desired item. Data were also collected on children's vocal manding (e.g., "*I want to eat popcorn*"). In addition to backward chaining, least-to-most prompts, a 5-s time delay, and differential reinforcement were used. Using a multiple probe across participants design, the results showed all children mastered criterion on both three-step iPad-based manding and vocal manding. However, one child required additional echoic prompts from the interventionist to increase his vocal manding.

Past studies on multistep manding via SGDs have shown some positive results (e.g., Genc-Tosun & Kurt, 2017). Additionally, there are some data suggesting that vocalizations may increase with systematic instruction and SGDs (Alzrayer et al., 2018; Muharib et al., 2018). Previous studies have also suggested that some children with

ASD/DD may require procedural modifications to increase their ability to perform more complex manding sequences on SGDs.

Manding via high-tech SGDs compared to other modalities. In addition to single-step and multi-step manding via SGDs, researchers have compared between high-tech SGDs and other communication modalities in terms of acquisition and preference. For instance, Flores et al. (2012) compared between SGDs and picture exchange (PE) for five children with ASD and ID. All children had a prior experience with PE but no experience with SGDs. The high-tech SGD in this study was Pic-a-Word application loaded on an iPad. The intervention, which took place in the participants' self-contained classroom, consisted of verbal and physical prompts, a 5-s time-delay, and reinforcement (edibles). Using a reversal design, the results showed a substantially higher level of acquisition of SGD-based manding compared to PE for two children, and showed a slightly higher level of acquisition of SGD-based manding compared to PE for three children.

A year later, Lorah et al. (2013) compared SGD and PE for five children with autism who had no experience with either communication modality. The intervention took place in an isolated area in children's classroom. Surveys were completed by teachers followed by a multiple-stimulus without replacement preference assessment (DeLeon & Iwata 1996) to identify each child's preferred stimuli. The SGD in this study was Proloque2go on an iPad. The intervention in each condition consisted of a 5 s time delay, full physical prompts, and 30 s access to the reinforcer. Using an alternating treatments design, the findings showed four children demonstrated higher and more rapid acquisition of and preference to SGD-based manding compared to PE. Conversely, one child showed higher and more rapid acquisition of and preference to PE-based manding compared to SGD.

More recently, Agius and Vance (2016) compared SGD (i.e., SoundingBoard application loaded on an iPad) and PECS for four preschool children with autism. Interviews with parents were conducted followed by free-operant preference assessments (Roane et al., 1998) to identify children's preferred stimuli. The PECS protocol (Boesch et al., 2013) was followed in the PECS condition, and was adapted for the SGD condition. Using a multiple baseline across participants with an embedded alternating treatments design, the findings showed all three children learned to mand for toys using the SGD and PECS. However, more rapid acquisition was associated with PECS. Additionally, results on preference for the SGD or PECS were mixed.

Researchers have also compared SGDs to manual sign (MS). For instance, van der Meer (2012a) compared a high-tech SGD and MS for four children, ages 5 to 10, who were diagnosed with autism, multi-system developmental disorder, Down syndrome and congenital myotonic dystrophy. All children had a prior experience with MS. Interviews with teachers were conducted followed by a multiple-stimulus without replacement preference assessment (DeLeon & Iwata 1996) to identify each child's preferred stimuli. The SGD used in this study was Proloquo2Go loaded on an iPod. The intervention in each condition (i.e., SGD, and MS) consisted of guided guidance, a 10-s time delay, and 30-s access to the reinforcer. Using a multiple-probe across participants with embedded alternating treatment design, the findings showed a higher rate and more rapid acquisition of SGD-based manding compared to MS for three children whereas one child showed a higher rate and more rapid acquisition of MS manding compared to SGD.

A plethora of studies have compared high-tech SGDs to both PE and MS. For example, van der Meer, Sutherland, O'Reilly, Lancioni, and Sigafoos (2012b) replicated the procedures of van der Meer (2012a) to compare between high-tech SGDs, PE, and MS in terms of acquisition and idiosyncratic preference of four children with autism and global developmental disabilities, ages 4 to 11, with prior history with PE. The results showed a higher rate and more rapid acquisition of and preference for SGD-based manding compared to PE and MS for two children. One child demonstrated high rates of acquisition in both SGD and PE-based manding, whereas one child showed mixed results.

Van der Meer et al. (2012c) also replicated the procedures of van der Meer et al. (2012a, 2012b) to compare high-tech SGDs, PE, and MS in terms of acquisition and idiosyncratic preference of four children with autism, pervasive developmental disorder not otherwise specified (PDD-NOS), Angelman syndrome, childhood disintegrative disorder, and ID. The results showed a higher rate and more rapid acquisition of and preference for SGD-based manding compared to PE and MS for one child. The other three children showed comparable rates of acquisition of and preference for both SGD and PE-based manding compared to MS.

Two years later, Achmadi et al. (2014) compared a high-tech SGD (i.e., iPod-based Proloquo2Go), PE, and MS in terms of acquisition and idiosyncratic preference of four children with autism and global developmental delay, ages 4 to 5, who communicated by pointing, leading, or engaging in problem behavior. The intervention took place in the homes and classrooms of the children. Children's preferred stimuli were identified through free-operant assessments (Roane et al., 1998). Intervention sessions began with toy play interruption followed by graduated guidance prompts delivered on a time delay schedule (0, 3, 5, and 10 s delay). Independent or promoted manding responses of "*more*" resulted in 60-s access to the reinforcer and social praise. Using an alternating treatments design, the results showed three out of the four children demonstrated high rates of acquisition of, maintenance, and preference for both SGD and PE compared to MS, whereas one child showed high rates of acquisition of and preference for SGD but did not maintain the skill in follow-up sessions.

Similarly, Couper et al. (2014) compared a high-tech SGD (i.e., iPod-based Proloquo2Go), PE, and MS in terms of acquisition and idiosyncratic preference of eight children with autism ages 4 to 12. The intervention took place in either the home of the participant, the classroom of the participant, or a clinic. Preference assessments, intervention procedures, and research design were replicated from Achmadi et al. (2014). The findings indicated five children learned to mand for "*more*" using the SGD, PE, and MS. More importantly, all eight children chose to mand via the SGD more than 50% of time compared to PE and MS.

A year later, McLay et al. (2015) replicated Achmadi et al.'s (2014) and Couper et al.'s (2014) procedures with four children with autism ages 5 to 10. The study took place in children's classroom. The results showed three children learned to mand for "more" using the high-tech SGD, PE, and MS. Maintenance data indicated manding via the SGD was the highest for all four children.

Previous studies comparing SGDs to other communication modalities for manding skills have shown overall better results for high-tech SGDs in terms of rate of acquisition, maintenance, and preference (e.g., Flores et al., 2012; van der Meer et al., 2012a, 2012b) by children with ASD/DD. This may be attributed to the engaging features of the SGDs (e.g., speech outputs, dynamic visual display), prior experiences with tablets for play purposes (Agius & Vance, 2016), or ease of use compared to PECS or MS.

High-Tech SGDs for Tacting Skills

Whereas an abundance of research has been done on high-tech SGDs to teach manding skills, very few studies have examined high-tech SGDs to teach tacting (i.e., labeling or naming) skills. A tact is a verbal response that is controlled by a nonverbal stimulus and maintained by generalized conditioned reinforcers (Skinner, 1957). For instance, a child saying "*water*" when looking at the ocean is a tact. However, to better evoke tact responses from children with ASD/DD, researchers have combined tact training with intraverbal components (e.g., asking "*what do you see?*"). For example, Lorah, Parnell, and Speight (2014) taught four preschool children with ASD, DD, and cerebellar hypoplasia to tact four objects via the Proloquo2Go application on an iPad. Children were taught to tact objects by responding to two questions ("*what do you see?*, "*what do you have?*"). During intervention, a 5-s time delay and physical prompts were used. Contingent on independent or prompted tacting/intraverbal, the child received praise. Using a multiple-baseline across participants design, the results showed a functional relation between the intervention package and tacting four objects by responding to the two questions.

Three years later, Lorah and Parnell (2017) also combined an intraverbal component to teach three preschool children with autism to tact two animals in books during circle time. The intervention took place in children's classroom. The intervention procedures were identical to Lorah et al.'s (2014) with the exception of reinforcement.

Lorah and Parnell used differential reinforcement; neutral praise for prompted responses, and enthusiastic praise for independent responses. The results showed two children learned to tact two animals and maintained the skill. However, one child reached mastery criterion for tacting one animal only.

Although there is a paucity of studies on high-tech SGDs to teach tacting to children with ASD/DD, previous studies have shown promising results when tact training was combined with an intraverbal component (Lorah et al., 2014; Lorah & Parnell, 2017).

High-Tech SGDs for Intraverbal Skills

Like high-tech SGDs to teach tacting, there is a dearth of studies that have examined high-tech SGDs to teach intraverbals (i.e., answering question, commenting). One study conducted by Carnett, Waddington, and Bravo (2017) examined the acquisition of intraverbal responding using Proloquo2Go on an iPad with a 5-year-old child with autism. The child had a prior experience with the iPad application. Carnett et al. used the behavior chain interruption strategy (BCIS) by signing a song and stopping to evoke an intraverbal response from the child. The child was required to touch and activate the correct icon (out of four) on the iPad to fill-in the song. In addition to BCIS, Carnett et al. also used a 5-s time delay, gestural and vocal prompts, and differential social reinforcement (neutral for prompted responses, and enthusiastic for independent responses). Using a multiple-baseline design across three songs, the findings indicated a functional relation between BCIS and fill-in intraverbal only when the child was allowed to choose the order of the three songs.

Although there has been only one study that purposefully targeted intraverbal responses of children with ASD/DD, BCIS may be an effective strategy to increase intraverbal responding via SGDs (Carnett et al., 2017).

Summary

Researchers in communication interventions for children with ASD/DD have incorporated Skinner's (1957) analysis of verbal operants and documented positive results (Carnett et al., 2017; Sundberg & Michael, 2001). In terms of using high-tech SGDs to increase verbal behavior of children with ASD/DD, results from previous studies have supported children's ability to mand for preferred stimuli by performing a single-step (e.g., King et al., 2014; Lorah, 2016) or multi-steps (e.g., Strasberger & Ferreri, 2014) on SGDs. Results for vocal manding suggested that children with ASD/DD may benefit from high-tech SGDs to increase their vocal manding (e.g., Alzrayer et al., 2018; Muharib et al., 2018). Additionally, results for acquisition of and preference for manding via SGDs compared to PE, and MS have shown an overall favor for SGDs in terms of both acquisition and preference (e.g., Achmadi et al., 2014; McLay et al., 2015). A common component in all previous studies that targeted manding skills was the identification of children's preferred stimuli through one or more preference assessments to ensure the presence of children's EOs during training.

Unlike the abundance of research on high-tech SGDs for manding, very few studies have examined high-tech SGDs for tacting or intraverbal responding. Overall, Lorah et al. (2014), and Lorah and Parnell (2017) have shown children with ASD/DD can learn to tact via SGDs when an intraverbal component was combined in the tact training (e.g., asking "*what do you see?*"). Regarding teaching intraverbal responding, Carnett et al. (2017) have suggested that BCIS can be effective to enhance intraverbal responding of children with ASD/DD. As teaching tacts and intraverbal responses does not rely on the EO of the child, preference assessments were not conducted on those studies. Hence, social reinforcement was used contingent on tacting and intraverbal responding. Because interventions based on an analysis of verbal behavior rely on the functional aspects of communication, Functional Behavior Assessment (FBA) and more specifically, Functional Analysis (FA), can be used to assess problem behavior and develop effective function-based interventions.

Functional Analysis

Functional analysis is one method of FBAs. FAs involve systematic manipulations of the antecedent and consequent variables in an attempt to identify the functions of the target behavior (Cooper et al., 2007). In 1976, Carr and colleagues published a seminal work of FBAs. They aimed to identify the functions of a child's SIB. The child was 8 years old with mild ID and childhood schizophrenia. The researchers systematically manipulated three conditions in a reversal design. The conditions were attention, demand, and free play. The researchers were able to determine that the child's SIB was maintained by escape from demands (Carr, Newsom, & Blinkoff, 1976).

Following this experiment, Carr (1977) hypothesized that SIB can serve several functions. According to Carr, SIB can be maintained by positive reinforcement (e.g., access to attention), negative reinforcement (e.g., removal of demands), or automatic reinforcement (i.e., sensory stimulation).

A few years later, Iwata et al. (1982/1994) tested those hypotheses with nine individuals with DD who engaged in SIB. The experiments took place in an inpatient clinic. In what Iwata et al. called functional analysis (FA), those individuals were exposed to four conditions in an attempt to identify the function(s) of their SIB. The conditions were (a) social disapproval, (b) academic demand, (c) unstructured play, and (d) alone. In the social disapproval condition, the therapist provided the child with toys and told the child to play while the therapist worked. Contingent on SIB, the therapist provided the child with attention (e.g., brief concern statements). In the academic demand condition, the therapist asked the child to complete an academic task and provided prompts. Contingent on SIB, the therapist ceased the task for 30 s. In the unstructured play condition which served as a control condition, the child was given continuous noncontingent access to toys, therapist's attention, and no demands. In the alone condition, the child was given no access to attention or toys and no demands. Incidences of SIB were ignored. The purpose of this condition was to determine if the function of SIB was automatic reinforcement. Data were collected on the rate of SIB. Each session lasted 15 min. Iwata et al. terminated testing for each participant based on the following criteria (a) stable data of SIB, (b) unstable data of SIB across all conditions for 5 days, or (c) sessions were delivered for 12 days. In a multielement design, the data clearly demonstrated a clear singular function of SIB for six participants. For the remaining three participants, the data showed undifferentiated patterns. Iwata et al. hypnotized that SIB may be multiply controlled for those three participants.

Since Iwata et al.'s (1982/1994) study, researchers have experimented a variety of FBAs in an attempt to identify methods that are valid, accurate, reliable, and efficient. Researchers have tested indirect assessments (e.g., Iwata, DeLeon, & Roscoe, 2013), direct assessments (e.g., Sasso et al., 1992), and variations of FAs (e.g., Hanley et al., 2014).

Indirect assessments include methods that attempt to identify the environmental variables maintaining the target behavior without actual observations of the behavior. These assessments include interviews, checklists, rating scales, and questionnaires. They typically are completed by a caregiver or teacher (Cooper et al., 2007). Prior research has suggested indirect assessments can lead to invalid and unreliable results on the function of problem behavior (Paclawskyj, Matson, Rush, Smalls, & Vollmer, 2000; Spreat & Connelly, 1996; Zarcone, Rodgers, Iwata, Rourke, & Dorsey, 1991). As such, Hanley (2012) suggested that indirect assessments should only be used to gather information in an attempt to individualize FA conditions.

Direct assessments include direct observations of the target behavior in the natural environment without a systematic manipulation of environmental variables (Cooper et al., 2007). Direct assessments, also known as descriptive assessments, include Antecedent-Behavior-Consequence (A-B-C) observations. In these observations, incidences of the target behavior are recorded as well as the antecedents (i.e., preceding events), and consequences (i.e., following events). Direct assessments also include scatterplots. The purpose of scatterplots is to record times of the day in which the target behavior occurs to inform subsequent observations (Cooper et al., 2007). According to Rooker, DeLeon, Borrero, Frank-Crawford, and Roscoe (2015), the results of direct assessments are correlational not causal. This is because of the absence of systematic manipulations in these assessments. Previous studies have found direct assessments to be problematic when used to identify the functions of problem behavior. This is because of the invalid results they may yield (e.g., Pence, Roscoe, Bourret, & Ahearn, 2009; St. Peter et al., 2005; Thompson & Iwata, 2007). Thus, Hanley (2012) recommended the use of direct assessments only to inform FA conditions.

In addition to indirect and direct assessments, researchers have investigated several variations of the traditional FA (Iwata et al., 1982/1994). These include brief functional analysis, interview-informed synthesized functional analysis, and functional analysis of idiosyncratic variables.

Brief Functional Analysis

Because the traditional FA can be time and resource consuming, researchers have investigated whether a brief FA can yield valid results on the function(s) of problem behavior. In a brief FA, a session for each traditional FA condition is typically conducted once (Cooper et al., 2007). To test the accuracy of brief FAs, Northup et al. (1991) included three individuals with DD who engaged in aggression. The brief FAs consisted of one cycle of the following conditions: tangible, demand, alone, and/or attention. Subsequent to this cycle, a contingency reversal was conducted. This consisted of three sessions. These sessions replicated the FA condition that had shown the most elevated responding. In the first and third sessions, an appropriate functionally equivalent behavior was reinforced and problem behavior was ignored (i.e., differential reinforcement of alternative behavior, DRA). In the second session (the middle), problem behavior was reinforced and an appropriate functionally equivalent behavior was ignored. The results suggested a clear function of aggression for each participant. Thus, Northup et al. suggested that a brief FA can be a valid alternative to traditional FAs. However, because the differential reinforcement of alternative behavior treatment was tested in an ABA design, no experimental control was established for the treatment.

Three years later, Arndorfer, Miltenberger, Woster, Rortvedt, and Gaffaney (1994) evaluated the accuracy of brief FAs for five 2 to 13-year-old children with ASD/DD who engaged in aggression, disruption, noncompliance, SIB, and property destruction. Arndorfer et al. used indirect assessments and direct A-B-C observations to inform subsequent brief FA conditions for each participant. Based on the results of indirect and direct assessment results, two conditions were chosen for each participant: high vs. low demands, interrupted vs. uninterrupted play, or high vs. low attention. These conditions were tested in a reversal design and each condition was replicated once to demonstrate an experimental control (ABAB). The findings of those reversals demonstrated a clear function of problem behavior for each participant (e.g., escape from high demand).

In a replication of Northup et al.'s (1991) procedures, Umbreit (1995) recruited a 5-year-old boy with mild ID who engaged in disruptive behavior and noncompliance. The brief FAs consisted of one cycle of five conditions: attention, escape, tangible, play, and alone. Problem behavior occurred mostly in the escape condition. Following this cycle, Umbreit replicated the escape condition and the free play (control) condition to further establish the accuracy of function identification. Problem behavior solely occurred in the escape condition. Subsequently, a contingency reversal was conducted. This consisted of three sessions. These sessions were a replication of the escape condition as it had shown the most elevated responding. In the first and third session, an appropriate functional communication response (i.e., vocally asking for a break) was reinforced with a termination of task for 15 to 20 s. Problem behavior was ignored. In the second session, problem behavior was reinforced with access to a 15 to 20-s break and appropriate requests for a break were ignored. The results further indicated that escape from demands was the function of the child's problem behavior. However, because the DRA treatment was tested in an ABA design, no functional relation was established.

Finally, Derby et al. (1992) summarized the results of 79 cases who had received brief FA sessions. Using the same procedures developed by Northup et al. (1991), Derby et al. were able to clearly identify the function of 66% of the cases using brief FAs. Based on these findings, Derby et al. recommended the use of brief FAs with children who demonstrate high frequency problem behavior.

In summary, previous research has shown brief FAs can be a valid method to identify the function(s) of problem behavior (e.g., Northup et al., 1991; Umbreit, 2005). However, according to Derby et al. (1992) brief FAs may not reveal conclusive results for low frequency problem behavior. Thus, brief FAs are recommended for high frequency problem behavior.

Interview-Informed Synthesized Functional Analysis

Because traditional FAs can consume resources, Hanley (2010, 2011, 2012) have developed a comprehensive model to identify the environmental variables responsible for maintaining problem behavior. The model is called interview-informed synthesized FAs. The aim of this model is to make FAs more time efficient and also assist in developing comprehensive interventions. In this model, an open-ended interview is conducted with caregivers or teachers. The purpose of the interview is to gather information on all potential variables that evoke and maintain problem behavior. After gathering information, a synthesized FA is conducted with two conditions: (a) test, and (b) control. In the test condition, all variables that have been identified in the interview are included in the antecedent and consequent arrangements. For example, if parents report their child tantrums after a presentation of a task or removal of a toy, then both of these variables are presented at once during the test condition of the synthesized FA. In the control condition, continuous access to attention and preferred items are provided noncontingently.

To examine this model, Hanley, Jin, Vanselow, and Hanratty (2014) included three 3-to-11-year-old children with ASD and PDD-NOS who engaged in aggression and disruption. To gather information on potential variables maintaining problem behavior, Hanley et al. conducted 15-to-30-min open-ended interviews with parents in the presence of the target children. Subsequent to interviews, FAs were conducted with each child in which the test condition was individualized for each based on the results of interviews that had identified putative reinforcers. In general, during the test condition, all putative reinforcers were removed from the child and all were returned to the child contingent on problem behavior for 30 s. As an example, attention diversion and tangible removal were reported to evoke problem behavior for one participant. Thus, the test condition consisted of removing both attention and tangible items once the session began. Contingent on problem behavior, both attention and tangibles were provided for this particular participant for 30 s. In the control condition, both attention and tangibles were available continuously and noncontingently. The results clearly identified the synthesized functions of children’s problem behavior. For one child, problem behavior was maintained by both escape from redirections, and access to tangible. For the second child, problem behavior was maintained by escape from demands, access to tangibles and attention, as well as compliance to his requests. Problem behavior for the final child was maintained by access to attention and tangibles only with her mother.

Since Hanley et al.'s (2014) study, a few studies have examined interview-informed synthesized FAs. For example, Ghaemmaghami, Hanley, and Jessel (2016) included four individuals ages 2 to 30 years who had been referred for treatment of severe problem behavior in an outpatient clinic. Their problem behavior consisted of aggression, disruption, and SIB. To identify the functions of their problem behavior, Ghaemmaghami et al. conducted an open-ended interview with primary caregivers which lasted 45 to 60 min each. The interview was followed by a 20-min informal observation with each participant interacting with his/her parents in an attempt to gather further information on participants' language skills and topographies of problem behavior. Next, two FA conditions were developed for each participant based on the results of the interviews. In general, in the test condition, putative reinforcers were delivered contingent on problem behavior for 30 s. For example, it was reported in an interview that one participant would engage in problem behavior when his siblings/peers/parents refused to play roles he had assigned, moved his preferred toys, or interrupted his play. Based on this information, the test condition for this participant involved interruptions of his play, denial of his requests, and a presentation of demands. Contingent of problem behavior, the therapist removed the demand, complied with his requests, and allowed him to resume playing for 30 s. The control condition consisted of continuously allowing the participant to play with no interruption, presenting no demands, and complying with his requests. The results of synthesized FAs revealed clear functions of problem behavior for each participant. Problem behavior was maintained by access to both tangibles and attention for two children, access to food for the third child, and access to attention and tangibles as well as compliance to requests for the fourth child.

A year later, Jessel et al. (2017) used interview-informed synthesized FAs in an attempt to identify the function(s) of elopement for two children who were diagnosed with ASD and ADHD. Jessel et al. conducted a 15 to 30-min open-ended interview with the primary caregiver of each child. The interview was followed by a 10-min informal observation of each child. An interview revealed that one participant would elope in public places to access water (e.g., fountains, people's cups of water). For this participant, the test condition of the FA consisted of having a bucket of water in the room. Contingent on elopement, he was given access to the water for 30 s. During the control condition, the participant was given continuous noncontingent access to the water bucket. Elopement was ignored. The second participant was reported that he would elope to preferred people or items. As such, the test condition for this participant consisted of having his mother sit in the other side of the room with his preferred toys. Elopement resulted in giving him access to his mother and toys for 30 s. In the control condition, this participant had continuous noncontingent access to his preferred items and attention from his mother. The results clearly showed the functions of elopement for both children. Elopement was maintained by access to water for one child, and access to tangibles and mother's attention for the second child.

A year later, Beaulieu, Nostrand, Williams, and Herscovitch (2018) also implemented interview-informed synthesized FAs. The participant was a 7-year-old girl with ASD who engaged in SIB, aggression, and elopement. Beaulieu et al. conducted a

45-min open-ended interview with the girl’s mother. Next, FAs were conducted which consisted of test and control conditions. The test condition, based on the results of the interview, began with removing a preferred item from the participant. Contingent on problem behavior, the participant was given the item for 15 s. In the control condition, the participant had continuous access to preferred items. Problem behavior was ignored. The results clearly showed problem behavior was maintained by access to tangibles.

Finally, Strand and Eldevik (2018) replicated the procedures of interview-informed synthesized FAs with a 4-year-old child with ASD who engaged in aggression and disruption. The assessments began with two 15-min open-ended interviews with the child’s parents followed by a brief informal observation of the child. Based on the interviews, the test condition of the FAs consisted of removing attention and tangibles every 30 s. Access to attention and tangibles was granted contingent on problem behavior. In the control condition, all putative reinforcers were available noncontingently. These two conditions were tested across two therapists, the father, and the mother. The results of FAs clearly indicated problem behavior was maintained by access to attention and tangibles with the father and one of the two therapists. Problem behavior did not occur with the mother or the second therapist.

In short, interview-synthesized FAs have shown to be a valid method in identifying evocative environmental variables maintaining problem behavior (e.g., Beaulieu et al., 2018; Hanely et al., 2014). This model can assist in developing compressive interventions (Hanely et al., 2014), and can help identify the functions of problem behavior in a fewer sessions compared to traditional FAs (e.g., Beaulieu et al., 2018; Jessel et al., 2017).

Functional Analysis of Idiosyncratic Variables

As the traditional FAs constitute five specific conditions (i.e., access to attention, escape from demands, access to tangible, alone, and free play), it may yield inconclusive results. A major reason to inconclusive results in FAs is idiosyncratic variables that control the target behavior that are not included in the traditional FAs. Examples of these idiosyncratic variables include escape from attention (e.g., Hagopian, Wilson, & Wilder, 2001), escape from walking (Volkert et al., 2009), interruption of toy play (Falcomata et al., 2012), and access to rituals (e.g., Rispoli, Camargo, Machalicek, Lang, & Sigafoos, 2014).

To identify the function(s) of problem behavior, Hagopian et al. (2001) implemented traditional FAs with a 6-year-old child with ASD and mild ID who engaged in severe problem behavior that consisted of SIB, aggression, and property destruction. The experiments took place in a clinic. The results of the traditional FAs were inconclusive as the rate of problem behavior was the highest in the control condition (i.e., free play). As a result, Hagopian et al. added a condition to test a potential idiosyncratic variable (i.e., escape from attention). In this condition, the therapist provided the participant with continuous praise as the participant played. Occurrences of problem behavior resulted in termination of adult's attention. The findings suggested the functions of the participant's problem behavior was escape from attention in addition to access to tangibles.

Similarly, Harper, Iwata, and Camp (2013) tested idiosyncratic variables subsequent to inconclusive FAs. They included four participants diagnosed with ID who engaged in aggression. The results of traditional FAs showed high rates of aggression in the free play condition and escape from demand condition. Consequently, the authors conducted another FA that consisted of a test condition and a control condition. In the test condition, the therapist provided the participant with attention and preferred items. Contingent of the problem behavior, the therapist terminated attention for 30 s. In the control condition, the participant had continuous access to preferred items. Incidences of problem behavior were ignored. The results of these FAs clearly suggested escape from attention as the function of the participants' aggression.

In addition to escape from attention, Volkert et al. (2009) tested another idiosyncratic variable for an 8-year-old girl who engaged in aggression and SIB. The experiments took place in an isolated area in the participant's classroom or an empty classroom. The results of traditional FAs for this participant were inconclusive as the rate of problem behavior was low across all FA conditions. Subsequently, Volkert et al. added a test condition based on observations and caregiver report. The test condition was escape from walking. That is, occurrences of problem behavior resulted in a break from walking. As a control condition, Volkert et al. replicated the traditional FA procedures for toy play. The results clearly showed that the participant's problem behavior was maintained by negative reinforcement in the form of escape from walking.

Another idiosyncratic variable that has been examined is interruption of toy play. Falcomata et al. (2012) included two 8-year-old children with Asperger syndrome and autism who engaged in SIB, aggression, disrobing, disruption, and property destruction. The results of traditional FAs showed no incidences of problem behavior. Subsequently, the authors developed two conditions based on observations and reports. These two conditions were toy play interrupt (test), and toy play no interrupt (control). In the test condition, the participants had access to preferred toys for 1 min prior to the session. Once the sessions began, the therapist interrupted the participant's toy play with a vocal statement and directed him to another activity. When the participant did not comply, the therapist provided a physical prompt. Attempts to return to toy play were blocked. Contingent on the problem behavior, the therapist ceased toy play interruption for 30 s. In the control condition, the participants had continuous access to the same preferred toys and their play was not interrupted. Problem behavior was ignored. The results of these FAs showed a clear function of problem behavior. For both children, problem behavior was evoked and maintained by the interruption and reinstating of toy play.

Further examination of idiosyncratic variables was conducted by Betz, Fisher, Roane, Mintz, and Owen (2013). An idiosyncratic variable testing was conducted with a 6-year-old child with diagnoses of obsessive compulsive disorder (OCD), adjustment disorder, and disturbance of conduct. The child engaged in aggression and disruption. The results of traditional FAs revealed no occurrences of problem behavior across all conditions. Consequently, Betz et al. added an idiosyncratic test based on prior observations of the child's problem behavior. These observations had shown that the child had a unique preference in having an adult read out a preferred book. Instead of starting reading from the beginning of the book, the child would ask an adult to read from one specific page. Thus, the test condition was adult-direct play in which the therapist would read the book from the beginning. Contingent of problem behavior, the therapist would comply with the child's request by reading the specific page he liked for 20 s. In the control condition (child-directed play), the therapist complied with the child's requests in regards to which parts of the book to read aloud independent of the occurrences of problem behavior. The results of these idiosyncratic tests showed elevated rates of problem behavior during the adult-directed play. That is, compliance with his reading requests was the idiosyncratic variable maintaining the child's problem behavior.

Another idiosyncratic variable that has been assessed is access to ritualistic behavior. For example, Hausman, Kahng, Farrell, and Mongeon (2009) implemented traditional FAs with a girl diagnosed with ASD, ID, and cerebral palsy who engaged in aggression, SIB, and property destruction. The results of traditional FAs were inconclusive. Consequently, Hausman et al. developed an idiosyncratic test condition based on previous parental reports and observations that suggested problem behavior occurred when the participant was blocked from access to ritualistic behavior. Based on these observations and reports, Hausman et al. developed a test condition in which the therapist would disturb the position of a door with a doorstop. Contingent on problem behavior, the participant was allowed to re-position the door. In the control condition, the therapist did not touch the door. The results showed that the participant's problem behavior was maintained by access to ritualistic behavior.

Similarly, Rispoli et al. (2014) tested access to ritualistic behavior as an idiosyncratic variable during traditional FAs. That is, access to rituals was simultaneously tested during the traditional FA. The participants included three 3 to 4-year-old children with ASD and PDD-NOS who engaged in aggression, SIB, property destruction, and disruption. The experiments were conducted in a clinic for two children, and in the home for one child. The access to rituals condition was individualized for each participant based on teacher and parent reports. For instance, turning off the T.V. was reported for one participant to be troubling. The access to rituals condition stated with a 10-s pre-session access to the materials associated with the individualized ritual. Once the session started, the interventionist interrupted the child's ritual (e.g., turning off the T.V). Occurrences of problem behavior resulted in reinstating the ritual for 10 s. The results of those FAs clearly demonstrated access to rituals as the maintaining variable for problem behavior of all children.

Based on prior research, the results of traditional FAs may be inconclusive. As a result, testing of idiosyncratic variables may be needed to further analyze the maintaining variables of problem behavior that are insensitive to traditional FA conditions. Roscoe, Schlichenmeyer, and Dube (2015) recommended the inclusion of idiosyncratic variables in FAs only when traditional FA conditions reveal inconclusive results.

Summary

FAs involve systematic presentations of environmental variables to identify the function(s) of problem behavior (Cooper et al., 2007). Since the seminal study by Iwata et al. (1982/1994), researchers have developed variations of the traditional FA to overcome some of its limitations. One limitation to traditional FA is resource consumption and exposing the participant to a large number of sessions (e.g., 20 sessions) before the introduction of treatment. Northup et al. (1991) introduced brief FAs in which each condition of the traditional FA is only introduced in one session. Previous studies have found brief FAs to be a valid method to identify the functions of problem behavior (Arndorfer et al., 1994; Northup et al., 1991; Umbreit, 2005), primarily those of high frequency problem behavior (Derby et al., 1992). Another variation of traditional FAs to limit exposure to large number of sessions was developed by Hanley (2010, 2011, 2012). Interview-informed synthesized FAs also assist in developing comprehensive interventions for problem behavior (Hanley et al., 2014). After conducting an open-ended interview with primary caregiver/teacher, two conditions (test and control) are created and individualized based on the results of the interview (Hanley et al., 2014). Several studies have found interview-informed synthesized FAs to be a valid method in identifying the functions of problem behavior (Beaulieu et al., 2018; Hanley et al., 2014; Ghaemmaghami et al., 2016; Jessel et al., 2017; Strand & Eldevik, 2018).

Finally, because the traditional FA consists of five specific conditions, it may yield inconclusive results as it can be insensitive to idiosyncratic variables. For this reason, researchers have tested idiosyncratic variables after the results of traditional FA came inconclusive (e.g., Betz et al., 2013; Hausman et al., 2009). Examples of idiosyncratic variables that have been examined in previous research include escape from attention (e.g., Hagopian et al., 2001), interruption of toy play (Falcomata et al., 2012), and access to rituals (e.g., Rispoli et al., 2014). Roscoe et al. (2015) pointed out testing idiosyncratic variables should only be conducted when the results of traditional FAs are inconclusive. One intervention that relies on FA results and often used to address problem behavior is functional communication training.

Functional Communication Training and Schedules of Reinforcement

Functional communication training (FCT) is a function-based intervention that relies on differential reinforcement of alternative behavior (DRA; Cooper et al., 2007). FCT consists of two sequential steps of (a) identification of the function(s) maintaining the problem behavior by one or more functional behavior assessments; and (b) teaching a new functional communication response (FCR) that serves the same function(s) as the problem behavior to be an alternative for the problem behavior (Carr & Durand, 1985). In other words, the new FCR results in the same reinforcement as the problem behavior. For instance, if the child engaged in self-injurious behavior to escape from demands, the child might be taught to mand for a "break" by saying the word "break," pointing to a "break" picture, manually signing a "break," or touching a "break" icon on a speech-generating device. Manding for a break, in this example, is functionally equivalent to the self-injurious behavior exhibited by the child because both behaviors serve the same function and both result in the same reinforcement of escape from demand. With FCT, problem behavior is typically placed on extinction in that the problem behavior no longer results in reinforcement (Cooper et al., 2007).

FCT also relies on establishing operations (EO). EO is a motivating operation that alters the effectiveness of a certain stimulus/reinforcer; and thus, it alters the frequency of the behavior that has been reinforced by that stimulus/reinforcer (Laraway, Snycerski, Michael, & Poling, 2003). For example, if a child is presented with a highly preferred item out of reach, the child is likely to engage in behavior, whether appropriate or inappropriate, to access the highly preferred item. To test the hypothesis of the role of EO in FCT, Brown et al. (2000) taught four children with a severe to profound intellectual disability who engaged in SIB and aggression to use appropriate mands. The experiments were conducted in either a clinic or participant's home. Brown et al. alternated between an EO-present condition and an EO-absent condition. In the EO-present condition, a mand that matched the function of the problem behavior was taught and reinforced (e.g., *done*). In the EO-absent condition, a mand that did not match the function of the problem behavior was taught and reinforced (e.g., *play with me*). When the child used the relevant mand (i.e., mand that matched the function of the problem behavior) during the EO-absent condition, the mand was ignored. The results showed problem behavior and relevant mands occurred more often in the EO-present condition. Problem behavior was eventually replaced by the relevant mand for the four children. This indicates that the child's EO needs to be a key in programming FCT. This can be accomplished by (a) matching the FCT program to the function(s) of problem behavior based on the results of functional behavior assessments; (b) presenting the putative EO (e.g., preferred items out of access); and (c) providing the child with the functional reinforcer contingent on appropriate manding.

Another key component of FCT is response effort. Response effort may influence response allocation during FCT. In other words, if the response effort of the new FCR is high, the child may be less likely to emit the new FCR and more likely to engage in problem behavior (Horner & Day, 1991). To examine this hypothesis, Buckley and Newchok (2005) taught a 7-year-old boy with autism who engaged in aggression to exchange a picture communication card to mand for preferred items in the participant's self-contained classroom. The researchers manipulated the experiments by requiring the child to engage in low-effort manding (i.e., picking the TV picture and handing it to the therapist) in one condition, and requiring the child to engage in high-effort manding (i.e., walking over 4 ft to pick a TV card and then handing it to the therapist) in the other condition. The findings clearly showed a substantial decrease of aggression and increase in FCR in the low-effort condition. Conversely, problem behavior elevated to the baseline level in the high-effort condition, whereas FCR remained at a zero level. Thus, it is essential in programming FCT to identify a low-effort FCR to teach to the child in order to increase his/her likelihood of emitting the new FCR.

The following section will describe how FCT has been examined for over 30 years to mitigate (a) singularly controlled problem behavior (e.g., Carr & Durand, 1985), and (b) multiply controlled problem behavior (e.g., Sigafoos & Mekeile, 1996). FCT has been examined as a stand-alone intervention (i.e., without additional procedures; e.g., Carr & Durand, 1985; Durand, 1999), or followed by additional schedule thinning procedures (e.g., Berg, Wacker, Harding, Ganzer, & Barretto, 2007) to increase tolerance to delay of reinforcement. In addition, SGDs such as iPads have been investigated for FCRs in FCT studies with and without additional procedures (e.g., Muharib et al., 2018).

Effects of FCT without Additional Procedures

The literature shows FCT without additional procedures can be effectively used to mitigate problem behavior such as aggression, SIB, property destruction, disruptive, and inappropriate vocalizations of children with ASD/DD (e.g., Carr & Durand, 1985; Franco et al., 2009; O'Neill & Sweetland-Baker, 2001). Research has indicated that FCT can be used to mitigate problem behavior that is singularly controlled (i.e., maintained by one function; e.g., Carr & Durand, 1985; Mancil, Conroy, & Nakao, 2006), or multiply controlled (i.e., maintained by two or more functions; e.g., Neidert, Iwata, & Dozier, 2005; Thomson, Fisher, Piazza, & Kuhn, 1998).

FCT without additional procedures to mitigate singularly controlled problem behavior. FCT was first introduced by Carr and Durand (1985). They aimed to treat singularly controlled problem behaviors of four children ages 7 to 14 who had diagnoses of autism, brain damage, developmental delay, and severe hearing impairments. Children engaged in a variety of SIB, destructive, and disruptive behavior. The experiments took place in an axillary classroom. After identifying the function(s) of each child's problem behavior, the researchers taught each child a vocal FCR that was functionally equivalent to the problem behavior, including (a) "*I don't understand*" for children whose problem behavior was maintained by escape from demand, or (b) "*Am I doing good?"* for children whose problem behavior was maintained by access to attention. Using a reversal design, researchers found a functional relation between FCT and the reduction in problem behavior of all four children. In addition, the study confirmed the hypothesis that problem behavior serves a specific function. When a new functionally equivalent FCR was taught and reinforced (i.e., by providing assistance to participants whose problem behavior was maintained by escape from demand, and providing praise to participants whose problem behavior was maintained by access to attention), problem behavior drastically decreased.

Over two decades later, Mancil, et al. (2006) examined the effects of FCT on tantrums exhibited by a 4-year-old boy with pervasive developmental disorder (PDD). The study was conducted in a therapy room. The results of the functional analysis revealed that the child's problem behavior was maintained by access to tangibles. Thus, Mancil et al. taught the child four different mands to access four different tangibles. The child was required to hand the corresponding picture communication card (e.g., blanket) to the primary researcher to receive access to the functional reinforcer. Using a multiple baseline across behaviors design, the findings demonstrated a functional relation between FCT and the reduction in problem behavior. In addition, the child discriminated between the picture communication cards to access different functional reinforcers.

In addition to examining the effects of FCT in clinical settings, FCT has been examined in naturalistic settings such as classrooms and the homes of participants. In O'Neill and Sweetland-Baker's (2001) study, the participants were two boys with ASD and severe ID ages 6 and 15 who engaged in aggression and elopement. Results of functional behavioral assessments suggested that both participants' problem behavior was maintained by escape. The classroom teacher, in a self-contained classroom, taught the participants to point to a picture communication card to mand for a break. Upon task completion, the teacher praised the participant and prompted him to point to the "break" picture. A 30-s access to break was provided contingent on pointing to the picture. Problem behavior was placed on extinction. That is, when problem behavior occurred during working on the task, the participant was redirected to continue working on the task. The researchers used a multiple baseline across settings and participants design. The findings showed decreases in problem behavior and increases in FCR for one participant in three settings (i.e., cleaning, matching, putting away), and variability in two other settings (i.e., writing, receptive ID). Although reductions in problem behavior and increases of FCR occurred with the second participant, some carryover effects occurred as the participant had learned to emit the FCR before intervention began in the second setting. Thus, there was no functional relation between FCT and FCR for the second participant.

Four years later, Schindler and Horner (2005) included three children with autism ages 4 and 5 who engaged in aggression, tantrum, screaming, and noncompliance in their study. Interviews suggested that problem behavior was maintained by access to escape for two children, and access to activities for one child. Each child was taught to point to a picture communication card (e.g., help). Pointing to the picture resulted in access to reinforcement (e.g., help). Occurrence of problem behavior resulted in redirection (e.g., "*ask the right way*"). When persisted, problem behavior was ignored. Teacher assistants and parents carried out the intervention in a preschool classroom (one-to-one, explore time, snack), and home. Using a multiple baseline across settings and participants design, the findings indicated a functional relation between FCT and problem behavior reduction. Increases in FCRs were evident for all participants.

Similarly, Gibson, Pennington, Stenhoff, and Hopper (2010) examined the effects of FCT, implemented by the classroom teacher in a preschool classroom, on the elopement of a 4-year-old boy with autism. Results of functional behavioral assessments suggested that elopement was maintained by access to tangibles. Thus, the teacher taught the child to raise his hand during circle time to get access to a box of preferred toys. When the child eloped from circle, he was redirected to the circle and his toy was retrieved. Contingent on sitting and hand-raising, the child was re-presented with the box to pick a toy. Through a reversal design, the results indicated a functional relation as there was a substantial decrease in problem behavior in the FCT phases.

More recently, Lambert, Bloom, and Irvin (2012) examined FCT in a preschool classroom. The study included three children with a developmental delay ages 3 and 4 who engaged in aggression and tantrums. Functional analyses conducted by the teacher revealed that problem behavior was maintained by escape for two children, and access to attention for one child. The teacher taught each child a new FCR (a vocal response for one child, and a picture communication card for two children) to access a reinforcer. Whether the FCR was independent or prompted, the child was given a 30-s access to the reinforcer (i.e., break or attention). Problem behavior resulted in no reinforcement. Using a multiple baseline across participants design, the researchers concluded that there was a functional relation between FCT and both problem behavior reduction and FCR increase.

As shown previously, FCT without additional procedures has been shown to be effective in mitigating singularly controlled problem behavior. Problem behavior decreased when FCRs increased to access a functional reinforcer whether the reinforcer was attention (e.g., Carr & Durand), tangible (e.g., Gibson et al., 2010), or escape (e.g., Schindler & Horner, 2005)

FCT without additional procedures to mitigate multiply controlled problem behavior. In addition to examining FCT effects on singularly controlled behavior, researchers have examined whether FCT can mitigate multiply controlled behavior. To evaluate whether FCT could mitigate problem behavior that is multiply-controlled, Sigafoos and Mekeile (1996) investigated the effects of FCT on problem behavior consisting of aggression, SIB, and property destruction of two 8-year-old boys with autism. The study took place in children's classroom. A teacher conducted a functional analysis as described by Iwata et al. (1982/1994). The results suggested that children's problem behavior was maintained by both access to attention and tangibles. Subsequently, the teacher taught each child two FCRs: one to mand for preferred items (e.g., toy, drink), and one to mand for teacher's attention. The participant with an echoic repertoire was taught to vocally mand (e.g., saying "*drink*" or calling the teacher by her name), whereas the participant with no vocal speech was taught to hand the teacher a picture communication card to mand for a preferred item, and tap the teacher on the shoulder to mand for her attention. After introducing FCT in a multiple baseline across behaviors and participants design, the problem behavior of both children substantially decreased and remained at a zero level in follow-up sessions. However, there were only two demonstrations of effects; thus, there was no functional relation demonstrated in this study.

Two years later, Thomson et al. (1998) examined FCT for a 7-year-old boy with a severe ID and PDD who engaged in aggression and chin grinding. A functional analysis (Iwata et al., 1982/1994) revealed that the child's problem behavior was maintained by access to attention and automatic reinforcement. The child was taught to hand a picture communication card to the therapist to receive verbal and physical attention (i.e., praise and hugs) for 30 s. Aggression and chin grinding were ignored. The results, in a reversal design, indicated a functional relation between FCT and aggression. However, as chin grinding was automatically reinforced, chin grinding did not decrease in the FCT phase. Thus, the researcher added a subsequent experiment in which they taught the child to press his chin against a soft device as an alternative behavior. This study suggested that additional procedure might be necessary to treat problem behavior that is automatically reinforced.

Similarly, Neidert et al. (2005) taught two different FCRs, which were functionally equivalent to the multiply controlled problem behavior, to two children with autism, ages 3 and 4, who engaged in aggressive and self-injurious behavior. The experiments took place in a clinic. Results of functional analyses revealed that children's problem behaviors were maintained by access to both attention and escape. Children were taught to mand for a 30-s break, and 20-s attention in two separate conditions. One child was taught to vocally mand whereas the other was taught to exchange a picture communication card for each response (break and attention). To facilitate compliance with demand, the researchers added a differential reinforcer (i.e., edible) contingent on task completion for one participant. The researchers used a multiple baseline across behaviors and participants design to evaluate the intervention effects. The results showed a substantial decrease in the multiply controlled problem behavior and increase in FCRs and task completion for both participants.

Falcomata, Wacker, Ringdahl, Vinquist, and Dutt (2013a) also used FCT to mitigate multiply controlled problem behavior of three children with ASD and DD ages 2 to 4 who engaged in aggression, tantrums, and SIB. Results of functional analyses revealed that problem behavior was maintained by escape, access to tangible, and access to attention for all children. Children were taught to mand using picture communication cards. A stimulus fading procedure was used to transfer stimulus control from picture touch to manual sign. In other words, children were subsequently taught to mand using manual signs (i.e., want, finished, please). Using a multiple baseline across reinforcers (i.e., escape, tangible, attention) and participants design, the results showed a substantial decrease in problem behavior, which remained at a zero level in maintenance, and increase in FCRs of all of the three children.

As indicated in previous literature, FCT can be effectively used to mitigate multiply controlled problem behavior of children with autism and other developmental disabilities. However, additional procedures may be needed when the problem behavior is partially maintained by automatic reinforcement (e.g., Thomson et al., 1998).

FCT with speech-generating devices (SGDs) and no additional procedures. As SGDs may involve low-effort compared to other modalities (e.g., manual sign; Torelli et al., 2016), they can be a viable option as an FCR to replace problem behavior. To examine whether SGDs can be used as alterative communication to problem behavior, Durand (1999) taught participants to mand for preferred items using an SGD. Participants included five individuals with ASD and moderate to severe ID between the ages 3 and 15 who engaged in SIB, aggression, and screaming. The results of brief functional analyses (Durand & Crimmins, 1988) conducted by the classroom teacher suggested that each participant's problem behavior was maintained by one specific function (i.e., tangible, attention, or escape). Each participant was taught, by the classroom teacher, to mand for the preferred stimulus (e.g., "*I want more*," "*I need help*") that presumably maintained the problem behavior using an Introtalker device. The device generates a digitized speech output and can save one to 16 messages. Using a multiple baseline across participants design, the findings indicated a substantial decrease in problem behavior, and increase in independent communication responses using the device for all of the five children. Additionally, Durand conducted a subsequent generalization study with the same five participants. Each participant was taught to use the Introtalker device in one community setting (i.e., movies, store, library, or mall). The data showed a functional relation between FCT and both problem behavior reduction and independent communication response increase in community settings for all children.

A few years later, Winborn, Wacker, Richman, Asmus, and Geier (2002) examined whether children with ASD/DD could be taught novel mands that did not exist in their repertoire, in addition to existing mands. Participants were two 2-year-old children with a DD and seizure disorder who engaged aggression, SIB, tantrums, and noncompliance. Problem behavior of both children was maintained by escape. The study was conducted in a clinic. The novel mand for one child was pressing a microswitch which generated "*break, please,*" whereas the existing mand was shaking her head "*no*".

The novel mand for the other child was handing a picture communication card to the therapist, while her existing mand was saying "*all done*." Children received a 30-s break contingent on complying with task, emitting the target mand, and engaging in no problem behavior. Using a multielement design, the results showed a functional relation between the FCT and problem behavior reduction with novel mands for both children. On the other hand, data on problem behavior were variable when children were required to mand for a break using an existing mand.

Within SGDs, Olive, Lang, and Davis (2008) examined the effects of FCT using a Four Button Touch Talk Direct for an FCR. The participant was a 4-year-old girl with autism who engaged in biting, hitting, screaming, eloping, and object mouthing. The study was conducted in the participant's home. Results of functional behavioral assessments revealed that those problem behaviors were maintained by access to attention. The mother taught the participant to press a button on the device that generated a speech output (e.g., "*I want you to play with me*") across three home activities. Results of the multiple baseline across four activities design indicated a functional relation between FCT and the reduction in problem behavior. However, there was a carryover effect across activities as the participant learned to use the device in the third and fourth baseline phases.

In addition to teaching children to use SGDs to produce single FCR, children with ASD/DD have been taught to use SGDs to emit more than one FCR. Franco et al. (2009) taught a 7-year-old student with autistic disorder who engaged in inappropriate vocalizations to mand for a break and access to preferred items using a GoTalk device. The device was made available every 15 s at the gym and playground. Contingent on touching an icon, which generated a speech output, the participant was given access to what he manded for (i.e., a break or a specific item). Using a multiple baseline across settings design, the results showed a decrease of problem behavior across both the gym and playground at the participant's school. Additionally, problem behavior decreased further in follow-up sessions. However, the study only showed two demonstrations of effect; hence, no functional relation was established.

Similarly, Simacek, Dimian, and McComas (2017) had parents teach their children with autism and Rett syndrome to mand for food, toys, attention, and a break in their homes. Results of functional behavioral assessments revealed that children's idiosyncratic behavior (e.g., pointing, reaching, leading an adult) was maintained by more than one reinforcer (e.g., escape, tangible). Thus, each child was taught to mand for three reinforcers in a multiple probe across mands and participants design. One child was taught to mand using a BIGmack microswitch while the other two children were taught to mand using a picture exchange communication system (PECS). The results showed decreases in idiosyncratic behavior and increases in FCRs.

More recently, iPads have been used as means of communication in FCT studies. Torelli et al. (2016) taught a 4-year-old boy with autism who engaged in aggression, presumably maintained by escape and access to tangible, to mand for a break and preferred items using an iPad loaded with Proloquo2Go® App. The experiments took place in a clinic. Torelli et al. first taught the participant to mand using three modalities; iPad, GoTalk device, and picture exchange using a progressive time-delay (Touchette & Howard, 1984). The results showed a reduction in problem behavior when the participant was required to mand using the iPad or GoTalk device. However, when he was required to mand using picture exchange, problem behavior was at a higher level. In the final phase of training, Torelli et al. continued with the iPad because of (a) positive effects on problem behavior and (b) parental preference. The final phase continued to demonstrate a positive effect on problem behavior in both the tangible and escape conditions.

Another study incorporating the use of an iPad for an FCR was conducted by Muharib et al. (2018). Muharib et al. examined the effects of FCT on grabbing and head-banging of two Caucasian-American children with autism ages 5 and 6. Results of the functional behavioral assessment revealed that problem behavior of both children was maintained by access to tangibles. Children were taught to mand for preferred items by touching an icon (a picture of the item and caption) on GoTalk Now App on an iPad which generated a speech output (e.g., "*I want a pump*"). Using a reversal design, the results demonstrated a functional relation between FCT and the reduction in problem behavior for both participants.

Previous research on FCT without additional procedures and SGDs (e.g., iPads, BIGmack, GoTalk devices) for FCRs suggests that children with ASD/DD can acquire the skill of manding for functional reinforcers via SGDs. As a result of increased appropriate manding, problem behavior decreased (e.g., Muharib et al., 2018; Winborn et al., 2002).

FCT and Non-Contingent Reinforcement (NCR)

In addition to investigating the effects of FCT without additional procedures, researchers have examined the role of the abolishing operation (AO) in FCT. AO is a motivating operation that decreases the effectiveness of a certain stimulus as reinforcement; and as a result, it decreases the frequency of the behavior (Laraway et al., 2003). One intervention that creates an AO for the problem behavior is NCR.

Both FCT and NCR rely on the delivery of the reinforcer maintaining the problem behavior. In NCR, the putative reinforcer is delivered on a fixed interval (FI) schedule independent of the occurrence of problem behavior. Delivering reinforcement on a dense schedule creates an AO for problem behavior (Hagopian, Fisher, & Legacy, 1994). On the other hand, the delivery of reinforcement in FCT is dependent on emitting the target communication response. FCT typically involves using a fixed ratio schedule (e.g., FR 1; Carr & Durand, 1985) to deliver the functional reinforcer. There is an advantage to each intervention. NCR may be easier to implement in applied settings as the teacher or caregiver does not need to be attentive to the child's behavior (Vollmer, Iwata, Zarcone, Smith, & Mazaleski, 1993). On the other hand, in FCT, the child learns to emit an FCR and be in control over reinforcement delivery (Kahng, Iwata, DeLeon, & Worsdell, 1997). To compare the efficacy of the two interventions, Hanley, Piazza, Fisher, Contrucci, and Maglieri (1997) recruited two children, 4 and 8 years old, who had been admitted to an inpatient clinic for treatment of destructive behavior. Functional analyses revealed that children's problem behavior was maintained by access to attention. Prior to comparison, children were taught to emit the FCR to receive a 20-s attention from the therapist. After mastering independence in FCR across two sessions, the comparison between FCT (20-s of attention contingent of FCR) and NCR (20-s attention, 20-s no attention) took place. Problem behavior was ignored in both conditions. The results showed both interventions were equally effective in treating problem behavior.

In addition to comparing FCT to NCR, the two interventions have been combined. Hagopian et al. (2001) combined FCT with NCR to treat aggressive, self-injurious, and disruptive behavior of a 6-year-old boy with ASD and a mild ID who had been admitted to an inpatient unit. His problem behavior, as indicated by functional analyses, were maintained by access to tangibles and escape from attention. Thus, the child was taught two vocal FCRs (one for each function) to access to reinforcers (i.e., toys and attention termination). Contingent on emitting the FCR, the child was provided with the requested reinforcer for 30 s. In addition, every 3 min (independent of the child's problem behavior), the child was given access to less preferred toys and books for 30 s. To increase tolerance to waiting, Hagopian et al. added a 10 s delay-to-reinforcement in the tangible condition. The findings indicated a substantial decrease in problem behavior in both the escape from attention condition and tangible condition. The findings also showed increases in both FCRs.

From previous literature, FCT and NCR were suggested to be equally effective in mitigating problem behavior of children with ASD/DD (Hanley et al., 1997). Additionally, FCT combined with NCR does not prevent the child from emitting an FCR as long as the EO for functional reinforcers is still present. NCR may, in fact, mitigate problem behavior that may, otherwise, arise in the delay-to-reinforcement intervals during FCT (Hagopian et al., 2001).

FCT and Thin Schedules of Reinforcement

As FCT results in access to reinforcement on a dense schedule (e.g., FR 1), FCT can be impractical or infeasible in educational or home settings (Hagopian, Fisher, Sullivan, Acquisto, & LeBlanc, 1998; Tiger, Hanley, & Bruzek, 2008). For example, the child may excessively emit the appropriate mand to access a stimulus that is not readily available in a certain situation, or excessively emit the appropriate mand to terminate academic tasks (Fisher et al., 1993). When the mand does not result in reinforcement in such situations, the risk for resurgence of problem behavior increases (Fisher, Thompson, Hagopian, Bowman, & Krug, 2000; Lalli, Casey, & Kates, 1995). Thus, researchers have incorporated reinforcement schedule thinning procedures following FCT (e.g., Greer, Fisher, Saini, Owens, & Jones, 2016; Rispoli et al., 2014). Those include delay-to-reinforcement (e.g., Hanley et al., 2014), alternative activities (e.g., Hagopian, Contrucci, Kuhn, Long, & Rush, 2005), demand fading/ chained schedules of reinforcement (e.g., Berg et al., 2007; Falcomata et al., 2012), response restriction (e.g., Roane, Fisher, Sgro, Falcomata, & Pabico, 2004), and multiple schedules of reinforcement (e.g., Greer et al., 2016).

FCT and delay-to-reinforcement. Delay-to-reinforcement is a time delay between the emission of an appropriate mand and provision of the functional reinforcer. The purpose of this procedure is to teach the child to tolerate delay of reinforcement (Day, Horner, & O'Neill, 1994). Braithwaite and Richdale (2000) taught a 7-year-old boy with ASD and ID who engaged in a multiply controlled SIB and aggressive behavior to emit two vocal FCRs to access preferred items and escape from demands. The study was carried out in the participant's classroom. After an initial phase of FCT, Braithwaite and Richdale introduced 2-s and 5-s delay-to-reinforcement phases, respectively. Using a multiple baseline across two conditions, the results showed problem behavior remained at a zero level with the reinforcement delay of both schedules (i.e., 2 s, and 5 s) and in both conditions (i.e., access to tangibles, and escape). Nevertheless, the study did not show a functional relation as it only showed two demonstrations of effects.

More recently, Hanley et al. (2014) taught three children with autism who engaged in aggression and disruption to tolerate delay and denial of reinforcement. After teaching each child a vocal FCR in FCT sessions, Hanley et al. introduced a delay and denial tolerance procedure by providing immediate access to reinforcement contingent on two of every five FCRs. Three of every FCRs resulted in either delay or denial of reinforcement. The child was taught to say "*okay*" when the adult said "*no*" in denial of reinforcement. Initially, the child was given immediate access to reinforcement contingent on saying "*okay*." Delay to reinforcement was gradually increased by requiring each child to engage in a less preferred activity (e.g., academic task) before accessing the functional reinforcer. For one child whose problem behavior persisted during delay-and-denial-tolerance training, differential reinforcement was used. When that child did not engage in problem behavior during the delay period and complied with adult's directions, the child was provided access to reinforcement for a longer period of time. The findings indicated strong effects of the delay and denial tolerance procedure on the reduction of problem behavior.

Very recently, Muething, Falcomata, Ferguson, Swinnea, and Shpall (2018) evaluated the impact of delay-to-reinforcement on the variability of communication responses and problem behavior of four children, ages 5 to 14, with ASD and ID. The experiments took place in an empty room in a self-contained school for two children, and in children's homes for two children. Functional analyses suggested that problem behavior was maintained by one function for each child (i.e., escape, attention, or tangibles). Varied mands consisted of manding for the functional reinforcer (e.g., attention) using three modalities; an iPad, iPhone, and a BIGmack. In the FCT phase, the first mand was immediately reinforced whether it was via the iPad, iPhone, or BIGmack. In the delay-to-reinforcement phase, a 10-s interval was implemented to determine whether children would mand using another modality. Using a multiple baseline design across participants design with an embedded reversal design, the findings indicated three children learned to use varied modalities to mand for functional reinforcers while maintaining a low to a zero level of problem behavior. However, the fourth child showed variable results in both varied manding and problem behavior.

Previous research on delay-to-reinforcement following FCT suggests that resurgence of problem behavior can be prevented by using an incremental delay-to-reinforcement intervals (e.g., Braithwaite & Richdale). For some children with ASD/DD, additional procedures such as differential reinforcement may be needed to enhance the effects of delay-to-reinforcement following FCT (Hanley et al., 2014). Additionally, research indicates that children with ASD/DD can be taught to use more than one SGD to access functional reinforcers by incorporating delay-to-reinforcement (Muething et al., 2018).

FCT and alternative activities. An alternative activity can be used in delay-tolerance training to enhance the effects of delay-to-reinforcement training. In an alternative activity intervention, the child is given access to an alternative preferred stimulus during the delay period (Hagopian et al., 2005). Hagopian et al. (2005) taught three boys, ages 7 to 13, with ASD and ID who engaged in aggression, disruption, and SIB to tolerate delay of reinforcement by providing non-contingent and continuous access to items that produced the lowest rate of problem behavior during a competing stimulus assessment. Children's problem behavior had to be maintained by either access to attention or tangible for children to be included in the study. After an initial phase of FCT with extinction, Hagopian et al. alternated between provision of alternative preferred stimuli, and no provision of alternative preferred stimuli during the time delay between FCR and reinforcement. The results suggested that problem behavior was at a lower level when alternative preferred stimuli were provided compared to when they were not. Hagopian et al. concluded that providing an alternative preferred stimulus may results in attenuation of EO for problem behavior; thus, the child is less likely to engage in problem behavior during the reinforcement delay.

FCT and demand fading/ chained schedules of reinforcement. Demand fading (also known as chained schedules of reinforcement), which is used to treat problem behavior that is maintained by escape, involves gradual introduction and increment of demands (Piazza, Moes, & Fisher, 1996). Hagopian, Fisher, Thibault-Sullivan, Acquisto, and Leblanc (1998) evaluated the efficacy of FCT for 21 clients. For one out of two children, whose results were graphed, demand fading was used following FCT. The child was diagnosed with a mild ID. He engaged in SIB, aggression, and disruption which were maintained by escape and access to attention. The intervention took place in an inpatient clinic. Increments of demand fading was gradual. During demand fading training, the child was instructed to complete a demand. When the child emitted a vocal FCR during demand, the therapist would deliver a statement such as "*nice asking, but finish your work*." Problem behavior was placed on extinction. The results showed variability in problem behavior when demand fading was used.

Almost a decade later, Berg et al. (2007) evaluated the effects of chained schedules of reinforcement following FCT and generalization across three generalization stimulus sets for four young children with DD who engaged in aggression, property destruction, and noncompliance. The experiments took place in children's living rooms in their homes. Following functional behavior assessments, children were taught to pick up 10 toy blocks and then given an opportunity to mand for a break. Contingent on manding, the child was given a 1-min break. Occurrences of problem behavior during task completion resulted in hand-over-hand assistance to complete the task. Occurrences of problem behavior during a break resulted in presence of task. The demand fading phase consisted of requiring the participants to pick up 30 toy blocks before they were given an opportunity to mand for a break. The results showed substantial increases in task completion and zero levels of problem behavior. Generalization pre-post probes suggested some improvements; however, generalization probes were bar-graphed. Thus, it is not possible to visually analyze generalization data to determine whether a functional relation exists between pre and post generalization probes. In addition, Berg et al. reported that manding generalized only 9% across tasks, 43% across settings, and 0% across persons.

Falcomata et al. (2012) introduced a unique way to conduct a chained schedule of reinforcement. In this method, participants were taught to request an S^D (e.g., necklace) which meant that the participants had control over their activity. Falcomata et al. included two 8-year-old children with Asperger syndrome and autism who had a history of SIB, aggression, disrobing, disruption, and property destruction. The study was conducted in a clinic room. A functional analysis of interruption of ongoing, free-operant leisure activities (Hagopian, Bruzek, Bowman, & Jennett, 2007) revealed that those problem behaviors were maintained by interruption of a preferred activity. Subsequently, an S^D was chosen for each child (e.g., necklace) and a chained schedule of reinforcement was implemented at FR 1/ FI 30 s. At the beginning of the session, the therapist had the S^D. Contingent on emitting the vocal FCR (e.g., "*can I have the necklace?*"), the child possessed the S^D which resulted in a 30-s access to the preferred activity with no interruptions. The findings indicated a functional relation between FCT and chained schedule of reinforcement and reduction in problem behavior. In a subsequent experiment, Falcomata et al. adjusted the chained schedule from FR 1/ FI 30 to FI 5 min/FI 30 s for one child, and to FI 10 min/FI 30 s for the other child. The purpose of this adjustment was to make the procedure more practical in natural settings. In the FI 5 min/10 min, the child was provided with a timer and required to complete an academic task. Engagement in academic task started with FI 2 min, and was gradually increased to the terminal goal (FI 5 min for one child, and FI 10 min for the other child). As a result of the chained schedule, both children's problem behavior maintained at a zero level. In addition, engagement in academic tasks increased substantially.

Similarly, Falcomata, Muething, Gainey, Hoffman, and Fragale (2013b) used FCT and a chained schedule of reinforcement to treat multiply controlled problem behavior (i.e., aggression, SIB, and disruption) of two boys with Asperger syndrome and autism. The experiments took place in the participants' classroom or a clinic room. An initial phase of FCT consisted of teaching the participants to mand for an S^D (i.e., wristband). Contingent on the target mand, the child was given the wristband which resulted in access to attention, highly preferred items, and no demand for 30 s.

Subsequently, a gradual 5-min delay to reinforcement was implemented using a timer. The results showed problem behavior maintained at a zero level for both participants. In a subsequent experiment, Falcomata et al. used a chained schedule of FI 5 min for mands for the wristband, and FR 1 for mands for each specific reinforcer (i.e., attention, tangible, escape). That is, when the 5 min elapsed, the therapist reinforced the target mand for the wristband, and any other mand for a specific reinforcer (e.g., break). The findings indicated that problem behavior remained at a zero level. In addition, although problem behavior was partially maintained by access to attention, a specific mand for attention did not occur. Falcomata et al. concluded that access to one form of reinforcement (e.g., access to toys) might have attenuated the putative EOs for other functional reinforcers (e.g., attention).

Studies on demand fading/chained schedules of reinforcement following FCT suggests that some children with ASD/DD may respond well to demand fading by completing tasks, manding appropriately, and engaging in low or zero problem behavior (e.g., Berg et al., 2007; Falcomata et al., 2012; 2013). However, data from previous studies suggest that demand fading may not be effective with some children with ASD/ DD(Hagopian et al., 1998) nor do its effects generalize across stimulus sets (Berg et al., 2007).

FCT and demand fading/ chained schedules of reinforcement with SGDs. In addition to demand fading following FCT, researchers have investigated demand fading following FCT with SGDs for FCRs. For example, Schieltz et al. (2011) included three young children with ASD and DD who engaged in aggression and SIB to teach them to use a BIGmack microswitch to mand to play. Parents of the participants served as interventionists. Results of functional analyses, conducted by parents, revealed that children's problem behavior was maintained by escape. In FCT, children were presented with one task, and were requested to complete it. Upon independent task completion, the child was presented with the microswitch to mand play. Contingent on manding, the child was given a 60-s access to play. Demand fading gradually increased to from one to eight tasks (12 tasks for one child). The findings showed a substantial decrease in problem behavior for two children, and some variability for one child.

Similarly, Wacker et al. (2011) taught two children with ASD, DD, ID, and Fragile X who engaged in aggression, property destruction, and SIB to mand play (one child vocally, and the other via a a BIGmack microswitch). The study was conducted in children's homes. Wacker et al. used the same procedure as Schieltz et al.'s (2011) including demand fading, and also had the parents serve as the interventionists. The results indicated substantial increases in task completion and manding, and zero levels of problem behavior.

Three years later, Suess et al. (2014) had parents, in their homes, teach their young children with a pervasive developmental disorder, not otherwise specified (PDD-NOS) who engaged in aggression, SIB, and property destruction to mand play using a microswitch that generated *"play please."* Functional analyses, conducted by the parents, revealed that problem behavior was maintained by access to tangibles. During intervention, children were required to complete one task before the microswitch was made available. Contingent on task completion and manding via the microswitch, the child was given a 2-min access to toys. Demand fading was introduced by gradually increasing the number of tasks from one to five. The findings showed zero levels of problem behavior with demand fading.

Previous research on demand fading following FCT with SGDs for FCRs has shown positive effects on task completion, appropriate manding, and problem behavior (Schieltz et al., 2011; Suess et al., 2014; Wacker et al., 2011). These studies show better results compared to studies on demand fading following FCT without SGDs (e.g., Hagopian et al., 1998). However, it is worth noting that studies on demand fading following FCT with SGDs were conducted in the homes of children by parents whereas studies on demand fading following FCT without SGDs were conducted by researchers in clinical settings. This may have attributed to the differentiated results.

FCT and response restriction. Another thinning schedule of reinforcement procedure is response restriction (RR). Response restriction involves limiting access to the communication mode (Hanley, Iwata, & Thompson, 2001). That is, the child can only emit an FCR when the communication mode is available. Thus, the communication mode serves as a discriminative stimulus (S^D, Ferster & Skinner, 1957) signaling the availability of reinforcement. Because the child's communication mode is removed in response restriction, response restriction can only be used when the communication mode is removable such as picture cards or SGDs. Roane et al. (2004) examined the effects of response restriction as a thinning schedule of reinforcement procedure on aggression displayed by two boys with ASD and ID ages 7 and 11. The study was carried out in a clinic room. During FCT, a 20-s access to reinforcement (i.e., attention for one child, and tangible for the other child) was contingent on handing a picture card or aggression (i.e., aggression was not placed on extinction). Following FCT, response restriction was in place by making the picture card unavailable, initially for 3 s, and gradually for up to 320 s. The results indicated that gradually decreasing access to reinforcement by using response restriction was effective in maintaining low levels of problem behavior for both participants.

Response restriction has also been used to treat stereotypy. Falcomata, Roane, Feeney, and Stephenson (2010) examined the effects of response restriction on elopement exhibited by a 5-year-old boy with autism. Functional analyses revealed that elopement was maintained by access to door play (i.e., repeatedly opening and closing a door). Following FCT, Falcomata et al. gradually restricted (from 2 s to 600 s) the child's access to the communication picture card. Once the timer sounded indicating the end of delay interval, the therapist made the picture card available. Contingent on touching the picture card, the child was given access to door play. The findings demonstrated a maintained zero level of elopement.

In addition, Fisher, Greer, Querim, and DeRosa (2014) examined the effects of response restriction on SIB, aggression, elopement, and property destruction of four children ages 4 to 7 who were diagnosed with ASD, ID, and comorbid conditions (i.e., stereotypic movement disorder, disruptive behavior disorder, and/or intermittent explosive disorder). All children's problem behavior was maintained by escape. Response restriction was implemented using 60/60 schedule (60/30 for one child). Specifically, for one child the communication picture card was made available for 60 s, and made unavailable for 60 s. The order of those two conditions was randomly counterbalanced in each trial response restriction resulted in substantial low levels of problem behavior.

Response restriction following FCT has shown positive effects on problem behavior of children with ASD/DD (Falcomata et al., 2010; Fisher et al., 2014; Roane et al., 2004). Nevertheless, to date, response restriction has been only examined with picture cards. Effects of response restriction of SGDs following FCT remain unknown.

FCT, mixed schedules, and multiple schedules of reinforcement. In addition to examining FCT with chained schedules of reinforcement, FCT with mixed and multiple schedules have been examined. Both mixed and multiple schedules involve the use of two or more simple schedules (e.g., FR, FI); however, unlike mixed schedules, multiple schedules involve the use of an S^D that signals the availability of reinforcement for an FCR. Thus, the FCR becomes under the stimulus control of the S^D (Cooper et al. 2007; Fisher et al., 1998). Betz et al. (2013) compared the effects of mixed and multiple schedules on problem behavior of four children, ages 5 to 9, diagnosed with adjustment disorder, ADHD, obsessive compulsive disorder, and bipolar disorder. Children's problem behavior, which consisted of aggression and elopement, were maintained by access to tangibles. The experiments took place in a clinic room. Following an FCT treatment, the comparison began using 60 s/60 s (i.e., 60 s reinforcement unavailable, 60 s reinforcement available) in both mixed schedule, and multiple schedule conditions. The S^D used in the multiple schedule condition was a bracelet for two children, and a colored vest the therapist wore as well as a card with the word “GAME” for the other two children. The results showed substantial decreases in problem behavior for all children in the multiple schedule condition. Problem behavior was variable in the mixed schedule condition.

A year later, Rispoli et al. (2014) followed an FCT with extinction treatment with a multiple schedule to treat problem behavior (i.e., aggression, SIB, property destruction, and disruption) of three young children with ASD and PDD-NOS. Functional analyses showed that children's problem behavior was maintained by access to rituals (e.g., only a certain show on TV). In multiple schedule conditions, Rispoli et al. used a kitchen timer to signal the availability of reinforcement. The multiple schedule started with 5 s/30 s (i.e., 5 s reinforcement unavailable, 30 s reinforcement available), and was gradually increased to 1 min/ 30 s. The results showed reductions in excessive manding for rituals and problem behavior of all children.

Recently, Fuhrman, Fisher, and Greer (2016) followed an FCT treatment with a comparison between traditional FCT and multiple FCT. The participants were two 5- and 7-year-old children diagnosed with autism, unspecified disruptive behavior, impulse control, and a conduct disorder who engaged in aggression, SIB, and property destruction. The experiments took place in a clinic room. In traditional FCT, an FCR was reinforced on a VI 20-s schedule. In multiple FCT, treatment started on a 30 s/ 60 s schedule (i.e., 30 s reinforcement available, and 60 s reinforcement unavailable), then on a 60 s/ 240 s schedule (i.e., 60 s reinforcement available, and 240 s reinforcement unavailable). A green card was used as an S^D, and a red card was used as an S-Delta. In both traditional FCT and multiple FCT conditions, problem behavior was placed on extinction. When problem behavior occurred simultaneously with appropriate manding, Fuhrman et al. implemented a 3-s changeover delay (Herrnstein, 1961). That is, reinforcement was withheld for 3 s, and then the child was required to emit another FCR without engaging in problem behavior. The results showed more stable and lower levels of both problem behavior and excessive manding in multiple FCT condition than during the traditional FCT condition.

In addition, Greer et al. (2016) summarized the results of 25 cases in which FCT followed by a thin schedule reinforcement was used to treat problem behavior. All experiments took place in a therapy room. Of the included cases, a multiple schedule was used with two children with autism and ADHD who engaged in aggression and disruption. As reported by Greer et al., an S^D differed between cases; nevertheless, colored cards and wristbands were among the common S^D used which signaled when the FCR would be reinforced. The interval in which reinforcement was not available was initially brief, and gradually increased based on clinical judgment. As in Fuhrman et al.'s (2016) study, a 3-s to 5-s changeover delay (Herrnstein, 1961) was implemented when problem behavior simultaneously occurred with appropriate manding. The results showed the multiple schedule was effective in decreasing and maintaining problem behavior at a low level for one child, but variable for the other child. For the latter child, restrictive response was added as an additional phase and resulted in a substantial decrease of problem behavior.

To examine whether an arranged S^D (e.g., a bracelet) was needed for an effective multiple schedule, Shamlian et al. (2016) compared between the effects of arranged versus naturally occurring (e.g., talking on the phone, cooking) discriminative stimuli in multiple schedules. The participants included three children diagnosed with autism, ages 5 to 10, who engaged in disruption, SIB, and aggression. Those problem behaviors were maintained by access to tangibles. The experiments took place in an outpatient clinic. Following an FCT with extinction treatment, comparison sessions of arranged versus naturally occurring S^D began. In the arranged S^D condition, the therapist wore a bracelet that signaled the availability of reinforcement. When the therapist did not have the bracelet on, this S^Δ signaled the unavailability of reinforcement. The therapist also provided contingency-specifying rules (e.g., "*when I have the bracelet on, you can ask for* [reinforcer] *and get it, when I don't have it on, you can ask for* [reinforcer] *but you won't get it*"). In the naturally-occurring S^D condition, an FCR was reinforced when the therapist was engaged in a non-busy activity (e.g., listening to music), and was not reinforced when the therapist was engaged in a busy activity (e.g., talking on the phone). In this condition, the therapist did not provide contingency-specifying rules. In both conditions, a 60 s/60 s schedule was used (i.e., 60 s reinforcement available, 60 s reinforcement unavailable). The results of the comparison were inconclusive. Problem behavior was lower in the arranged S^D condition for one participant, and was equally low in both conditions for the other two participants.

Finally, to examine whether the effects of a multiple schedule following FCT could generalize across people and settings, Fisher, Greer, Fuhrman, and Quirim (2015) used a multiple baseline across therapists design with one participant, and a multiple baseline across rooms design with two participants. Participants were 5 to 10 years old who were diagnosed with autistic disorder, PDD-NOS, oppositional defiant disorder, stereotypic movement disorder, and adjustment disorder. Their aggression, SIB, and property destruction were maintained by access to tangibles. Following an FCT treatment, a multiple schedule (60 s/ 60 s) was implemented. The S^D was a wristband worn by the therapist. At the beginning of each session, the therapist provided contingency-specifying rules to alter children's discrimination between conditions.

Findings showed decreases in problem behavior and FCRs during S^{Δ} and increases in FCRs during S^{D} across rooms/therapists.

Previous research on multiple schedules following FCT have shown positive impact on maintained low levels of problem behavior and excessive manding of children with ASD/DD. These results may be attributed to the established stimulus control of the FCR by using schedule-correlated stimuli (Fisher et al., 2015; Shamlian et al., 2016). Nevertheless, it is worth noting that none of those studies used SGDs for FCRs. Thus, the effects of multiple schedules of FCT using SGDs for FCRs remain unclear.

Summary

FCT is among the most frequently studied function-based interventions for severe problem behavior (Tiger et al., 2008). Since the seminal article by Carr and Durand (1985), researchers have shown positive effects of FCT to treat problem behavior of children with ASD/DD (e.g., Franco et al., 2009; Mancil et al., 2006). FCT has also been examined and shown positive impact on multiply controlled problem behavior by teaching children to emit a different FCR for each function (e.g., Sigafoos & Miekle, 1996). Additionally, researchers have examined SGDs such as iPads (e.g., Muharib et al., 2018) for FCRs and shown positive results beginning with Durand (1999) who used BIGmack. As shown in Winborn et al. (2002), the child who was taught to emit an FCR to access the functional reinforcer using an SGD engaged in a substantial low level of problem behavior compared to when he was required to emit a vocal FCR. This could be attributed to the low response effort (Horner & Day, 1991) required in emitting an FCR using SGDs.

To make FCT more practical and feasible in natural settings, researchers have examined a variety of procedures to gradually thin the schedule of reinforcement and increase tolerance to delays for functional reinforcers. These included delay-to-reinforcement (e.g., Hanley et al., 2014), alternative activities (e.g., Hagopian et al., 2005), demand fading/ chained schedules of reinforcement (e.g., Berg et al., 2007), response restriction (e.g., Roane et al., 2004), and multiple schedules of reinforcement (e.g., Greer et al., 2016). These procedures suggested that children with ASD/DD can be taught to emit FCRs only when it is appropriate (e.g., after a set of tasks, when the mother is not on the phone), thus, making FCRs feasible to reinforce in natural settings while preventing resurgence of problem behavior. Although previous research has demonstrated positive effects of various lean schedules of reinforcement, there is a lack of generalization and maintenance measures across studies.

CHAPTER THREE: METHOD

Participants

Two participants were included in the study. The inclusion criteria for this study were having a diagnosis of ASD and/or DD, and being enrolled in a lower elementary grade (K-2). In addition, participants had to exhibit limited to no functional spoken communication skills. This was defined as non-vocal verbal, as well as "nonfunctional use of words, inability to initiate a vocal request with one or more words, and/or unintelligible use of words" (Muharib et al., 2018, p. 3). Participants had to engage in problem behavior such as aggression, SIB, disruption, or destruction. Problem behavior had to be maintained by positive reinforcement (e.g., attention, tangible) because the use of multiple schedules of reinforcement has been supported by the literature for problem behavior maintained by positive reinforcement. This last criterion was tested by the experimenter through functional behavior assessments to ensure participants met this criterion. The classroom teacher(s) were asked to nominate potentially eligible children. Children were excluded from the study when they did not have a diagnosis of ASD or DD, could communicate fluently via speech or AAC, exhibited no problem behavior, or engaged in problem behavior maintained by negative or automatic reinforcement. Table 1 shows the characteristics of the participants.

Amber (pseudonym) was a Caucasian female (8 years and 3 months old) who had an educational diagnosis of autism. Evaluations had been completed by a teacher and parent 4 months before the study began. On the *Gilliam Autism Rating Scale* (GARS-3), Amber's scores fell in the very likely range (112 and 118). On the *Adaptive Behavior Assessment System* (ABAS-3), Amber's scores fell in the extremely low range (52 to 57).

A psychologist administered the *Kaufman Assessment Battery for Children* (K-ABC-II), and Amber scored in the extremely low range (49). In addition to standardized assessments, observations indicated that Amber mainly communicated via prelinguistic behaviors such as pointing and leading adults. Additionally, Amber showed vocal skills when she was given a prompt (e.g., "*do you want milk or ice cream?*"). Amber was nominated by the classroom teacher as she had frequently exhibited problem behaviors in the forms of self-injury (i.e., head banging against hard objects or other people's heads), disruption (i.e., screaming), and aggression (i.e., hitting and kicking). Because of her problem behaviors, Amber had been suspended from school a few times. For safety, she wore a foamy helmet at school every day. Amber was not receiving speech or behavioral therapy at the time of the study.

Selena (pseudonym) was a Latina female (5 years and 5 months old) who had a medical diagnosis of autism and global developmental delay. Selena had scored 74 (significant) on the *Autism Spectrum Rating Scale* (ASRS). An evaluation using Transdisciplinary Play-Based Assessment (TPBA2) had been completed 2 years prior to the study. As her records showed, Selena fell in the 8-month level in the adaptive behavior domain, the 5-month level in the cognitive domain, the 3-month level in the receptive language domain, and the 6-month level in the expressive language domain. Selena was non-vocal, and used prelinguistic behaviors to communicate (e.g., pushing things away, grabbing). Selena was nominated by the classroom teacher because she often engaged in problem behavior in the form of disruption (i.e., crying, screaming). Selena received applied behavior analysis (ABA)-based therapy at home after school.

Table 1

Characteristics of Participants

Participant	Gender/ Age/race	Diagnosis	Communication level	Problem behavior
Amber	Female/ 8yr: 3m/ Caucasian	Autism	One-word vocalizations, prelinguistic	Self-injury, disruption, aggression
Selena	Female/ 5yr: 5m/ Latina	Autism, Global Developmental Delay	Prelinguistic	Disruption

Setting

The study took place in two rural public schools in the southeast United States. Amber's classroom was a self-contained classroom for students with autism ages 5 to 11. The classroom consisted of four other students, a lead teacher (Caucasian), and two paraprofessionals (Caucasians). Selena's classroom was a self-contained classroom for students with multiple disabilities ages 5 to 10. The classroom consisted of five other students, a lead teacher (Caucasian), and two paraprofessionals (Caucasian, African-American). For Amber, functional analysis, baseline, training, generalization across teachers, and maintenance sessions took place at an isolated area within the classroom. Other students kept away from the area. Generalization across setting took place in bean bag corner where other students were around. For Selena, functional analysis, baseline, training, generalization across teachers, and maintenance sessions took place at a storage room in the classroom. All stored items kept in the back behind Selena to eliminate distraction. Other students were not allowed to be in the room. Generalization across setting took place at U-shaped table in the classroom where other students were around. In all sessions, the experimenter sat on the participant's side or in front of the participant.

Materials

An iPad loaded with the GoTalk Now application (Attainment Company, n. d.) was used. GoTalk Now is an augmentative and alternative communication application that can be customized based on the communication level and interests of the user. Upon touching an icon, GoTalk Now generates a speech output (e.g., "I want an apple"). Prior to baseline, the experimenter created a page for Selena based on the function of her problem behavior (i.e., *"iPhone and book*"). The page consisted of a caption and a corresponding picture (i.e., iPhone and book). A communication picture card was later created for Selena to replace the iPad. Because Selena engaged in touching the iPad in a form of motor stereotypy (i.e., touching the icon nonstop when the experimenter attempted a mixed schedule), the iPad was removed. The communication picture card was 2 by 2 inches and had a picture and caption of "iPhone and book." Other materials included preferred items of the participants. These included iPad (Amber), iPhone, hard-cover children's book, and a sensory bottle (Selena).

Experimenter and Interventionist

The experimenter and interventionist was a doctoral candidate in special education and a Board Certified Behavior Analyst. In addition to designing the study, she was responsible for (a) conducting the functional behavior assessments (FBAs); (b) developing FCT interventions; (c) implementing the baseline, intervention, and maintenance phases; and (d) training and supervising the teachers who were be responsible for carrying out the generalization across teachers sessions.

Research Design

The current study consisted of three phases: FA, FCT, and thinning schedules of reinforcement. FAs were completed using a reversal design (Cooper et al., 2007) with Amber, and a multielement design with a contingency reversal with Selena. The FCT phase was conducted using a reversal design (Amber; A-B-A-B/ Selena; A-B-A-B-C). A reversal design was used as it demonstrated the strongest experimental control compared to other single-case designs (e.g., multiple baseline across participants, multielement). Additionally, this design allowed for immediate introduction of intervention after a brief baseline. That is, the second participant did not have to wait for the first participant to show positive effects of treatment before she began intervention. Participants entered baseline at the same time. Intervention was introduced to participants once a stable or increased trend of problem behavior was established with a minimum of three data points. Once they mastered criteria of FCT, they were introduced to the following phase (thinning schedules of reinforcement). This phase was also conducted using a reversal design (Amber; A-B-C-A-C-D/ Selena; A-B-C-D-C-E-C-E-F). The first condition was a mixed schedule of reinforcement followed by a multiple schedule of reinforcement. An alternative activity was added for Selena only when her FCRs went to a zero in the multiple schedule of reinforcement condition. A reversal to a previous condition was conducted to establish an experimental control. Only three data points were collected in the reversal phase to establish experimental control without prolonging engagement of problem behavior. Generalization probes were conducted throughout aforementioned phases. Follow-up probes were collected for participants within 2 to 4 weeks.

Dependent Variables

In the FA phase, data were collected on the participants' problem behavior. Amber's problem behavior were defined as: (a) self-injury; banging her head against a table, floor, cabinet, wall, the experimenter's, or hitting her head with closed fists, (b) disruption; screaming that was above the conversational level for 1 to 3 seconds, and (c) aggression; hitting the experimenter by placing her hand with force on any part of the experimenter's body, or kicking the experimenter by placing her foot with force on any part of the experimenter's body. Selena's problem behavior was defined as disruption; screaming that was above the conversational level for 1 to 3 seconds. A rate was generated by dividing the number of incidences of problem behaviors by the total of minutes.

In the FCT phase, data were collected on the participants' FCR and problem behavior. FCR for Amber was defined as vocally saying "*iPad*." FCR for Selena was defined as touching any part of the iPad screen that showed "*Book and iPhone*." In the final phase of the FCT, the iPad was replaced with a picture "*Book and iPhone*" for Selena. In the thinning schedule phase, the picture was either "*iPhone*" or "*bottle*" depending on the results of the preference assessment (MSWO) for that day. This FCR was defined as picking the picture off the desk and handing it to the experimenter. The definitions of problem behaviors remained the same for both participants. A rate was generated by dividing the number of FCRs by the total of minutes and dividing the number of incidences of problem behaviors by the total of minutes.

In the thinning schedule of reinforcement phase, data were collected on three FCRs during the S^D condition, FCRs during S-Delta condition, and problem behavior. The definitions of FCRs remained the same for Amber and Selena (picture exchange).

These data were collected during both the S^D and S-Delta conditions to test whether participants were discriminating between the conditions. The definitions of problem behaviors remained the same for Amber. For Selena, two additional problem behaviors were added as they emerged during this phase of the study. In addition to screaming, data were collected on throwing the picture card on the floor. This was defined as picking up the picture card off the desk and throwing it on the floor (behind her or to the other side where the experimenter was not sitting). Data were also collected on crying. This was defined as continuous vocalizations above the conversational level that lasted more than 3 seconds. A rate per minute was generated for FCRs during S^D, FCRs during S-Delta, and problem behaviors except for crying (Selena). Crying was collected using duration (seconds per minute).

Procedures

Time of day in which sessions took place was kept consistent for each participant across the study phases to control temporal variables. The study began with preference assessments. Phases of the study began with FA, followed by FCT, and then thinning schedules of reinforcement. FAs consisted of four conditions (demand, attention, tangible, and free play). FCT consisted of baseline and training sessions, reversal to baseline, and intervention reinstatement. Sessions of these two phases of the study lasted 5 minutes.

Thinning schedules of reinforcement, for Amber, consisted of mixed (S^D 30 s, S-Delta 60 s, S^D 30 s), multiple FCT (S^D 30 s, S-Delta 60 s, S^D 30 s), multiple FCT “hat and music” (S^D 30 s, S-Delta 60 s, S^D 30 s), mixed (S^D 30 s, S-Delta 60 s, S^D 30 s), multiple FCT “hat and music” (S^D 30 s, S-Delta 60 s, S^D 30 s), and multiple FCT “hat and music”

(S^D 30 s, S-Delta 180 s, S^D 30 s). Each session lasted for the length of intervals (i.e., 2 minutes or 4 minutes).

Thinning schedules of reinforcement, for Selena, consisted of mixed (S^D 30 s, S-Delta 60 s, S^D 30 s), mixed (S^D 30 s, S-Delta 120 s, S^D 30 s), multiple FCT with an alternative activity (S^D 30 s, S-Delta 120 s, S^D 30 s), multiple FCT (S^D 30 s, S-Delta 120 s, S^D 30 s), alternative activity (S^D 30 s, S-Delta 120 s, S^D 30 s), multiple FCT (S^D 30 s, S-Delta 120 s, S^D 30 s), alternative activity (S^D 30 s, S-Delta 120 s, S^D 30 s), and alternative activity (S^D 30 s, S-Delta 240 s, S^D 30 s). Each session lasted for the length of intervals (i.e., 2 minutes, 3 minutes, or 5 minutes).

Preference assessments. Indirect and direct preference assessments were conducted to identify a hierarchy of participants' preferred items. First, classroom teachers were asked to identify the top three to five preferred items for each participant. The identified items were then assessed using a multiple stimulus without replacement procedure (MSWO; DeLeon & Iwata, 1996). The identified items were presented on a table in front of the participant. Then, the experimenter instructed the participant to select one item. When the participant pointed to, reached for, or selected an item, the remaining items were removed and the selected item was recorded as the most preferred item. The participant was allowed to play with the item for 20 s. The aforementioned procedure was continued until all items were selected or not selected. The order in which the items were selected was recorded. This assessment was conducted three times before the FBAs. MSWO was also conducted once before each alternative activity (and multiple plus alternative activity) session for Selena to identify her second preferred item.

FBAs. FBA began with interviewing the teachers and teacher assistants who worked directly with the participants. Open-ended questions were asked (see Appendix A for the list of questions). Then, A-B-C observations were conducted in the classroom during activities that were reported by teachers as likely to evoke the problem behavior. There were two observations for each participant during the troubling activities. Each observation lasted 15 to 20 min. Upon the occurrence of problem behavior during those observations, the experimenter recorded the incidence, the events that preceded it, and the events that followed it. Subsequently, a functional analysis (FA; Iwata et al., 1982/1994) was conducted for each participant to ensure that the intervention will be based on the function of the problem behavior and to decrease the likelihood of treatment failure. There were four conditions; demand, attention, tangible, and free play. An alone condition was not conducted as teacher reports and observations did not suggest a likelihood of engagement in problem behavior without socially-mediated consequences. The order of the conditions was fixed based on a study that indicated randomizing the conditions often led to unclear results (Hammond, Iwata, Rooker, Fritz, & Bloom, 2013). Each session lasted 5 min and consisted of testing one condition.

Demand. In the demand condition, a non-preferred demand identified by teacher reports (e.g., academic task) was placed in front of the participant. The participant was asked to complete the demand. Least to most prompting (vocal, modeling, physical) was implemented when the participant did not comply with the experimenter's instruction within 3 s. An incidence of problem behavior resulted in a termination of the demand for 20 s (i.e., a break).

Attention. In the attention condition, a low preferred item was kept with the participant throughout the session. The experimenter interacted with the participant for approximately 1 min and then told the participant that she would be working on paperwork. The experimenter then withheld attention from the participant. When the participant engaged in problem behavior, the experimenter contingently gave the participant positive attention for 20 s (e.g., talking to the participant).

Tangible. In this condition, a low preferred item was kept with the participant throughout the session. The participant was given her preferred item, identified through preference assessments, to interact with for 1 min. Then, the experimenter retrieved the item (e.g., saying "*my turn*"). When the participant engaged in problem behavior, the experimenter immediate gave the participant the preferred toy/item for 20 s (e.g., saying "*okay, you can have it*").

Play. In this condition, the participant had continuous access to the experimenter's attention, preferred tangibles, and no demands. Occurrences of problem behavior were ignored.

Because Selena did not discriminate between the conditions (she engaged in problem behavior during the breaks in the demand condition suggesting that a break was not a reinforcer and that problem behavior was maintained by another variable), another therapist conducted four sessions to confirm the function of Selena's problem behaviors. These were demand, tangible, free play, and tangible.

FCT. This phase of the study consisted of baseline, FCT, return to baseline, and reintroduction of FCT. Each session lasted 5 minutes.

Baseline phase. Baseline sessions were identical to the tangible FA with one exception: an iPad was placed in front of Selena. Emitting the FCR (vocal for Amber, iPad for Selena) produced no reinforcement (i.e., ignored). On the other hand, engaging in problem behavior resulted in accessing the functional reinforcer (i.e., iPad for Amber, iPhone and book for Selena) for 20 s. Sessions lasted 5 min. The experimenter implemented those sessions.

FCT phase. During this phase, least to most prompting and progressive time delay (0 s, 5 s, 10 s, 30 s) were used to teach the participants to use the new FCR. In the session, the participant received the functional tangible reinforcer(s) for 1 min. Next, the experimenter retrieved the functional reinforcer (e.g., saying "*my turn*"). Once the functional reinforcer was retrieved from the participant, the interventionist prompted the Selena to touch the icon (gestural, verbal and gestural), and verbally prompted Amber to vocally emit the FCR (say "iPad"). Physical prompts were not used with Selena because she reacted to physical prompts with whining. The progressive time delay started with 0 s. Then, it increased gradually each session based on the participant's performance (i.e., 100% independent FCRs for two consecutive sessions before increasing the time delay). Whether independent or promoted, the participant was given the functional reinforcer for 20 s. Incidences of problem behavior were ignored. When problem behavior occurred simultaneously while emitting an FCR, a 3-s changeover delay (Herrnstein, 1961) was implemented. That is, the functional reinforcer was withheld for 3 s. Then, the experimenter instructed the participant to re-emit the FCR without engaging in problem behavior. Sessions lasted 5 min. Participants received three to five sessions a day three to four days a week. The mastery criteria for this phase were 100% independent emission of

FCR, and at least 80% decrease of problem behavior compared to baseline levels for three consecutive sessions. A generalization probe by paraprofessionals was conducted once.

Thinning schedules of reinforcement. This phase of the study aimed to examine the effects of a multiple schedules of reinforcement on both FCRs and problem behaviors.

Mix FCT (S^D 30 s, S-Delta 60 s, S^D 30 s). Sessions in this condition started with a 30-s interval in which independent FCRs resulted in 20-s access to the functional reinforcer. Before the start of the session, the experimenter delivered a statement to the participant (e.g., "*sometimes you say iPad and I will give it to you, sometimes you say iPad and I will not give it to you*"). The participant was given the functional reinforcer for approximately 1 minute before the session started. Then, the experimenter retrieved the functional reinforcer form the participant (e.g., saying "*my turn*"). The reinforcer was given immediately to the participant for 20 s. When problem behavior occurred simultaneously while emitting an FCR, a 3-s changeover delay was implemented. That is, the functional reinforcer was withheld for 3 s. Then, the experimenter instructed the participant to re-emit the FCR without engaging in problem behavior. When the participant emitted an FCR during the final 10 s of a reinforcement component, the FCR resulted in 10 s access to the functional reinforcer and then, the following extinction component began on schedule (Betz et al., 2013). All problem behaviors were ignored. When Selena threw her picture card on the floor, the experimenter returned the picture card on the desk without giving attention to Selena.

Mix FCT (S^D 30 s, S-Delta 120 s, S^D 30 s)/ Selena. Because Selena did not engage in a high level of problem behaviors that would warrant intervention, the extinction component was increased to 120 s. All procedures remained the same as the previous condition.

Mult FCT (Amber: S^D 30 s, S-Delta 60 s, S^D 30 s: Selena: S^D 30 s, S-Delta 120 s, S^D 30 s). For Amber, two salient, clearly discriminable stimuli (i.e., S^D; bright red necklace worn by the experimenter, S-Delta; white baseball cap worn by the experimenter) were used to signal the availability and unavailability of reinforcement for Amber. The use of clearly discriminable stimuli was based on recent research (Perez, Bacotti, Pizarro, Peters, & Vollmer, 2018; Pizarro, 2018) that found children attend to the therapist's behavior, instead of the programmed stimuli, when the stimuli were not clearly discriminable (e.g., two cards of different colors).

The two stimuli were later changed to a sombrero hat and music (i.e., S^D; hat worn by the experimenter while music played, S-Delta; no hat/no music) for Amber due to a lack of discrimination between the stimuli. For Selena, the experimenter only wore a sombrero hat during the reinforcement components (i.e., S^D; hat, S-Delta; no hat). The experimenter chose not to include music as an S^D for Selena because her iPhone game had music. That is, there would have been two types of music playing at the same time which would have made the music not salient as an S^D signal.

The procedures in this condition were identical to the mix FCT with a few exceptions. First, the signaling stimuli were used. Second, contingency-specifying rules (Betz et al., 2013) were added in the 10th Mult FCT session for Amber, and was introduced from the beginning for Selena (e.g., "*when the hat and music are on, you can* *ask for the [functional reinforcer] and I will give it to you, when the hat and music are off, you can ask for the [functional reinforcer] but I will not give it to you*"). Third, the first FCR emitted in the S-Delta component resulted in a statement (e.g., "*good job asking but you need to wait*", "*no hat, no iPhone, you need to wait*"). The mastery criteria for this phase were a minimum of 80% decrease of problem behavior compared to baseline levels for three consecutive sessions.

Mult FCT (S^D 30 s, S-Delta 120 s, S^D 30 s) plus alternative activity/ Selena. Because Selena engaged in a high level of problem behavior, and her FCRs went back to a zero level (i.e., extinction) in the Mult FCT condition, an alternative activity was added during the S-Delta interval. The procedures were identical to the previous condition with one exception. An alternative toy was given to Selena once the S-Delta interval started (Fuhrman, Greer, Zangrillo, & Fisher, 2018). That is, once the S-Delta interval began, the interventionist retrieved Selena's functional reinforcer, and at the same time gave her an alternative toy that was identified through MSWO at the 2nd rank on that day (i.e., either iPhone or sensory bottle). Once the S-Delta interval ended, the interventionist removed the alternative toy.

Alternative activity alone (S^D 30 s, S-Delta 120 s, S^D 30 s)/ Selena. As a component analysis, this condition was conducted to test whether the contingency-specifying rule as well as the contrived signaling stimulus (i.e., the sombrero hat) were needed. The procedures were identical to Mult FCT plus alternative activity sessions with the exceptions of no contingency-specifying rules were given and the sombrero hat was not worn by the experimenter during S^D.

Mult FCT (S^D 30 s, S-Delta 180 s, S^D 30 s)/ Amber. The programmed stimuli and procedure were identical to the Mult FCT condition with the exception of the length of S-Delta interval. The S-Delta interval length was rapidly increased from 60 s to 180 s (Fuhrman et al., 2016). Sessions lasted 4 min. The mastery criteria for this phase were a minimum of 80% decrease of problem behavior compared to baseline levels for three consecutive sessions.

Alternative activity alone (S^D 30 s, S-Delta 240 s, S^D 30 s)/ Selena. The procedures were identical to the alternative activity alone condition with the exception of the length of S-Delta interval. The S-Delta interval length was rapidly increased from 120 s to 240 s (Fuhrman et al., 2016). Sessions lasted 5 min. The mastery criteria for this phase were a minimum of 80% decrease of problem behavior compared to baseline levels for three consecutive sessions.

Generalization. Generalization sessions were conducted once in each phase of the study. These were generalization across a classroom setting (Amber; bean bag chair in a corner of the classroom, Selena; a table in the classroom) as well as generalization to a paraprofessional. The generalization procedures were identical to the intervention phases. In addition to probing in each phase of the study, generalization was also assessed across the classroom lead teacher. These probes were conducted after the termination of intervention. For Amber, these final generalization sessions were identical to the Mult FCT (S^D 30 s, S-Delta 180 s, S^D 30 s). For Selena, they were identical to the alternative activity alone (S^D 30 s, S-Delta 240 s, S^D 30 s).

Teacher training. Prior to having teachers/ paraprofessionals implement a generalization session, they received training from the experimenter. First, on the same day, they observed a session conducted by the experimenter with the participant. Afterward, the experimenter provided explicit oral instructions on the procedures. In addition, the teacher/ paraprofessional was asked to repeat the steps of the procedures and had the opportunity to ask questions to the experimenter. After they conducted a session, the experimenter provided the teacher/ paraprofessional with descriptive performance feedback. During these generalization sessions, the experimenter sat in the back and collected data on the participants as well as procedural fidelity data.

Maintenance. Maintenance sessions were conducted to test whether the effects of the intervention would maintain. These sessions started 11 days after the last intervention session for Amber, and started two weeks after the last intervention session for Selena. The procedures were identical to the Mult FCT (S^D 30 s, S-Delta 180 s, S^D 30 s) for Amber, and were identical to the alternative activity alone (S^D 30 s, S-Delta 240 s, S^D 30 s) for Selena. These sessions were conducted by the experimenter.

Social Validity

Social validity was assessed via a questionnaire delivered to teachers and paraprofessionals who conducted generalization probes with the participants. The parents were not surveyed due to their inability to come to school to watch the videos and complete the questionnaire. The survey included closed-ended questions using a 6-point (6 = strongly agree, 1 = strongly disagree) Likert scale (See Appendix B). The following areas of social validity were assessed: (a) appropriateness of behaviors targeted to decrease and increase, (b) acceptability of the FCT Mult procedure (FCT/alternative activity for Selena), (c) significance of behavior change, and (d) feasibility for the implementation of FCT Mult/ alternative activity. This was done immediately after the conclusion of the study.

Interobserver Agreement

Interobserver agreement (IOA) was conducted for 30% of sessions across all phases of the study. A trained second-year doctoral student collected these data by attending 30% of sessions in the second phase of the study (FCT) and by watching videotapes in the third phase of the study (thinning schedules of reinforcement). All sessions were divided into 20-s intervals (see Appendix D). Mean count per interval IOA method was used to determine percent agreement on all the dependent variables except for Selena's crying (Cooper et al., 2007). For crying, mean number of seconds per interval IOA was used. For each dependent variable, the smaller number was divided by the larger number and multiplied by 100 for each of the 20-s intervals. IOA for Amber in the FCT phase of the study was 93.3% (range = 76.6% - 100%) on FCRs, and 96.4% (range = 86.6% - 100%) on problem behavior. IOA for Amber in the thinning schedules of reinforcement phase of the study was 100% on FCR- S^D, 97.8% (range = 83.3% - 100%) on FCR-S-Delta, and 98.4% (range = 63.8% - 100%) on problem behavior. This one-time low agreement was due to collecting IOA data live. IOA data, after that first session, were collected via videotapes to increase accuracy. IOA for Selena in the FCT phase of the study was 95.9% (range = 78.3% - 100%) on FCRs, and 98.2% (range = 93% - 100%) on problem behavior. IOA for Selena in the thinning schedules of reinforcement phase of the study was 100% on FCR- S^D and crying, 98.6% (range = 85% - 100%) on FCR-S-Delta, and 99.3% (range = 92.5% - 100%) on screams and throws of the picture card.

Procedural Fidelity

Procedural fidelity data were collected for 30% of the sessions for each condition of the FCT phase of the study as well as the thinning schedules of reinforcement phase of the study. A trained second-year doctoral student collected these data by using checklists created by the experimenter to record whether each component of the procedure was implemented (see Appendices E, F, G, H, I, and J). In addition, procedural fidelity data were collected on the implementation of the procedures by the teachers and paraprofessionals in the generalization probes. These data were collected by the experimenter for 100% of the sessions.

Procedural fidelity data collected on the experimenter for the FCT phase (baseline and FCT training) were 100%. Procedural fidelity data collected on the paraprofessional (Amber's classroom) for the FCT phase (baseline and FCT training) were 100%. Procedural fidelity data collected on the paraprofessional (Selena's classroom) for the FCT phase were 94% for baseline procedures, 97.7% for the FCT procedures (using the iPad), and 100% for the FCT procedures (using the picture card).

Procedural fidelity data collected on the experimenter for the thinning schedules of reinforcement phase were 100% for each condition (Mix FCT, Mult FCT, Mult plus alternative activity, and alternative activity alone).

Procedural fidelity data collected on the paraprofessional (Amber's classroom) were 87.5% for Mix FCT, and 90% (range = 86% - 100%) for Mult FCT. Mult FCT procedural fidelity data were also collected on the classroom lead teacher (Amber's classroom). The result was 89.5% (range = 86% - 93%).

Procedural fidelity data collected on the paraprofessional (Selena's classroom) were 100% for Mix FCT, Mult FCT, and alternative activity alone. Alternative activity alone procedural fidelity data were also collected on the classroom lead teacher (Selena's classroom). The result was 100%.

CHAPTER FOUR: RESULTS

This chapter reviews the results of the present study. It begins by reviewing the results of the FAs as well as the FCT phase for each participant. Following this, the outcomes for each specific research question will be detailed. Research questions pertaining to the effects of multiple schedules of reinforcement will be reviewed first. Next, questions regarding generalization and maintenance of effects will be detailed. Finally, the questions regarding social validity and teacher perceptions will be provided.

Functional Analysis

Prior to implementing the intervention, functional analysis (FA) sessions were conducted with each participant to determine the function of each participant's problem behavior. The graphs below represent the results of the FA for Amber and Selena.

Amber. The results of FA for Amber are displayed in Figure 2. FA conditions included demand, attention, tangible, and free play (control), in this order, and then a contingency reversal of a tangible and free play conditions. An alone condition was not included for two reasons (a) school constraints that did not allow to isolate Amber in a room, and (b) the A-B-C observations did not suggest that problem behavior was maintained by automatic reinforcement.

As shown in the graph, Amber did not engage in problem behavior during any of the demand, attention, or free play conditions. However, in the first tangible condition, Amber engaged in problem behavior at a 0.6 per minute. To confirm the hypothesis of the function of her problem behavior, a contingency reversal was conducted. Amber engaged in problem behavior at approximately 2.0 per minute. This suggested that Amber's problem behavior was maintained by access to tangibles (i.e., an iPad).

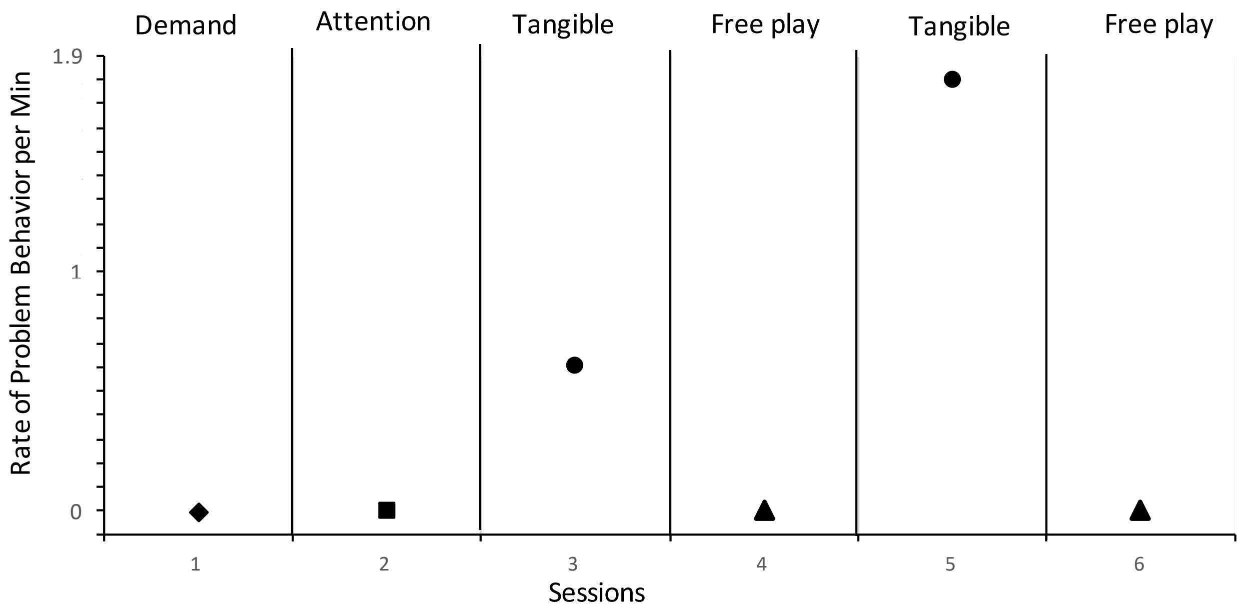

Figure 2. Rates of problem behavior exhibited by Amber during functional analysis.

Selena. The results of FA for Selena are shown in Figure 3. FA conditions included demand, attention, tangible, and free play (control) conducted in a multielement design. Because Selena engaged in problem behavior during the demand condition even after the removal of the task (i.e., negative reinforcement), it suggested the she did not discriminate between the conditions. In other words, if her problem behavior was maintained by negative reinforcement, she would have stopped engaging in problem behavior once the task was removed. However, that did not occur. Because of that, another researcher conducted a demand condition session, followed by a tangible, free play, and a reversal to a tangible condition to confirm the function of Selena's problem behavior. An alone condition was not included for the same two reasons as Amber.

As displayed in the graph, Selena did not engage in problem behavior during either the attention or free play conditions. However, during the demand condition, Selena engaged in a rate of 2.2 per minute in the second and third sessions. During the tangible condition, Selena engaged in problem behavior in a rate of 0.6 to 1.4 per minute. To determine whether Selena's problem behavior was maintained by positive or negative reinforcement, a contingency reversal was conducted by another researcher to enhance condition discrimination. Selena engaged in problem behavior during the demand condition in only a rate of 0.2 per minute. She engaged in substantially higher rates of problem behavior during the tangible condition sessions at 1.2 and 1.6 per minute. This suggested that Selena's problem behavior was mainly maintained by access to tangibles.

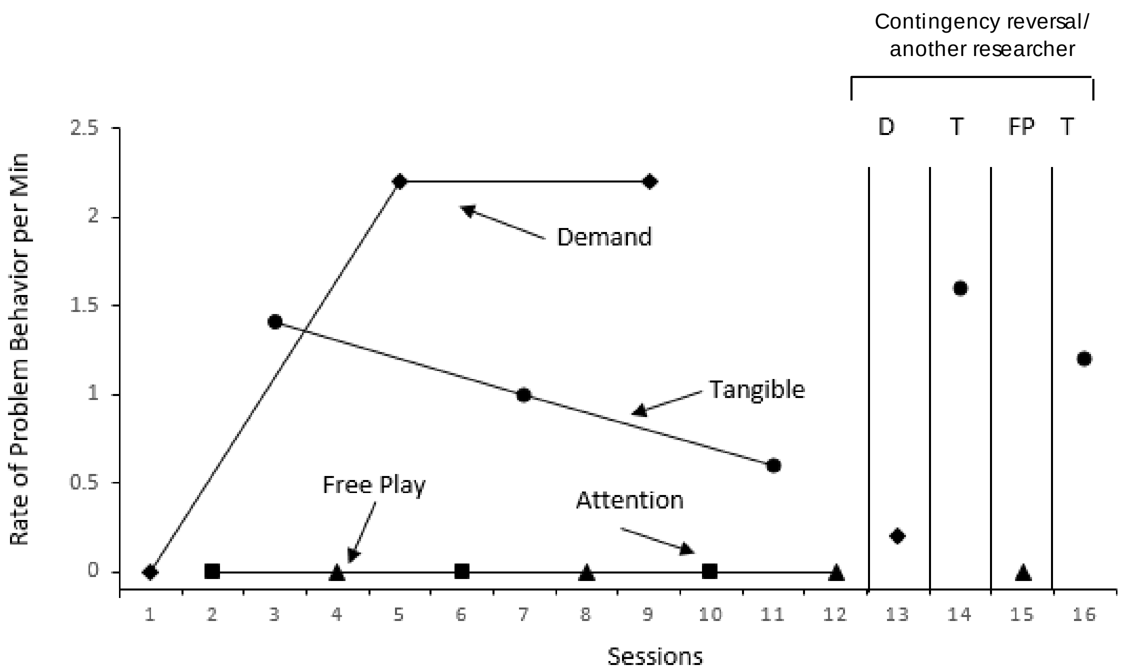

Figure 3. Rates of problem behavior exhibited by Selena during functional analysis.

Notes. D = demand, T = tangible, FP = free play.

Functional Communication Training

Prior to thinning schedules of reinforcement following FCT, each participant was taught to emit an alternative functional communication response (FCR) in FCT sessions. Amber was taught to emit a vocal response (i.e., iPad). Selena was first taught to touch an icon on an iPad as an SGD to request her functional reinforcer. However, because the iPad as an SGD became a reinforcer in itself for Selena, the researcher taught her another functional response. Selena was taught to exchange a picture card for a reinforcer.

Amber. FCT results for Amber are presented in Figure 4. Amber engaged in problem behavior during the first baseline phase approximately once per minute. After establishing a stable baseline level, the FCT was introduced. An increase level of problem behavior was observed suggesting an extinction burst. However, after four FCT sessions, Amber's problem behavior began to decrease. Overall, the first intervention phase shows a decrease level of problem behavior and some variability. In a brief reversal to baseline, the data show an increased level of problem behavior that exceeded the rate in the first baseline phase. In a reinstatement of FCT, Amber exhibited a decreased rate of problem behavior which stabilized at zero for the last three sessions.

In terms of Amber FCRs, Amber emitted an independent FCR at a rate of 0.2 per minute during the first baseline phase, however, it stabilized at zero for the last two baseline sessions. During the first FCT phase, Amber began to independently emit an FCR during the 10th session. The data show a change in level compared to the previous phase. Amber's FCRs stabilized at 2.4 to 2.6 per minute. In a brief reversal to baseline, Amber engaged in a high rate of FCRs (8 FCRs per minute) which suggested an extinction burst. However, the data show a decreased trend of FCR during this brief phase. During the second FCT phase, Amber's independent FCRs remained at a stable rate of 2.4 to 2.6 per minute.

A pre and post generalization probes across a paraprofessional (Figure 5) as well as a classroom setting (Figure 6) were conducted. As shown in Figure 4, Amber engaged in a high rate of problem behavior (2 per minute) during the generalization baseline across a paraprofessional. During the FCT condition, Amber did not exhibit problem behavior with the paraprofessional. In terms of FCRs, Amber emitted independent FCRs during both conditions. Her FCR emission during baseline may be attributed to the fact that this generalization baseline probe was conducted during the second baseline of the FCT; thus, she had learned to emit FCRs during the intervention phases with the interventionist.

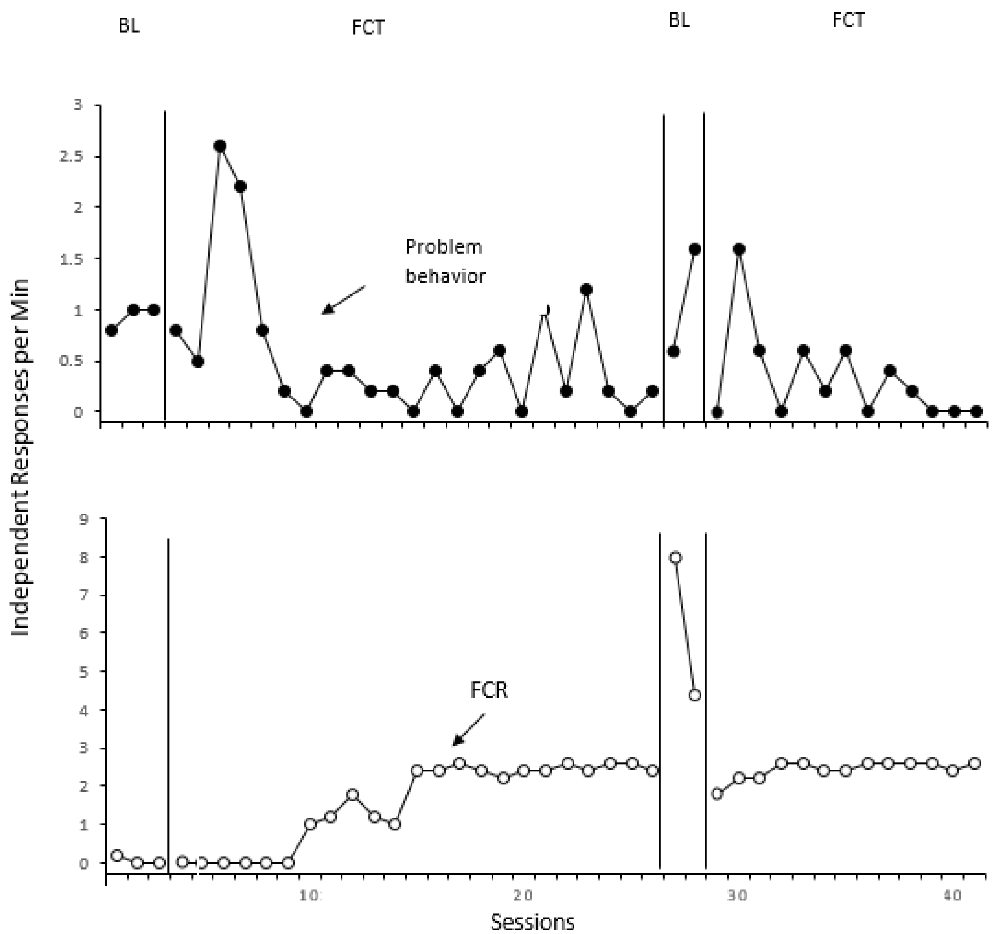

Figure 4. Amber's problem behavior per minute in the first tier. Amber's independent FCRs per minute in the second tier.

Note. BL = baseline, FCT = Functional Communication Training, FCR = functional communication response

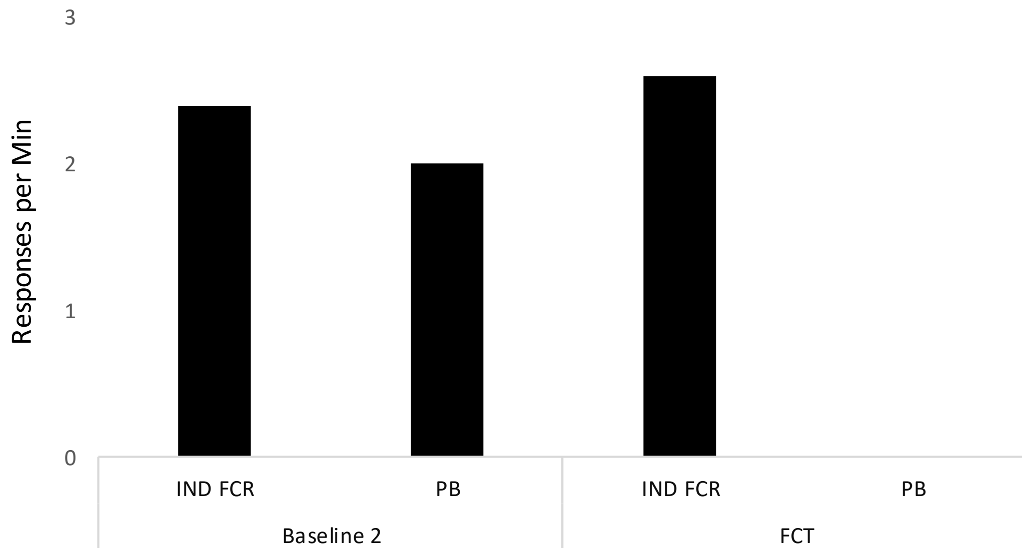

Figure 5. Independent functional communication responses and problem behavior per minute for Amber during generalization probes across a paraprofessional.

Notes. IND = independent, PB = problem behavior.

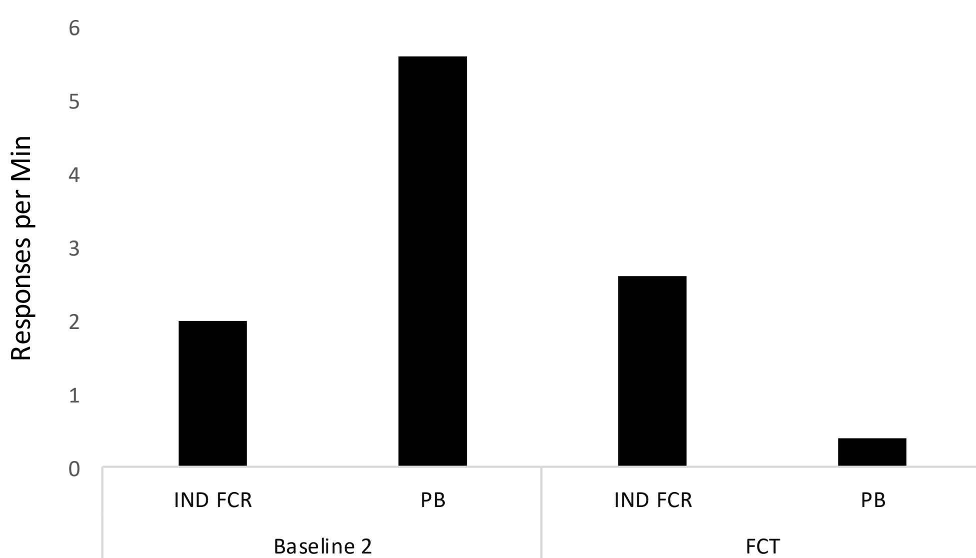

Figure 6. Independent functional communication responses and problem behavior per minute for Amber during generalization probes across a classroom setting.

Notes. IND = independent, PB = problem behavior.

Similarly, Amber engaged in a high rate of problem behavior during the generalization baseline probe (rate = 5.6 per minute). A substantial decrease of problem behavior was observed during the FCT generalization probe (rate = 0.4 per minute). No substantial differences in FCRs between the baseline and FCT conditions. Again, this may have resulted from her learning of emitting FCRs during the FCT intervention phase with the interventionist (generalization baseline was conducted during the second baseline of the FCT phase).

Selena. Selena's FCT data are depicted in Figure 7. In terms of problem behavior, Selena engaged in problem behavior at a rate of 2 to 2.2 per minute during the first baseline phase. At the beginning of the FCT (SGD) phase, the data show high variability in problem behavior. A decreased trend and change in level of problem behavior was evident starting from the 10th session until the 23rd. In a brief reversal to baseline, problem behavior showed an increased trend and immediate change in level (range = 0.8 to 1.4 per minute) compared to the first FCT phase. Once FCT was reintroduced, an immediate change in level and a stable level were observed in terms of problem behavior. Problem behavior remained at zero during the picture card exchange phase.

In terms of Selena's independent FCRs, she emitted an independent FCR at a rate of 0.2 during the second baseline session. However, her FCR went back to zero during the first baseline phase. A change in level of independent FCRs was observed starting from the 14th session. Selena's independent FCRs stabilized at 2.2 to 2.4 per minute during the first FCT phase. In a brief reversal to baseline, the data show a decreased trend of independent FCRs which reached to zero in the second session. An immediate change in level was observed once FCT was reintroduced. In terms of the picture card exchange phase, Selena mastered the criterion in four sessions only. Her FCRs stabilized at 2 per minute.

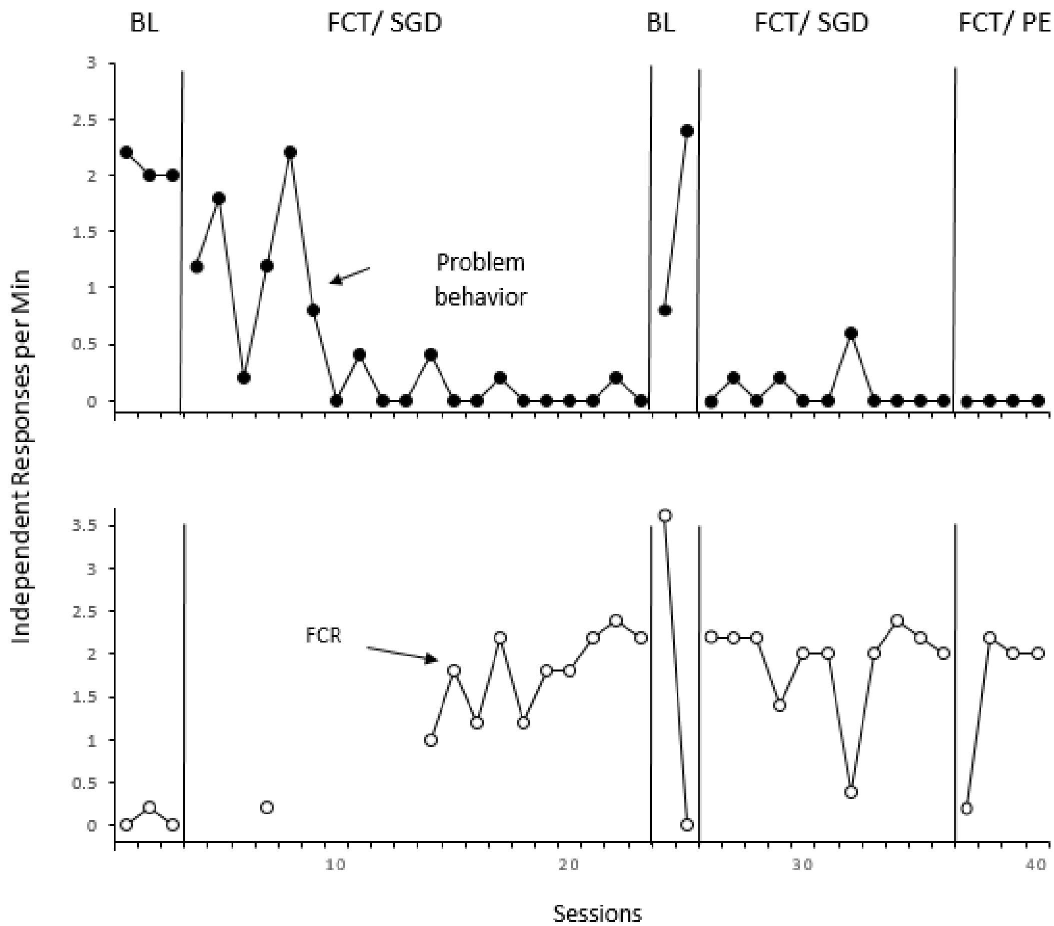

Figure 7. Selena's problem behavior per minute in the first tier. Selena's independent FCRs per minute in the second tier

Notes. BL = baseline, SGD = speech-generating device, PE = picture exchange.

Pre and post generalization probes across a paraprofessional (Figure 8) as well as a classroom setting (Figure 9) were conducted. Generalization across a paraprofessional results demonstrated that Selena engaged in a high rate (2.2 per minute) of problem behavior during baseline. During both FCT/SGD as well as FCT/PE, Selena did not exhibit problem behavior. In terms of independent FCRs, Selena did not emit independent FCRs during baseline. Selena generalized FCRs with the paraprofessional as she emitted FCRs using an SGD at a rate of 2.2 per minute, and using a picture card at a rate of 1.8 per minute.

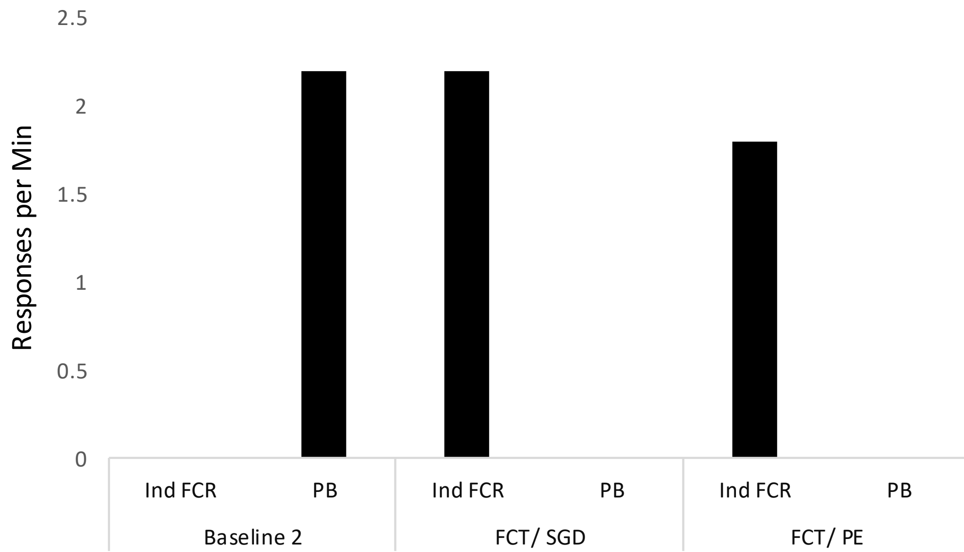

Figure 8. Independent functional communication responses and problem behavior per minute for Selena during generalization probes across a paraprofessional.

The results of generalization across a classroom setting showed that Selena engaged in a high rate of problem behavior during baseline. During both FCT/SGD and FCT/PE conditions, Selena engaged in no problem behavior. In terms of FCRs, Selena emitted independent FCRs during baseline. This may be attributed to the fact that baseline generalization probe was conducted during the second baseline of the FCT phase. Selena was able to emit independent FCRs during both FCT/SGD (rate = 2.4 per minute) and FCT/PE (rate = 1.8 per minute) phases in the generalization across a classroom setting probes.

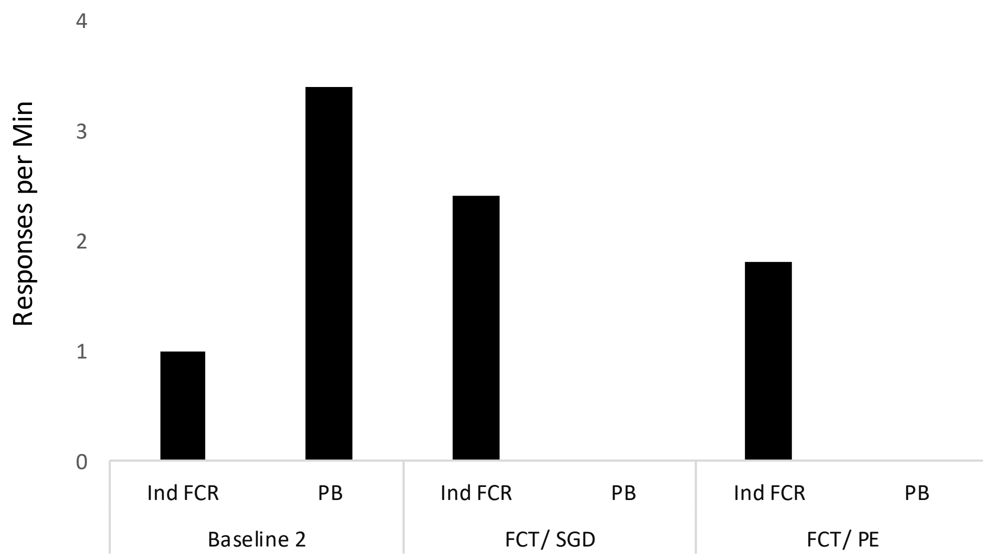

Figure 9. Independent functional communication responses and problem behavior per minute for Selena during generalization probes across a classroom setting.

Research Question 1- What are the effects of FCT and a multiple schedule of reinforcement with one S-Delta interval on problem behavior and FCRs in children with ASD?

The results of multiple schedules of reinforcement are presented in Figure 10 for Amber, and Figure 11 for Selena. The figures show the results on FCRs during both SD and S-Delta, as well as problem behavior.

Amber. Amber engaged in problem behavior during the first mixed schedules of reinforcement at a mean rate of 3.8 per minute (range = 2 to 5.5). Following an introduction of a multiple schedule of reinforcement, the data show an immediate decrease of problem behavior with high variability during the 19th through the 29th session. Once the signaling stimuli were changed, Amber engaged in an increasing level of problem behavior, which started to decrease in the 40th session. Overall, Amber's problem behavior had a stable trend in this phase compared to the first mixed schedule and the multiple schedule when the signaling stimuli consisted of a necklace and a baseball hat. In a return to mixed schedules of reinforcement, Amber returned to engaging in problem behavior at a mean rate of 2 per minute (range = 1 to 2.5). An immediate decrease of problem behavior was observed once the multiple schedule of reinforcement was reintroduced. Data show high variability beginning at the 77th session which may have resulted from a 10-day discontinuation of the intervention (i.e., a school break). Amber's problem behavior substantially decreased starting from the 97th session and stabilized at a zero level for the last eight sessions.

In terms of Amber's FCRs, Amber did not discriminate between the SD and S-Delta intervals during the first mixed schedule phase which was evident by her FCR emissions during S-Delta, as well as her emission of FCRs during SD twice only (she did not maximize it at four times). When the multiple schedules of reinforcement were introduced, Amber still did not discriminate between the two conditions as the data show high variability and an overlap of FCRs during SD and S-Delta. When the signaling stimuli were changed, Amber required 24 sessions before there was a separation in the FCR data paths which indicated a discrimination between the two conditions. In a return to mixed schedules of reinforcement, the data show an overlap of FCRs during SD and S-Delta which suggested no discrimination between the two conditions. Once multiple schedules of reinforcement were reinstated, a separation in data path for FCRs was observed. Amber met the criterion of four FCRs during SD and zero FCR during S-Delta for three consecutive sessions in the 106th session.

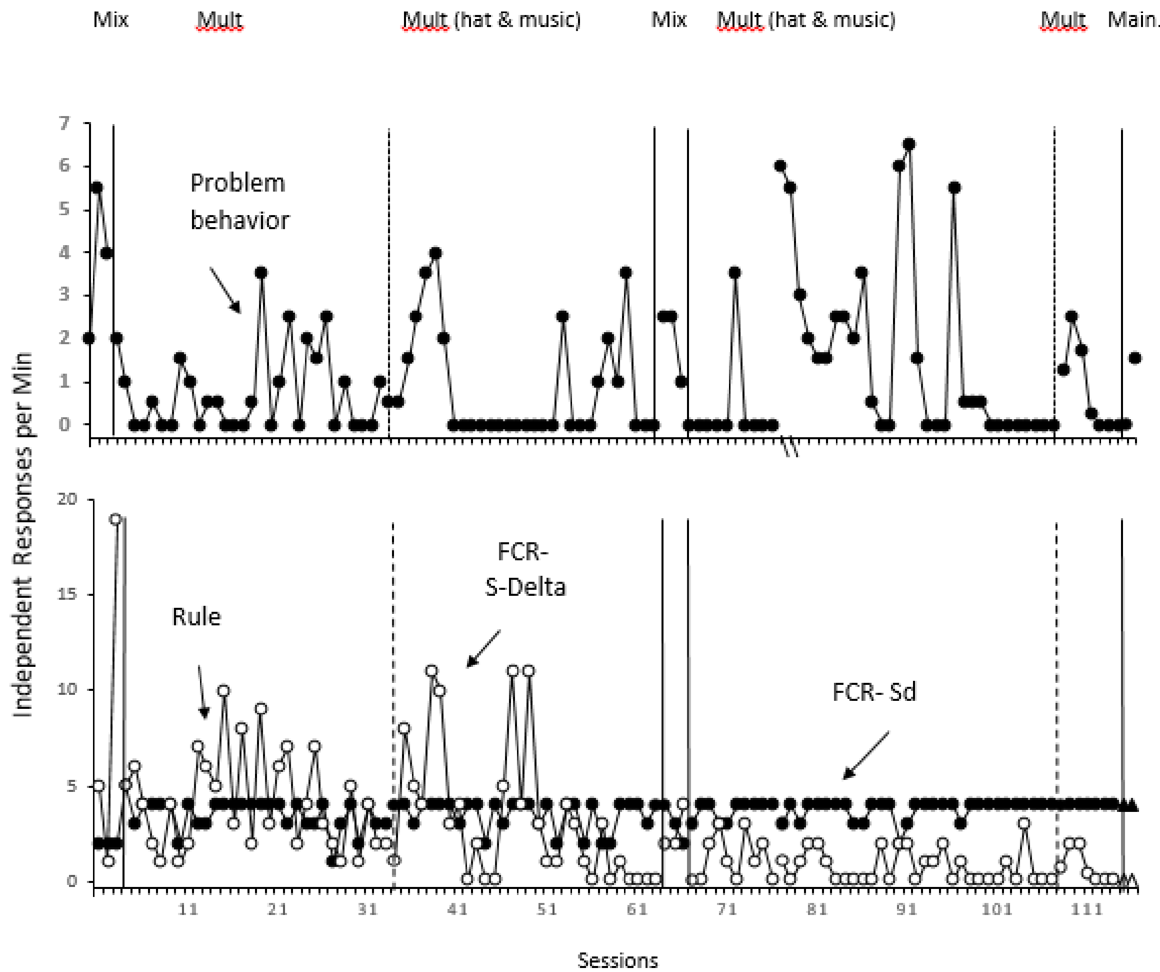

Figure 10. Amber's problem behavior per minute in the first tier. Amber's independent FCRs during SD and S-Delta intervals per minute in the second tier.

Notes. Mix = mixed schedule, Mult = multiple schedule, res. = resurgence, Main = maintenance. The first maintenance probe was 11 days, the second probe was 4 weeks after the intervention phase. The break tracks donate a 10-day school break.

Selena. As presented in Figure 11, Selena did not engage in problem behavior during two out of three mixed schedules of reinforcement (30 s/ 60 s/ 30 s). Once the S-Delta was increased to 120 s, Selena displayed screams, throws of picture cards (*M* = 1.6 per minute), and cry (*M* = 4.3 seconds per minute). During a multiple schedule of reinforcement, Selena engaged in a higher rate of screams, throws of picture cards (*M* = 2.8 per minute), and longer period of crying (*M* = 8.6 seconds per minute) compared to the previous mixed schedule phase. A change in level and an immediate decrease of problem behavior were achieved once an alternative activity was added. In a return to a multiple schedule, the data show a change in level and an immediate increase of problem behavior as Selena returned to engaging in scream and throws of the picture card. Using an alternative activity alone, the data present a stable zero level of problem behavior. In a brief return to a multiple schedule, the data demonstrated an immediate increased level of problem behavior. In a reinstatement of alternative activity alone, the data, again, show a stable zero level of problem behavior for Selena.

In regards to Selena's FCRs, the data show an overlap of FCRs in the SD and S-Delta conditions during the two mixed schedules phases which suggested no discrimination between the two conditions. An overlap of FCR data path was also observed during the first multiple schedule of reinforcement phase. Selena's FCRs substantially decreased which required an FCT re-training (data not displayed). Once an alternative activity was added, the data demonstrated a clear separation in the data paths. In a return to a multiple schedule, a similar data path was observed for FCRs during the SD and S-Delta conditions. When an alternative activity alone was introduced, Selena maximized FCRs during SD (four responses), and showed a decreased FCR emission during S-Delta. In a brief return to a multiple schedule, the data show an immediate increase of FCRs during S-Delta, and an immediate decrease of FCRs during SD. When the alternative activity alone was reinstated, the data demonstrated an immediate decrease of FCRs during S-Delta, and immediate increase of FCRs during SD.

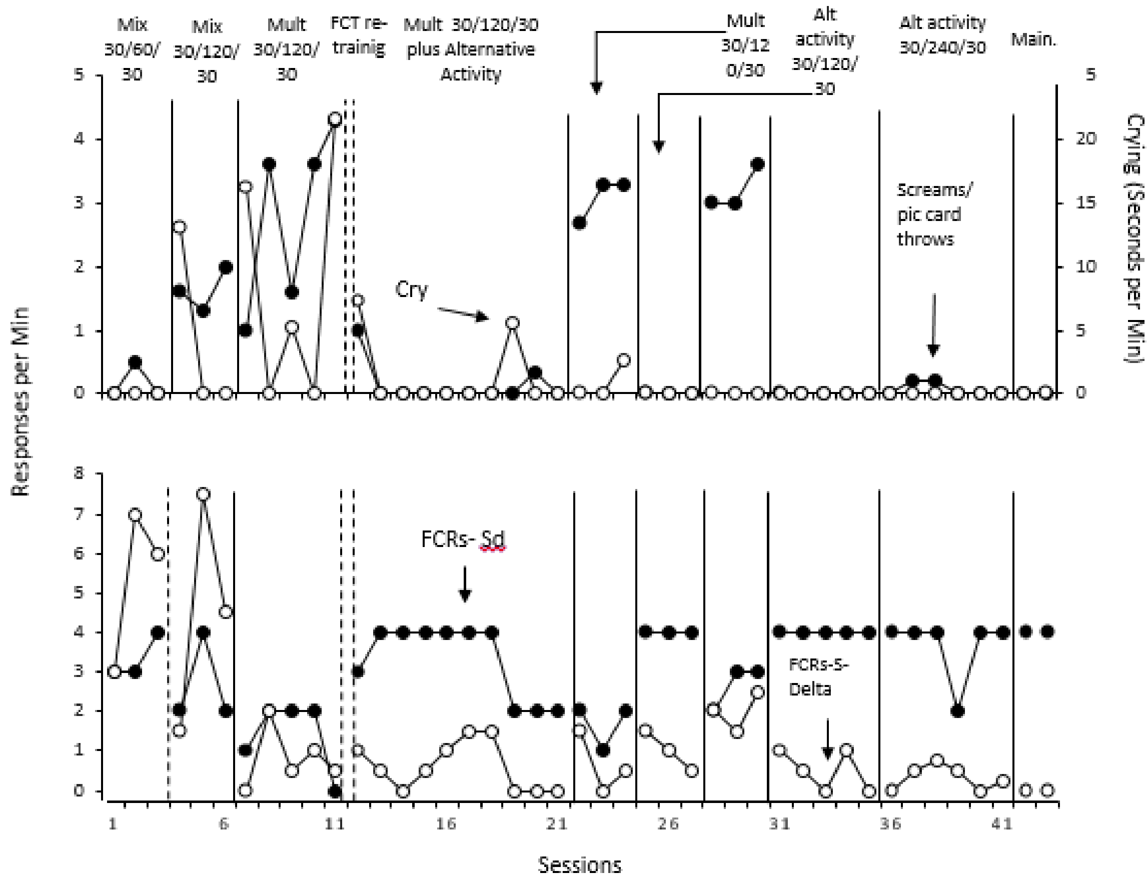

Figure 11. Selena's problem behavior (screams and throws of picture card) per minute, and crying in seconds per minute in the first tier. Selena's independent FCRs during SD and S-Delta intervals per minute in the second tier.

Notes. Mix = mixed schedule, Mult = multiple schedule, Alt = alternative, Main = maintenance. The first maintenance probe was 2 weeks, the second probe was 4 weeks after the intervention phase.

Research Question 2- To what extent does rapidly thinning the schedule of reinforcement cause resurgence of problem behavior when the multiple schedules consist of one S-Delta component?

The results of resurgence are presented in Figure 10 for Amber, and Figure 11 for Selena. For both, the results are shown prior to the follow-up sessions.

Amber. Resurgence of problem behavior was observed with Amber during multiple schedules of reinforcement 30 s/180 s/30 s phase. She engaged in problem behavior during the first four sessions at a rate of 0.25 to 2.5 per minute (*M* = 1.4). However, in comparison to the first mixed schedule of reinforcement phase (range = 2 to 5.5, *M* = 3.8) and the second mixed schedule of reinforcement phase (range = 1 to 2.5, *M* = 2), problem behavior was still lower during the resurgence test.

Selena. Because multiple schedules of reinforcement was not effective for Selena, the resurgence test was conducted using alternative activities (30 s/ 240 s/ 30 s). The resurgence test results demonstrated a stable almost a zero level of problem behavior for Selena.

Research Question 3- To what extent will the effects of FCT and a multiple schedule of reinforcement on problem behavior and FCRs in children with ASD generalize across the classroom teachers?

Generalization across a paraprofessional and a classroom teacher was assessed for both Amber and Selena. Figures 12 and 13 present the results of these generalization probes.

Amber. Figure 12 shows the results of generalization across teachers for Amber. As shown, Amber engaged in problem behavior in the mixed schedules of reinforcement condition at a rate of 2.5 with the paraprofessional. During multiple schedules of reinforcement (30 s/ 60 s/ 30 s), Amber engaged in a lower rate (0.5 per minute) of problem behavior in the first session with the paraprofessional, and did not engage in problem behavior during the second session with the same paraprofessional. A similar result was observed with the classroom teacher as Amber engaged in problem behavior at a rate of 0.5 during the same condition. Variable results on problem behavior were observed during multiple schedule (30 s/ 180 s/ 30 s). Amber engaged in a lower rate (2 per minute) of problem behavior compared to mixed schedule in the first session with the paraprofessional. However, in the second session, Amber engaged in a higher rate (4.75 per minute) of problem behavior compared to mixed schedule with the same paraprofessional. When the session was conducted by the classroom lead teacher, Amber did not engage in problem behavior during multiple schedule (30 s/ 180 s/ 30 s).

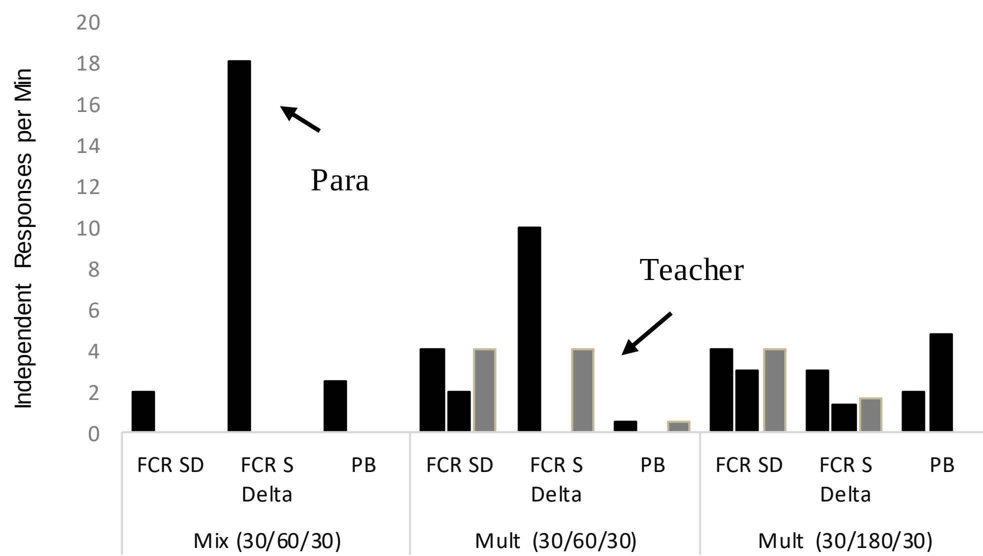

Figure 12. Amber's problem behavior and FCRs per minute in generalization probes across teachers.

Notes. PB = problem behavior, Mix = Mixed schedule of reinforcement, Mult = multiple schedule of reinforcement. The black bars donate to probes across the paraprofessional. The gray bars donate to probes across the classroom lead teacher.

In terms of Amber's FCRs, Amber emitted FCRs during S-Delta in the mixed schedule condition at a high rate (18 per minute). Although at a lower rate (*M* = 4.6), Amber still emitted FCRs during S-Delta in the multiple schedules of reinforcement (30 s/ 60 s/ 30 s) condition with both the paraprofessional (first session, rate = 10 per minute), and the teacher (rate = 4 per minute). Although she did not emit an FCR during S-Delta the second session of multiple schedules of reinforcement (30 s/ 60 s/ 30 s) with the paraprofessional, she also did not maximize reinforcement (four FCRs) during SD intervals. During multiple schedule (30 s/ 180 s/ 30 s), Amber still emitted FCRs during S-Delta with both the paraprofessional and teacher; however, at a lower rate (*M* = 1.9) compared to the previous two conditions.

Selena. Figure 13 presents the results of generalization across teachers for Selena. As shown, Selena engaged in problem behavior (screams and throws of the picture card) in the mixed schedules of reinforcement condition at a rate of 4.3 per minute with the paraprofessional. During multiple schedules of reinforcement (30 s/ 120 s/ 30 s), Selena engaged in a lower rate (0.3 per minute) of problem behavior with the paraprofessional. In the alternative activity conditions (30 s/ 120 s/ 30 s) and (30 s/ 240 s/ 30 s), Selena neither engaged in problem behavior with the paraprofessional nor the classroom lead teacher.

In regards to Selena's FCRs, she emitted FCRs during S-Delta in the mixed schedule condition at a higher rate (2.4 per minute) compared to her emission during SD (1 per minute). Selena emitted FCRs during S-Delta in the multiple schedule condition even higher (3.5 per minute) compared to the previous mixed schedule condition. During the alternative activity condition (30 s/ 120 s/ 30 s), Selena did not emit an FCR during S-

Delta with the paraprofessional. However, she did not maximize reinforcement as she only emitted an FCR twice during SD (as opposed to four). With the same paraprofessional, Selena did not emit an FCR during S-Delta, and also maximized reinforcement during SD by emitting four FCRs per minute during the alternative activity condition (30 s/ 240 s/ 30 s). With the classroom teacher, Selena emitted FCRs during S-Delta at a rate of 1 per minute during the alternative activity condition (30 s/ 120 s/ 30 s), and at a rate of 0.5 per minute during the alternative activity condition (30 s/ 240 s/ 30 s). She only maximized reinforcement by emitting four FCRs during the alternative activity condition (30 s/ 240 s/ 30 s).

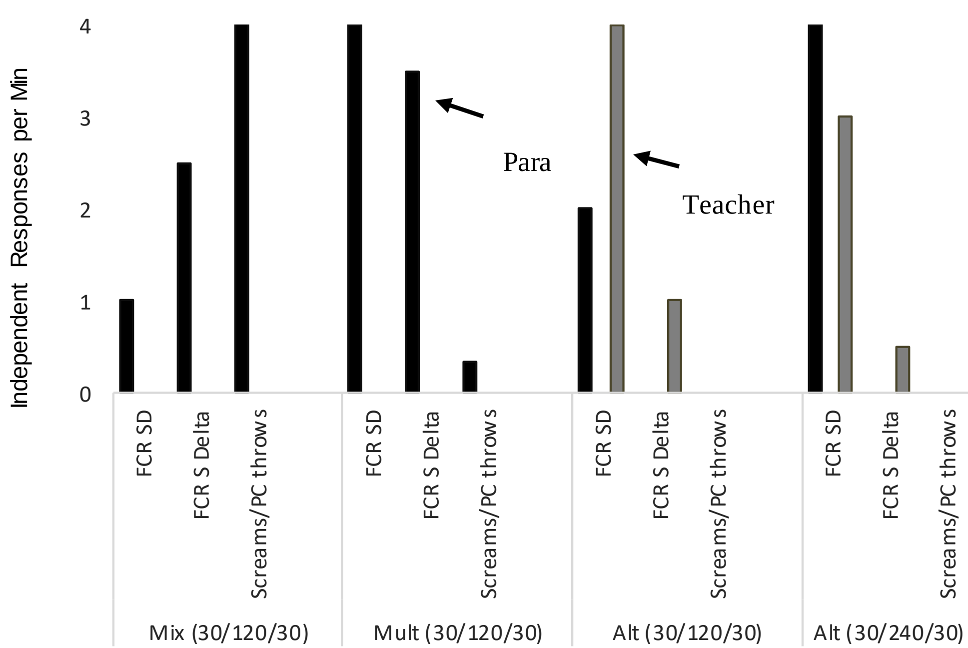

Figure 13. Selena's problem behavior and FCRs per minute in generalization probes across teachers.

Notes. Mix = Mixed schedule of reinforcement, Mult = multiple schedule of reinforcement, Alt = alternative activity. The black bars donate to probes across the paraprofessional. The gray bars donate to probes across the classroom lead teacher.

Research Question 4- To what extent will the effects of FCT and a multiple schedule of reinforcement on problem behavior and FCRs in children with ASD generalize across school settings?

The results of generalization across a classroom setting are presented in Figures 14 and 15. Data were collected for both Amber and Selena in the classroom in a different area than the intervention setting.

Amber. Amber's data are shown in Figure 14. Amber engaged in problem behavior in the mixed schedule of reinforcement condition at a rate of 0.5 per minute. She did not engage in problem behaviors during two multiple schedule of reinforcement (30 s/ 60 s/ 30 s) sessions. However, during the resurgence test (multiple schedules 30 s/ 180 s/ 30 s), Amber engaged in a higher rate of problem behavior compared to mixed schedules of reinforcement (*M* = 1.3 per minute).

In regards to FCRs, Amber emitted a high rate (5 per minute) of FCRs during S-Delta in mixed schedules of reinforcement. Similar rates occurred during the 30 s/ 60 s/ 30 s multiple schedules of reinforcement (*M* = 4 per minute). During the 30 s/ 180 s/ 30 s multiple schedule condition, Amber did not emit any FCRs during the S-Delta intervals.

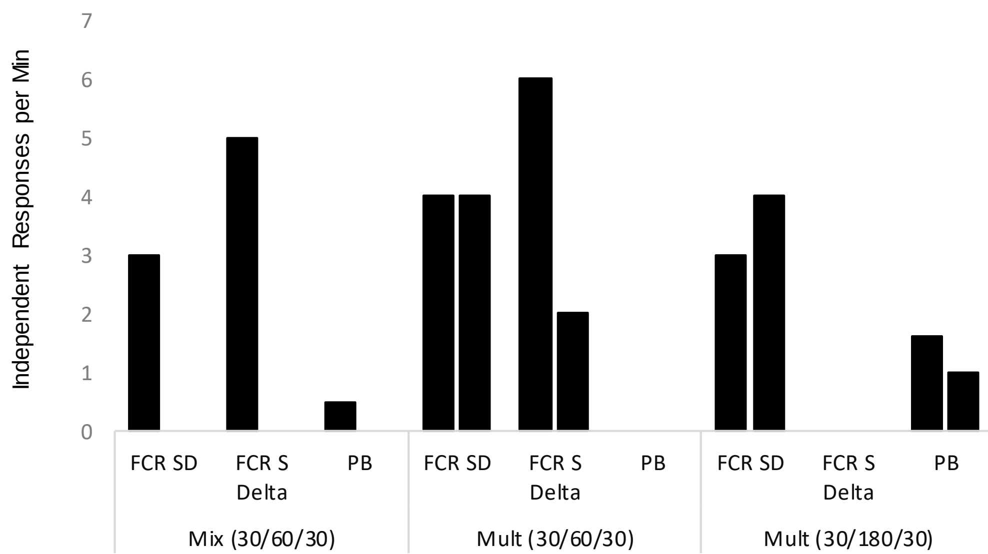

Figure 14. Amber's problem behavior and FCRs per minute in generalization probes across a classroom setting.

Notes. Mix = Mixed schedule of reinforcement, Mult = multiple schedule of reinforcement.

Selena. Figure 15 shows the results for Selena. As presented, Selena engaged in a high rate (3.3 per minute) of problem behavior (screams and throws of the picture card) during the mixed schedule of reinforcement condition. Although she engaged in a lower rate (1.6 per minute) of screams and throws of picture card during the multiple schedules of reinforcement, she engaged in crying for 13 seconds per minute. Once an alternative activity was introduced in that setting, Selena did not engage in problem behavior during either the 30 s/ 120 s/ 30 s, or the 30 s/240 s/30 s conditions.

In terms of Selena's FCRs, Selena emitted FCRs during S-Delta intervals during both the mixed (rate = 5 per minute) and multiple (rate = 6 per minute) schedules of reinforcement condition. Once an alternative activity was introduced, she was able to generalize FCR emission during SD intervals only.

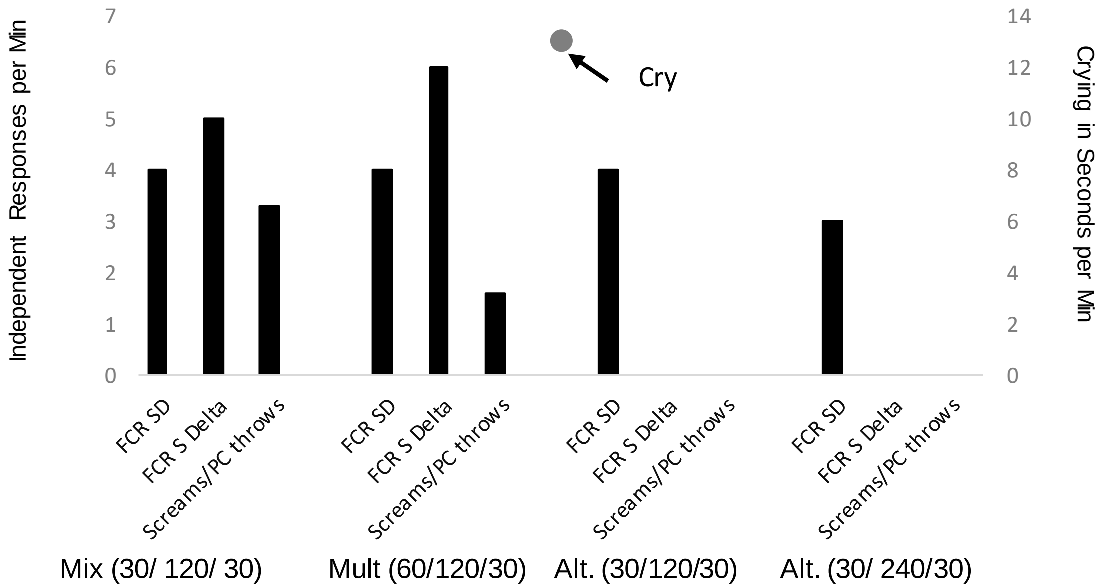

Figure 15. Selena's problem behavior and FCRs per minute in generalization probes across a classroom setting.

Notes. Mix = Mixed schedule of reinforcement, Mult = multiple schedule of reinforcement, Alt = alternative activities.

Research Question 5- To what extent will the effects of FCT and a multiple schedule of reinforcement on problem behavior and FCRs maintain in children with ASD?

The last phases in figures 10 and 11 present the results of maintenance. Follow-up sessions started after at least 11 days of the termination of intervention.

Amber. Figure 10 presents the results for Amber. The first follow-up probe was conducted 11 days after the termination of intervention. The data show that Amber was able to maintain FCRs as she did not emit FCRs during S-Delta and maximized FCRs (4 responses) during SD. She also did not engage in problem behavior during that probe.

The second follow-up probe was conducted 4 weeks after the termination of intervention. Amber was able to maintain FCRs as she only emitted FCRs during SD. She also maximized her FCRs during SD. However, Amber's problem behavior reemerged at a rate of 1.5 per minute during that probe.

Selena. Figure 11 shows the results for Selena. The first follow-up probe was conducted two weeks after the termination of intervention, and second follow-up probe was conducted four weeks after the termination of intervention. The data demonstrate that Selena maintained FCRs as she did not emit FCRs during S-Delta and maximized FCRs (4 responses) during SD. She also did not engage in problem behavior during either probe.

Research Question 6- What are the teachers', paraprofessionals', and parents' perceptions of the intervention?

The perceptions of teachers and paraprofessionals are presented based on the most effective intervention. That is, multiple schedules of reinforcement for Amber, and alternative activities for Selena.

Multiple schedules of reinforcement. The teacher and paraprofessional in Amber's classroom rated the importance of the behaviors targeted in the intervention, as well as the need to teach the student an appropriate FCR, and when to use to request at a mean of 5.5 (agree to strongly agree). In terms of acceptability of the intervention, the mean was 4 (slightly agree). Regarding the intervention effectiveness, the mean was 4 (slightly agree). They both rate the feasibly of using the intervention at 3 (slightly disagree). They both orally expressed they would change the signals from music and a hat to a color light switch to make the intervention feasible.

Alternative activities. The teacher and paraprofessional in Selena's classroom rated the importance of the behaviors targeted in the intervention, as well as the need to teach the student an appropriate FCR, and when to use to request at a mean of 6 (strongly agree). In terms of acceptability and effectiveness of the intervention, the mean was 5.7 (agree to strongly agree). They both rate the feasibly of using the intervention at 6 (strongly disagree).

CHAPTER FIVE: DISCUSSION

The purpose of the study was to evaluate the effects of a multiple schedule of reinforcement using one S-Delta interval on the differentiated FCRs and problem behavior of children with ASD. To investigate the effects, a reversal design was used and replicated across two children. For one child, a multiple schedule of reinforcement with one S-Delta interval was effective in increasing her differentiation of when to emit an FCR and also decreasing her problem behavior. For the second child, the intervention was ineffective and the introduction of an alternative activity during S-Delta was necessary. For her, an alternative activity was effective in increasing her discrimination of when to emit an FCR and substantially decreasing her problem behavior. Perceptions of the teachers seemed to lean towards alternative activities as an acceptable intervention.

Research Question 1- What are the effects of FCT and a multiple schedule of reinforcement with one S-Delta interval on problem behavior and FCRs in children with ASD?

A functional relation was established for one participant demonstrating the effectiveness of a multiple schedule of reinforcement with one S-Delta interval. For the second participant, a functional relation was not established to demonstrate the effects of a multiple schedule of reinforcement with one S-Delta interval; however, it was established to demonstrate the effects of an alternative activity.

Amber. Before the introduction of a multiple schedule of reinforcement, Amber showed an increased rate of problem behavior. Once the intervention was introduced, her problem behavior demonstrated a decrease, however, with high variability. After the signaling stimuli were changed, her problem behavior began to stabilize at the zero level with some variability. When the intervention was discontinued for 10 days (a school break), Amber engaged in a high and variable level of problem behavior for 20 consecutive sessions suggesting resurgence of problem behavior and a lack of maintenance. However, after that, Amber's problem behavior stabilized at near zero to a zero level for 12 consecutive sessions. With regards to her FCRs, Amber began to discriminate between when and when not to emit an FCR after a few sessions from changing the signaling stimuli. Prior to that, Amber emitted FCRs during S-Delta in a high rate suggesting her lack of discrimination between the SD and S-Delta conditions.

There are a few considerations worth noting in terms of Amber's results. First, the initial signaling stimuli (a necklace and a hat) were not salient enough to prompt Amber to only mand during the SD condition. The switch to a large hat and music deemed necessary as she had engaged in very minimal eye contact. Thus, the inclusion of an audio stimulus (i.e., music) was necessary. However, it is still unknown whether the audio stimulus alone would have been sufficient.

Second, because the study was conducted in a classroom setting, some variables could not have been controlled. During the 20 sessions in which her problem behavior reemerged after the 10-day discontinuation, Amber had just been made to wear coveralls to block her from engaging in self-stimulation. Therefore, incidences of problem behavior during those sessions may have served another function.

Selena. The introduction of a multiple schedule of reinforcement with Selena increased her problem behavior compared to the control condition (mixed schedule). Once an alternative activity was added, Selena's problem behavior substantially decreased. To investigate the necessity of a contrived stimulus (a hat), the contrived stimulus was removed. Selena sustained her low level of problem behavior during the alternative activity alone condition. In regards to Selena's discriminated FCRs, she did not discriminate between the SD and S-Delta condition during either the mixed schedule overlaps) or multiple schedule of reinforcement (overlaps or a decreased trend). With an alternative activity, Selena's discrimination between the conditions increased as the data show no overlap between FCRs during SD and FCRs during S-Delta. A functional relation was established demonstrating the effects of alternative activities on both her FCRs and problem behavior.

There are two points worth discussing. First, the lack of Selena's discrimination during a multiple schedule of reinforcement may be due to her receptive language skills (at a 3-month level) that may have impeded her grasp of the contingency-specifying rules. Therefore, the addition of an alternative activity may have served as a more concrete signal for her not to emit an FCR during S-Delta intervals. Second, because the alternative activity may have served as a signaling stimulus by introducing it once the S-Delta began, and removing it once the S-Delta ended, this arrangement may also be considered a multiple schedule of reinforcement. Instead of a signaling stimulus during the SD intervals (e.g., a hat), the arrangement for Selena included a signaling stimulus during the S-Delta intervals (i.e., an alternative activity).

Conclusions. A multiple schedule of reinforcement was effective in increasing FCR discrimination and decreasing problem behavior for one child. This is consistent with prior studies demonstrating the effects of multiple schedules of reinforcement on FCRs and problem behavior (e.g., Betz et al., 2013; Fisher et al., 2015). However, for the other child, the intervention was ineffective and an alternative activity was needed. This is consistent with a prior study in which children with ASD and other DD engaged in a lower rate of problem behavior and more discriminated FCRs when an alternative activity was introduced (Fuhrman et al., 2018).

Research Question 2- To what extent does rapidly thinning the schedule of reinforcement cause resurgence of problem behavior when the multiple schedules consist of one S-Delta component?

The data indicate a resurgence of problem behavior for one child. For the second child, problem behavior remained at the zero to near zero level during the resurgence test.

Amber. Once the schedule of reinforcement was thinned rapidly, Amber's problem behavior resurged for three consecutive sessions. However, the resurgence did not exceed the baseline conditions (mixed schedule phases). This may suggest that Amber was still under stimulus control of the signaling stimuli that were not used during the mixed schedule phases.

Selena. Thinning the schedule of reinforcement for Selena included an alternative activity during S-Delta intervals. When the S-Delta intervals rapidly increased to 240 s, problem behavior of Selena did not resurge. This may suggest an alternative activity still served as a competing stimulus with problem behavior even when the schedule of reinforcement was rapidly thinned.

Conclusions. As Briggs et al. (2018) indicated, 76% of cases that involved a thinning schedule of reinforcement procedure experienced a resurgence of problem behavior. This was true for Amber as her problem behavior reemerged when the S-Delta was increased from 60 s to 180 s. However, Selena's problem behavior did not reemerge when the S-Delta rapidly increased from 120 s to 240 s which may be due to the use of an alternative activity during S-Delta intervals which may have served as a suppressor of problem behavior.

Research Question 3- To what extent will the effects of FCT and a multiple schedule of reinforcement on problem behavior and FCRs in children with ASD generalize across the classroom teachers?

The results on generalization across teachers/paraprofessionals during multiple schedules of reinforcement are variable. For one child, a lack of discrimination between the SD and S-Delta conditions was evident. The second child, however, was able to discriminate between the conditions based on the generalization data.

Amber. The first multiple schedule of reinforcement probes with the paraprofessional and then teacher, Amber emitted a high rate (10 per minute, 4 per minute, respectively) of FCRs during S-Delta suggesting her lack of discrimination between the SD and S-Delta conditions. Another possible explanation is that Amber may have been under stimulus control of the researcher and that she was testing the paraprofessional and the teacher. Nevertheless, in the same two sessions, she engaged in a lower rate of problem behavior compared to the mixed schedule of reinforcement condition conducted by the paraprofessional. In the second multiple schedule of reinforcement probe conducted the paraprofessional, Amber engaged in no problem behavior and no FCRs during S-Delta. However, this may be due to a lack of EO evident by her emission of FCRs during SD only two times as opposed to four times.

Similarly, no discrimination between the conditions was evident in the two multiple schedules of reinforcement (30 s/ 180 s/ 30 s) conducted by the paraprofessional. Additionally, Amber engaged in problem behavior at or above the rate of problem behavior during mixed schedule of reinforcement. In the one probe conducted by the classroom teacher (multiple schedule of reinforcement - 30 s/ 180 s/ 30 s), Amber showed discrimination by emitting a higher rate of FCRs during SD (4 per minute) compared to FCRs during S-Delta (1.6 per minute). In addition, Amber did not engage in problem behavior with the teacher. This suggests that Amber generalized across the classroom teacher but not with the paraprofessional.

Selena. In the alternative activity probe (30 s/ 120 s/ 30 s) conducted by the paraprofessional, Selena engaged in no problem behavior and no FCRs during S-Delta. However, this may be due to a lack of EO evident by her emission of FCRs during SD only two times as opposed to four times. In the same condition, Selena discriminated between the SD and S-Delta conditions with the classroom teacher as she emitted a higher rate of FCRs during SD (4 per minute) compared to FCRs during S-Delta (1 per minute). She engaged in no problem behavior. Similar results were demonstrated during the alternative activity probes (30 s/ 240 s/ 30 s). Selena continued to discriminate between the SD and S-Delta conditions with the paraprofessional and the teacher by emitting low (0.5 per minute) to zero FCRs during S-Delta. Additionally, she did not engage in problem behavior with either the paraprofessional or the teacher.

Conclusions. The results of generalization across classroom teachers were variable. One child showed variability in generalizing across the classroom teachers. This is inconsistent with Fisher et al. (2015) in which a child was able to generalize across therapists in a multiple baseline across therapists design. The inconsistency may be due to (a) generalization probes in this study were conducted as a pre and posttest. If Amber had consistently been introduced to a multiple schedule of reinforcement with the classroom teachers, her generalization may have improved, and (b) unlike receiving the intervention from novel therapists, Amber received the intervention in those probes from her classroom teachers whom she may have had a long history of reinforcement of problem behavior with. On the other hand, Selena demonstrated generalization across teachers. The use of an alternative activity may have facilitated her generalization.

Research Question 4- To what extent will the effects of FCT and a multiple schedule of reinforcement on problem behavior and FCRs in children with ASD generalize across school settings?

Similar to the generalization across teachers' results, the results of generalization across settings were variable. One child was not able to generalize FCRs and problem behavior in another setting while the other child did.

Amber. Amber did not demonstrate discrimination between the SD and S-Delta intervals during the first multiple schedule of reinforcement probe. This was evident by her FCR emission during S-Delta at a rate of 6 times per minute. During the second probe, she emitted FCRs during S-Delta at a lower rate (2 per minute) compared to the previous probe suggesting an increased discrimination. In both probes, Amber did not engage in problem behavior. When the reinforcement schedule was thinned (30 s/ 180 s/ 30 s), Amber did not emit an FCR during S-Delta during neither probe. Nevertheless, she engaged in a higher rate of problem behavior (1.6 per minute, and 1 per minute, respectively) compared to the previous phases suggesting a lack of generalization.

Selena. Selena generalized FCRs and problem behavior across a setting in the alternative activity conditions. This was evident by her zero FCR emission during S-Delta and no engagement in problem behavior.

Conclusions. Amber's results are inconsistent with a prior study in which two children generalized FCRs and problem behavior across clinic rooms demonstrated in a multiple baseline across settings design (Fisher et al., 2015). The inconsistency may be due to the fact that generalization probes in this study were conducted as a pre and posttest. If Amber had consistently been introduced to a multiple schedule of reinforcement across several settings, her generalization may have improved. On the other hand, Selena generalized both her FCRs and problem behavior across a classroom setting. This may be due to the use of an alternative activity that may have supported her generalization.

Research Question 5- To what extent will the effects of FCT and a multiple schedule of reinforcement on problem behavior and FCRs maintain in children with ASD?

The maintenance results suggest that children with ASD were able to maintain FCRs. However, results on problem behavior were variable.

Amber. Amber's results showed that she was able to maintain discriminated FCRs for a month. Nevertheless, in the second follow-up probe conducted a month after the termination of the intervention, Amber's problem behavior reemerged. This may suggest that the intervention should have been continued and incorporated in her routine to facilitate long-term maintenance.

Selena. Selena was able to maintain the results on both dependent variables for a month. The use of an alternative activity that was based on the results of MSWO conducted prior to each follow-up probe may have contributed to successful maintenance. That is, engaging in an alternative activity that served a lesser EO may have suppressed problem behavior of Selena.

Conclusions. Both participants were able to maintain discriminated FCRs. Nevertheless, Amber's problem behavior resurged a month later.

Research Question 6- What are the teachers' and paraprofessionals' perceptions of the intervention?

Overall, all teachers and paraprofessionals agreed that the behaviors targeted in the interventions were socially important. Perceptions seemed to differ based on the interventions and the participants. For Amber, the teacher and paraprofessional slightly agreed that the multiple schedule of reinforcement was effective. This may be due to the fact the Amber showed variable results during the generalization across teachers' probes. Additionally, the teacher and paraprofessional slightly disagreed that the intervention was feasible to implement in the classroom. They both orally expressed that using one stimulus that was not distracting to other students (e.g., a light as opposed to music) would have made the intervention more feasible. Therefore, before selecting signaling stimuli, teachers should be asked about their preferences as well as their opinions on what stimuli may work for a certain child.

On the other hand, both the teacher and paraprofessional in Selena's classroom agreed that the alternative activity intervention was effective, acceptable, and feasible. They may have perceived the alternative activity as effective because Selena generalized FCRs and problem behavior across the teacher and paraprofessional. They may have perceived it as acceptable and feasible because the intervention did not require a contrived stimulus.

Specific Contributions of the Study

The current study offers several contributions to the literature. First, the results of FAs using a fixed condition sequence led to a quick and valid hypothesis on the function of problem behavior for both participants. This adds to the current small body of research on the validity of this approach (Hammond et al., 2013).

Second, the present study used a sequence of presenting the conditions in a multiple schedule of reinforcement that had rarely been used in the literature (Beth-Tung et al., 2018). Although this study did not compare this presentation of conditions to other types of presentations (e.g., multiple S-Delta intervals in one session), this study suggests that using one S-Delta interval may be a valid method.

Third, the results of the current study add to the literature on the use of alternative activities (Fuhrman et al., 2018; Hagopian et al., 2005). For some children with ASD, the incorporation of an alternative activity may be a necessary component to enhance the effectiveness of a multiple schedule of reinforcement.

Fourth, this study responded to the urgent need expressed in the literature (Falcomata & Wacker, 2013; Neely et al., 2018) to include measures of FCT generalization and maintenance. Although the findings were variable, they contribute to the literature by promoting the need for further investigation.

Finally, perceptions of stakeholders are often overlooked in the FCT literature. The present study contributed to the literature by providing perceptions of teachers and paraprofessionals on the intervention. The perceptions tended to prefer the incorporation of an alternative activity.

Limitations of the Study

The results of this study should be interpreted with consideration to the following limitations. First, because the study was conducted in the participants' schools, a variable could not be controlled. During the 20 sessions in which Amber's problem behavior reemerged after the 10-day discontinuation, Amber had just been made to wear coveralls to block her from engaging in self-stimulation. Therefore, incidences of problem behavior during those sessions may have served another function. However, if she was not wearing coveralls, her problem behavior may have not escalated but that would have probably been due to a competing stimulus (i.e., playing with her private parts).

Second, during all generalization across teachers' probes for both participants, the researcher was physically present to collect data. The presence of the researcher may have influenced the results of generalization across teachers for Selena.

Third, the inclusion of two signaling stimuli for Amber (a large hat and music) may be unnecessary. The use of music alone may have been sufficient and more feasible to use in the classroom. However, music sufficiency as a signaling stimulus remains unknown without a component analysis.

Directions for Future Research

The results of this study lead to several directions for future research. First, future research investigating the effects of multiple schedules of reinforcement may consider adding additional procedures to increase the discrimination between conditions and decrease problem behavior more rapidly. To increase discrimination, researchers may add prompting (e.g., least to most) and prompt fading procedures to facilitate discrimination between SD and S-Delta conditions (e.g., Call et al., 2018). To decrease problem behavior more rapidly, researchers should investigate the addition of differential reinforcement of other behavior. One way to include this procedure is by switching the S-Delta to SD once the child has not engaged in problem behavior for a pre-determined criterion.

Second, future research should investigate procedures to facilitate generalization across natural change agents and settings. This may be done by having natural change agents (e.g., teachers) conduct generalization probes often (e.g., daily) and in multiple settings so that participants' behavior does not come under stimulus control of the researcher and the intervention setting.

In addition, future research should examine how to transfer stimulus control from contrived signaling stimuli to naturally occurring stimuli. This may be done by embedding the contrived stimuli (e.g., music, flashlight) into naturally occurring stimuli (e.g., being on the phone, reading a book) and gradually fading out the contrived stimuli. This is critically needed to enhance the practicality and feasibility of multiple schedules of reinforcement in natural settings.

Finally, researchers should examine multiple schedules of reinforcement using signaling stimuli determined by natural change agents. This may increase the acceptability and feasibility of the intervention because of the use of input of natural change agents who are typically in close contact with the participant.

Implications for Practice

This study has several implications for practice. First, practitioners should select signaling stimuli that are salient and feasible to use in the classroom. The saliency helps the child respond the stimulus which can enhance the effectiveness of the intervention.

The feasibility of selected stimuli helps practitioners be consistent in implementing the intervention.

Second, practitioners may incorporate an alternative activity to rapidly suppress problem behavior. The results of social validity seem to favor the use of alternative activities. Additionally, it is possibly more age appropriate to have the child engage in an alternative activity in the waiting periods (S-Delta). This may also prevent the child from engaging in problem behavior or developing stereotypy behavior during those periods.

Finally, although Amber engaged in problem behavior during the resurgence test in only three sessions, practitioners should gradually and systematically thin the schedule of reinforcement, especially when the problem behavior is self-injurious or aggressive. Practitioners should also be consistent in implementing the intervention across settings and people who directly work with the child.

Summary

The purpose of this study was to examine the effects of a multiple schedule of reinforcement following FCT on behaviors of two children with ASD who engaged in problem behavior. The specific dependent variables were FCRs during SD, FCRs during S-Delta and problem behavior. After the FAs results confirmed the function for each of the participant's problem behavior (access to tangibles), participants were taught to mand for the functional reinforcer using FCT procedures. Then, the multiple schedule of reinforcement intervention began using a reversal design. The results demonstrated the effectiveness of a multiple schedule of reinforcement on discriminated FCRs and problem behavior for one child. For the second child, an alternative activity was necessary to enhance the effectiveness of the intervention. In addition, one child had variable results on generalization across teachers and a setting as well as maintenance whereas the second child demonstrated the ability to generalize and maintain discriminated FCRs and problem behavior. Social validity results showed that teachers/paraprofessionals found the use of an alternative activity to be acceptable and feasible to implement. Teachers/paraprofessionals orally expressed that they would change the signaling stimuli to a single stimulus that is more feasible to use in the classroom.

In conclusion, the current study adds to the body of literature on the use of a multiple schedule of reinforcement following FCT (e.g., Betz et al., 2013; Fisher et al., 2015). Additionally, the study suggests that for some children with ASD, an alternative activity may be a key component to enhance the effectiveness of a multiple schedule of reinforcement (Fuhrman et al., 2018).

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Appendix A: FBA Interview Questions

A. What are the child's problem behaviors?

B. What seems to trigger the child's problem behavior?

C. What do you do when the participant engages in problem behavior?

D. How/when does the participant stop engaging in problem behavior?

E. When do these problem behavior occur (name parts of the day)?

F. Where do these problem behavior occur (name activities or places in school)?

G. With whom do these problem behaviors occur (name the teacher/peer)?

Appendix B: Social Validity Questionnaire (Teachers)

Instructions: Please circle your responses.

1. **The communication response and problem behavior targeted in the interventions are important/socially significant.**

Strongly disagree Disagree Slightly disagree Slightly agree Agree Strongly agree

2. **The student's needs to learn a communication response warrant the use of this intervention.**

Strongly disagree Disagree Slightly disagree Slightly agree Agree Strongly agree

3. **This is an acceptable intervention to increase an appropriate communication response.**

Strongly disagree Disagree Slightly disagree Slightly agree Agree Strongly agree

4. **The intervention effectively decreased the student's problem behavior.**

Strongly disagree Disagree Slightly disagree Slightly agree Agree Strongly agree

5. **The intervention is a good way to decrease student's problem behavior.**

Strongly disagree Disagree Slightly disagree Slightly agree Agree Strongly agree

6. **Overall, the intervention is beneficial for the student's problem behavior.**

Strongly disagree Disagree Slightly disagree Slightly agree Agree

Strongly agree

7. **The intervention is feasible to use in the classroom.**

Strongly disagree Disagree Slightly disagree Slightly agree Agree

Strongly agree

Appendix C: Social Validity Questionnaire (Parents)

Instructions: Please circle your responses.

1. **The communication response and challenging behavior targeted in the interventions are important.**

Strongly disagree Disagree Slightly disagree Slightly agree Agree

Strongly agree

2. **My child's needs to learn a communication response warrant the use of this intervention.**

Strongly disagree Disagree Slightly disagree Slightly agree Agree

Strongly agree

3. **This is an acceptable intervention to increase my child's appropriate communication response.**

Strongly disagree Disagree Slightly disagree Slightly agree Agree

Strongly agree

4. **The intervention effectively decreased my child's challenging behavior.**

Strongly disagree Disagree Slightly disagree Slightly agree Agree

Strongly agree

5. **The intervention is a good way to decrease my child's challenging behavior.**

Strongly disagree Disagree Slightly disagree Slightly agree Agree

Strongly agree

6. **Overall, the intervention is beneficial for my child's challenging behavior.**

Strongly disagree Disagree Slightly disagree Slightly agree Agree

Strongly agree

7. **The intervention is feasible to use in the home.**

Strongly disagree Disagree Slightly disagree Slightly agree Agree

Strongly agree

Appendix D: FCT Data Collection Sheet

Student: ___________ Date: _______________________ Session#: _____

(Directions: Tally the number of responses during each 20-s interval for the duration of the session)

	Problem behavior	IOA	FCR (Sd)	IOA	FCR (S-Delta)	IOA
20-s interval						
20-s interval						
20-s interval						
20-s interval						
20-s interval						
20-s interval						
20-s interval						
20-s interval						
20-s interval						
20-s interval						
20-s interval						
20-s interval						
20-s interval						

20-s interval						
20-s interval						

Appendix E: Procedural Fidelity (FCT Baseline)

Student:………………… Session #: ………………… Date: …………………

(Directions: mark Y, N in front of each step for each opportunity during sessions)

STEPS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Place the iPad/picture within the child's reach, turned on to the correct page															
Retrieve/remove the functional reinforcer from the child															
Ignore FCRs															
Provide the corresponding reinforcer immediately after the child engages in problem behavior.															
Keep the reinforcer with the child for 20 s, before moving on to the next trial															

Appendix F: Treatment Fidelity Checklist (FCT pre-training)

Student:………………… Session #: ………… Date: …………………

(Directions: mark Y, N in front of each step for each opportunity during teaching sessions)

STEPS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Place the iPad/picture within the child's reach, turned on to the correct page															
Retrieve/remove the functional reinforcer from the child															
After 0 s (3 s, 5 s/ depending on the session/*ask interventionist*) of no responding or immediately after occurrence of challenging behavior, prompt the child gesturally to touch the icon on the iPad/touch the picture															
After 0 s (3 s, 5 s/ depending on the session/*ask interventionist*) of no responding or immediately after occurrence of challenging behavior, prompt the child vocally to touch the icon on the iPad/touch the picture															

After 0 s (3 s, 5 s/ depending on the session/*ask interventionist*) of no responding or immediately after occurrence of challenging behavior, prompt the child physically to touch the icon on the iPad/touch the picture															
Provide the corresponding reinforcer immediately after the child touches the icon/picture, whether independently or prompted.															
Keep the reinforcer with the child for 20 s, before moving on to the next trial.															

Appendix G: Treatment Fidelity Checklist (Mix FCT)

Student:..................... Session #: .... Date: ....

(Directions: mark Y, N in front of each step for each opportunity during teaching sessions)

STEPS	1	2	3	4	5	6	7	8	9	10
Place the picture within the child's reach, turned on to the correct page										
Retrieve/remove the functional reinforcer from the child										
Withhold reinforcement upon problem behavior										
Provide the corresponding reinforcer immediately after the child touches the picture (or vocally requests) independently during Sd condition.										
Keep the reinforcer with the child for 20 s, before moving on to the next trial.										
Provide a one-time statement after the first time child emits FCR during S-Delta "not right now"										
Ignore FCRs and problem behavior during S-Delta										

Appendix H: Treatment Fidelity Checklist (Mult FCT)

Student:………………… Session #: ………………… Date: …………………

(Directions: mark Y, N in front of each step for each opportunity during teaching sessions)

STEPS	1	2	3	4	5	6	7	8	9	10
Place the picture within the child's reach, turned on to the correct page										
Wear the stimulus corresponding with the condition										
Retrieve/remove the functional reinforcer from the child										
Withhold reinforcement upon problem behavior										
Provide the corresponding reinforcer immediately after the child touches the picture (or vocally requests) independently during Sd condition.										
Keep the reinforcer with the child for 20 s, before moving on to the next trial.										
Provide a one-time statement after the first time child emits FCR during S-Delta "not right now"										
Ignore FCRs and problem behavior during S-Delta										

Appendix I: Treatment Fidelity Checklist (Mult FCT Plus Alternative Activity)

Student:………………… Session #: ………………… Date: …………………

(Directions: mark Y, N in front of each step for each opportunity during teaching sessions)

STEPS	1	2	3	4	5	6	7	8	9	10
Place the picture within the child's reach, turned on to the correct page										
Wear the stimulus corresponding with the condition										
Retrieve/remove the functional reinforcer from the child										
Withhold reinforcement upon problem behavior										
Provide the corresponding reinforcer immediately after the child touches the picture (or vocally requests) independently during Sd condition.										
Keep the reinforcer with the child for 20 s, before moving on to the next trial.										
Provide a one-time statement after the first time child emits FCR during S-Delta "not right now"										
Ignore FCRs and problem behavior during S-Delta										
Provide the alternative toy immediately once the S-Delta begins										
Remove the alternative toy immediately once the S-Delta ends										

Appendix J: Treatment Fidelity Checklist (Alternative Activity Alone)

Student:………………… Session #: ………………… Date: …………………

(Directions: mark Y, N in front of each step for each opportunity during teaching sessions)

STEPS	1	2	3	4	5	6	7	8	9	10
Place the picture within the child's reach, turned on to the correct page										
Retrieve/remove the functional reinforcer from the child										
Withhold reinforcement upon problem behavior										
Provide the corresponding reinforcer immediately after the child touches the picture (or vocally requests) independently during Sd condition.										
Keep the reinforcer with the child for 20 s, before moving on to the next trial.										
Provide a one-time statement after the first time child emits FCR during S-Delta "not right now"										
Ignore FCRs and problem behavior during S-Delta										
Provide the alternative toy immediately once the S-Delta begins										
Remove the alternative toy immediately once the S-Delta ends										