AN ASSESSMENT OF DIGITAL STIMULUS PROMPTS TO TEACH CONDITIONAL DISCRIMINATIONS TO CHILDREN WITH AUTISM

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Effective and efficient skill-acquisition procedures must be identified to support individualized behavioral programming for children with autism spectrum disorder (ASD). To do this, practitioners and researchers may use assessment-based instruction. Prompts are a common teaching strategy to promote skill acquisition. The purpose of this applied study was to use assessment-based instruction to evaluate the efficacy and efficiency of within- and extra-stimulus prompts to teach conditional discriminations to two children with ASD. We identified stimulus prompts using a survey of popular children's games and conducted a tablet-based instruction readiness assessment. Stimulus prompts involved motion (within-stimulus) and pointing (extra-stimulus) to evoke correct responses in the presence of a discriminative stimulus. We used an adapted alternating treatments design with a no-treatment control condition to evaluate the effects of both prompt types across multiple sets of stimuli. Both stimulus prompt types were efficacious in facilitating skill acquisition for two of three participants. Little difference was observed in the time to mastery with either prompt. Neither stimulus prompt was efficacious for the third participant. Assessment results will be used to inform clinical programming to teach conditional discriminations to participants and contribute to research on designing and implementing assessments of skill-acquisition procedures.

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LIST OF ABBREVIATIONS

ABA: Applied behavior analysis

BCBA: Board Certified Behavior Analyst

CCS: Condition-correlated stimulus

EC: Error correction

ES: Extra-stimulus

DR: Differential reinforcement

MSWO: Multiple-stimulus without replacement

S+: Positive stimulus; that stimulus correlated with reinforcement.

S-: Negative stimulus; that stimulus not correlated with reinforcement.

SR+: Reinforcement

WS: Within-stimulus

CHAPTER 1

GENERAL INTRODUCTION

Applied behavior analytic intervention for a child with autism spectrum disorder (ASD) is guided by individualized goals that are selected through skills assessments (Green et al., 2002). The role of a Board Certified Behavior Analyst (BCBA) is to support a child in mastering many goals in a short amount of time (Behavior Analyst Certification Board, 2022; Reichow, 2012). Rapid skill acquisition requires BCBAs to select efficacious and efficient intervention strategies for each learner. Despite a wealth of empirically supported intervention strategies from which to choose, not every intervention leads to similar rates of skill acquisition or positive outcomes for every learner (Howard et al., 2014; Roane et al., 2016). One method to support behavior analysts in selecting individualized interventions that are efficacious and efficient is to develop tools that allow BCBAs to assess intervention strategies for individual learners. One such tool that can assist BCBAs in comparing multiple interventions to identify those that will support rapid skill acquisition with a learner is assessment-based instruction.

Assessment-based instruction involves using an adapted alternating treatments design to simultaneously implement two or more empirically supported intervention strategies with similar skills and comparing the acquisition data to evaluate their efficacy and efficiency (Kodak & Halbur, 2021; Sindelar et al, 1985). For example, if a BCBA is deciding whether to use model prompts or physical guidance to teach one-step instruction following with a specific learner, they could design an assessment wherein they compare acquisition of stand, point, and stomp when teaching involves model prompts and clap, sit, and wave when teaching involves physical guidance. If the acquisition data suggests that only one prompt is efficacious, the BCBA should use that prompt type to teach instruction following. If both prompts are efficacious, the BCBA should compare relative efficiency or other factors (e.g., ease of implementation, learner preference) to select the most optimal option for the learner and their environment. This approach may be beneficial because it promotes the customization of a learner's applied-behavior analytic (ABA) intervention to that which is most likely to benefit them and reduces their exposure to ineffective or relatively inefficient teaching strategies. When efficacious and efficient interventions can be identified, assessment-based instruction may maximize the time, cost, and effort of training staff to implement interventions for consumers (Kodak & Halbur, 2021).

Assessment-based instruction has been used to evaluate numerous intervention components including prompting, prompt-fading, reinforcement, antecedent stimulus presentation order, and error-correction strategies for learners with ASD (e.g., Carroll et al., 2018; Johnson et al., 2017; Kodak et al., 2016; Petursdottir & Aguilar, 2015; Schnell et al., 2019). Although prompting is a commonly used behavioral-intervention strategy in skill-acquisition programs (Love et al., 2009), not all supplementary sources of control function as prompts for all learners. Therefore, assessment-based instruction could be an option for identifying prompts that facilitate the transfer of stimulus control. In a simple discrimination, a prompt is delivered to evoke correct responding to a discriminative stimulus (S^D), or a stimulus that is correlated with reinforcement contingent on a specific response. No prompts are provided in the presence of S-deltas, or stimuli that are not correlated with reinforcement. In a conditional discrimination, a conditional stimulus determines which stimuli in the environment are correlated with reinforcement (S+) and which are not (S-). A prompt is delivered to evoke responding to S+ only in the presence of the conditional stimulus (Dinsmoor, 1995). Intervention programs to teach simple and conditional discriminations should be designed to provide the learner with prompts that effectively evoke correct responding early in acquisition, and prompts are gradually removed to promote transfer of stimulus control for correct responding from the prompt to the S^D or S+ (MacDuff et al., 1996; Wolery & Gast, 1984).

Behavior analysts can choose from a variety of prompt types; however, prompts generally fall into two categories: response prompts and stimulus prompts. Response prompts occasion the correct response directly by guiding, instructing, or modeling the target response without altering the S+ (e.g., modeling a correct selection in a letter discrimination task). Stimulus prompts involve additions, manipulations, or enhancements of the S+ that increase the probability of a correct response (e.g., making the target letter bold and larger than S- in a letter discrimination task; MacDuff et al., 1996; Schreibman, 1975; Wolery & Gast, 1984). Prompt fading is used to remove prompts and transfer stimulus control to the S+. Comparative evaluations of prompting strategies have been limited to response prompts or combinations of response and stimulus prompts.

Cengher et al. (2016) designed an assessment to compare most-to-least (MTL) and least-to-most (LTM) prompt fading to teach one-step instruction following to three children with ASD. Both prompt-fading procedures involved delivering the same prompt types (e.g., partial physical guidance, full physical guidance) but in opposite orders. For example, MTL fading presented partial physical and full physical prompts and LTM fading delivered full physical and partial physical prompts in order from first to last. A prompt type assessment was conducted prior to the prompt-fading assessment to determine which antecedent stimuli (e.g., models, gestures, partial physical guidance) evoked correct responding from each participant. For all participants, physical guidance was determined to be the type most likely to evoke correct responding. Using that information, Cengher et al. (2016) developed partial physical and full physical prompt topographies for all target responses and compared rates of acquisition using MTL and LTM fading procedures. All prompts were delivered using a constant prompt delay of 2 s. The criterion for decreasing the prompt level using MTL was two consecutive trials with correct responding on the present prompt level. The criterion for increasing the prompt level using LTM was two consecutive trials with incorrect responses on the present prompt level. All participants acquired the target skill using MTL prompt fading. LTM prompt fading was ineffective for all participants. These assessment results were consistent across all participants. The consistency in Cengher et al.'s (2016) results could guide BCBAs to consider a MTL prompt hierarchy when teaching similar skills to learners with similar repertoires. However, outcomes of other prompt assessments suggest that different prompt types and prompt-fading procedures have different effects for some learners.

Seaver and Bourret (2014) assessed the efficacy and efficiency of three types of response prompts (vocal instruction and gesture, modeling, and physical prompts) and three prompt-fading procedures (most-to-least, least-to-most, and delay) to teach behavior chains to 10 children with ASD or pervasive developmental disorder. The assessment results demonstrated that efficacious and efficient prompting and prompt-fading procedures varied across learners. That is, no prompt type or prompt-fading procedure was effective for all. On generality tests, they compared the most-efficient and least-efficient prompting procedures to teach novel behavior chains to five of the participants. The results confirmed that the initial assessment permitted identification of an efficacious and relatively efficient method to teach behavior chains to the individual learners.

Schnell et al. (2019) conducted an assessment to identify individual prompting and prompt-fading strategies to teach auditory-visual conditional discriminations (AVCDs) to three children with ASD. The assessment compared three types of response prompts (model, partial physical, and full physical) and three types of prompt-fading procedures (progressive delay, most-to-least, and least-to-most). The results indicated that not all prompt types resulted in acquisition for all learners, and there were differences in efficiency for those that did. However, the same prompt-fading type (least-to-most) was most efficient for all. The most efficient and least efficient prompt type and prompt-fading combinations were applied to new sets of AVCDs. The combinations identified as most efficient in the assessment produced mastery level responding in fewer sessions than the least-efficient combination. Results of Seaver and Bourrett (2014) and Schnell et al. (2019) demonstrated that intersubject replication of the effects of behavioral-intervention strategies is not guaranteed.

Whereas several studies have compared response prompt types and fading strategies (e.g., Cengher et al., 2016; Libby et al., 2008, Schnell et al., 2019), there are no studies using assessment-based instruction methodology to evaluate the efficacy and efficiency of stimulus prompts. An extension of assessment-based research to stimulus prompts is warranted because evidence suggests that stimulus prompts may be more effective and efficient methods of stimulus control transfer compared to response prompts (Cengher et al., 2018). Cengher et al. (2018) reviewed studies that compared the efficacy and efficiency of stimulus and response prompts. In six of the eight experiments, stimulus prompts resulted in transfer of stimulus control and independent skill acquisition more quickly than response prompts (Aeschleman & Higgins, 1982; Dorry & Seaman, 1973; Karsh et al., 1990; Karsh & Repp, 1992; McGee & McCoy, 1981; Repp et al., 1990; Strand & Morris, 1986).

Stimulus prompts may be categorized by two different kinds of antecedent manipulations which make correct responding more likely: within-stimulus (WS) and extra-stimulus (ES) prompts. WS prompts involve enhancing or exaggerating existing features of the S+ (e.g., increased hue and saturation for target colors on a visual discrimination by color task).[1] Dube et al. (1991) taught two adults with intellectual disabilities to construct a match to a printed word using an array of letters presented on a computer screen. Participants needed to select the correct letters in the correct order from left to right. They used a flashing prompt (correct letter in the array flashed on and off; within-stimulus prompt) to teach participants to select the matching letter. One participant required an intensity prompt (individual letter to be matched in sample was darker than the rest in the word; WS prompt) to teach him to match one letter at a time from left to right. Dube et al. (2019) faded prompts across trials based on correct responding to the prompt, and both participants learned how to construct matching words by selecting letters in the proper order. ES prompts involve adding something additional to the environment to indicate the correct response (e.g., an arrow pointing to the target color; Schreibman, 1975). Fisher et al. (2007) compared a LTM prompt-fading procedure with

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[1]Within-stimulus prompts are sometimes referred to as criterion-related prompts because they can involve enhancing or exaggerating features of the S+ that should control responding during the terminal performance when prompts have been faded. Extra-stimulus prompts are sometimes referred to as non-criterion related prompts because prompts involve adding something to the S+ that should not control responding during terminal performance. This distinction has been called in to question because the features of the stimulus that control responding during the terminal performance cannot be defined by the experimenter (Etzel & LeBlanc, 1979).

embedded an identity-matching picture prompt (therapist held up matching image of S+) and simultaneous point prompt (both ES prompts) to a LTM fading procedure with model prompts to teach conditional discriminations to two children with ASD. Both participants acquired conditional discriminations in the ES prompt condition but did not acquire the discriminations with the LTM fading procedure with model prompts.

Cengher et al. (2018) reviewed six studies comparing the efficacy and efficiency of WS and ES prompts. The review concluded that WS prompts were effective for more participants when compared to ES prompts to acquire a variety of simple and conditional discriminations. Three of those studies concluded that ES prompts were ineffective (Arick & Krug, 1978; Collier & Reed, 1987; Richmond & Bell, 1983; Schreibman, 1975; Summers et al., 1993; Wolve & Cuvo, 1978). For example, Wolfe and Cuvo (1978) compared WS and ES prompts to teach letter discriminations to 24 individuals with intellectual disabilities. They compared bold letter features (WS) faded by intensity to a point prompt (ES) faded by distance. Probe trials were conducted without prompts when participants met the mastery criteria with each fading step to identify when transfer of stimulus control occurred. Results indicated that the bold letter features (WS prompt) were efficacious for more participants when compared to the point prompt (ES prompt), and WS prompts required fewer trials to mastery for participants who learned with both prompt types.

Schreibman (1975) compared WS and ES prompts to teach visual and auditory simple discriminations to six children with ASD. In the visual discrimination task, the experimenter presented two stimulus cards with printed images. The same images served as the S^D and S-delta across trials. The target response was pointing to the S^D. Schreibman (1975) compared increased intensity and size of the S^D (WS) to a point prompt (ES; required pre-training to respond to the point). They faded WS prompts by intensity and size and ES prompts by distance. The WS prompt was efficacious for five of six participants; the ES prompt was efficacious for three of six participants. When the ES prompt did not result in transfer of control to the S^D, two of the three participants acquired the task when the WS prompt was implemented. In the auditory discrimination task, the experimenter presented one of two sounds. The target response was to press a bar located within the participant's reach in the presence of the S^D. Schreibman (1975) compared increased volume of the S^D (WS) to the sound of a buzzer played simultaneously with the S^D (ES). All participants required pre-training to respond correctly to the sound of the buzzer. The WS prompt was efficacious for all learners; the ES prompt was efficacious for four of six participants. When the ES prompt did not result in transfer of control to the S^D, the WS prompt was implemented, and all learners acquired the task.

In a more recent study, Yorlets et al. (2018) used WS and ES prompts to teach complex conditional discriminations to a child with ASD. They used stimulus prompts to teach the child to select the correct printed word when presented with an American Sign Language (ASL) sign and spoken word (e.g., select printed word Michigan given the ASL sign and auditory stimulus "dairy"). Bold and enlarged fonts (WS) to teach ASL and spoken-word-to-printed word relations. They used ES prompts to teach the child to select correct image when presented with the ASL sign paired with the spoken word (e.g., touch image of Maryland when presented with "dairy" spoken word and sign). They placed colored, glowing boxes (ES) around the S+. They did not conduct a formal assessment of the efficacy or efficiency of either prompt; however, the authors reported the need to modify the ES prompt to support acquisition. The ES prompt was replaced by a WS prompt (bold shape borders). The experimenters reported acquisition of conditional discriminations with both WS prompts.

Apart from point prompts delivered by an instructor, stimulus prompts are uncommon in modern ABA interventions and research despite their documented efficacy (Cengher et al., 2018). In fact, there has not been a comparative evaluation of stimulus prompts to teach simple or conditional discriminations in nearly 30 years (Summers et al., 1993). This may be due to the practical challenges and effort required to prepare and train staff to use stimulus prompts. Stimulus prompts often require unique material preparation for each program. For example, in Schreibman (1975), experimenters created five different versions of S+ and S- stimuli to fade intensity. Training for each individual program with which stimulus prompts are implemented can also be effortful. For example, in Schreibman (1975), the extra-stimulus prompt required the experimenter to measure the distance of their finger to the S+ on every session so that it could be placed in a consistent position. Because of these and other barriers, stimulus prompts are not recommended to teachers or researchers as practical interventions for transfer of stimulus control (Wolery & Gast, 1984).

Many technological advancements have occurred in the last 30 years, and these advancements may help reduce the barriers of implementing stimulus prompts in behavioral intervention. Digital programming via computers and tablets has become more common in ABA intervention. Specifically, tablet-based instruction has been implemented to teach language, academic, reading, motor, and adaptive skills to children with ASD (Goldsmith & LeBlanc,2004; Kagohara et al., 2013; Ramdoss et al., 2010). Some studies have compared acquisition with tablet-based instruction to more traditional paper-based instruction. For example, LeBlanc et al. (2017) and Pellegrino et al. (2019) compared acquisition of AVCDs using tablet-based instruction to traditional paper flashcards with children with ASD and found that tablet-based instruction was efficacious for all learners.

One unique feature of tablet-based instruction is that several steps of discrete-trial instruction, including prompts, can be automated using software (Cariveau et al., 2020; Cummings & Saunders, 2019; Ellington et al., 2023; Mittelman, 2023). For example, Microsoft PowerPoint can be programmed to detect participant's selection of experimenter-defined correct and incorrect visual stimuli and provide differential consequences (e.g., chime after correct responses and arrow after incorrect responses; for tutorials on programming discrete trial instruction using PowerPoint, see Cummings & Saunders 2019 and Mittelman, 2023). Automating stimulus prompts may reduce the time and cost of material preparation and training while still functioning as an efficacious technology of stimulus control transfer. Nevertheless, few studies have utilized digital prompts during tablet-based instruction.

Chebli et al. (2019) used digital WS prompts to teach AVCDs to seven children with ASD. Experimenters programmed the S+ to grow larger and removed prompts using delay fading. Chebli et al. (2019) was successful in fading prompts for three of seven participants. Lorah and Karnes (2016) also used digital WS prompts to teach AVCDs to two children with ASD. The experimenter decreased the intensity of the S- stimuli and faded them back to their terminal intensity across trials. Both participants acquired the target skill using this procedure. Lorah et al. (2014) used digital WS prompts to teach mands to four children with ASD using images presented on a speech-generating device (color intensity). All of the participants acquired the task with an array of up to four images. All of these studies support the potential for digital stimulus prompts to facilitate skill acquisition. Further, they present examples of a variety of digital prompts that become available to BCBAs when they use digital materials (e.g., color intensity, size).

There are numerous stimulus prompt types from which to choose (e.g., size enhancement, color enhancement, movement, arrows), but like response prompts, not all stimulus manipulations or additions will be efficacious for all learners. BCBAs can utilize assessment-based instruction to make data-informed decisions about which stimulus prompt to use to promote rapid skill acquisition with an individual learner. As such, research aimed at developing an assessment of stimulus prompts and identifying efficacious and efficient stimulus prompts could improve clinical outcomes for children with ASD. The purpose of this study was to extend the literature on assessment-based instruction to stimulus prompts through an assessment of WS and ES prompts. We taught conditional discriminations to children with ASD using digital stimulus prompts programmed in PowerPoint on a tablet. To guide our selection of stimulus prompts, we surveyed popular children's apps and games to determine whether and what kind of stimulus prompts were used. To confirm that all participants could respond to instructional stimuli presented on a tablet, we conducted a tablet-based instruction readiness assessment. To identify which stimulus prompts were efficacious and efficient for each participant, we replicated and extended the prompt assessment designed and conducted by Schnell et al. (2019) by utilizing digital stimulus prompts and tablet-based instruction to reduce barriers to using stimulus prompts in behavioral intervention for children with ASD.

CHAPTER 2

SURVEY OF STIMULUS PROMPTS IN CHILDREN'S APPS AND GAMES

Introduction

Stimulus prompts can facilitate stimulus-control transfer and teaching conditional discriminations, but they can be effortful to program and implement (Cengher et al., 2018; Wolery & Gast, 1984; Wolery et al., 1988). Computer-based or tablet-based instruction may provide a feasible way to program using stimulus prompts with reduced effort. Furthermore, children are exposed to prompts that are programmed in games and applications on computers and tablets. Based on a review of prompt efficacy research, Soni et al. (2019) recommends game designers provide touchscreen interaction prompts that use visual supports to draw attention to items on the screen (e.g., shaking items, blinking items). They also recommend game designers only ever use auditory instructions with supplemental visual supports because children are unlikely to respond to auditory stimuli in isolation. Soni et al.'s (2019) recommendations are informative for understanding which prompt types may be more or less effective for children to interact with stimuli on a touchscreen device.

Considering how apps and games designed for children are programmed to teach children to complete various on-screen tasks (e.g., pick up treasure; tap character) may be informative for understanding the kinds of digital prompts that may be effective. For example, a survey of 100 apps designed for children under 5 years old found that the most common prompts were auditory instructions and visual changes that draw children's attention to certain items (i.e., stimulus prompts; present in 41% of games they reviewed; Hiniker et al., 2015). Games were less likely to use textual prompts and models by a cartoon hand (presented in 19%

and 14% of games respectively). Hiniker et al.'s (2015) findings align with recommendations from Soni et al. (2019) for designing touchscreen interaction prompts for children. We conducted a survey of apps and games designed for children to understand whether stimulus prompts were still common. Additionally, we categorized prompts by WS and ES prompts to understand how common each type was. The results of this survey informed which digital stimulus prompts would be used in an assessment of digital stimulus-prompts to teach conditional discriminations to children with ASD.

Method

Materials and Procedure

We used a Lenovo TB-8505F tablet and one 8th Generation Apple iPad to survey stimulus prompts used in 50 apps and games designed for children for free download or purchase in the Google Play Store or Apple IOS Apple Store.

Procedures

The apps and games were downloaded on August 12, 2021. Apps were filtered using the search categories “Children” (Google Play Store) or “Kids & Family” (Apple App Store) and “Free” or “Paid.” The top 15 paid and top 10 free games from each platform were surveyed (see Table x for a list of apps and games).

We collected data on the total count of WS and ES prompts and the prompt sub-types across all 50 games. The primary coder used a digital timer to play each game for 10 minutes, and she recorded each time a stimulus prompt appeared in the game. When she encountered a stimulus prompt, the coder recorded (a) a description of the task that was prompted (e.g., press the play button); (b) whether the prompt was an example of WS, ES, or both; and (c) the subtype(s) of the prompt (e.g., pointing, intensity).

The WS prompts were defined as exaggerated or emphasized features or components of the S+ to increase the likelihood of responding (Schreibman, 1975). Sub-types of WS prompts were intensity, motion, and size (see Table 1 for operational definitions and examples). The ES prompts were defined as additional stimuli added to the discriminative stimulus to increase the likelihood of responding (Schreibman, 1975). Sub-types of ES prompts were pointing, light, symbol/shape added, and surround (see Table 1).

Another independent coder played 72% (18/25) of Google Play games and 56% (14/25) of Apple games. The secondary coder was given written instructions, a list of tasks that would be prompted within each game, and operational definitions for prompt types and subtypes (see Appendix A). We calculated occurrence/nonoccurrence agreement for all prompt types and sub-types. We calculated whether coders agreed on the *presence* of certain prompt types and sub-types and the *absence* of certain prompt types and sub-types. For example, an agreement was counted if both coders scored a prompt as ES. A disagreement would be counted if one coder scored a prompt as ES and the other scored it as WS. An agreement would be counted if both coders scored that a point prompt did not occur. A disagreement would be counted if one coder scored a point prompt and the other scored an intensity prompt. Agreement was calculated by dividing the sum of agreements on prompt types or sub-types over the combined number of agreements and disagreements and multiplying by 100. Agreement was 97% for prompt types (246 agreements, 12 disagreements) and 97% for sub-types (961 agreements, 39 disagreements).

Table 1

Prompt Types and Sub-Types Definitions and Examples

Sub-Type	Definition	Example
	Extra-Stimulus Prompt	
Point	The addition of a finger, hand, or arrow leading to the S+; excludes instances in which fingers or hands model the action by moving objects on the screen (e.g., dragging items to new location on screen)	A cartoon hand points to a treasure box that the player should open.
Symbol/shape added	The addition of some symbol or shape to the side or in front of the S+	An exclamation mark appears above a treasure box that the player should open.
Surround	The addition of some stimulus surrounding the perimeter of the S+ on all sides	Arrows surround a treasure box that the player should open.
Light	The addition of illumination on or around the S+	Sparkles glistening on a treasure box that the player should open.
Within-Stimulus Prompt		
Intensity	A difference in the hue, saturation, or brightness of the S+ when compared to the background or S- stimuli	A treasure box that the player should open is brightly colored and all other items in view are grayscale.
Motion	A change in S+ location or rotation around an axis	A treasure box that the player should open moves side to side.
Size	A change in size of the S+ or S- stimuli	A treasure box that the player should open grows larger than its original size.

Note. S+ are those stimuli to which the player should respond, S- are those stimuli to which the player should not respond.

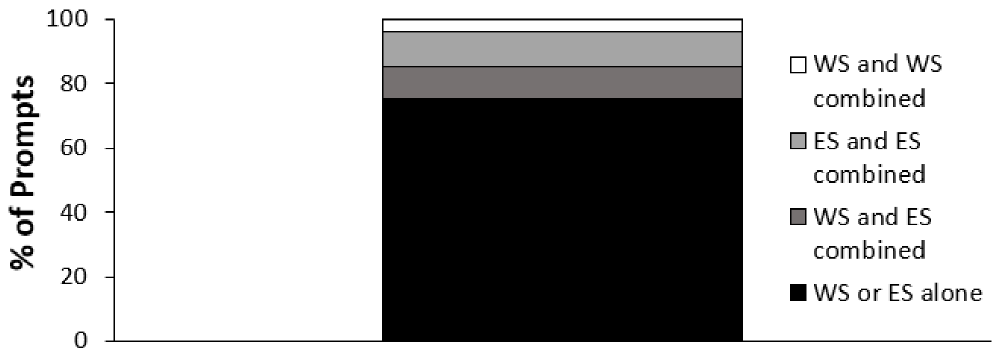
Results

Combined across the 50 games, we identified 204 instances of stimulus prompts. There were 89 WS prompts and 115 ES prompts. The WS and ES prompts were rarely combined; that is, it was mostly likely that only one prompt sub-type was programmed for a task in a game

(Figure 1). Prompt sub-types were combined less than 25% of the time across both prompt categories (e.g., motion and intensity; Figure 1) We identified instances of each prompt sub-type in the games surveyed, but they were used to varying degrees. Motion was the most common WS prompt sub-type, and pointing was the most common ES prompt sub-type (Figure 2). We did not identify any differentiation in prompt types across purchasing platforms.

Figure 1

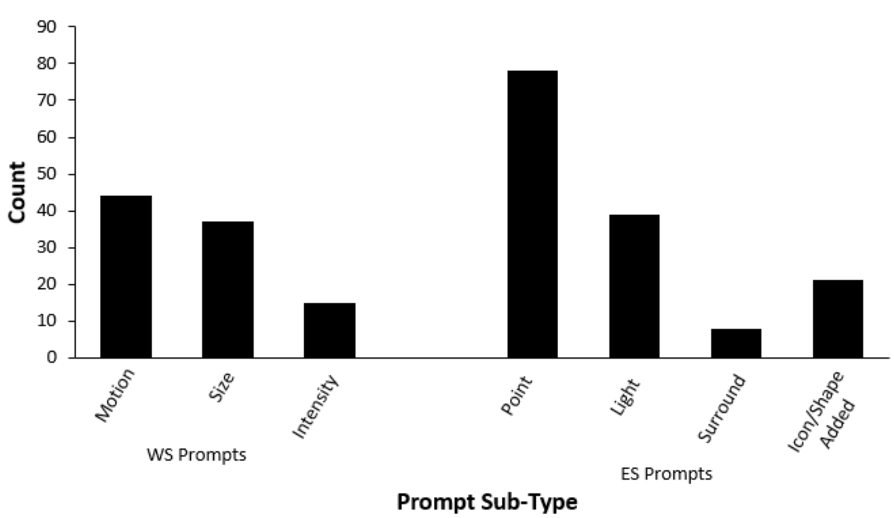
Percent of Stimulus Prompts Presented Alone or in Combination with other Stimulus Prompts



Note. WS = Within-stimulus prompts, ES = Extra-Stimulus Prompts

Figure 2

Count of Stimulus Prompts by Sub-Type



Note. WS = Within-stimulus prompts, ES = Extra-Stimulus Prompts

Discussion

We surveyed popular children's apps and games to determine whether the programmers used stimulus prompts to teach children how to interact with them. We categorized the stimulus prompts by type (i.e., WS or ES) and sub-type (e.g., motion, intensity). Consistent with Hiniker et al.'s (2015) findings, we determined that stimulus prompts are commonly programmed in children's apps and games to teach children how to interact with different stimuli on the screen. We found that WS prompts were less common than ES prompts. Motion was the most common type of WS prompt, and pointing was the most common type of ES prompt.

We did not collect interobserver agreement on the occurrence of prompted tasks in games, which is a limitation of this survey. The lead experimenter played each game for the same amount of time and recorded each time they observed a stimulus prompt to complete a task. It is possible that some prompted tasks were missed. We also did not collect data on the occurrence of response prompts in the games. While completing the survey, we observed that response prompts (e.g., auditory instructions) were sometimes presented with stimulus prompts. It is possible the simultaneous presentation of stimulus and response prompts may increase correct responding to the prompt and transfer of stimulus control. Future studies may consider collecting data on all prompt types to inform selection of prompts to teach using tablet-based instruction.

We used the survey results to inform which prompts we selected for an assessment of stimulus prompts to teach conditional discriminations on a tablet to children with ASD (Chapter 4). In the prompt assessment, we compared whether the two most common types of digital stimulus prompt (motion and pointing) would be efficacious to teach conditional discriminations. Before we conducted the prompt assessment, we designed and conducted a tablet-based instruction readiness assessment (Chapter 3) to determine whether participants would be likely to interact successfully with the tablet in a learning context.

CHAPTER 3

TABLET-BASED INSTRUCTION READINESS-ASSESSMENT

Introduction

Children across the globe are growing up in the digital age. In 2021, 75% of households in America with children under 5 years old reported owning tablets. Those tablets are primarily used for leisure activities (e.g., YouTube, games; Mejia, 2023). Because of the experience that many children may have with only using tablets for leisure apps and games, it may be necessary to provide training to support so that they can with the tablet as an instructional device (Cariveau et al., 2020). When using tablets for instruction rather than leisure, children may not be permitted to pick up the tablet, navigate between apps and games as the instructor uses the tablet to provide learning opportunities, or wait for the response interval to begin before touching the screen. Additionally, using the tablet as an instructional device might require them to look at different parts of the screen or scan visual arrays in ways that are different from other instructional arrangements. For example, the distance between visual stimuli or the size of the stimuli in an array may be smaller and more limited depending on the size of the tablet. Additionally, the tablet may need to be propped up by a kickstand to make the screen easy for both the child and therapist to see. This arrangement would present visual stimuli vertically and perpendicular to the table's surface, whereas paper flashcards are usually presented horizontally and parallel to the top of the table. For some children, interacting with a tablet for instructional purposes rather than leisure may be challenging and require specific training aimed at preparing them for tablet-based instruction (Cariveau et al., 2020).

Because children with ASD may demonstrate rigidity in the ways they interact with tablets or be unable to perform tasks they have mastered in a tabletop format when stimuli are digital, Cariveau et al. (2020) recommended several antecedent-based procedures to increase the likelihood that children with ASD are successful with tablet-based instruction. They recommend positioning tablets at a 120-degree angle so that the child does not have to hold or rest their hands on the tablet screen. To prevent children from navigating to other apps or games during instruction, they recommend using guided access to disable the “home” or “power” buttons. The unfamiliar material presentation may mean that children also need to be taught how to scan arrays or touch digital visual stimuli on a screen. Cariveau et al. (2020) recommend starting with images of things the child likes (e.g., cartoon characters) or mastered tasks (e.g., AVCDs the child has mastered using flashcards) to increase the likelihood that the child attends, emits a target response, and contacts reinforcement.

Saunders et al. (1997) attempted to teach a visual identity matching task to 17 adult participants with intellectual disabilities using a touch screen computer. Before training, each participant received pre-training that involved learning to touch a visual stimulus on the screen within 5 s of presentation and refrain from touching the screen when it was blank. Participants only received reinforcement for touching the visual stimulus and not anywhere else on the screen. Visual stimuli were presented in one of five different positions on the screen across trials. All participants mastered the pre-training, and 16 of the 17 participants mastered the visual identity matching task during training.

Considering that children with ASD may need to learn how to learn via tablet-based instruction, we designed a tablet-based instruction readiness assessment (Referred to as Readiness Assessment) to determine whether children could interact with the tablet as an instructional device before participating in the stimulus-prompt assessment. The Readiness Assessment was informed by recommendations from Cariveau et al. (2020) and a study by Saunders et al. (1997). The Readiness Assessment evaluated participants' abilities to perform mastered tasks on the tablet. If participants were unable to perform mastered tasks on the tablet, we conducted training followed by a post-training Readiness Assessment.

Method

Participants

The study was approved by the center's Executive Director and described to all of the BCBAs working at the center to identify clients who would benefit from tablet-based instruction with stimulus prompts to teach conditional discriminations. Three children were referred by their BCBAs based on clinical goals related to the acquisition of conditional discriminations and interest in incorporating tablets during instruction. All three children had been diagnosed with ASD by a professional not affiliated with the study and were enrolled at a university-based autism center where they received 1:1 ABA services. The participants' families provided consent to share all of the child's deidentified data collected during intervention with the research team for analysis and dissemination. This process was reviewed and approved by the institution's human subjects review board.

Miles was a 3-year, 8-month-old biracial (African American and White) boy who began receiving 35 hours per week of 1:1 ABA services when he was 2 years and 10 months old. Miles communicated using gestures and some sign language. He could echo less than 10 single-syllable phonemes and obtained a score of 3 on the Early Echoics Skills Assessment in the same month he began the assessment (EESA; Esch, 2008). During the study, Miles was attending speech therapy to learn how to use Proloquo2go on an iPad. In the same month that he began participating in the study, Miles obtained a score of 10 on the visual-perceptual/match-to-sample (VP/MTS) domain and five on the listener domain of the Verbal Behavior Milestones Assessment and Placement Program (VB-MAPP; Sundberg, 2008). He obtained a score 45 on the VB-MAPP Barriers assessment, with elevated scores in the categories of defective tact, imitation, echoic, intraverbal, social skills, articulation, and hyperactive behavior. Miles' clinical team referred him to the study because of clinical goals related to acquisition of auditory-visual conditional discriminations (AVCDs) and challenges transferring response prompts to the intended S^D during programs to teach listener discriminations and behavior chains. During instruction, Miles frequently engaged in behaviors (e.g., grabbing the therapist's hand, looking for visual cues in the therapist's eye gaze) that indicated correct responding was not under the control of relevant stimuli. He had no history of instruction with stimulus prompts or tablet-based instruction other than using the speech generating device. Prior to the study, he had acquired 25 AVCDs with response prompts (i.e., gesture) and a 5-s constant prompt delay. Miles typically enjoyed watching YouTube videos, playing letter matching or tracing games, and using image distortion apps (e.g., Apple Photobooth).

Silas was a 3-year, 7-month-old biracial (African American and White) boy who began receiving 35 hours per week of 1:1 ABA services when he was 2 years and 5 months old. Silas communicated using single words and short phrases. He echoed multi-word phrases and short sentences and had a score of 85.5 on the EESA. One month before he began participating in the study, Silas scored 74 on the Expressive Vocabulary Test- Second Edition (EVT-2; Williams, 2007) and 73 on the Peabody Picture Vocabulary Test- Fourth Edition (PPVT-4; Dunn & Dunn, 2007).

Silas obtained a score of six in the VP/MTS domain and five in the listener domain of the VB-MAPP. He obtained a score of 30 on the VB-MAPP Barriers assessment, with elevated scores in the categories of defective intraverbals, social skills, reinforcer dependent, self-stimulation, and hyperactive behavior. He was referred to the study because of clinical goals related to acquisition of AVCDs and his BCBA’s interest in using tablet-based instruction to teach skills. Silas had no reported history with transfer of stimulus control with response prompts, however, the tablet was one of his most highly-preferred leisure items. His clinical team was interested in programming learning opportunities on the tablet as it may have been a preferred instructional context compared to other tabletop instruction and provided an opportunity to vary instructional formats. He had no history of instruction with stimulus prompts or tablet-based instruction. Prior to the study, he had acquired approximately 18 AVCDs with response prompts and least-to-most (gesture, partial physical, full physical). Silas enjoyed storytelling apps, racing apps (e.g., Minion Rush) and children’s mini-game apps (e.g., SagoMini).

June was a 5-year, 8-month-old Korean-American girl who began receiving 35 hours per week of 1:1 ABA services when she was 4 years old. June communicated using a Picture Exchange Communication System. She could echo less than 10 single-syllable phonemes and 5 words and had a score of 21 on the EESA. In the month that she began participating in the study, June did not pass the testing items on the EVT-2 nor the PPVT-4. June obtained a score of 10 on the on the VP/MTS domain and 3.5 on the listener domain of the VB-MAPP. She obtained a score of 41 on the VB-MAPP Barriers Assessment, with elevated scores in the categories of defective tact, listener, intraverbal, conditional discrimination, articulation, and obsessive-compulsive behavior. She had a history of successful acquisition of generalized identity matching using picture cards and response prompts (gesture prompt and physical guidance). June's clinical team reported repeated unsuccessful attempts to fade response prompts and stimulus prompts (intensity) during tabletop AVCD instruction. They referred her for the present study to determine whether digital stimulus prompts may be a viable teaching strategy for conditional discriminations. She had no history of tablet-based instruction. June typically enjoyed watching YouTube videos or playing children's cooking games (e.g., Cooking Mama).

Setting and Materials

The study was conducted at a university-based autism center where the clients received ABA services. All sessions were conducted in a 2.4 m by 3 m individual treatment room with three chairs, one table, toys, an 8th Generation Apple iPad, and two camcorders on tripods. All stimulus prompts were programmed on Microsoft PowerPoint slideshows. Images were sourced via online image searches and PowerPoint's Online Pictures feature and sized to 6.5 cm by 4 cm in the slideshow. The lead experimenter used the audio recording feature in PowerPoint to record spoken auditory stimuli. Slideshows were created on a desktop computer and presented on the iPad with the PowerPoint application. Slideshows were stored on Microsoft OneDrive so that they could be accessed using the iPad or a computer for programming. Each participant had a folder of pre-programmed slideshows for experimental conditions and phases. The experimenter designed four versions of each slideshow so that stimuli were presented in different positions across sessions. Stimuli were balanced so that they appeared as S+ and S- in all positions within each session. Stimuli were also pseudorandomized so that the same stimulus did not serve as S+ on more than two consecutive trials (Green, 2001).

Dependent Variables

The experimenter recorded correct-unprompted responses, correct-prompted responses, incorrect-unprompted responses, incorrect-prompted responses, orienting, interfering behavior, and challenging behavior for each session. A correct-unprompted response was defined as selecting the correct comparison stimulus that corresponded with the sample (S+) prior to the delivery of the prompt. We calculated the percentage of correct-unprompted responses by dividing the number of trials with correct-unprompted responses by the total number of trials and multiplied by 100. A correct-prompted response was defined as selecting the S+ following the delivery of a prompt. We calculated the percentage of correct-prompted responses by dividing the number of trials with correct-prompted responses by the total number of trials in which a prompt was presented and multiplied by 100. An incorrect-unprompted response was defined as selecting an incorrect comparison stimulus (S-) or no comparison stimulus prior to the delivery of the prompt. We calculated the percentage of incorrect-unprompted responses by dividing the number of trials with incorrect-unprompted responses by the total number of trials presented and multiplied by 100. An incorrect-prompted response was defined as selecting an S- or no comparison stimulus following the prompt. We calculated the percentage of incorrect-prompted responses by dividing the number of trials with incorrect-prompted responses by the total number of trials in which a prompt was presented and multiplied by 100. The mastery criterion for the Readiness Assessment was 80% or more correct-unprompted responding across two consecutive sessions.

Orienting was defined as the participant making eye contact with the tablet screen within 5 s of the presentation of the trial slide or the prompt without the co-occurrence of interfering or challenging behavior. We calculated the percentage of trials with orienting by dividing the number of trials where the behavior occurred over the total number of trials multiplied by 100. Interfering behavior was defined as touching the “home” or power buttons or picking up the tablet so that it was no longer touching the table. We calculated the percentage of trials with interfering behavior by dividing the number of trials where the behavior occurred over the total number of trials multiplied by 100.

The experimenter scored the occurrence or nonoccurrence of challenging behavior on each trial. Challenging behavior topographies and operational definitions were based on the participant’s clinical programming (see Appendix B for operational definitions). For Miles, the experimenter recorded crying. For Silas, the experimenter recorded crying, flopping, aggression, elopement, throwing, swiping, biting, self-injury, and stripping. For June, the experimenter recorded crying, flopping, swiping, throwing, kicking, pinching, scratching, and hitting. We calculated the percentage of trials with challenging behavior by dividing the number of trials where the behavior occurred over the total number of trials multiplied by 100.

The experimenter recorded the session duration in minutes using a digital timer. She started the timer immediately before the presentation of the first trial and timed out of the session immediately following the end of the last reinforcement interval or the last trial if no reinforcement was delivered. We calculated the total duration of the Readiness Assessment and component skills training by summing the total duration of all sessions for each participant.

Procedural Fidelity and Interobserver Agreement

Two independent observers collected procedural-fidelity data on 50% of sessions for Miles and Silas and 37% of sessions for June using an all-or-nothing checklist of procedure steps (see Appendix J for all fidelity checklists). The observers watched sessions in-vivo or from video recordings. The observers scored a component as correct (+) if they observed that the procedural component was implemented correctly on every opportunity for the entire session. The observers scored a component as incorrect (-) if they observed one or more errors on any opportunity. The observers scored not applicable (N/A) if a component did not need to be implemented for the entire session (e.g., blocks interfering behavior when no interfering behavior occurred). Mean procedural fidelity for Miles and Silas was 100%. Mean procedural fidelity for June was 97.1% (range: 83.3%-100%).

A secondary observer scored the participant's unprompted and prompted responses and the occurrence/nonoccurrence of orienting, challenging behavior, and interfering behavior on all trials for 50% of sessions for Miles and Silas and 42% of sessions for June. Exact agreement was used to calculate agreement for all participant responses on every trial. An agreement was counted if both observers marked the same behavior on a trial (e.g., both observers marked a correct-unprompted response). A disagreement was counted if the observer's behavioral data did not match (e.g., observer one marked correct unprompted and observer two marked incorrect prompted). Percent agreement was calculated by dividing the total number of agreements over the total number of agreements and disagreements within a session and multiplying that number by 100. This calculation was conducted for each dependent variable. Mean agreement for all dependent variables for Miles and Silas was 100%. Mean agreement for all dependent variables for June was 99.6% (range: 97.4%-100%).

A secondary observer scored duration for 50% of sessions for Miles and Silas and 36% of sessions for June. Total agreement was used to collect IOA data on session duration by dividing the shorter duration in seconds over the longer duration in seconds and multiplying by 100. Mean total agreement for Miles was 99.8% (range: 99.7%-100%). Mean total agreement for Silas was 100%. Mean total agreement for June was 99.9% (range: 99.5%-100%).

Pre-Experimental Procedures

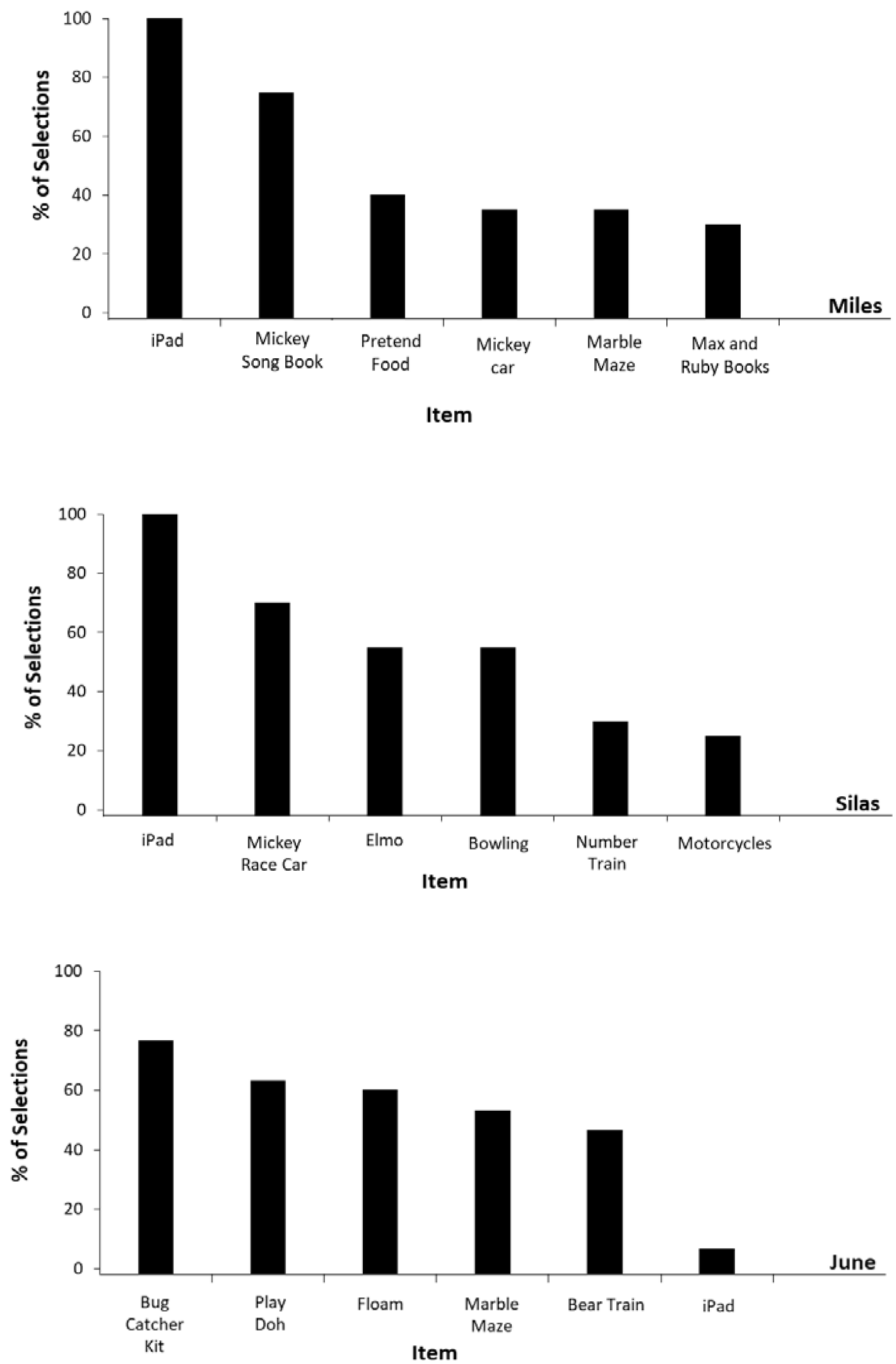
To identify toys for a paired-stimulus preference assessment (Fisher et al., 1992), we conducted three to five free-operant preference assessments (Sautter et al., 2008). Five toys were placed in a circle equidistant from one another around the treatment room. The child was asked to sit or stand in the doorway while the experimenter demonstrated how each toy worked for 10 to 15 s. The child was given 5 min to interact with all of the items in the room during the free-operant preference assessment. The experimenter scored duration of interaction with each item or combinations of items (e.g., holding cars and play doh; see Appendix C for data sheet). If the child engaged with the same item for the entire session, it was omitted and replaced with a new item during the subsequent free-operant preference assessment. Items were ranked based on duration of engagement across sessions, and the top six items were included in a paired-stimulus preference assessment (Fisher et al., 1992; see Appendix D for data sheet).

Two paired-stimulus preference assessments were conducted with Miles and Silas and three paired-stimulus preference assessments were conducted with June. During the paired-stimulus preference assessment, the experimenter sat across from the child at a table. Prior to the assessment, the experimenter placed one item on the table at a time and allowed 10 to 15 s for the child to sample each item. Following the exposure trials, the experimenter began the paired-stimulus preference assessment. The experimenter placed two toys or representatives (e.g., one bowling pin from a bowling set) on the left and right sides of the table equidistant from the participant and said, "Pick one." The experimenter waited 5 s for the child to point to, reach for, or state the name of an item. After a selection, the child was given 20 s (Miles) or 30 s (Silas and June) to play with the item. The experimenter removed the selected item before the next trial was conducted. If the child did not choose either item, the experimenter gave the child 10 s to sample each option before re-presenting the trial. If the child did not select either item on the second presentation, the experimenter moved on to the next trial. Items were counterbalanced across trials so that each item was paired with all other items in the assessment two times, once on both sides of the table.

The experimenter scored percentage of selections per item by dividing the total number of times the item was selected over the total number of times it was presented and multiplying by 100. Items were ranked based on selection percentages to identify the three to four items that the child selected most often (Figure 3). The experimenter presented one of the top three (iPad, Mickey Song Book, and Pretend Food for Miles) or four (iPad, Mickey Race Car, Elmo, and Bowling for Silas) items from the paired-stimulus preference assessment during reinforcement intervals of all phases of the study. We eliminated Play Doh from the group of preferred items for June because we observed her engaging in high rates of pica with that set of toys. Given that June selected three of the five remaining items (Floam, Marble Maze, Bear Train) items with relatively equal frequency during her paired-stimulus preference assessment, we conducted a brief multiple-stimulus without replacement (MSWO) preference assessment with all five items, including iPad, before each day's sessions to identify the top three items (Carr et al., 2000). The children could mand for any other item from the grouping at any point in the reinforcement interval and it was provided for the remainder of the interval.

Figure 3

Results of Paired-Stimulus Preference Assessment for Miles, Silas, and June



Procedure

The Readiness Assessment was a nine-trial session of three previously mastered AVCD targets (Miles and Silas) or identical visual matching targets (June) with auditory and visual stimuli presented on the iPad (see Appendix E). The lead experimenter consulted with the participant's BCBA to identify 3 targets with which the client demonstrated mastery-level responding using paper flashcards.

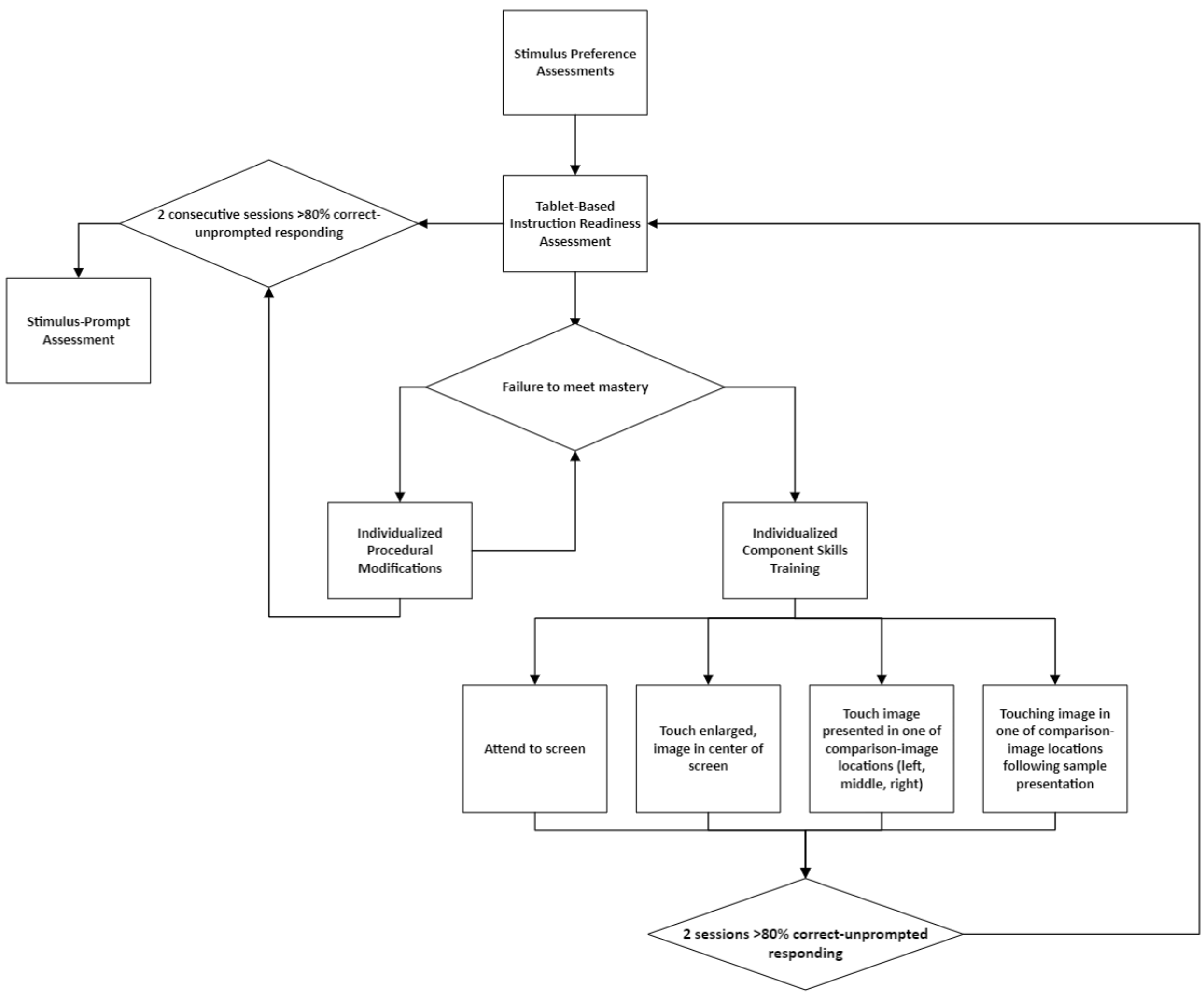
The lead experimenter met the child and their regular therapist in the treatment room or classroom and walked to the treatment room together. When they entered the room, the participant asked the child to sit at the table. The experimenter sat next to the child on the same side of the table. The child was permitted to play with preferred items while the cameras and tablet were set up. To begin the session, the experimenter removed the preferred items using the child's individually prescribed protocol (e.g., place preferred item in bin). Next, the experimenter said, "You're going to work on the iPad" and placed the tablet on the table in front of the child. The iPad was placed at an 115-degree angle to the table using a protective case with a kickstand.

Based on past instructional history, June and Miles were required to display "ready hands" prior to the presentation of each trial. Ready hands meant that the child's hands were flat or folded and still on the table or their lap. If the child did not independently place their hands in the ready position within 5 s of the presentation of the tablet, the experimenter said, "Get ready." If the child did not place their hands in the ready position within 5 s of the instruction, the experimenter repeated the instruction and gently guided the child's hands into the ready position.

To start the trial, the experimenter used a swiping motion on the screen to present the array of visual stimuli. To teach the task, response prompts (described below) were used on the first three trials of every session if the participant did not engage in any unprompted responding within the 5-s response interval. No prompts were provided on the remaining six trials.

Figure 4

Flow Chart of Tablet-Based Instruction Readiness Assessment and Component Skills Training



There was at least a one-week delay in between all participant's tablet-readiness pre-assessment and the beginning of their prompt assessment (see Chapter 4). Therefore, we conducted one (Silas and June) to two (Miles) maintenance sessions in the week preceding the beginning of their prompt assessment. The maintenance sessions were conducted in the exact same manner as the pre-assessment sessions.

For children who did not pass the Readiness Assessment, we used a pretest-posttest design to evaluate the effects of component-skills training on mastery of the Readiness Assessment (Bell, 2010; see Figure 4). Mastery criterion for each component skill was set at two sessions with 80% or more correct-unprompted responding. We reconducted the Readiness Assessment after each component skill was mastered (see Appendix F for data sheet).

Auditory-Visual Conditional Discriminations (Miles and Silas)

We used a simultaneous sample and comparison presentation based on both participants' previous experience with this instructional arrangement (Cubicciotti et al., 2018). The experimenter used a swiping motion to move through the slideshow. At the beginning of a trial, the PowerPoint automatically played the auditory sample of the target word (e.g., "Hammer"; see Appendix G for a list of stimuli). The three comparison stimuli appeared in a horizontal array in the center of the screen. Stimuli were spaced equidistant from one another and the edges of the screen. The child was given 5 s to respond. The auditory sample was programmed to repeat after 2 s (Bergmann et al. 2020; Cubicciotti et al., 2018).

If the child engaged in a correct-unprompted response, the slideshow moved automatically to the inter-trial interval (ITI) slide; the experimenter provided enthusiastic, general praise (e.g., "Great work!") and access to a tangible item for 20 s (Miles) and 30 s (Silas) on a fixed-ratio of 1 (FR1) schedule. If the child engaged in an incorrect-unprompted response, the slideshow moved immediately to the ITI slide; no programmed consequences were provided by the therapist. If the participant did not respond within 5 s on any of the first three trials, the therapist provided a gesture prompt. The participant had 5 s to respond to the prompt. Consequences for correct and incorrect-prompted responses were the same as correct and incorrect-unprompted responses.

Visual Matching (June)

We used a sample-first presentation based on June's previous experience with this instructional arrangement (Cubicciotti et al., 2018). The experimenter used a swiping motion to move through the slideshow. At the beginning of a trial, the visual sample stimulus was presented in the center of the screen approximately 1 in from the top edge of the tablet and remained on the screen throughout the trial. After a 1-s delay, the three comparison stimuli appeared in a horizontal array approximately 1.5 in below the comparison stimulus. Stimuli were spaced equidistant from one another and the edges of the screen. An audio recording of the experimenter saying "Match" was recorded using PowerPoint's audio recording feature and presented simultaneously with the presentation of the comparison stimuli.

After the presentation of the comparison array, the child had 5 s to respond. If the child engaged in a correct-unprompted response, the presentation moved automatically to the ITI, and the experimenter provided enthusiastic, general praise and access to a tangible item for 30 s on a FR1 schedule. If the child engaged in an incorrect-unprompted response, the slideshow moved immediately to the ITI slide; no programmed consequences were provided by the therapist. If the child did not respond within 5 s on any of the first three trials, a response prompt was provided by the therapist. The therapist swiped back to re-present the trial and immediately gestured to the S+ with their index finger. The consequences for correct-prompted responses were the same as correct-unprompted responses.

We made a series of modifications to June's tablet-readiness pre-assessment to determine whether some aspect of the experimental arrangement was preventing her from engaging in correct-unprompted responses. First, we changed gesture prompts to full-physical prompts because June did not engage in any unprompted or prompted responding to stimuli on the iPad. The procedures were the same as above except that if June did not respond on the first three trials, the experimenter gently guided her hand into the form of a pointed finger, placed their hand over her hand, and guided her to touch the S+ on the screen.

June engaged in correct responding to the physical prompt; however, we did not observe any instances of unprompted responding. We made a second modification which involved removing the requirement for June to display "ready hands" before each trial in case this requirement inadvertently indicated to June that she was not supposed to move her hands from this position. The procedures were the same as above except that the experimenter presented the trial stimuli regardless of how June's hands were placed prior to the trial. We did not observe a consistent increase in correct-unprompted responding after this modification.

We made a third modification in which the experimenter placed the iPad flat on the table to mimic the perspective of visual comparison stimuli when they were presented as two-dimensional paper cards on the tabletop. The procedures were the same except that when the experimenter placed the iPad in front of June and said, "You're going to work on the iPad", the kickstand was not in use. We did not observe a consistent increase in correct-unprompted responding after this modification.

In a final modification, the experimenter removed the digital sample stimulus from the slideshow. Instead, the sample was presented on a printed card 11 cm by 7.5 cm held approximately 2.5 cm above the iPad screen by the experimenter approximately 1 s before she swiped to present the comparison stimuli. This mimicked the arrangement with which June had previously been successful in visual matching programs with a sample-first presentation using paper stimuli. We did not observe a consistent increase unprompted responding after this modification; therefore, we proceeded to component skills training.

Because June oriented during 100% of the Readiness Assessment trials and her correct-unprompted responding was less than 33% across all sessions, her component skills training consisted of learning to touch an enlarged, stationary image on the screen. The experimenter used a swiping motion to move through the slideshow. During the trial, a 19 cm x 11 cm image of a teddy bear with which June had no instructional history was shown on all nine trial slides. A progressive prompt delay (PD; 0-s PD, 5-s PD) was used to fade physical guidance (See Appendix H for data sheet).

During 0-s PD sessions, the experimenter swiped to present the trial slide and immediately physically guided June to touch the image on the screen with her pointer finger. If she engaged in a correct-prompted response, the slideshow moved automatically to the ITI and the experimenter provided enthusiastic, general praise and access to a tangible item for 30 s on an FR1 schedule. June engaged in a correct-prompted response on every trial. However, if she had engaged in an incorrect-prompted response, the experimenter would have moved to the next trial without any programmed consequences. The prompt delay was increased to 5 s after one session with greater than 90% correct-prompted responding.

During 5-s PD sessions, the experimenter swiped to present the trial slide and the child had 5 s to respond. If she engaged in a correct-unprompted response, the slideshow moved automatically to the ITI, and the experimenter provided enthusiastic, general praise and access to a tangible item for 30 s on a FR1 schedule. June engaged in a correct-unprompted response on every trial. However, if she had engaged in an incorrect-unprompted response, the experimenter would have moved to the next trial without any programmed consequences.

Results

Miles mastered the Readiness Assessment in two sessions (i.e., two consecutive sessions with 80% correct-unprompted responding; Figure 5). He oriented on 100% of trials and engaged in one instance of interfering behavior. He maintained mastery-level correct-unprompted responding during two maintenance sessions. Miles did not engage in any challenging behavior during any phase of the Readiness Assessment. Total time for Miles to complete the assessment was 26.98 minutes.

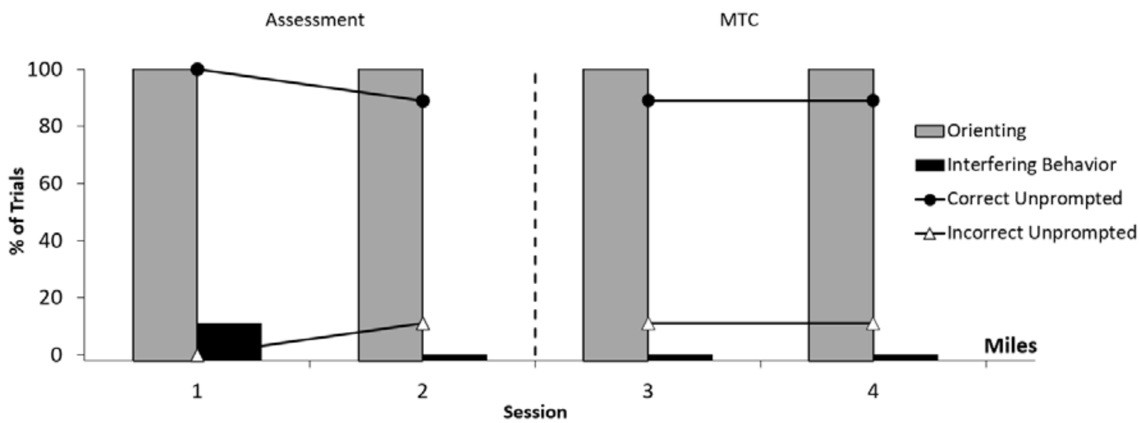
Silas mastered the Readiness Assessment in three sessions with zero instances of interfering behavior (Figure 6). He oriented on 100% of trials and engaged in zero instances of interfering behavior. He maintained mastery-level accuracy during his maintenance session. Silas did not engage in any challenging behavior during any phase of the Readiness Assessment. Total time for Silas to complete the assessment was 32.11 minutes. Neither Miles nor Silas required response prompts on the first three trials of each Readiness Assessment to engage in correct responding. That is, they did not require any prompts to respond correctly to mastered AVCDs on the tablet.

During the Readiness Assessment, June engaged in zero instances of correct-unprompted or prompted responding when a gesture prompt was used for the first three trials.

She engaged in one instance of interfering behavior. June oriented on 100% of trials for the first three sessions (Figure 6).

Figure 5

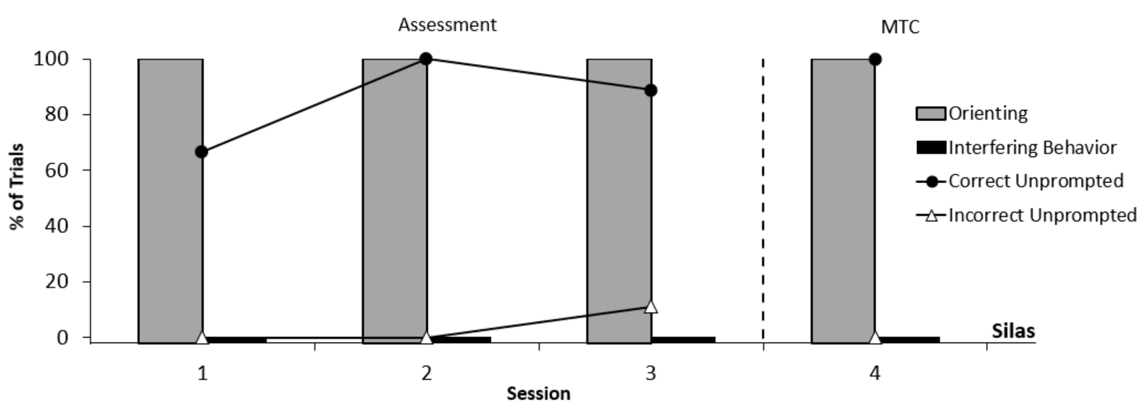
Percentage of Trials with Correct and Incorrect-unprompted Responses, Orienting, and Interfering Behavior for Miles



Note. MTC = maintenance

Figure 6

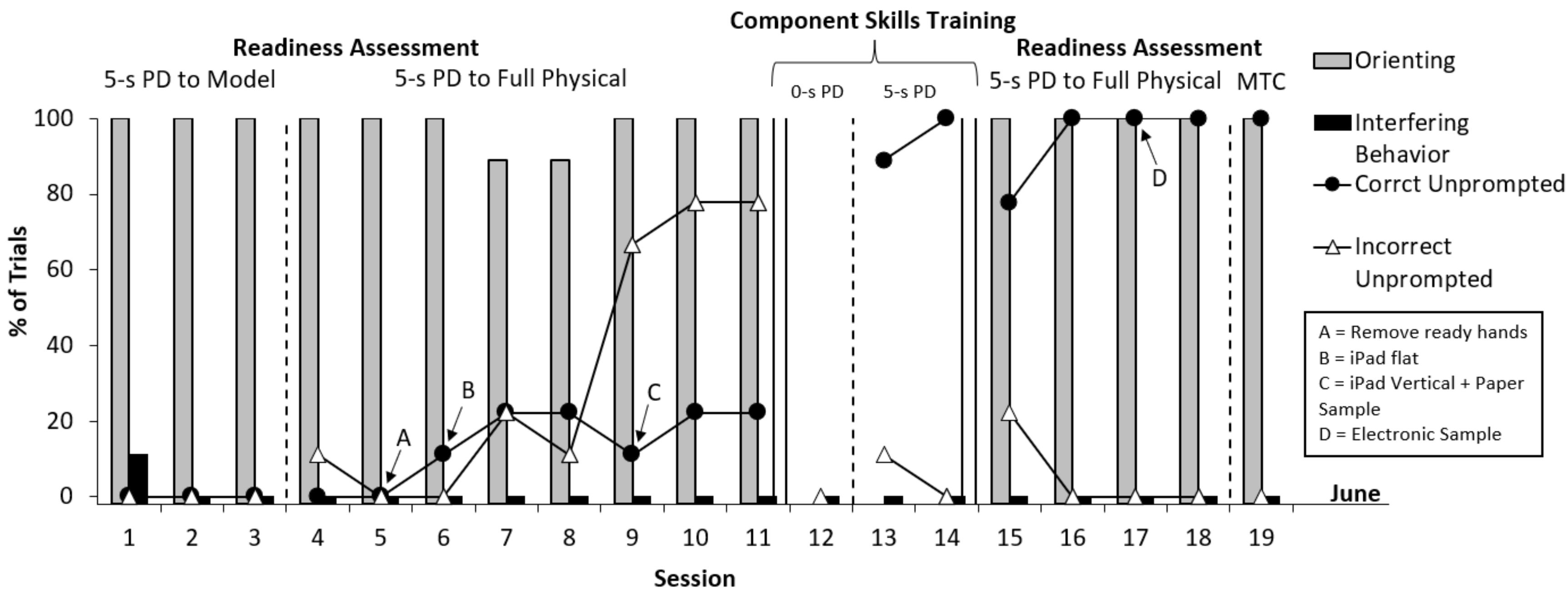
Percentage of Trials with Correct and Incorrect-unprompted Responses, Orienting, and Interfering Behavior for Silas



Note. MTC = maintenance

Figure 7

Percentage of Trials with Correct and Incorrect-unprompted Responses, Correct Prompted, Orienting, and Interfering Behavior for June



Note. MTC = maintenance

When we implemented physical prompts, we observed low levels of correct-unprompted responding. Despite multiple modifications to how we presented the materials, correct-unprompted responding never exceeded 20%. Therefore, we conducted component skills training to first teach June to touch images when presented on the screen. June engaged in 100% correct-prompted responding during the 0s-PD condition (Figure 7). June engaged in 88% unprompted-correct responding during the 5-s PD. Following mastery of this component skill, we returned to the most recent phase of the Readiness Assessment (paper sample stimulus). June met the mastery criterion on the Readiness Assessment with paper sample stimuli in two sessions. In the following two sessions, June met mastery on the with a digital sample stimulus in the slideshow. June maintained mastery-level accuracy in her maintenance session. June did not engage in any challenging behavior during any phase of the Readiness Assessment or component skills training. Total time for June to complete the assessment and component skills training was 143.4 minutes.

Discussion

We designed the Readiness Assessment based on literature that suggested children with ASD may need supplemental training to interact with tablets as instructional devices (Cariveau et al., 2020; Saunders et al., 1997). Miles and Silas both mastered the Readiness Assessment without additional training and engaged in low levels of interfering behavior. June did not pass the initial Readiness Assessment; however, she engaged in high levels of orienting and low levels of challenging or interfering behavior. Several modifications were required before June emitted any prompted or unprompted responding to visual stimuli presented on the tablet. June began engaging in unprompted responding when we introduced the paper sample stimulus; however, she still did not master the Readiness Assessment. This indicated no control by the sample stimulus. Using the strategies recommended by Cariveau et al. (2020), we implemented training to teach her to select an enlarged, visual stimulus when it was presented in isolation on the screen. After June mastered this skill, we reconducted the Readiness Assessment. June's responding met the mastery criteria in the post-training Readiness Assessment. It is possible that component skills training with only one visual stimulus and no sample stimuli increased June's orienting to stimuli on tablet's screen and/or contact with reinforcement for selecting images on the tablet. Most of June's responding on the pre-training Readiness Assessment was incorrect, so we had few opportunities to reinforce touching stimuli on the tablet.

Future research should continue to evaluate the extent to which children with ASD may be able to perform mastered tasks when presented using tablet-based instruction. Two of our three participants responded to mastered stimuli on the tablet without additional instruction. Further research is needed to evaluate pre-requisite skills that may be necessary for a child to participate in and benefit from tablet-based instruction. None of our participants needed training to orient to the screen during instructional trials or reduce interfering or challenging behavior during the Readiness Assessment. This may not be the case for all children; therefore, more research is needed to identify efficacious and efficient training procedures for learners who need individualized instruction to interact with tablets as learning devices.

CHAPTER 4

ASSESSEMENT OF DIGITAL STIMULUS PROMPTS TO TEACH CONDITIONAL DISCRIMINATIONS

Introduction

With the conclusion of the Readiness Assessment (Chapter 3), all participants performed previously mastered AVCDs or visual non-identity matching tasks at mastery levels when presented on the tablet using digital auditory and/or visual stimuli. The final part of our study was to assess the efficacy and efficiency of digital stimulus prompts to teach new conditional discriminations to children with ASD. We compared the most common digital stimulus prompt types identified in the review of children's apps and games (motion and pointing; see Chapter 2).

Method

Participants, Setting, and Materials

The participants and setting were the same as those in the Readiness Assessment. The materials and setting were the same as the Readiness Assessment except for a portion of June's sessions that were conducted in the classroom at her individual desk with two chairs and two partitions to minimize distractions. An additional set of preferred items was identified for June (see Additional Preference Assessment).

All stimuli were presented using Microsoft PowerPoint slideshows. Slideshows for each condition of the prompt assessment had a unique colored background that was visible during all trials and ITI. The colors were identified in a color-preference assessment (described below). Trial slides were programmed to automatically progress to the ITI slide after the child's finger contacted one of the sample stimuli or the response interval passed without a selection. The experimenter programmed a condition-correlated stimulus matching trial at the beginning of every session (see Appendix I). The condition-correlated stimulus was the background color of the slideshow.

Each trial slide displayed an array of three comparison stimuli and played an auditory sample every 2 s (Miles and Silas) or presented a visual sample stimulus above the array (June). Each trial slide was separated by an ITI slide that was blank except for the colored background and a white border approximately .60 cm to indicate the ITI to the child and experimenter (see Appendix I).

Dependent Variables

The dependent variables were the same as the Readiness Assessment except that we did not measure orienting during prompt-assessment sessions. We added data collection on licking for June as it was observed across multiple skill acquisition programs and assessments, including the present assessment. Licking was defined as June's tongue making contact with her hands, fingers, and/or objects or any part of her hands, fingers, or objects passing the lips into the mouth. The mastery criterion for the prompt assessment was 3 consecutive sessions with 8 out of 9 correct-unprompted responses.

The experimenter recorded the session duration in minutes using a digital timer. The timer was started immediately following a correct response to the condition-correlated stimulus. The experimenter counted down from three ("3..2..1..start") and started the timer before the presentation of the first trial. The experimenter timed out of the session by counting down from three immediately following the end of the last reinforcement interval or the last trial if no reinforcement was delivered. We calculated the total duration of the assessment per participant by summing the total duration of all sessions.

Procedural Fidelity and Interobserver Agreement

Procedural fidelity data were collected and calculated in the same manner as in Chapter 3 (see Appendix J for prompt assessment fidelity checklists). We calculated procedural fidelity for 33% of sessions in each experimental phase and 33% of the total number of sessions for each participant. Mean procedural fidelity for Miles was 94.4% (Range, 66.7%-100%). Mean procedural fidelity for Silas was 99.5% (Range, 88%-100%). Mean procedural fidelity for June was 97.3% (Range, 77.8%-100%).

As in Chapter 3, a secondary observer scored the participant's unprompted and prompted responses and the occurrence/nonoccurrence of challenging behavior and interfering behavior on all trials. Exact agreement was used to calculate agreement on all participant responses on every trial for at least 33% of sessions in each experimental phase and 40% (Miles), 35% (Silas), and 41% (June) of the total number of sessions. Mean agreement for Miles was 99.5% (Range, 98.1%-100%). Mean agreement for Silas was 98.8% (Range, 94.4%-100%). Mean agreement for June was 99.1% (range: 97.6%-100%).

As in Chapter 3, a secondary observer scored duration for a portion of sessions for each participant. Total agreement was used to calculate agreement on duration. We calculated total agreement for 57% (Miles), 62% (Silas), and 33% (June) of all sessions. Mean total agreement for Miles was 99.7% (range: 98.5%-100%). Mean total agreement for Silas was 99.8% (range: 97.3%-100%). Mean total agreement for June was 99.8% (range: 97.1%-100%).

Pre-Experimental Procedures

Additional Preference Assessment (June)

We identified additional preferred items for June during the prompt assessment. Three additional free-operant preference assessments were conducted with novel items, and the top five items were included in daily MSWO sessions in the same way as described in Chapter 3.

Color Preference Assessment and Color Matching

Condition-correlated stimuli were used to enhance the discriminability of conditions (Kodak & Halbur, 2021). Condition-correlated stimuli were different colored backgrounds, each condition had a different color, and the colored backgrounds were presented on all presentation slides. To identify the colors used, we conducted two paired-stimulus preference assessments on the tablet.

The experimenter sat next to or across from the child at the table and placed the iPad in front of the child. The experimenter said, “You’re going to pick some colors on the iPad.” The experimenter swiped through a slideshow with pairings of all seven colors (lime green, blue, red, orange, yellow, purple, and fuchsia). On each slide, two colors were presented at a time with each color filling half of the tablet screen. The experimenter said, “Pick one, ” and the child had 5 s to respond. Participants could indicate preference by pointing to, touching, or stating the name of one color (see Appendix K for data sheet). After the participant responded, the experimenter swiped to a black ITI slide. Praise for appropriate session behavior (e.g., “You’re sitting up in your chair! Super job!”) and 1-min access to tangibles were provided on approximately every five trials until all trials had been conducted or until the participant did not make any selections for three consecutive trials. If the participant did not respond for three consecutive trials, the assessment ended.

June did not respond during any trials of the color preference assessment presented on the tablet. We conducted two modified assessments with colored paper stimuli and 3-D colored blocks presented on the table. The instructions, response interval, and discontinuation criteria were the same for both modified assessments. June did not engage in any selection responses. June had responded in previous color preference assessments conducted by her clinical team. In those assessments, June selected red most frequently; therefore, red was eliminated. The remaining six colors were entered into a random generator, and we used the first three colors identified (orange, green, blue) for random assignment to the experimental conditions. Miles selected yellow, blue, and green equally; therefore, one of these three colors was randomly assigned to each experimental condition using a random generator. Silas selected purple most often, therefore, purple was eliminated. Three colors (red, blue, green) were randomly selected and assigned to each experimental condition.

Prior to the study, all participants demonstrated generalized identity and non-identity matching with flashcard stimuli. We conducted color-matching trials on the tablet to confirm that participants could discriminate the difference in background colors across conditions. Stimuli were presented identically to June's Readiness Assessment (sample first with auditory instruction "Match"). Prompting procedures and mastery criteria were identical to the Readiness Assessment. All participants passed color matching.

Stimulus Probes and Selection

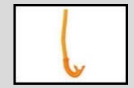
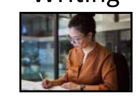
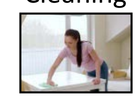
I met with each client's BCBA to determine teaching targets that aligned with their clinical goals. Miles' targets were AVCDs based on feature (i.e., location they could be found), Silas' targets were AVCDs of verbs, June's targets were matching items that go together (e.g., tennis racquet and tennis ball). Three unique stimuli were assigned to each of the three experimental conditions; therefore, 9 targets were taught simultaneously.

To identify visual matching and AVCD targets to which the participants could not respond correctly, we conducted probe trials in 9-trial sessions with 3 stimuli rotated as the S+ three times each until all targets were assessed. We presented pictures using paper flashcards. Targets were eliminated if the number of correct responses to that stimulus was greater than the number of incorrect responses. For example, a target was eliminated if it was selected three times when it was the S+ and two times when it was an S-, but a target was retained if it was selected two times when it was an S+ and two times when it was an S-. This criterion was used because selecting the stimulus equally as both an S+ and S- did not suggest stimulus control. No feedback was provided for correct or incorrect-unprompted responses during probe sessions. We provided praise for on-task behavior (e.g., "You're sitting in your chair. Great!") and tangibles on a VR2 schedule (Schnell et al., 2019). We conducted additional probe trials for any targets that met the initial inclusion criteria to identify generalization stimuli.

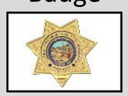
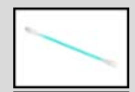
We included all targets that met the inclusion criteria for primary and generalization stimuli in the logical analysis of stimuli sets to identify the stimuli to include in the study (Wolery et al., 2014). I met with my graduate advisor to review the number of syllables, similarity of phonemes, and physical characteristics (e.g., colors, shapes, skin tones, background) of all stimuli. We equated the number of syllables in spoken words across sets and ensured that no words had overlapping beginning sounds (e.g., "park" and "playground") or rhyming words (e.g., "chopping" and "shopping") within sets.

Table 2

Targets for Prompt Comparison for Miles, Silas, and June

Child	Skill	Within-Stimulus Prompt			Extra-Stimulus Prompt			Control		
		Conditional Stimulus	Target Stimulus	Generalization Stimulus	Conditional Stimulus	Target Stimulus	Generalization Stimulus	Conditional Stimulus	Target Stimulus	Generalization Stimulus
Miles	AVCD	"Yard"	Lawn Mower 	Lawn Mower 	"Pool"	Snorkel 	Snorkel 	"School"	Glue 	Glue 
		"Office"	Keyboard 	Keyboard 	"Bathroom"	Comb 	Comb 	"Garage"	Drill 	Drill 
		"Grocery"	Cookie 	Cookie 	"Kitchen"	Pot 	Pot 	"Closet"	Shirt 	Shirt 
Silas	AVCD	"Calling"	Calling 	Calling 	"Chopping"	Chopping 	Chopping 	"Writing"	Writing 	Writing 
		"Singing"	Singing 	Singing 	"Stacking"	Stacking 	Stacking 	"Cleaning"	Cleaning 	Cleaning 
		"Fishing"	Fishing 	Fishing 	"Paddling"	Paddling 	Paddling 	"Mowing"	Mowing 	Mowing 

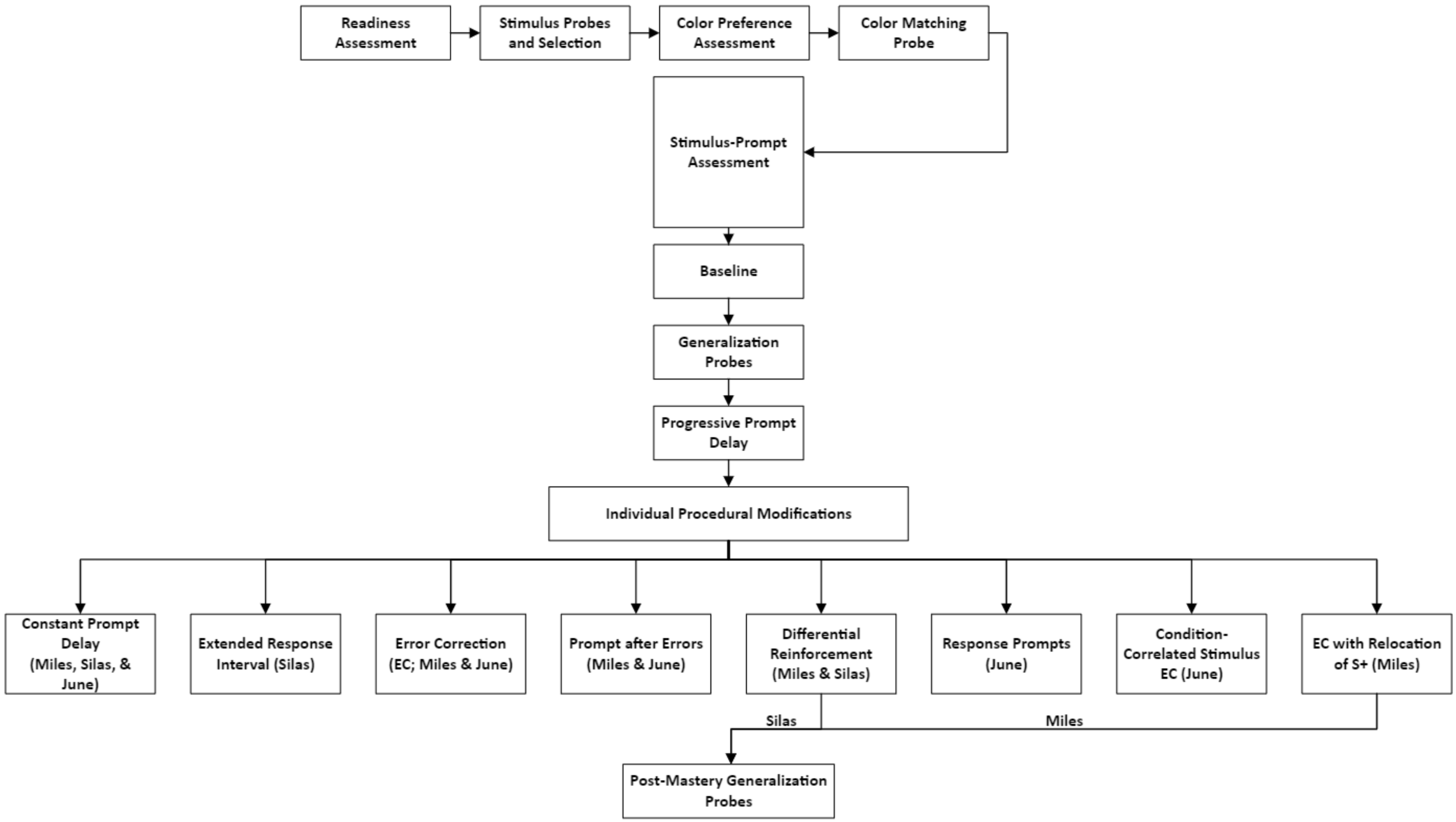
(table continues)

Child	Skill	Within-Stimulus Prompt			Extra-Stimulus Prompt			Control		
		Conditional Stimulus	Target Stimulus	Generalization Stimulus	Conditional Stimulus	Target Stimulus	Generalization Stimulus	Conditional Stimulus	Target Stimulus	Generalization Stimulus
June	VVCD	Bookmark 	Book 	Bookmark and Book  	Cat 	Litter Scoop 	Ambulance and Stretcher  	Map 	Compass 	Map and Compass  
		Snorkel 	Flippers 	Snorkel and Flippers  	Ambulance 	Ear 	Cat and Litter Scoop  	Clothes Pin 	Iron 	Clothes Pin and Iron  
		Police Car 	Badge 	Police Car and Badge  	Cotton Swab 	Stretcher 	Cotton Swab and Ear  	Truck 	Gravel 	Truck and Gravel  

Note. AVCD = Auditory-Visual Conditional Discrimination, VVCD = Visual-Visual Conditional Discrimination (non-identity matching)

Figure 8

Flow Chart of Pre-Experimental Procedures and Experimental Phases for all Participants in the Stimulus Prompt Assessment



Note. Miles and Silas' names are on the line connecting their last phase of intervention to Post-Mastery Generalization Probes to indicate the phase in which their responding met the mastery criterion.

All verb stimuli were gerunds and ended with the sound "-ing". We did not assign visual stimuli to the same set if they had similar general shapes or dominant colors. Images of people were balanced so that each was holding an accessory (e.g., oar for target "paddling"). We balanced sets so that the number of presenting genders across individuals was equated across sets. We used a random generator to assign stimuli to each experimental condition (random.org, n.d.; See Table 2 of target stimuli for each participant).

Experimental Design

We used an adapted alternating treatments design with a no-treatment control condition (Cariveau & Fetzner, 2022; Sindelar et al., 1985). Sessions of the conditions were alternated in a random order, generated from a random number generator, without replacement.

General Procedure

We conducted 3 to 4 sessions per day, 1 to 5 days per week, depending on the child's clinical schedule and attendance (see Figure 8 for a flow chart of all pre-experimental procedures and experimental phases). Breaks between sessions were typically 1 to 2 min. Sessions were conducted by the lead experimenter and an undergraduate research assistant who was trained to implement the procedures with fidelity before conducting sessions with the children.

All preferred items were the same as those identified using the stimulus preference assessments in Chapter 3. During intervention, Miles' reinforcers included general praise ("You got it!") in an enthusiastic tone and 20-s access to a preferred item. Silas' reinforcers included general praise in an enthusiastic tone and 30-s access to a preferred item. June's reinforcers included the word "Good!" with an enthusiastic tone and 30-s access to one of the top three stimuli from the pre-session MSWO. In all conditions, the experimenter started the session by placing the tablet on the table in front of the child and saying, "You're going to work on the iPad." The tablet was placed at approximately a 115-degree angle perpendicular to the tabletop.

The experimenter started the timer as soon as the child engaged in a correct prompted or unprompted response to the condition-correlated stimulus matching trial (except June's Condition-Correlated Stimulus Error Correction). The experimenter then swiped in a horizontal motion using her finger to present the first trial slide. Consistent with his previous programming, Miles was the only participant required to display ready behavior prior to the presentation of the trial slide. We did not require June to display ready behavior because of the observations in the Readiness Assessment that this may discourage her from touching the iPad. Sessions continued until participants met the mastery criteria, which was three consecutive sessions with 8 out of 9 correct-unprompted responses, or until the discontinuation criterion was met, which was the total number of training sessions in an unmastered condition was 25% more than the initial mastered condition's total number of sessions (Schnell et al., 2019).

Baseline, No-treatment Control, and Generalization Probes

Baseline and progressive-prompt-delay procedures were replicated from Schnell et al. (2019). The experimenter presented sample and comparison stimuli on the tablet and waited 5 s for a response (see Appendix L). No prompts were presented. No feedback was provided for correct- or incorrect-unprompted responding. The experimenter collected data and presented the next trial after a brief ITI. To encourage continued participation, descriptive praise for appropriate session behavior (e.g., facing forward, looking at tablet) and access to a preferred item was provided on average every two trials (see Appendix O for data sheet).

Progressive Prompt Delay

0-s PD. During 0-s prompt delay (PD) sessions, the experimenter swiped to present the trial slide. The prompt appeared simultaneously with the comparison stimuli. Similar to Schnell et al. (2019), the participant had 5 s to respond. The slideshow automatically moved to the ITI slide after the participant responded or the response interval passed without a selection. We implemented non-differential reinforcement, meaning praise and access to tangible items was provided for every correct-prompted response. The experimenter collected data during the reinforcement interval or ITI. We increased the prompt delay after two consecutive sessions with 100% correct-prompted responding (see Appendix P for data sheet).

- *Within-stimulus prompt.* The PowerPoint “Teeter” animation was programmed to tilt the S+ image left and right 4 times per second. The animation played for the entire 5-s response interval (see Appendix M).

- *Extra-stimulus prompt.* An animated hand with a pointed index finger was programmed to ascend from the bottom edge of the screen using the PowerPoint “Fly In” animation (see Appendix N). The animation played for .50 s until the tip of the finger met the edge of (Miles and Silas) or partially overlapped (June) the S+. The hand was centered below the S+ and remained for the 5-s response interval.

- *3-s PD*. The 3s-PD procedure was adapted from Schnell et al. (2019). First, the experimenter swiped to present the trial slide. The prompt was delayed by 3 s to provide participants an opportunity to respond independently. The prompt was presented if no selection was made after 3 s. Participants had 5 s to respond to the prompt. We implemented non-differential reinforcement in this phase, meaning praise and access to tangible items was provided after every correct-unprompted or correct-prompted response. No prompts were provided after incorrect-unprompted responses; the experimenter collected data and moved to the next trial. Per Schnell et al. (2019), we implemented a move-back criterion to reduce the prompt delay to 0 s if participants engaged in incorrect-unprompted responses on 5 or more trials.

Procedural Modifications

Constant Prompt Delay (Miles, Silas, and June)

None of the participants engaged in levels of correct-unprompted responding that resulted in multiple consecutive exposures to the 3-s PD condition in the Progressive Prompt Delay phase. With the move back criterion from Schnell et al. (2019), the participants were not exposed to multiple 3-s PD sessions in a row. Thus, they were rarely provided opportunities to engage in unprompted responses. After participants had moved back to 0-s PD at least three times with one of the prompt conditions, we removed the move-back criterion. That is, the participants remained in the 3-s PD phase to try to provide opportunities to engage in unprompted responding. In the Constant Prompt Delay phase, participants experienced the 3-s PD condition described above.

Prompt After Errors and Non-Differential Reinforcement (Miles and June)

With the constant 3-s PD, Miles emitted incorrect-unprompted responses before the 3 s elapsed and did not have an opportunity to experience either stimulus prompt for at least three consecutive sessions. Because of a short latency to respond, June also did contact either stimulus prompt for at least three consecutive sessions during Re-present until Independent Error Correction (described below). The 3-s PD procedure adapted from Schnell et al. (2019) included prompts following 3 s without a response and no prompts following incorrect-unprompted responses. To increase exposures to the prompt and reinforcement for correct-prompted responding, the experimenter programmed the prompt to appear at the end of the response interval (constant PD) *and* incorrect-unprompted responses. The PowerPoint Trigger function was programmed so that the prompt animation began following an incorrect-unprompted response. The experimenter waited 5 s for the participant to respond to the prompt. If the participant engaged in a correct-prompted response, the experimenter delivered reinforcement. We implemented non-differential reinforcement in this phase, meaning praise and access to tangible items was provided after correct-unprompted and prompted responses. If the participant engaged in an incorrect-prompted response, the experimenter went immediately to the ITI or Error Correction.

Re-Present until Independent Error Correction (Miles and June)

Miles continued to respond quickly throughout the Prompt After Errors phase, and June had stopped engaging in any unprompted responding in either prompt condition. When June did engage in unprompted responses, they were almost exclusively to the stimulus in the middle position. Therefore, we implemented re-present until independent error correction (EC). This EC procedure involved re-presenting the same trial after a prompted response until the child engaged in a correct-unprompted response, which increased practice opportunities and programmed for a delay to reinforcement contingent on incorrect responding (Cariveau et al., 2018). June's clinical team had reported success using this EC procedure to facilitate acquisition in previous visual non-identity matching tasks.

Miles was already experiencing Prompt After Errors when Re-present Until Independent EC was put in, therefore, all unprompted-incorrect responses were followed by the presentation of the prompt. Regardless of his response to the prompt, the experimenter moved immediately to the EC trial. Due to the order of modifications for June, we did not provide prompts following incorrect-prompted or unprompted responses; the experimenter moved immediately to the EC trial. On EC trials for both participants, the experimenter used the "Link" tool in PowerPoint by tapping a hidden shape in the top left-hand corner of the screen. Touching the shape moved to the ITI slide that preceded the current trial. The experimenter then swiped forward to re-present the trial. The experimenter re-presented the trial in this manner until the child engaged in a correct-unprompted response or until 10 EC trials had been conducted (Kangas & Branch, 2008; see Appendix Q for data sheet). We implemented non-differential reinforcement in this phase, meaning praise and access to tangible items was provided after a correct-unprompted response regardless of whether it was on the initial trial (first exposure) or on a re-presentation (EC trial). No feedback was provided if the EC cap was met; the experimenter collected data during the ITI and moved to the next initial trial.

Differential Reinforcement (Miles and Silas)

We observed temporary increases in Miles' correct-unprompted responding during Re-present until Independent Error Correction and non-differential reinforcement. However, after four series, Miles stopped engaging in any unprompted responding. Similarly, Silas was not engaging in any unprompted responding during the Extended Response Interval phase (described below). Therefore, differential reinforcement was implemented to try to increase the likelihood of unprompted responses (Gorgan & Kodak, 2019). Miles received praise and 20-s access to a preferred item contingent on correct-unprompted responses on initial trials and praise only following correct-unprompted responses on EC trials. Silas received praise and 30-s access to a preferred item contingent on correct-unprompted responses and praise only following correct-prompted responses.

Error Correction with Relocation of S+ (Miles)

Miles responded so quickly on initial trials and error-correction trials with differential reinforcement that we observed increases in incorrect-prompted responses across both prompt conditions. In addition, we observed no consistent increasing trend in correct-unprompted responding. We implemented Re-present until Independent Error Correction with Relocation of the S+ to increase attending to visual stimuli and prompts across initial and error-correction trials. The experimenter programmed a total of five repeated trial slides with the S+ in a different position across trials. For example, if the S+ was in the left position for the initial trial, it was programmed to appear in any position other than the left on the next EC trial. If more than one EC trial was needed, the S+ never appeared in the same position on consecutive trials. The experimenter swiped through the slides to conduct the error-correction procedure with relocation of the S+. The “Link” tool was used to skip ahead in the slideshow to the next initial trial if at any point Miles engaged in a correct-unprompted response. If more than five EC trials were needed, the “Link” tool was used to repeat the five EC trials until a correct-unprompted response occurred or a maximum of 10 EC trials were presented. Miles received praise and 20-s access to a preferred item contingent on correct-unprompted responses. If Miles reached the EC cap, no feedback was delivered. The experimenter collected data and moved to the next trial.

Extended Response Interval (Silas)

During response intervals in the Constant Prompt Delay phase, we observed that Silas would echo the auditory stimulus repeatedly and hover his finger over or stare in the direction of the S+ without selecting any stimulus. In an effort to increase unprompted responding, we doubled the response interval from 3 s to 6 s (Gorgan & Kodak, 2019). The auditory stimulus repeated at 2 s, 4 s, and 6 s. We implemented non-differential reinforcement in this phase, meaning praise and 30-s access to tangible items were provided after every correct unprompted or prompted response. The prompt was delivered after 6 s. If he engaged in an incorrect-prompted response, the experimenter progressed immediately to the ITI and collected data.

Condition-Correlated Stimulus Error Correction (June)

June began to err during the condition-correlated stimulus matching trial, despite documented generalized identity matching and mastering the color matching pre-assessment on the iPad. We were concerned that these errors may interfere with the discriminability of conditions, therefore, we used Repeat until Independent Error Correction to promote correct-unprompted responding to the MTS trial. If June engaged in an incorrect-unprompted or -prompted response to the MTS trial, the experimenter swiped back to re-present the MTS trial with an immediate full-physical prompt. After a correct-prompted response, the experimenter swiped back again to re-present the matching trial. Error-correction trials were repeated until

June engaged in a correct-unprompted response to the matching trial. No cap was included for matching error-correction trials. After a correct-unprompted response to the matching trial, the experimenter provided praise and presented the first trial of the session.

Classroom Sessions (June)

Over time, we had concerns about June's extended exposure to programs with no or slow acquisition in the individual treatment room. We observed June engaging in high rates of licking, which was suspected to be incompatible with correct-unprompted responding during her time in the treatment room (Figure 12). We began conducting sessions in June's classroom where she spent the majority of her 7-hr treatment day. Sessions were conducted behind two privacy partitions at June's individual desk.

Response Prompts (June)

Following a failure to transfer control from the stimulus prompts, we implemented response prompts to determine whether June would acquire any of the targets presented on the tablet. After the 3-s response interval, the experimenter delivered a gesture prompt by pointing to the correct comparison in the array with her index finger. Re-present until Independent Error Correction was still in effect during this phase. If June engaged in a correct-unprompted or correct-prompted response, praise and 30-s access to tangible items were provided.

Results

To describe the level of correct-unprompted responding emitted by the participants in each phase, we used ranges described in Dube et al.'s (2016) analysis of response patterns in match-to-sample procedures with three-comparison arrays. In Dube et al. (2016), chance-level responding (no control by sample stimuli) was designated as 40% correct which is approximately midway between the score of pure chance (33%) and control by one sample stimulus (55%). Therefore, we describe low levels of correct responding as falling between 0% and 44%, moderate levels as falling between 45% and 77%, and high levels as falling between 78% and 100%.

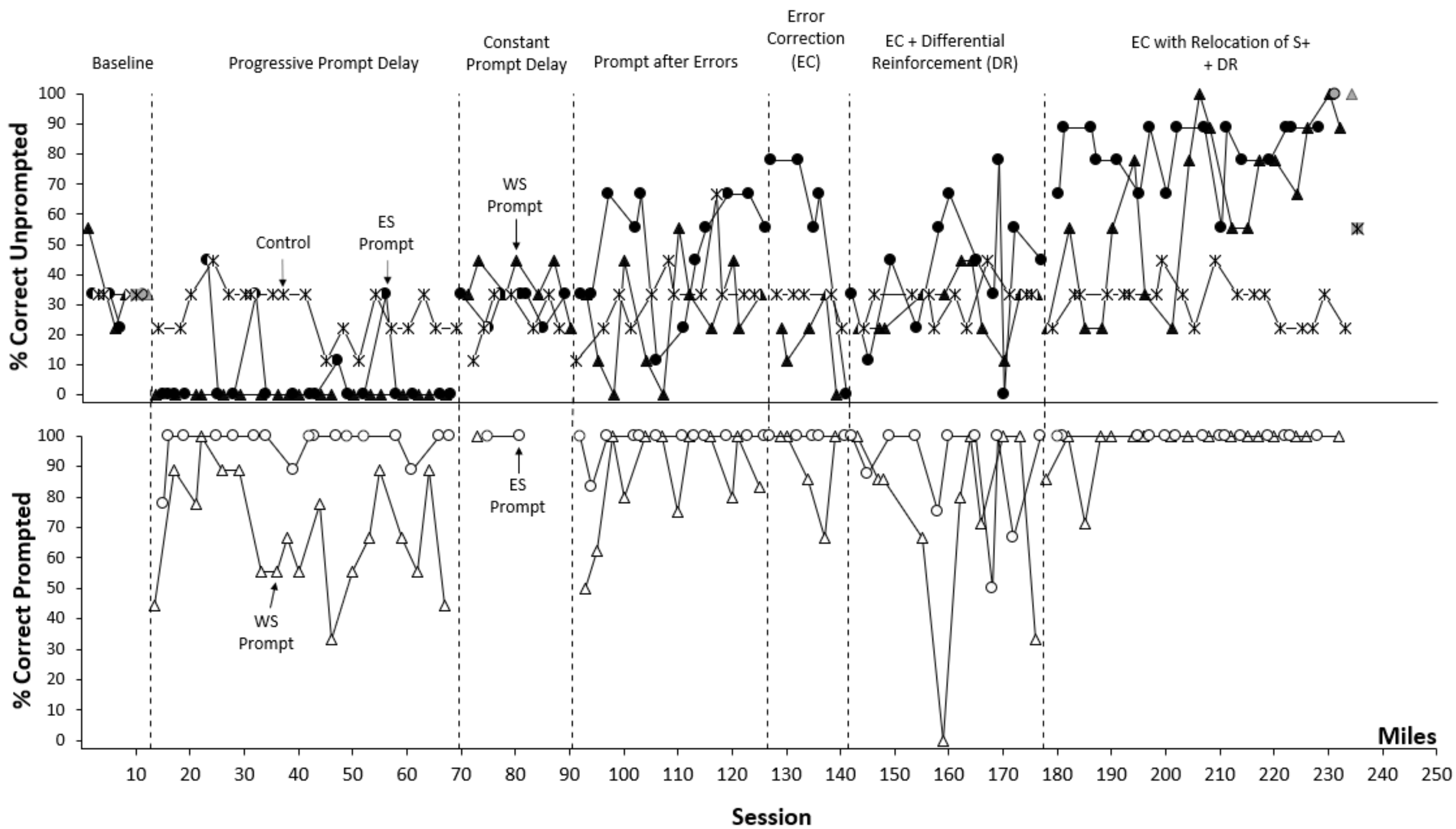
Miles

Data for Miles' correct-unprompted and correct-prompted responding is shown in Figure 9. During Baseline, Miles engaged in low to moderate levels of correct-unprompted responding, never exceeding 55% across all experimental conditions. Correct-unprompted responding to generalization stimuli was 33% across all three experimental conditions.

During the Progressive Prompt Delay phase, levels of correct-unprompted responding in the ES-prompt condition were low, never exceeding 44%. In the WS-prompt condition, correct-unprompted responses remained low, never exceeding 33%. Responses in WS condition never met criteria to increase the PD to 3 s. Correct-unprompted responses in the control condition were low, never exceeding 44%. Miles engaged in high levels of correct-prompted responding to the ES prompt, never falling below 77%. Correct-prompted responding to the WS prompt was variable (range: 33%-100%). The ES prompt condition met criterion to increase to the 3-s PD on four sessions (Sessions 24, 31, 47, and 56). However, the move-forward-and-backward criterion in this phase prevented exposure to the 3-s PD for the WS prompt condition and extended exposure to the 3-s PD in the ES-prompt condition. Therefore, we removed the criterion and implemented a constant3-s PD for both prompt conditions.

Figure 9

Correct-Unprompted and Prompted Responding for Miles



Note. WS = within-stimulus, ES = extra-stimulus. The top panel depicts correct-unprompted responding for Miles across all three experimental conditions. Gray data points indicate responding in generalization probes. The bottom panel depicts Miles' correct-prompted responding for the WS- and ES- prompt conditions.

During the Constant Prompt Delay phase, correct-unprompted responding was low in both prompt conditions, never exceeding 44%. Correct-unprompted responding in control remained low, never exceeding 33%. Miles' latency to respond rarely exceeded 3 s and most of his responses were incorrect; therefore, he only contacted prompts in one WS-prompt session and two ES-prompt sessions. On the rare occasions he contacted prompts, his correct-prompted responding was 100% for both conditions. Infrequent exposure to prompts could prevent transfer of stimulus control to the conditional stimulus and the S+, so we modified the slideshow to prompt after Miles engaged in an incorrect-unprompted response.

During the Prompt after Errors phase, correct-unprompted responding in the ES-prompt condition increased to moderate levels with responding above 45% for seven out of 12 sessions. Despite the level increase, correct-unprompted responding continued to be variable (range: 11%-66%), and we never observed a consistent increase in correct-unprompted responding. Correct-unprompted responding in the WS-prompt condition increased to moderate levels (55%) for one of 12 sessions. Overall, correct-unprompted responding was variable (range: 0%-55%), and we never observed a consistent increasing trend. Correct-unprompted responding in the control condition remained low, never exceeding 44%. Miles engaged in high levels of correct-prompted responding in the ES-prompt condition, never falling below 80%. Correct-prompted responding in the WS-prompt condition was variable (range: 50%-100%). In this phase, we observed that Miles selected the stimulus in the middle of the screen on most trials and responded very quickly. To increase practice opportunities for correct responding and program a delay to reinforcement for incorrect responses, we implemented EC.

During the Error-Correction phase, correct-unprompted responding in the ES-prompt condition increased initially to moderate levels for four sessions before decreasing to 0% correct-unprompted responding. Correct-unprompted responding in the WS-prompt condition was low, never exceeding 33% with the final session at 0% correct unprompted. Correct-unprompted responding in the control condition was low, never exceeding 33%. Correct-prompted responding in the ES-prompt condition was consistently high at 100%. Correct-prompted responding in the WS-prompt condition occurred at moderate to high levels but was variable (range: 66%-100%). In the final sessions of this phase, Miles stopped engaging in any unprompted responding in both prompt conditions. Therefore, we implemented differential reinforcement of correct-unprompted responses in an effort to increase unprompted responses.

During the Error Correction with Differential Reinforcement phase, correct-unprompted responding in the ES-prompt condition increased to moderate levels in four out of 12 sessions. However, responses were variable (range: 0%-77%), and we never observed steady increases in correct-unprompted responding. Correct-unprompted responding in the WS-prompt condition was low, never exceeding 44%. Correct-unprompted responding in the control condition remained low, never exceeding 44%. Correct-prompted responding in both prompt conditions was variable. The range was 50%-100% and 0%-100% in the ES- and WS-prompt conditions, respectively. In this phase, Miles responded quickly on all trials, including EC trials. Quick responding resulted in more errors to both prompt types. To increase attending to visual stimuli in the array across trials, we moved the position of the S+ on EC trials.

During the Error Correction with Relocation of S+ and Differential Reinforcement phase, correct-unprompted responding in the ES-prompt condition increased to moderate and high levels, never falling below 55%. Miles' responding met the mastery criterion the ES-prompt condition after 17 sessions of this phase, 72 intervention sessions total, and 6 hr and 13 min. Correct-unprompted responding in the WS-prompt condition vacillated between low and moderate levels, until an increasing trend was observed when he was near mastery levels with the ES condition. Miles' responding met the mastery criterion in the WS-prompt condition after 19 sessions in this phase, 74 intervention sessions total, and 6 hr and 12 min. The total assessment time was 16 hr and 52 min. Correct-unprompted responding in the control condition remained low, never exceeding 44%. Correct-prompted responding to the ES prompt was consistently 100%. Correct-prompted responding to the WS prompt was 100% for all but two sessions. In generalization probes, correct-unprompted responding was at 100% accuracy in both prompt conditions and 55% in control.

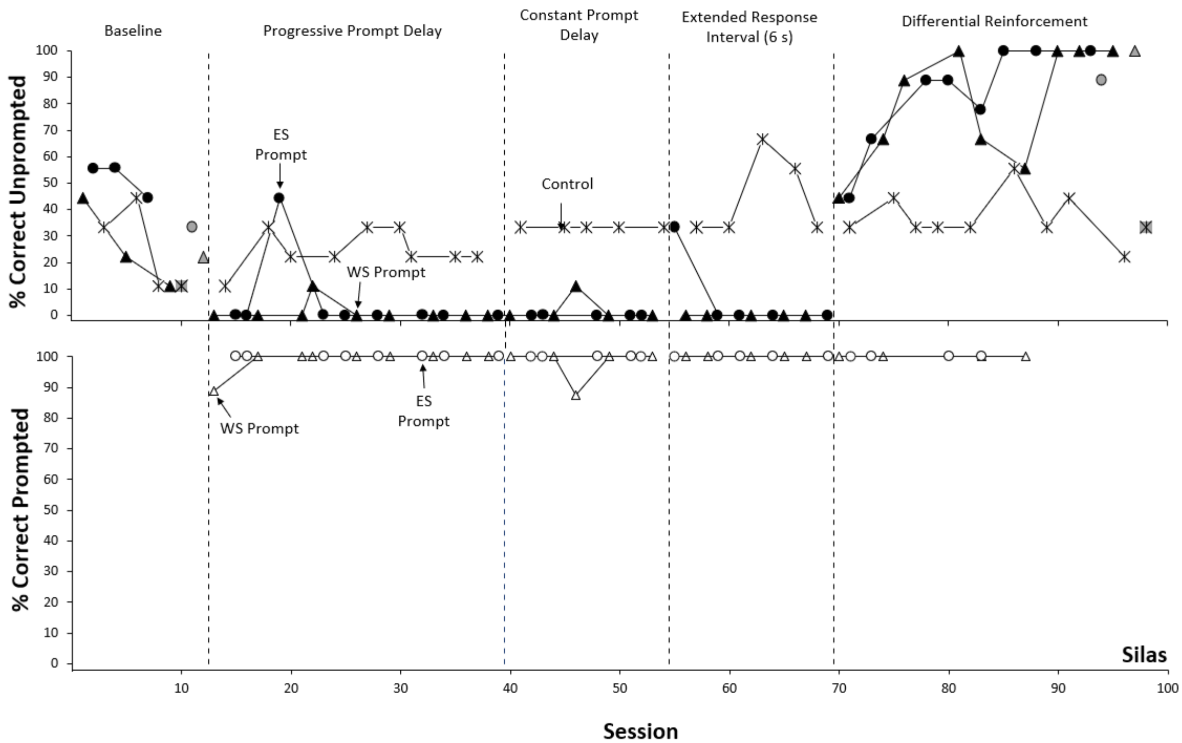
We computed the mean number of trials that Miles engaged in challenging behavior across phases of the study. On average, Miles engaged in challenging behavior on 1% of trials per phase (range: 0%-5% of trials per phase). We also computed the mean number of trials that Miles engaged in interfering behavior across all phases of the study. On average, Miles engaged in interfering behavior on 4% of trials per phase (range: 3%-25% of trials per phase).

Silas

Data for Silas' correct-unprompted and correct-prompted responding is shown in Figure 10**.** During Baseline, Silas engaged in low to moderate levels of correct-unprompted responding, never exceeding 55% across all experimental conditions. Correct-unprompted responding to generalization stimuli was low, never exceeding 33% across all three experimental conditions.

Figure 10

Correct-Unprompted and Prompted Responding for Silas



Note. WS = within-stimulus, ES = extra-stimulus. The top panel depicts correct-unprompted responding for Silas across all three experimental conditions. Gray data points indicate responding in generalization probes. The bottom panel depicts Silas' correct-prompted responding for the WS- and ES- prompt conditions.

During the Progressive Prompt Delay phase, levels of correct-unprompted responding in the ES-prompt condition were low, never exceeding 44%. Levels of correct-unprompted responding in the WS-prompt condition were low, never exceeding 11%. Correct-unprompted responding in the control condition remained low, never exceeding 33%. Correct-prompted responding to both stimulus prompts was high, never falling below 88%. Silas' responding met the move-forward criterion on three and two occasions in the ES- (Sessions 19, 28, 39) and WS- (Sessions 23, 34) conditions, respectively. Similar to Miles, Silas' unprompted responding in the 3-s PD condition never met criteria to experience extended exposure to the 3-s PD in either prompt condition, therefore, we removed the criterion and implemented a constant-prompt delay for both prompt conditions.

During the Constant Prompt Delay phase, correct-unprompted responding rarely occurred in the ES condition (range: 0%-11%) and never occurred in the WS condition because Silas seldom engaged in any unprompted responding. That is, he waited to respond until after the prompt was presented to select any comparison stimulus. Correct-unprompted responding in the control condition was low, never exceeding 33%. Correct-prompted responding to both stimulus prompts was high, never falling below 88%. We observed that Silas would wait for the prompt for the majority of sessions in this phase; Silas would often hover his finger over the S+ during the response interval until the prompt appeared. We implemented an extended response interval to try to increase unprompted responding (Gorgan & Kodak, 2019).

During the Extended Response Interval phase, correct-unprompted responding in the ES- prompt condition was low, never exceeding 33%. Correct-unprompted responding never occurred in the WS-prompt condition Correct-unprompted responding in the control condition was moderate to low, never exceeding 66%. Correct-prompted responding to both stimulus prompts never fell below 100%. Silas continued to wait for the prompt during the extended-response interval, therefore, we implemented Differential Reinforcement to try to increase correct-unprompted responding (Gorgan & Kodak, 2019).

During the Differential Reinforcement phase, we observed a steady increase in correct-unprompted responding in the ES-prompt condition. Silas' responding met the mastery criterion in the ES-prompt condition after 8 sessions of this phase, 27 intervention sessions total, and 3 hr and 5 min. Silas' responding met the mastery criterion in the WS-prompt condition after 9 sessions of this phase, 28 intervention sessions total, and 3 hr and 11 min. The total assessment time was 8 hr and 15 min. Correct-unprompted responding in the control condition never exceeded 55%. During post-mastery generalization probes, correct-unprompted responding was at 88% and 100% in the ES- and WS-prompt conditions, respectively. Generalization probes in the control condition were low at 33%. Silas never engaged in challenging behavior or interfering behavior on any of the trials throughout all phases of the study.

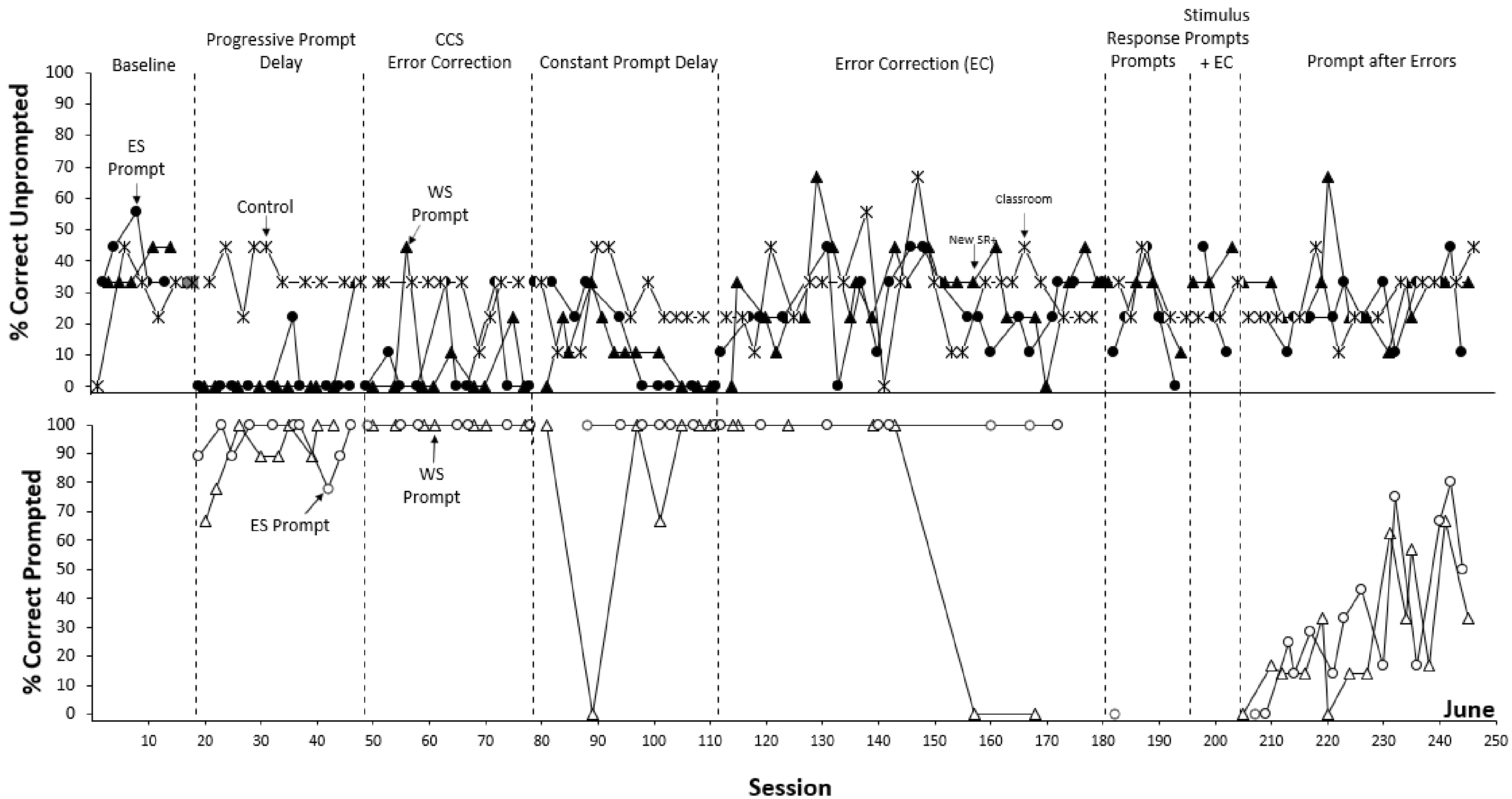
June

Data for June's correct-unprompted and correct-prompted responding is shown in Figure 11. During Baseline, June engaged in low to moderate levels of correct-unprompted responding, never exceeding 55% across all experimental conditions. Correct-unprompted responding to generalization stimuli was low at 33% across all three experimental conditions.

During the Progressive Prompt Delay phase, levels of correct-unprompted responding in the ES-prompt condition were low, never exceeding 33%. Levels of correct-unprompted responding in the WS-prompt condition were low, never exceeding 44%. Correct-unprompted responding in the control condition remained low, never exceeding 44%. June engaged in high levels of correct-prompted responding to the ES prompt, never falling below 77%. June's correct-prompted responding in the WS-prompt condition was initially variable (range: 66%-100%), then increased to consistently high with 100% accuracy after the seventh session. During this phase, we observed June begin to make errors during the condition-correlated stimulus matching trials, therefore, we implemented an EC procedure to try to increase correct responding on the matching trial.

Figure 11

Correct-Unprompted and Prompted Responding for June



Note. WS = within-stimulus, ES = extra-stimulus, CCS= condition-correlated stimulus. The top panel depicts correct-unprompted responding for June across all three experimental conditions. Gray data points indicate responding in generalization probes. The bottom panel depicts June's correct-prompted responding for the WS- and ES- prompt conditions.

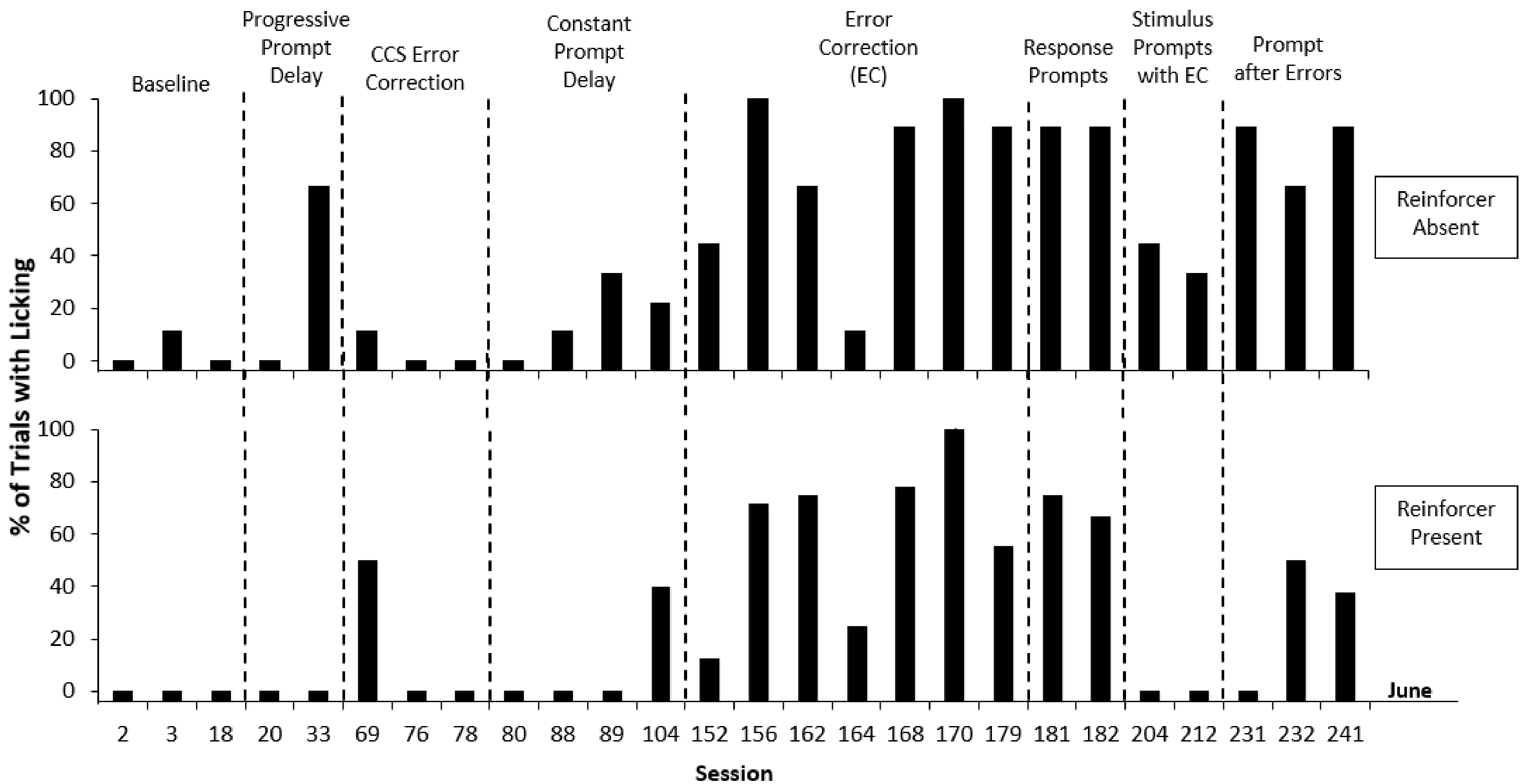
During the Condition-Correlated Stimulus Error Correction phase, levels of correct-unprompted responding in the ES-prompt condition were low, never exceeding 33%. Levels of correct-unprompted responding in the WS-prompt condition were low, never exceeding 44%. Correct-unprompted responding in the control condition was low, never exceeding 33%. Correct-prompted responding across prompt conditions was consistently high, never falling below 100%. During this phase, June was still experiencing the progressive PD procedure. The WS-prompt condition met criterion to increase to the 3-s PD on four occasions (Sessions 47, 56, 64, and 75). The ES-prompt condition also met criterion to increase to the 3-s PD on four occasions (Sessions 36, 53, 63,72). The move-forward-and-backward criterion in this phase prevented extended exposure to the 3-s PD for both prompt conditions, therefore, we removed the criterion and implemented a constant PD for both prompt conditions.

During the Constant PD phase, correct-unprompted responding in the ES-prompt condition was initially low, never exceeding 33%. Accuracy decreased to 0% during the last three sessions. Correct-unprompted responding in the WS-prompt condition was initially low, never exceeding 33%. Accuracy decreased to 0% for the last five sessions. Correct-unprompted responding in the control condition was low, never exceeding 44%. Correct-prompted responding to the ES prompt was consistently high, never falling below 100%. Correct-prompted responding to the WS prompt was variable (range: 0%-100%). Over time, June stopped engaging in any unprompted responding during either prompt condition. We implemented EC to try to increase practice opportunities for responding to the S+ in the presence of the conditioned stimulus and response effort required contingent on waiting for the prompt.

During the Error Correction phase, correct-unprompted responding in the ES-prompt condition was variable (range: 0%-44%) and low; we did not observe a consistent increasing trend. Correct-unprompted responding in the WS-prompt condition was variable (range; 0%-66%), occurring at low to moderate levels, and we did not observe a consistent increasing trend. Correct-unprompted responding in the control condition was low to moderate, never exceeding 66%. June's correct-prompted responding in both prompt conditions was high at 100%. In the middle of the EC phase, we noticed that June appeared less interested in the tangible items we provided during the reinforcement intervals (e.g., not immediately selecting a video on her iPad, rolling marbles but not building the marble maze). We also observed that she had started to engage in high rates of licking as soon as tangible reinforcers were removed (Figure 12). For transfer of stimulus control to occur, correct responding in the presence of the conditional stimulus must be reinforced (Green, 2001); we could not expect this to occur if we did not have effective reinforcers. Based on this, we re-conducted free-operant preference assessments in an attempt to create an establishing operation (EO) to engage in unprompted-correct responding and compete with potential EOs to engage in licking during instructional trials (Michael, 1982; Goh et al., 1995; Vollmer, 1994). We did not see any increase in correct-unprompted responding; June continued to engage in quick unprompted responses which reduced her exposure to the stimulus prompts. We observed June engage in high rates of licking as soon as she entered the treatment room. Therefore, we relocated experimental sessions from an individual treatment room to June's classroom in case a change reduced behaviors that may compete with skill acquisition. This change had no effect on June's correct-unprompted responding in any condition.

Figure 12

June's Licking Behavior in a Sub-set of Sessions per Phase



Note. Ten percent of sessions in each phase were scored. Numbers on the x-axis correspond with session numbers. CCS= condition-correlated stimulus

Correct-unprompted responding in all conditions did not change following the introduction of new reinforcers or the move to the classroom workspace. Although correct-unprompted responding did not differ with these changes, correct-prompted responses in the WS condition decreased markedly from 100% to 0%. Given this, we decided to move forward with trying to teach the target responses with response prompts.

During the Response Prompts phase, correct-unprompted responding in all three experimental conditions was low, never exceeding 44%. The same gesture prompt was used across both prompt conditions. June only contacted response prompts on one initial trial during one session in the ES-prompt condition. Correct responding to the response prompt was 0%. We discontinued this phase when we observed no change in correct-unprompted responding. We decided to go back to the phase that had preceded Response Prompts and then introduce Prompt after Errors.

When we re-introduced stimulus prompts with EC, correct-unprompted responding was low in all three experimental conditions, never exceeding 44%. During the Prompt after Errors phase, correct-unprompted responding in the ES-prompt condition was low and variable, never exceeding 44%. Correct-unprompted responding in the WS-prompt condition was low to moderate and variable (range: 11%-66%). Correct-unprompted responding in the control condition was low, never exceeding 44%. During the first session of each prompt condition, correct responding to both prompts was low at 0%. We observed increases in correct-prompted responding in the ES-prompt condition, however, accuracy was variable (range: 0%-80%) and never maintained at high levels. We observed increases in correct-prompted responding in the WS-prompt condition, however, accuracy was variable (range: 0%-66%) and never reached high levels. We discontinued June's assessment when no consistent increasing trends were observed in levels of correct-unprompted or prompted responding in any experimental condition. June did not reach the mastery criterion any of the conditions, and her total assessment time was 25 hr and 23 min. We recommended that June's clinical team attempt to teach the targets using tabletop instruction with response prompts. This program is currently in progress.

Figure 12 shows the percentage of trials that licking was observed across 10% of sessions for all phases of the assessment. Except for session 33, licking occurred on less than 50% of trials when the reinforcer was present or absent for the portion of sessions observed during Baseline, Progressive Prompt Delay, Constant Prompt Delay. We observed an increase in licking during Error Correction. June was more likely to lick when the reinforcer was absent than when the reinforcer was present. During Error Correction, June engaged in licking on an average of 71% of trials when the reinforcer was absent and 58% of trials when the reinforcer was present. During Response Prompts, June engaged in licking on an average of 88% of trials when the reinforcer was absent and 70% of trials when the reinforcer was present. Upon return to Stimulus Prompts and Error Correction, June engaged in licking on an average of 44% of trials when the reinforcer was absent and 0% of trials when the reinforcer was present. During Prompt After Errors, June engaged in licking on an average of 69% of trials when the reinforcer was absent and 21% of trials when the reinforcer was present.

We computed the mean number of trials that June engaged in challenging behavior across phases of the study. On average, June engaged in challenging behavior on 1.87% of trials per phase (range: 0%-10% of trials per phase). We also computed the mean number of trials that June engaged in interfering behavior across all phases of the study. On average, June engaged in interfering behavior on 1.75% of trials per phase (range: 3%-11% of trials per phase).

Discussion

This study extends the literature on assessment-based instruction to identify efficacious and efficient prompt types, specifically stimulus prompts. Stimulus prompts have resulted in transfer of stimulus control in previous studies, but they may be arduous to implement in practice (Etzel & LeBlanc, 1979; Wolery & Gast, 1984) Therefore, we evaluated digital stimulus prompts in an effort to make stimulus prompts a more accessible intervention strategy. We evaluated the efficacy and efficiency of digital WS and ES prompts to teach conditional discriminations. All participants had goals related to learning conditional discriminations and were recommended for participation in the study by their treatment teams due to challenges fading other prompt types while teaching conditional discriminations (Miles and June) or an interest in using tablet-based instruction with stimulus prompts to teach conditional discriminations and other skills (Silas).

The WS and ES prompts were both efficacious for Miles and Silas to learn one set of conditional discriminations. June did not acquire conditional discriminations in either prompt condition. We closely replicated the procedures of a published prompt assessment to design our own assessment (Schnell et al., 2019). However, we needed to implement several procedural modifications (described below) for all three participants to address individualized patterns of incorrect-unprompted responding.

The WS and ES prompts that we chose to compare could have impacted the outcomes of our study, and the efficacy or efficiency of a stimulus prompt may be dependent on the sub-type used. In our review of the extant literature on stimulus prompts, intensity (e.g., Schreibman, 1975) was the most used WS prompt and point was the most used ES prompt to teach simple and conditional discriminations. To date, we are not aware of any studies that have evaluated the efficacy of motion as a WS prompt, likely because motion prompts can be challenging to deliver without technological support. We are also unaware of any studies that evaluated digital point prompts, either with an arrow or an animated hand. The most common examples of ES point prompts in published research and practice guides describe using the therapist's finger (Arick & Krug, 1978; Cooper et al., 2019, Green, 2001; Mayer et al., 2011; Richmond & Bell, 1983; Schreibman, 1975; Schreibman et al., 1982; Smeets & Streifel, 1990; Strand & Morris, 1988; Summers et al., 1993). We selected digital motion and point as prompts based on the review of children's apps and games in Chapter 2. The prompts that we selected are two of many available digital stimulus prompts (Cooper et al., 2019). Future research should evaluate the efficacy and efficiency of other digital stimulus prompts (e.g., color intensity, light) to teach conditional discriminations. It is also possible that our findings do not apply to the same stimulus prompts presented manually (e.g., manual motion and therapists' finger point). Future research could compare the efficacy and efficiency of the same or different stimulus prompts presented manually if they are feasible to deliver during instruction.

Miles and Silas mastered targets in both stimulus prompt conditions with relatively little differences in efficiency. Miles mastered targets in the ES-prompt condition two sessions prior to the WS-prompt condition, and Silas mastered targets in the ES-prompt condition one session prior to the WS-prompt condition. When multiple procedures are efficacious and similar in efficiency, we can use participant preference to select an intervention best suited for their behavioral intervention. We are prepared to conduct a concurrent–chains preference assessment using the colored slideshow backgrounds as condition-correlated stimuli should the outcomes of Miles and Silas' replications indicate both stimulus prompts are efficacious and similarly efficient (Hanley et al., 1997).

We measured the generalization of skill acquisition to other exemplars of the target stimuli for Miles and Silas. Both boys engaged in high levels of correct-unprompted responding on post-mastery generalization probes. We did not assess maintenance of target skills in our study, nor did we assess the generalization to other stimulus presentations (e.g., paper flashcards, three-dimensional objects, live models). This is a limitation because we cannot say whether either set of targets maintained or whether one prompt type resulted in better maintenance of target responses across time or whether participants were able to demonstrate the same skills with other stimulus presentations. Future studies should evaluate differences in maintenance of skills when stimulus prompts are used to facilitate acquisition (e.g., Wolfe & Cuvo, 1978) and generalization of skills taught using digital stimuli and prompts to other two- or three-dimensional presentations.

Throughout the assessment, we implemented several procedural modifications to address factors that may have been impacting acquisition. These included infrequent exposures to the prompt delay, infrequent exposures to the prompts, infrequent exposure to reinforcement, prompt dependence, and the indiscriminability of intervention conditions. Below we describe the participant-specific modifications we made to the original procedure we used from Schnell et al. (2019).

Changing Progressive Prompt Delay to Constant Prompt Delay

We began intervention for all participants with the progressive PD procedure outlined by Schnell et al. (2019), but none met the mastery criterion in this phase. Progressive Prompt Delay procedures typically begin with immediate (0 s) prompts to facilitate correct responding and exposure to reinforcement for correct responding. Prompts are systematically faded across time (e.g., 3 s, 5 s) to provide an opportunity to reinforce unprompted responses (MacDuff et al., 1996; Wolery & Gast, 1984). In conditional discriminations, reinforcement for correct prompted responses to the S+ in the presence of the conditional stimulus should facilitate transfer of stimulus control from the prompt to the conditional stimulus as the prompt delay increases and the participant is given an opportunity to respond without the prompt. Frequent errors when the prompt is delayed are typically followed by a decrease in the PD to re-establish a history of reinforcement for correct responding (Wolery & Gast, 1984).

During the progressive PD phase, none of the participants could meet the criteria set (unprompted-correct responding greater than or equal to 55%) to stay at the 3-s PD. Participants either emitted inconsistent correct-unprompted and prompted responses (Miles and June) or were not emitting any unprompted responses (Silas). Because of this, participants experienced frequent switching between 0-s and 3-s PD. We were concerned that extended exposure to the 0-s PD could create prompt dependence, therefore, we implemented a constant PD. Constant PD has been shown to be an effective procedure to promote unprompted responding and transfer stimulus control with and without procedural modifications (Wolery et al., 1992). No participants acquired the target skills during the Constant Prompt Delay phase. Both Miles and June engaged in frequent incorrect-unprompted responses in the Constant Prompt Delay condition. For June, this persisted into the Error Correction phase also. Miles and June's frequent unprompted-incorrect responding resulted in infrequent exposure to the prompts because during Constant Prompt Delay, the prompts were only presented if the response interval elapsed without a response as in Schnell et al. (2019).

Incorrect-unprompted responses may have persisted due to the probability of reinforcement for chance-level responding (33%). However, due to the infrequent exposure to reinforcement in the Constant Prompt Delay phase, the contingencies Miles and June experienced may have been more similar to Trial-and-Error instruction during which reinforcement is provided for unprompted-correct responses and no feedback is provided for unprompted incorrect responses. Trial-and-Error has been shown to be an ineffective or inefficient intervention procedure to teach conditional discriminations for many learners with ASD (O'Neill et al., 2018; Schilmoeller et al., 1979). This is likely because in order to transfer control from prompts to the intended S+, the learner needs to experience repeated reinforcement for correct-prompted or unprompted responding in the presence of the S+.

Increasing Exposure to Prompts

In the procedure that we replicated from Schnell et al. (2019), prompts were only delivered if the participant did not respond during the response interval. If the participant engaged in an unprompted-incorrect response, the slideshow immediately moved to the ITI, and no prompts were delivered. We were concerned because this procedure had resulted in infrequent contact with the prompts for both Miles (end of Constant Prompt Delay) and June (end of EC and during Response Prompts). Therefore, we modified the procedure to diverge from Schnell et al.'s (2019) arrangement to present prompts following unprompted-incorrect responses (Prompt after Errors phase). Miles and June both had a history of prompts being presented following incorrect-unprompted responses in other skill acquisition programs.

For Miles, we observed moderate increases in correct-unprompted responses, however, quick unprompted responses persisted. It is likely that this pattern of responding persisted because responding was reinforced by access to the prompt. At this point, we were still implementing non-differential reinforcement, and Miles did not need to observe the stimuli nor respond correctly without a prompt to earn tangible reinforcers. When we implemented this change for June, correct-prompted responding to both stimulus prompts was low. This may have been due to the amount of time that had passed since June had been exposed to the stimulus prompts and her recent history in this context with response prompts. We observed an increase in correct-prompted responding with repeated exposure to the prompts; however, we never regained 100% correct-prompted responding. Ultimately, we concluded the assessment when correct-prompted responding to both stimulus prompts decreased. We could not expect transfer of stimulus control without an effective prompt (Green, 2001).

Increasing Exposure to Conditional Stimulus and S+

We observed Miles engage in quick, unprompted responses during Prompt after Errors. He often responded with such short latencies that the conditional stimulus (auditory sample) hadn't finished playing all the way through. We suspect that this was because unprompted-incorrect responses now resulted in presentation of the prompt and subsequent non-differential reinforcement for correct-prompted and unprompted responding. This response chain, coupled with short latencies to respond that made attending to stimuli in the comparison array unlikely, ultimately hindered skill acquisition. Therefore, we implemented Remove and

Re-Present Error Correction. We wanted to establish joint control by the conditional stimulus and S+ by increasing practice opportunities for correct-unprompted responses. Additionally, we wanted to program a delay to reinforcement contingent on unprompted-incorrect responses (Cariveau et al., 2018; Kangas & Branch 2008). Initially, we observed the highest levels of unprompted-correct responding yet for Miles, however, the effects did not maintain, and Miles stopped engaging in any unprompted responding. We suspect that the EC procedure did not strengthen control by the conditional stimulus to respond to the S+, therefore, correct-unprompted responses were unlikely to occur. Instead, incorrect-unprompted responses resulted in the stimulus prompt and EC trials. Rather than engaging in unprompted responses, Miles began waiting for the prompt on initial trials. This behavior was likely reinforced by access to the prompt. On subsequent EC trials, Miles could respond correctly based on the position of the prompt on the initial trial and contact reinforcement relatively quickly because this phase was in non-differential reinforcement.

During the Constant Prompt Delay phase, June engaged in frequent unprompted-incorrect responses and eventually stopped engaging in any unprompted responding. June did not emit any unprompted responses for the last three sessions of either prompt condition. We suspected that this occurred due to the non-differential reinforcement reinforcement contingency in the Constant Prompt Delay Phase. In consultation with June's clinical team, we decided to implement Error Correction. We made this modification rather than implementing differential reinforcement because June engaged in overselective responding to stimuli in the middle position on earlier sessions in the Constant Prompt Delay phase, in the control condition, and in other discrete-trial programs. We were concerned that differential reinforcement would exacerbate overselective responding to the middle position (Kangas & Branch, 2008).

When we introduced EC, we observed an increasing trend in correct-unprompted responses in the WS-prompt condition, however, it did not maintain. After session 134, June was absent from clinical sessions for about a week due to illness, and we noticed she was engaging in high rates of licking upon her return. Her clinical team reported this behavior also occurred throughout her day at the center regardless of activity (e.g., other discrete-trial programs, naturalistic instruction). During our assessment sessions, licking occurred most often when tangible reinforcers were not present (Figure 12). Occasionally June also licked toys when they were handed to her at the beginning of the reinforcement interval. We did not conduct a functional analysis of licking. At the time of this assessment, June's clinical team was conducting functional assessments on licking. Licking may have persisted during trials in the Error Correction phase because the time between reinforcement intervals increased as June continued to engage in incorrect-unprompted responses. The mean session length during the Error Correction phase was 9 min 57 s as compared to the Constant Prompt Delay phase which was 5 min 33 s.

Prompt Dependence

At different points during the assessment Miles (end of Remove and Re-Present Error Correction) and Silas (Constant Prompt Delay) were not engaging in any unprompted responding. Rather, they waited through the response interval for the presentation of the prompt. This pattern of behavior is indicative of prompt dependence. Prompt dependence has been defined as a response pattern in which the learner consistently waits for the prompt rather than responding independently (Oppenheimer et al., 1993), and response patterns in which the learner requires a prompt on at least 80% of response opportunities (Gorgan & Kodak, 2019). Interestingly, both boys did not wait through the response interval in the control condition. This pattern of responding was detectable through the inclusion of a no-treatments control condition in the adapted-alternating treatments design where a history of no prompts had been established. This suggests that the condition-correlated stimulus matching trials and the condition-specific colored background in the control condition exerted some control over unprompted responding in the control condition.

Before we implemented Differential Reinforcement for both boys, we implemented an Extended Response Interval for Silas. We did this first because we were concerned that implementing differential reinforcement when his correct-unprompted responding was 0% might result in infrequent contact with reinforcement. Further, we had observed EC reduce unprompted responding to zero-levels for Miles, and we wanted to avoid exacerbating prompt dependence for Silas. Therefore, we implemented Extended Response Interval. Extended Response Interval is a recommended procedure for remediating prompt dependence (Gorgan & Kodak, 2019). Silas' only engaged in one instance of unprompted responding during one of five ES-prompt sessions in the Extended Response Interval phase, so he continued waiting for the prompt during ES- and WS-prompt sessions of Extended Response Interval. We also observed Silas hover his finger over and/or stare at the S+ with close facial proximity during the response interval on many trials. Based on this, we suspected that Silas could respond correctly without a prompt if the reinforcement contingency favored unprompted responses.

We implemented Remove and Re-Present Error Correction with Differential

Reinforcement for Miles and Extended Response Interval with Differential Reinforcement for Silas. Differential reinforcement involves arranging for reinforcement of responses that meet specified criteria, and it is a recommended procedure to facilitate independent skill acquisition when learners are observed to wait for prompts (Cooper et al., 2019; Gorgan & Kodak, 2019; Neef, 1994). Different dimensions of reinforcement may be provided for responses that meet criteria versus those that do not. In this case, we programmed for a higher quality of reinforcement of unprompted-correct responses. Miles and Silas received praise only for correct-prompted responses and praise with tangible reinforcers for correct-unprompted responses.

In Differential Reinforcement, Miles' correct-unprompted and prompted responses were variable in both prompt conditions, and short latencies to respond persisted across initial and EC trials. We suspected that Miles was still not attending to the S+, but instead he was tracking the position of the prompt to which responding was negatively reinforced by the end of the present trial. To remediate this, we implemented Error Correction with Relocation of the S+ with Differential Reinforcement. We programmed error-correction trials so that the S+ never appeared in the same position as it had on the previous trial (initial or error correction). This required Miles to track the position of the S+ across trials, rather than respond in the position in which he had last seen the prompt. Miles' responding met the mastery criteria in the ES-prompt condition followed by the WS-prompt condition one session later. In Extended Response Interval with Differential Reinforcement, Silas' responding met the mastery criteria in ES-prompt condition followed by the WS prompt condition one session later.

Discriminability of Conditions

During the Progressive Prompt Delay phase, June began to error on the condition-correlated stimulus matching trial. We were concerned that this could interfere with the discriminability of conditions, therefore, we added EC to the matching trial. With this change, we observed a return to correct-unprompted responses on the matching trial. We also observed increases in correct-prompted responding in both prompt conditions, but no increase in correct-unprompted responding in either prompt condition. Increases in correct-prompted responding may have been the result of extended exposure and/or increased attending to comparison stimuli following EC in the matching trial.

Change from Stimulus to Response Prompts

When we did not observe any change in responding in either prompt condition for June, we suspected that stimulus prompts and/or tablet-based instruction were not efficacious interventions for her. We decided to try to teach the target skills using tablet-based instruction and response prompts. June had a history of successful acquisition of other visual conditional discriminations with response prompts (gesture prompts delivered by the therapist) using paper flashcards and tabletop instruction. If June had successfully acquired the targets in this phase, we may have evidence that stimulus prompts were ineffective for her, but tablet-based instruction may still be a viable option. However, June did not acquire targets in this phase. She continued to engage in incorrect-unprompted responses on initial trials, which meant that her exposure to the response prompts was less frequent and often occurred primarily on EC trials.[2]

[2] Figure 11 displays correct-prompted responding on initial trials only. June also contacted response prompts on error-correction trials during this phase.

However, we did not observe any increase in correct-unprompted responding in any condition.

General Findings

Our results differ from existing comparisons of WS and ES prompts (see Cengher et al., 2018, for a review of comparison studies). Previous studies indicate that WS prompts are more likely to transfer control to S^Ds more often than ES prompts (e.g., Schreibman, 1975; Wolfe & Cuvo, 1978). It has been suggested that this may be because the WS prompt involves enhancing or exaggerating the S+, whereas the ES prompt presents some additional stimulus to which the participant needs to attend (Etzel & LeBlanc, 1979; MacDuff et al., 1996; Rincover, 1978). ES prompts may promote attending only to the prompt and hinder attending to relevant features of the S+. In order for either prompt to be effective, they need to be “obvious” or salient so that they promote correct-prompted responses (Etzel & LeBlanc, 1979). Data from all three participants’ correct-prompted responding (bottom panel of Figures 9, 10, 11) indicate that they were more likely to respond correctly to the ES prompt as compared to the WS prompt. We suspect that this may have been because the ES prompt was more salient than the WS prompt. The ES prompt was a white gloved hand which contrasted with the colored background of the tablet screen. Additionally, the ES prompt rose up from the bottom of the screen below the S+ using an animation. Participants needed only to attend to the area below the comparison array to locate the prompt. In contrast, the WS prompt involved movement of the S+ which was only detectable by scanning the three-comparison array. This arrangement may have promoted repeated scanning of all stimuli in the array to observe the motion prompt. The efficacy of this ES prompt may also differ from published studies because previous comparisons (e.g., Schreibman, 1975) often only used the experimenter’s hand pointing to the S+ stimuli from across a table. It may be that when point prompts are delivered by another person the learner is more likely to attend to that person's body orientation than the comparison array. Additionally, the experimenter's hands are likely paired with other events such as delivery of reinforcers or data collection, and therefore are S^Ds for a variety of behaviors for the learner.

We used the same prompt-fading procedure across stimulus prompt type. This also impacted our results and limits the conclusions of our study. Most comparative studies on stimulus prompts employ prompt-specific fading procedures (Etzel & LeBlanc, 1979). For example, Schreibman (1975) faded the WS prompt by intensity and faded the ES prompt (point) by distance to the S+. However, Wolery et al. (1988) recommends using a prompt-delay procedure over stimulus fading to fade stimulus prompts because they require less time and effort to implement. The type of prompt-fading procedure may impact whether or not stimulus control is successfully transferred. We do not know how acquisition may have been impacted if we had faded prompts differently (e.g., faded motion prompt by the angle of the teeter and point prompt by distance to S+). Like Schnell et al.'s (2019) prompt assessment, we used the same prompt-fading procedure across conditions because the purpose of our assessment was to evaluate the efficacy of the WS and ES prompts themselves rather than specific fading procedures. Schnell et al. (2019) conducted a separate prompt-fading assessment at the conclusion of the prompt assessment and identified that the same fading procedure (least-to-most) was efficacious for all participants. The Progressive Prompt Delay used in Schnell et al.'s (2019) prompt-fading assessment was efficacious for two of the three participants but was never the most efficient fading procedure. Both Miles and Silas' assessment outcomes demonstrated successful fading by time and suggest that delay fading may be an efficacious procedure to fade stimulus prompts with some learners. This could be a fruitful avenue for future research to evaluate the efficiency of material preparation when stimulus prompts are faded by time compared to some physical dimension of the prompt (e.g., size).

Participant-specific learning histories should also be considered when interpreting the results of the assessment. Recent exposure to certain prompt types has been shown to impact their efficacy (Coon & Miguel, 2012; Roncati et al., 2019). Both Miles and Silas had a recent history of responding to stimulus prompts in apps and games with which they interacted. This included some of the games they played during assessment reinforcement intervals. Miles interacted with games that used point prompts, and Silas interacted with games that used color intensity prompts. It is possible that history with these prompts made correct-prompted responding more likely and supported the transfer of stimulus control. June did not have any known history of responding to stimulus prompts presented in apps and games. In fact, we observed June failed to respond to stimulus prompts delivered by at least two games during reinforcement intervals in the final phase of the study. When June needed help interacting with the game, she grabbed the experimenter's hand and moved it to the tablet screen. Understanding a learner's history with certain prompt types and how those might impact the results of an instructional assessment is an important consideration for BCBAs. If familiar interventions are included in an assessment, learners may perform better due to recency and a history of differential reinforcement for responding to the prompt. All three participants had a history of acquisition of conditional discriminations with response prompts and tabletop instruction, but none of the participants in this study had a history of instruction with either of the stimulus prompts included in the assessment. Future studies on digital stimulus prompts may consider conducting a formal survey of the apps and games individual participants are known to engage with to inform their selection of prompts and strengthen the ecological validity of the assessment.

Few studies on skill-acquisition assessments have reported the total time it took to complete the assessment (Schnell et al., 2019). We calculated the total time to complete the prompt assessment for all three participants. This did not include the time to complete the pre-experimental procedures such as the color preference assessments and baseline sessions. Miles' assessment took 16 hr and 52 min, Silas' assessment took 8 hr and 15 min, and June's assessment took 25 hr and 23 min. This is significantly longer than the duration of assessments in other studies (e.g., Schnell et al., 2019). The length of the assessment may be attributed to the number of targets we attempted to teach at a time because all participants had a history of acquisition with four or fewer targets at once. Additionally, we alternated between multiple interventions to teach similar target skills using the adapted-alternating treatments design. All participants had a history of exposure to a single intervention at a time. Although three targets were assigned to specific prompt conditions with condition-correlated stimuli, the nature of the adapted-alternating treatments design creates the possibility of multiple treatment interference (Cariveau et al., 2022).

Despite the length, the time investment may be warranted for learners like Miles who had significant challenges acquiring conditional discriminations with response prompts. Schnell et al. (2019) call for more research aimed at improving the efficiency of instructional assessments because length of an assessment could understandably deter clinicians from implementing assessment-based instruction. For example, Carroll et al. (2018) used an abbreviated assessment to identify efficacious and efficient EC procedures for children with ASD and developmental delays. They concluded the assessment before the mastery criterion was reached. In the assessment validation phase, they taught additional targets using each procedure from the assessment while comparing rates of acquisition. Results of the validation phase indicated that the abbreviated assessment data predicted the most efficient procedure for two of four participants. Future research should seek to identify ways that assessments can be shortened and evaluate them. One way that we may have been able to improve the efficiency of our assessment would be if we had incorporated intervention components with which the individual learners had a history of acquisition from the start (e.g., Error Correction and Prompt after Errors for Miles and June). Further, we do not know whether some or all the modifications we combined for Miles or Silas were necessary for acquisition. For example, we do not know if Silas would have acquired the target skills with differential reinforcement only and not the Extended Response Interval with differential reinforcement. The lack of intrasubject replication is also a limitation of this study. We are currently in progress replicating the assessment with Miles and Silas using the final phase of intervention from the present assessment.

Miles and Silas had a history of successful skill acquisition across programs and were generally responsive to commonly-prescribed behavioral interventions. Miles engaged in some problematic patterns of responding during programs with response prompts as reported by his clinical team. The outcomes of Miles and Silas' assessments provide information about digital stimulus prompts that are efficacious for them and may be used to teach conditional discriminations. These outcomes may also be indicative of success with other tablet-based skill-acquisition programs. Finally, the individual procedural modifications and their effects on Miles and Silas' responding provide information about other behavioral-intervention strategies that may support skill acquisition and reduce prompt dependence (e.g., Error Correction with Relocation of S+ for Miles). The results of June's assessment are less clinically informative. The outcomes suggest that her clinical team should not pursue using tablet-based instruction to teach any skills because June was not able to master non-identity visual matching targets on the tablet, however, she had acquired similar skills in tabletop instruction with flashcards. June's outcomes also shed some light on those learners for whom assessment-based instruction may not be beneficial. Specifically, June's rate of acquisition with other DTI programs was slow relative to other learners with ASD, she was absent frequently from intervention sessions, and she often demonstrated positional biases. Behaviors such as licking were occurring throughout intervention sessions and may have interfered with skill acquisition. Future research should continue to identify learners for whom assessment-based instruction may be beneficial and the conditions under which assessments to identify learner-specific behavioral intervention strategies may be indicated (Kodak & Halbur, 2021).

CHAPTER 5

GENERAL DISCUSSION

Digital stimulus prompts were efficacious for two of our three participants as they learned conditional discriminations using tablet-based instruction. Using tablet-based instruction and digital stimulus prompts allowed us to program using motion as a WS prompt and an animated point as an ES prompt in our assessment. Without the automation of Microsoft PowerPoint or similar software, these prompts may have been arduous or even impossible to implement. Manual motion prompts would require the therapist to maintain continuous movement of the S+ during the response interval while managing the other parts of the trial (e.g., data collection). Similarly, an animated point prompt would require additional materials to those used for the program. PowerPoint has many other options for emphasizing, exaggerating, and embedding stimuli or timing animations (e.g., motion, flash of light) of stimuli. It may also be a more cost-effective software compared to others that are designed to present computer or tablet-based conditional discrimination tasks (Ellington et al., 2023). This study extends the literature on stimulus prompts by including examples of more flexible, digital stimulus prompts. Miles and Silas' assessment outcomes demonstrate their efficacy for some learners. Future research should continue to evaluate the efficacy and efficiency of different types of digital WS and ES prompts to teach conditional discriminations because successful stimulus control transfer and/or differences in time to mastery may depend on the prompt sub-type used.

Previous publications have defined WS and ES prompts by the stimulus feature(s) they manipulate and whether those features should control responding in the terminal discrimination. Specifically, WS prompts have been described as criterion-related or distinctive feature prompts because they may be designed to manipulate features of the stimulus relevant to the discrimination task (Barthold & Egel, 2001). For example, if an exaggerated size prompt (WS) is used to teach a size discrimination task. ES prompts have been described as non-criterion because the prompt is unrelated to any feature of the terminal discrimination (Etzel & LeBlanc, 1979; Schillmoeller & Etzel, 1977). For example, if an arrow is used to teach a size discrimination task. The stimulus prompts we chose for the assessment were based on the survey of children's apps and games in Chapter 2. The most common prompts identified in the survey are indicative of the digital prompts children may be experiencing in other contexts. However, it is important to mention that the prompts used in the present study would both be considered non-criterion related, and this may have impacted the outcomes of our assessments. Additionally, the distinction between criterion and non-criterion-related prompts should be used with caution as the experimenter may incorrectly identify the stimulus features that exert control over responding in the terminal discrimination (Deitz & Malone, 1985; Rincover, 1978). Future research could consider evaluating what may be criterion versus non-criterion-related prompts and how those prompts, as defined by the experimenter, compare in facilitating stimulus control transfer (e.g., Strand & Morris, 1988).

We were able to successfully fade digital stimulus prompts using a prompt-delay procedure. This finding is important because most stimulus prompts are not used in behavioral intervention due to the time-consuming and complicated task of developing and implementing a prompt-specific fading procedure (Etzel & LeBlanc, 1979; Wolery & Gast, 1984; Wolery et al., 1988). Future studies should continue to evaluate the efficiency and feasibility of programming using digital stimulus prompts and delay-fading procedures. We implemented the prompt-delay procedure using timed animations in Microsoft PowerPoint, which meant that the experimenter did not need to time any prompt delays or manipulate materials to present or remove prompts. Automation of some intervention components is a potential benefit of tablet-based instruction because it means that therapists can allocate their behavior to other parts of the session (e.g., data collection, interacting with the child; Cummings & Saunders, 2019; Cariveau et al., 2020). Automation may also reduce the possibility of procedural-fidelity errors in delivering behavioral interventions. Descriptive assessments of procedural fidelity in behavioral intervention show that prompts are often delivered with much lower integrity compared to other components of intervention (e.g., presenting S^Ds; Carroll et al., 2013; Kodak et al., 2018). Automation may reduce the possibility for error on this step. PowerPoint can also be used to automate other components of interventions that are frequently implemented with reduced fidelity (e.g., consequence delivery; Mittelman, 2023) Future research should evaluate the effects of automated intervention components on procedural fidelity and conduct social-validity surveys to determine therapist preference for digital materials and/or automated program components.

We created three to four sets of materials per participant to conduct baseline and the prompt-delay sessions, and we used slideshow templates to increase the efficiency of material preparation. The customizable features of PowerPoint also permitted us to program using some best-practice recommendations for using AATDs and teaching conditional discriminations. For example, we were able to program automated condition-correlated stimuli, present consistent auditory stimuli using recordings, counterbalance positions of the S+ and S-, and program participant-specific antecedent stimulus presentation orders (Green, 2001; Grow & LeBlanc, 2013; Kodak & Halbur, 2021). Some recent practical tutorials provide further guidance and examples of ways that digital slideshows may be customized to deliver customized behavioral interventions (Bergmann et al., 2021; Mattson et al., 2020; Cummings & Saunders, 2019). We are not able to report the time that it took the lead experimenter to prepare materials for the assessment; however, future research should evaluate the efficiency of creating digital intervention materials as compared to traditional tabletop materials. Additionally, more research is needed on the efficacy of tablet- and computer-based instruction to facilitate skill acquisition for learners with ASD.

Tablet-based instruction is a growing area of research in applied behavior-analytic intervention, and many BCBAs may be interested in leveraging its features to customize and increase the efficiency of interventions. However, it is important to try to determine whether a learner may benefit from tablet-based instruction before implementing it. We found that June was unable to perform tasks that had been mastered in table-top instruction when they were presented on the tablet. Individualized training to respond to instruction on the tablet was necessary for June, and that may be the case for other learners. June was also the only participant who did not complete the prompt assessment. It is possible that our Readiness Assessment was lacking in the identification of necessary pre-requisites for tablet-based instruction. For example, we did not include any formal measure of attending to sample or comparison stimuli (e.g., differential observing response to sample or array scanning). It is also possible that her performance on the Readiness Assessment task (visual identity matching) was not indicative of success on the prompt assessment task (visual non-identity matching). As digital programming materials are becoming more popular, additional research is needed to evaluate the Readiness Assessment or modified versions of it with other learners to identify potential indicators of successful acquisition of conditional discriminations on using tablet-based instruction (Cariveau et al., 2020).

Although multiple procedural modifications were made and the ES and WS were both efficacious with the two learners who finished the assessment, this study provides a model for conducting assessment-based instruction with learners with ASD. Selecting efficacious prompts can prevent learners from being exposed to ineffective behavioral interventions and prevent errors. Frequent errors during instruction have been shown to increase challenging behavior for children with ASD (Heckaman et al., 1998; Weeks & Gaylord-Ross, 1981). Further, selecting an efficient prompting procedure can support learners in faster skill acquisition relative to other procedures, thus creating more time for that learner to tackle other socially significant goals. Other assessments have shown that different response prompt types result in stimulus control transfer for different learners, and when more than one prompt type is efficacious there may be differences in efficiency (Cengher et al., 2015; Seaver & Bourett, 2014; Schnell et al., 2019). We may be able to assume that the same is true for stimulus prompts. Therefore, more research on assessment-based instruction of stimulus prompts is needed to identify whether and which stimulus prompts may lead to stimulus control transfer, whether any learner-specific characteristics are indicative of the stimulus prompt types that may be efficacious, and which methods may increase the efficiency of assessments overall.

In sum, assessment-based instruction of prompts is an important area of research because prompting is a commonly used instructional procedure, and assessment-based instruction can support BCBAs in identifying the procedure that is best suited for individual learners. This supports the push for individualization of behavioral treatments for individuals with ASD (Stahmer et al., 2011). Stimulus prompts may be a valuable technology to facilitate stimulus control transfer and support skill acquisition for learners with ASD, but they have been mostly abandoned due to the logistical challenges of programming and implementation. We extended the literature on assessment-based instruction to evaluate digital stimulus prompts to teach conditional discriminations to children with ASD. Both stimulus prompts were efficacious for two out of the three participants, and there were relatively no differences in their efficiency. These outcomes provide some support for the use of digital stimulus prompts to teach conditional discriminations to learners with ASD. Additionally, they open doors for new ways to deliver historically effective interventions. This also creates new avenues for researchers to explore the implications of automated behavioral intervention components on other areas of skill acquisition and procedural fidelity.

APPENDIX A

TABLE OF APPS AND GAMES

Game	Task	Prompt Type(s)	Prompt Sub-Type(s)
Barbie Dream House Adventures	Click play button	Within-Stimulus + Extra-Stimulus	Size + Light
	Click the fruit basket	Extra-Stimulus	Light
	Tap on heart	Within-Stimulus	Motion
	Tap on present	Within-Stimulus + Extra-Stimulus	Size + Light
	Tap on kitchen appliances	Extra-Stimulus	Shape/Icon added
	Tap on phone	Within-Stimulus	Motion
	Click on bonus gift 1	Within-Stimulus	Size
	Click on shovel	Extra-Stimulus	Light
	Dig	Extra-Stimulus	Point + Light
	Grab watering can	Extra-Stimulus	Light
	Grab fertilizer	Extra-Stimulus	Light
	Tap plant	Extra-Stimulus	Point + Shape/icon added
Toca Hair Salon	Press red play button	Within-Stimulus	Size
	Click on female character	Within-Stimulus	Motion
	Click on radio to change music	Within-Stimulus	Motion
Disney Coloring World	Select Disney castle	Extra-Stimulus	Shape/icon added
	Click key	Within-Stimulus + Extra-Stimulus	Motion + Light
	Click on castle stairway	Extra-Stimulus	Shape/icon added
Toca Life: Hospital	Select play button	Within-Stimulus	Size
	Touch yellow people sign	Within-Stimulus	Motion
	Touch purple sign with heart	Within-Stimulus	Motion
Toca Kitchen	Select food from fridge	Extra-Stimulus	Point
Toca Life: Vacation	Select Play button	Within-Stimulus	Size
	Touch yellow sign with people	Within-Stimulus	Motion
Stack the States	None		
Math Bingo	None		
Stack the Countries	Select World or "?" button	Within-Stimulus	Size
Teach Your Monster to Read	Click on squirrel	Within-Stimulus	Size
My Play Home	Select play button	Within-Stimulus	Size

Game	Task	Prompt Type(s)	Prompt Sub-Type(s)
Paw Patrol: Adventure Bay!	Click green play arrow	Within-Stimulus	Size
	Swipe screen to choose pup	Extra-Stimulus	Point
	Wake up pup	Extra-Stimulus	Point
	Tap dog bowl	Extra-Stimulus	Point
	Move dog bowl to catch treats	Extra-Stimulus	Point + Light
	Tap toothbrush picture	Extra-Stimulus	Point
	Tap toothbrush	Extra-Stimulus	Point
	Brush teeth	Extra-Stimulus	Point
	Tap wash paws picture	Extra-Stimulus	Point
	Turn on water	Extra-Stimulus	Point
	Put soap on paws	Extra-Stimulus	Point
	Rinse off soap	Extra-Stimulus	Point
	Dry with towel	Extra-Stimulus	Point
	Tap brush dog	Extra-Stimulus	Point
	Tap hairbrush	Extra-Stimulus	Point
	Brush dog	Extra-Stimulus	Point
	Touch check weather	Extra-Stimulus	Point
	Open door	Extra-Stimulus	Point
	Tap clothes picture	Extra-Stimulus	Point
	Put on clothing	Extra-Stimulus	Point
	Tap yellow arrow	Within-Stimulus	Size
Wild Kratts Rescue Run	Tap circle in lower right corner	Within-Stimulus	Size + Intensity
	Stop tapping circle	Within-Stimulus	Intensity
	Tap kangaroo dash circle power button	Within-Stimulus	Size + Intensity
	Choose level to play	Within-Stimulus	Motion + Intensity
Slice Fractions 2	Touch snail	Extra-Stimulus	Point
Pettson's Inventions 2	None		
Shapes and Colors Educational Games for Kids	Click “start” button	Within-Stimulus	Size

Game	Task	Prompt Type(s)	Prompt Sub-Type(s)
LEGO Ninjago	Select Play button	Extra-Stimulus	Surround
	Tap circle character button	Within-Stimulus	Size
	Hit symbol	Extra-Stimulus	Light
	walk in certain directions	Extra-Stimulus	Icon/Shape added
	Attack certain player	Extra-Stimulus	Icon/Shape added
Sight Words Ninja- Slicing Game to Learn to Read	None		
My Town: School	Select play button	Within-Stimulus	Size
	Go into school	Extra-Stimulus	Point
	Click collect	Within-Stimulus	Size
	Click on hearts you find	Extra-Stimulus	Light
	Click on present in top right corner	Within-Stimulus	Motion
	Pick one of 3 present options	Within-Stimulus	Intensity
Ryan's Lab	Click on door	Extra-Stimulus	Point + Light
	Pick a category "Just a phase"	Extra-Stimulus	Point
	Tap on video	Extra-Stimulus	Point
	Watch available video	Within-Stimulus + Extra-Stimulus	Intensity + Point
Monkey Preschool Lunchbox	None		
English Playground- Easy Learning for kids	Tap blue screen	Extra-Stimulus	Point
	Swipe through games	Extra-Stimulus	Point
	Click black star	Within-Stimulus + Extra-Stimulus	Motion + Pointing + Light
Crayola Scribble Scrubbie Pets	Put pet on scale	Extra-Stimulus	Light
Train Driver- Driving Games	Click play button	Within-Stimulus	Size
	Select blue train	Within-Stimulus	Intensity
	Select blue station	Within-Stimulus	Motion + Intensity
	Pull red lever	Within-Stimulus	Size
	Pull horn	Within-Stimulus	Size
Sago Mini World: Kids Games	Click present	Within-Stimulus	Motion

Game	Task	Prompt Type(s)	Prompt Sub-Type(s)
Lightbot: Programming Puzzles	Click play button	Extra-Stimulus	Point
	Click basics level 1	Extra-Stimulus	Point
	Click basics level 1 square	Extra-Stimulus	Point
	Tap up arrow	Extra-Stimulus	Point
	Tap light bulb	Extra-Stimulus	Point
	Tap run	Extra-Stimulus	Point
	Tap replay >>	Extra-Stimulus	Point
Puzzle Kids- Animals Shapes and Jigsaw Puzzles	Select game on tree trunk	Within-Stimulus	Motion
	Click white arrow on red square icon	Within-Stimulus	Size
	Tap on balloons	Extra-Stimulus	Point
	Drag X to left side of screen	Extra-Stimulus	Point
ABC Kids- Tracing & Phonics	Trace Path	Extra-Stimulus	Point + Symbol/Shape added
	Click next page	Within-Stimulus	Size
	Touch matching letter	Within-Stimulus	Size
Coloring Games: Coloring Book, Painting, Glow Draw	Click play button	Within-Stimulus	Motion
	Click on unlocked coloring sheets that are “new” or “free”	Extra-Stimulus	Symbol/Shape added
	Color in spot designated for color	Within-Stimulus	Intensity
	Pick unused color/number	Within-Stimulus	Intensity
Learning Games for Toddlers Age 3	Select jungle game	Within-Stimulus	Motion
	Click parts of monkey	Extra-Stimulus	Point
Thinkrolls Logic Puzzles	Press play button	Within-Stimulus	Motion
	Move through maze	Extra-Stimulus	Symbol/Shape added
	Click redo button	Within-Stimulus	Size + Intensity
Subway Surfers	Click "Tap to play"	Within-Stimulus	Motion
	Jump up	Extra-Stimulus	Point
	Jump up	Extra-Stimulus	Point
	Jump down	Extra-Stimulus	Point

Game	Task	Prompt Type(s)	Prompt Sub-Type(s)
	Jump down	Extra-Stimulus	Point
	Move left	Extra-Stimulus	Point
	Move right	Extra-Stimulus	Point
	Move right	Extra-Stimulus	Point
	Move right	Extra-Stimulus	Point
	Double tap screen for hover board	Extra-Stimulus	Point
	Move towards pogo stick	Within-Stimulus + Extra-Stimulus	Motion + Light
	Move towards A	Within-Stimulus + Extra-Stimulus	Motion + Light
	Move towards coins	Within-Stimulus + Extra-Stimulus	Motion + Light
	Collect coins	Within-Stimulus	Motion
	Click "Tap to continue"	Within-Stimulus	Size
	Click "Claim reward"	Within-Stimulus + Extra-Stimulus	Motion + Light
	Click "CLAIM"	Extra-Stimulus	Point + Light
Thinkrolls Kings & Queens- Full	Tap play button	Within-Stimulus	Motion
	Tap next arrow in top right corner	Within-Stimulus	Size
	Get to key	Within-Stimulus + Extra-Stimulus	Motion + Light
	Move through archway	Extra-Stimulus	Light
	Get pink diamond	Within-Stimulus + Extra-Stimulus	Motion + Symbol/Shape added
Talking Carl	None		
Learning & Coloring Game for Kids & Preschoolers	Tap on crayon color	Extra-Stimulus	Point + Light
	Click on art gallery	Extra-Stimulus	Point + Light
	Tap on balloons to pop	Extra-Stimulus	Point + Light
	Tap on orange arrow	Within-Stimulus	Size
Sesame Street Alphabet Kitchen	Pick cookie making partner (Elmo or Cookie Monster)	Within-Stimulus	Motion
	Pick either “a” or “e” cookie cutters	Within-Stimulus	Intensity
	Select yellow icing	Within-Stimulus	Motion + Size
	Share cookies with Cookie Monster	Within-Stimulus + Extra-Stimulus	Motion + Point

Game	Task	Prompt Type(s)	Prompt Sub-Type(s)
	Take picture of cookies	Extra-Stimulus	Light
	Select letter cookie cutter to put in word	Extra-Stimulus	Point
Cosmic Express	Drag road out	Extra-Stimulus	Point
	Press play button	Within-Stimulus	Size
	Click level 2	Within-Stimulus	Size
	Press edit button	Within-Stimulus	Size
	Play levels 3 or 4	Within-Stimulus	Intensity
	Play levels 5 or 8	Within-Stimulus	Intensity
inbento	Tap food to change orientation	Extra-Stimulus	Point
Thinkrolls Space	Press play button	Within-Stimulus	Motion
	Get tunnel key	Within-Stimulus	Motion + Light
Toca Life World: Build Stories	Select play button	Within-Stimulus	Size
	Select building	Within-Stimulus	Size
	Select “pick character” sign	Within-Stimulus	Motion
	Select heart sign	Within-Stimulus	Motion
Paw Patrol Rescue World	Follow line in car	Extra-Stimulus	Point + Shape/icon added
	Pick up dog treats	Within-Stimulus + Extra-Stimulus	Motion + Point + Light + Surround
	Open treasure box	Within-Stimulus + Extra-Stimulus	Motion + Light
	Click on ramp to go up	Extra-Stimulus	Point + Light
	Click on tree to hang birdhouse	Extra-Stimulus	Point + Light
	Find bird houses	Extra-Stimulus	Point
	Tap on bench	Within-Stimulus + Extra-Stimulus	Motion + Point + Light
	Tap on broken bench	Extra-Stimulus	Point + Light + Surround
	Tap boy (Ryder) icon	Extra-Stimulus	Point + Light
	Move towards chicken	Extra-Stimulus	Surround
	Tap on pink prize badge	Extra-Stimulus	Point + Light
	Tap on dog (Sky) in the helicopter	Extra-Stimulus	Point + Light
	Fly through gold ring	Extra-Stimulus	Point + Light

Game	Task	Prompt Type(s)	Prompt Sub-Type(s)
	Tap on woman to see what she needs	Extra-Stimulus	Point + Surround
World of Peppa Pig: Playtime	Play and Learn: sticker book game, select sticker	Extra-Stimulus	Surround
	Play and learn (easy mode matching): matching select card	Extra-Stimulus	Surround
	Play and Learn (George's racing car): turn page	Within-Stimulus + Extra-Stimulus	Motion + Point
PBS Kids Games	None		

APPENDIX B

PARTICIPANT CHALLENGING BEHAVIOR OPERATIONAL DEFINITIONS

Miles Challenging Behavior Definitions

- *Crying***:** 3 s or more of inarticulate sounds above conversational volume with or without the presence of tears or rapid breathing (short quick audible breaths).

Silas Challenging Behavior Definitions

- *Crying:* Any occurrence in which the child contracts his face and emits crying sounds. Includes occurrences in which there are no tears. Excludes occurrences during contextually appropriate instances (e.g., pretending that a doll is crying). An episode of crying begins when the child has engaged in two or more of the crying features (facial contraction, crying sounds, and/or tears [if there are tears]) for three consecutive seconds, and ends once he stops emitting two of the crying features.
- *Flopping:* any instance in which the child moves from a standing/sitting position to lying on the ground for more than 3 seconds. Excludes contextually appropriate instances (e.g., spinning in circles and falling during play, pretending to sleep during a game, etc.).
- *Aggression:* any instance in which the child makes forceful contact with another person. This might include hitting, kicking, pushing, biting, etc. Excludes contextually appropriate instances (e.g., he runs into your arms, and you tickle him) and accidents (e.g., he bumps into another child on the playground). An instance begins once contact is made and ends when contact terminates.
- *Elopement:* any instance in which the child leaves the classroom without the therapist.
- *Strip:* any instance in which the child attempts to remove his shirt or pants. Excludes contextually appropriate instances (e.g., he spills soda on his shirt and then tries to take it off,

he helps with removing his clothes during a diaper change, etc.) and instances of removing a jacket, sweater, socks, or shoes.

- *Swiping:* any instance in which the child uses a swiping motion with their hands or arms (side to side or up and down) that results in an item being displaced from their original position. Includes instances in which the child swipes items off a table or out of someone's hands. Excludes contextually appropriate swiping motions (e.g., pushing a car down a track and it falls off).

- *Throwing:* any instance in which the child holds an object in their hand, moves their arm in a forward, backward, upward, or downward motion, and releases the object from their hand resulting in the object traveling a minimum of approximately one foot away from the child and making an audible sound upon landing. Excludes dropping items on the floor and contextually appropriate throws (e.g., bouncy balls, bean bags, etc.).

- *Bite:* any instance in which the child's teeth make contact with an object. Excludes contextually appropriate instances (e.g., eating real food, pretending to eat toy food, etc.).

- *Self-Injury:* any instance in which the child uses a portion of his body or an object to make forceful contact with any portion of his body. This may include hitting his head with a toy or his hands, biting his hand, pinching his leg, etc. Excludes contextually appropriate instances (e.g., slaps his cheek to squish a mosquito, pushes a squishy ball against his head, etc.).

June Challenging Behavior Definitions

- *Crying:* Any occurrence in which the child contracts her face and emits crying sounds. Includes occurrences in which there are no tears. Excludes occurrences during contextually appropriate play (e.g., pretending that a doll is crying). Crying begins when the child engages in two or more of the crying features (facial contraction, crying sounds, and/or tears) for three consecutive seconds, and ends when she stops emitting at least two crying features for 5 consecutive seconds.

- *Flopping:* Any instance in which the child engages in a movement from a standing position to sitting or lying on the ground for more than 5 seconds. Excludes contextually appropriate movements to the ground (e.g., spinning in circles and falling during play, pretending to sleep during a game, etc.).

- *Swiping:* Any instance in which the child uses a swiping motion with their hands or arms (side to side or up and down) that results in an item being displaced from their original position. Includes instances in which the child swipes items off of a table or out of someone's hands. Excludes contextually appropriate swiping motions (e.g., pushing a car down a track and it falls off).

- *Throwing:* any instance in which the child holds an object in their hand, moves their arm in a forward, backward, upward, or downward motion, and releases the object from their hand resulting in the object traveling a minimum of approximately one foot away from the child and making an audible sound upon landing. Excludes dropping items on the floor and contextually appropriate throws (e.g., bouncy balls, bean bags, etc.).

- *Kicking:* any instance in which any part of the child's foot makes forceful contact with the body of another individual (e.g., face, leg, torso, etc.) or with an object (e.g., wall, table, cabinet, toy, etc.).

- *Pinching:* any instance in which the child uses their fingers to squeeze any part of another person's body that results in redness or a visible depression of the skin or clothing.

- *Scratching:* any instance in which the child's *fingernails* make contact with another person's body that results in redness or a visible depression of the skin.
- *Hitting:* any instance in which any part of the child's hand makes forceful contact with the body of another individual (e.g., leg, arm, torso, etc.) or with an object (e.g., wall, table, cabinet, toy, etc.).

APPENDIX C

FREE-OPERANT PREFERENCE ASSESSMENT DATA SHEET

Participant: _______ Date: _______

Items 1) 2) 3) 4) 5)

Write item name in box, add combinations of items on new line	Duration(s) of engagement separated by comma

Participant: _______ Date: _______

Items 1) 2) 3) 4) 5)

Write item name in box, add combinations of items on new line	Duration(s) of engagement separated by comma

Participant: _______ Date: _______

Items 1) 2) 3) 4) 5)

Write item name in box, add combinations of items on new line	Duration(s) of engagement separated by comma

APPENDIX D

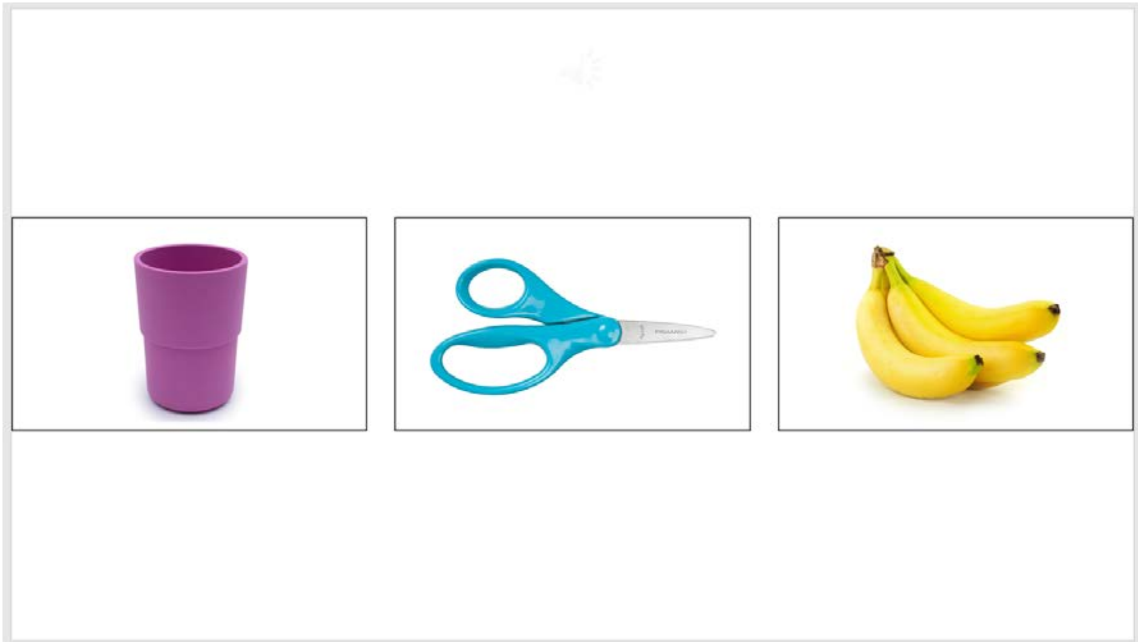
PAIRED-STIMULUS PREFERENCE ASSESSMENT DATA SHEET

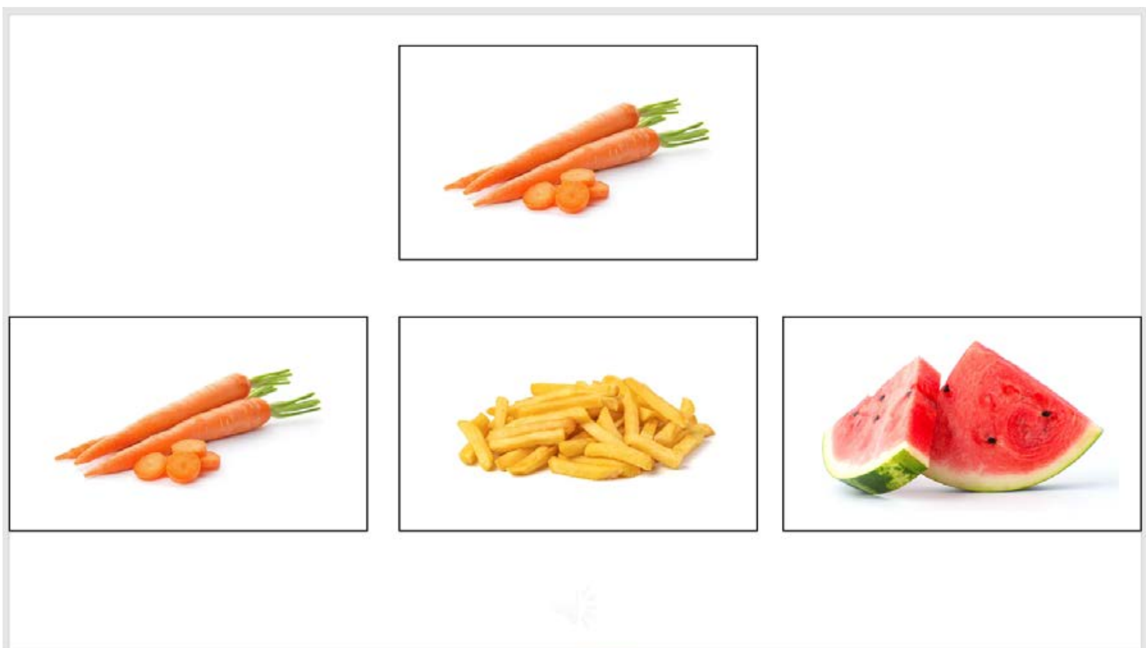
Child: _____ Date:_______ Session #:_______ Therapist: _____

TRIAL	Left Side	Right Side	Refused Both
1.	ITEM 1	ITEM 4	Refused
2.	ITEM 2	ITEM 6	Refused
3.	ITEM 3	ITEM 5	Refused
4.	ITEM 5	ITEM 4	Refused
5.	ITEM 4	ITEM 2	Refused
6.	ITEM 3	ITEM 6	Refused
7.	ITEM 6	ITEM 3	Refused
8.	ITEM 1	ITEM 5	Refused
9.	ITEM 2	ITEM 3	Refused
10.	ITEM 3	ITEM 4	Refused
11.	ITEM 6	ITEM 2	Refused
12.	ITEM 4	ITEM 3	Refused
13.	ITEM 5	ITEM 6	Refused
14.	ITEM 2	ITEM 1	Refused
15.	ITEM 2	ITEM 5	Refused
16.	ITEM 1	ITEM 6	Refused
17.	ITEM 5	ITEM 3	Refused
18.	ITEM 5	ITEM 2	Refused
19.	ITEM 6	ITEM 1	Refused
20.	ITEM 3	ITEM 1	Refused
21.	ITEM 4	ITEM 6	Refused
22.	ITEM 3	ITEM 2	Refused
23.	ITEM 4	ITEM 5	Refused
24.	ITEM 1	ITEM 3	Refused
25.	ITEM 4	ITEM 1	Refused
26.	ITEM 6	ITEM 5	Refused
27.	ITEM 2	ITEM 4	Refused
28.	ITEM 5	ITEM 1	Refused
29.	ITEM 6	ITEM 4	Refused
30.	ITEM 1	ITEM 2	Refused
# Chosen	**ITEM 1= ITEM 2= ITEM 3 = ITEM 4= ITEM 5 = ITEM 6=**		

APPENDIX E

READINESS ASSESSMENT TRIAL EXAMPLES





Note. The top image shows example trials for Miles and Silas (AVCDs), and the bottom trial shows and example trial for June (VVCD identity matching).

APPENDIX F

READINESS ASSESSMENT DATA SHEET

Date: Client: BT: Condition: Session #: Primary / Reli

Trial	Orienting	Unprompted Response	Prompt Response	CB	Interfere Bx
1.	+ / -	+ / - / NR	+ / - / NR	+ / -	+ / -
2.	+ / -	+ / - / NR	+ / - / NR	+ / -	+ / -
3.	+ / -	+ / - / NR	+ / - / NR	+ / -	+ / -
4.	+ / -	+ / - / NR		+ / -	+ / -
5.	+ / -	+ / - / NR		+ / -	+ / -
6.	+ / -	+ / - / NR		+ / -	+ / -
7.	+ / -	+ / - / NR		+ / -	+ / -
8.	+ / -	+ / - / NR		+ / -	+ / -
9.	+ / -	+ / - / NR		+ / -	+ / -

Arrangement: A B C D Duration: ________

APPENDIX G

LIST OF TARGETS FOR READINESS ASSESSMENT

Child	Skill	Conditional Stimulus	Target Stimulus
Miles	AVCD	“Scissors” “Banana” “Cup”	Scissors  Banana  Cup 
Silas	AVCD	“Hammer” “Fan” “Couch”	Hammer  Fan  Couch 
June	Visual Identity Matching	Fries  Watermelon  Carrots 	Fries  Watermelon  Carrots 

Note. AVCD = Auditory-Visual Conditional Discrimination

APPENDIX H

JUNE TOUCHING VISUAL STIMULI DATA SHEET

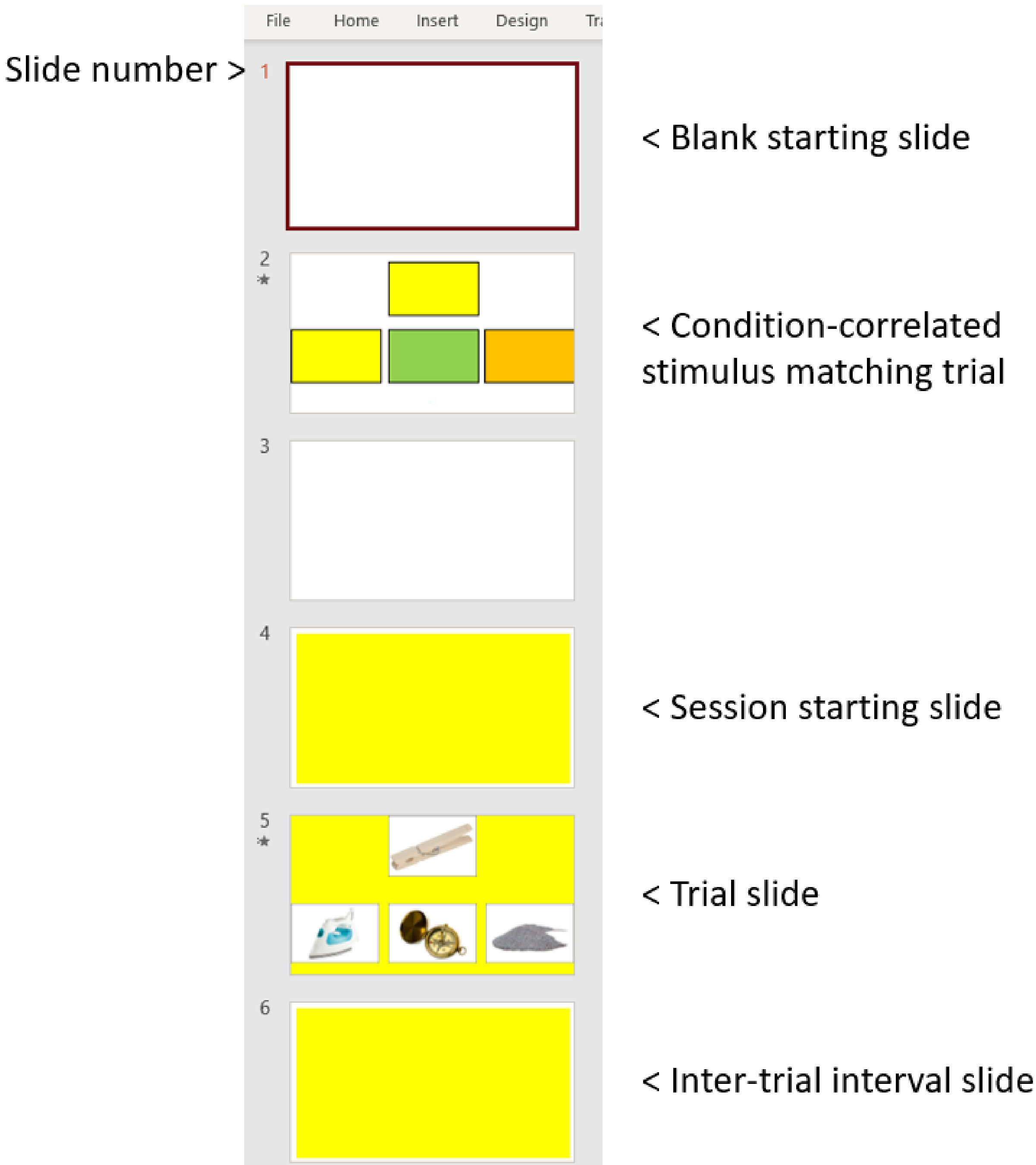
BT: Condition: Session #: Primary / Reli

Trial	Unprompted Response	Prompted Response	CB	Interfere Bx
1.	+ / -	+ / - / NR	+ / -	+ / -
2.	+ / -	+ / - / NR	+ / -	+ / -
3.	+ / -	+ / - / NR	+ / -	+ / -
4.	+ / -	+ / - / NR	+ / -	+ / -
5.	+ / -	+ / - / NR	+ / -	+ / -
6.	+ / -	+ / - / NR	+ / -	+ / -
7.	+ / -	+ / - / NR	+ / -	+ / -
8.	+ / -	+ / - / NR	+ / -	+ / -
9.	+ / -	+ / - / NR	+ / -	+ / -

Arrangement: A B C D Duration: ________

APPENDIX I

DIGITAL TRIAL SCHEMATIC


File
Home
Insert
Design
Slide number >
1
< Blank starting slide
2
< Condition-correlated stimulus matching trial
3
4
< Session starting slide
5
< Trial slide
6
< Inter-trial interval slide

APPENDIX J

PROCEDURAL-FIDELITY CHECKLISTS

<table>
<tr><th colspan="5">Readiness Assessment Fidelity Checklist</th></tr>
<tr><td>Date:</td><td>Session #</td><td>BT:</td><td>Phase: Terminal Task Probe</td><td>Data collector:</td></tr>
<tr><td colspan="5">Key:
“+” indicates component was implemented correctly for every trial
“-“ indicates component was implemented incorrectly at least one time
“N/A” indicates there was no opportunity to implement the component</td></tr>
</table>

Component	Score
Experimenter places iPad in front of child	
Experimenter delivers instruction “You’re going to work on the iPad.”	
Experimenter prompts observing response.	
Experimenter provides reinforcement after correct observing response.	
Experimenter presents instructional stimuli on the iPad by swiping to trial slide.	
First 3 trials only: Experimenter delivers prompt (model-Miles & Silas, model or full physical-June) contingent on incorrect unprompted responses	
Experimenter moves to the next trial without feedback following an incorrect prompted or no response	
Experimenter delivers praise and tangible reinforcer for correct unprompted responses only or correct prompted responses on **first 3 trials only**	
Experimenter does not delay task presentation due to challenging behavior.	
Experimenter blocks interfering behavior.	
Total Session Duration:	
Percent Fidelity (correct components / total components applicable) x 100	

<table>
<tr><td colspan="5">Prompt Assessment Fidelity Checklist for Miles</td></tr>
<tr><td>Date:</td><td>Session #</td><td>BT:</td><td>Phase: BL / 0s / 3s / 3s+PE / 3s + EC / 3s + EC + DR</td><td>Data collector:</td></tr>
<tr><td colspan="5">Key:
“+” indicates component was implemented correctly for every trial
“-“ indicates component was implemented incorrectly at least one time
“N/A” indicates there was no opportunity to implement the component</td></tr>
</table>

Component	Score
Experimenter places iPad in front of child	
Experimenter delivers instruction “You’re going to work on the iPad.”	
Experimenter presents stimuli for observing response.	
Experimenter waits appropriate number of seconds for observing response (5s).	
Experimenter prompts observing response.	
Experimenter provides reinforcement after correct observing response.	
Experimenter presents instructional stimuli on the iPad by swiping to trial slide.	
BL: Experimenter delivers reinforcement (praise and tangibles) for on-task session behavior on a VR2 during baseline sessions. **0s, 3s PD, 3s PD + Prompt after Errors:** Experimenter delivers praise and tangible reinforcer for correct (unprompted or prompted) responses. **3s PD + Error Correction:** Experimenter delivers praise and tangible reinforcer for correct unprompted responses on initial and error correction trials. **3s PD + Error Correction + DR:** Experimenter delivers praise and tangible reinforcer for correct unprompted responses on initial trials only and praise only for correct unprompted responses on error correction trials.	
Error Correction (Re-present until independent and Rearrange S+): Experimenter presents an error correction trial following an incorrect unprompted, no response, or prompted correct response for up to 10 error correction trials	
Experimenter removes tangible reinforcer at the end of reinforcer interval (+/- 3s)	
Experimenter does not delay task presentation due to challenging behavior.	
Experimenter blocks interfering behavior.	
Percent Fidelity (correct components / total components applicable) x 100	

Prompt Assessment Fidelity Checklist for Silas				
Date:	Session #	BT:	Phase: BL / 0s / 3s / 6s /DR	Data collector:

Key:
"+" indicates component was implemented correctly for every trial
"-" indicates component was implemented incorrectly at least one time
"N/A" indicates there was no opportunity to implement the component

Component	Score
Experimenter places iPad in front of child	
Experimenter delivers instruction "You're going to work on the iPad."	
Experimenter presents stimuli for observing response.	
Experimenter waits appropriate number of seconds for observing response (5s).	
Experimenter prompts observing response.	
Experimenter provides reinforcement after correct observing response.	
Experimenter presents instructional stimuli on the iPad by swiping to trial slide.	
BL: Experimenter delivers reinforcement (praise and tangibles and/or tokens) for on-task session behavior on a VR2 during baseline sessions. **0s, 3s PD, 6s PD:** Experimenter delivers reinforcer for correct (unprompted or prompted) responses. **6s + DR:** Experimenter delivers praise only for correct prompted responses and praise + tangibles for correct unprompted responses	
Experimenter removes tangible reinforcer at the end of reinforcer interval (+/- 3s)	
Experimenter does not delay task presentation due to challenging behavior.	
Experimenter blocks interfering behavior.	
Percent Fidelity (correct components / total components applicable) x 100	

Prompt Assessment Fidelity Checklist for June				
Date:	Session #	BT:	Phase: BL / 0s / 3s / 3s+EC / 3s + EC + RP / 3s + EC + PAE	Data collector:

Key:
"+" indicates component was implemented correctly for every trial
"-" indicates component was implemented incorrectly at least one time
"N/A" indicates there was no opportunity to implement the component

Component	Score
Experimenter places iPad in front of child	
Experimenter delivers instruction "You're going to work on the iPad."	
Experimenter presents stimuli for observing response.	
Experimenter waits appropriate number of seconds for observing response (5s).	
Experimenter prompts observing response.	
DOR Error Correction: Experimenter repeats observing response trial until unprompted correct.	
Experimenter provides reinforcement after correct observing response.	
Experimenter presents instructional stimuli on the iPad by swiping to trial slide.	
BL: Experimenter delivers reinforcement (praise and tangibles and/or tokens) for on-task session behavior on a VR2 during baseline sessions. **0s & 3s PD:** Experimenter delivers reinforcer for correct (unprompted or prompted) responses. **3s PD + Error Correction (+ Prompt after Errors or + Response Prompts):** Experimenter delivers reinforcer for correct unprompted responses only.	
3s PD + EC+ Response Prompts (RP): Experimenter delivers response prompt after no response and waits 5 s for prompted response	
3s PD + Error Correction: After prompted correct or unprompted incorrect, experimenter presents error correction trials (up to 10) until correct independent.	
Experimenter removes tangible reinforcer at the end of reinforcer interval (+/- 3s)	
Experimenter does not delay task presentation due to challenging behavior.	
Experimenter blocks interfering behavior.	
Percent Fidelity (correct components / total components applicable) x 100	

APPENDIX K

COLOR PREFERENCE ASSESSMENT DATA SHEET

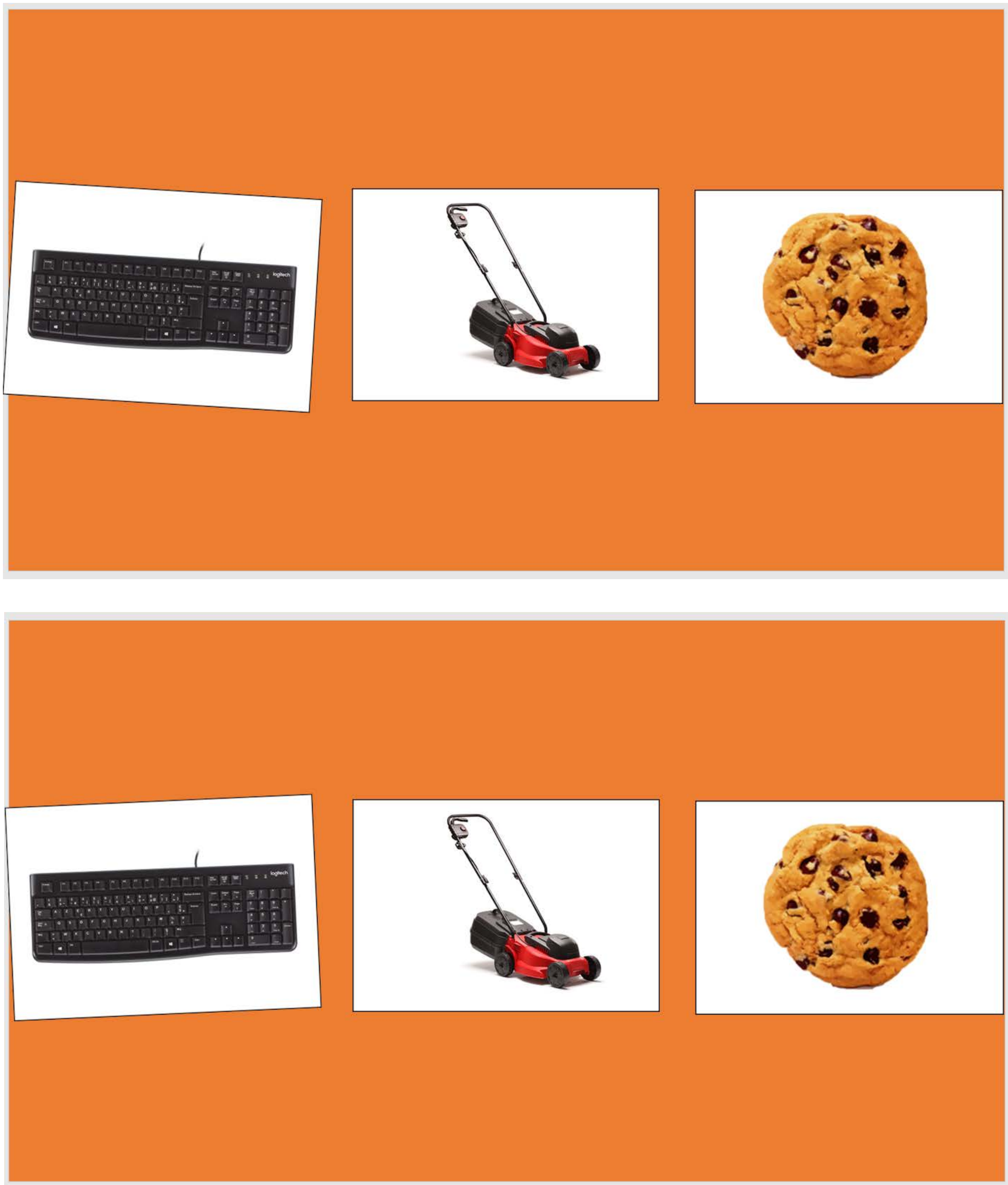
Child: _____ Date:_______ Session #:_______ Therapist: _____			
TRIAL	Left Hand	Right Hand	Refused Both
1.	COLOR 7	COLOR 5	Refused
2.	COLOR 1	COLOR 2	Refused
3.	COLOR 6	COLOR 4	Refused
4.	COLOR 3	COLOR 2	Refused
5.	COLOR 4	COLOR 5	Refused
6.	COLOR 6	COLOR 3	Refused
7.	COLOR 5	COLOR 1	Refused
8.	COLOR 6	COLOR 2	Refused
9.	COLOR 7	COLOR 3	Refused
10.	COLOR 2	COLOR 6	Refused
11.	COLOR 1	COLOR 3	Refused
12.	COLOR 7	COLOR 4	Refused
13.	COLOR 1	COLOR 6	Refused
14.	COLOR 2	COLOR 3	Refused
15.	COLOR 3	COLOR 7	Refused
16.	COLOR 6	COLOR 5	Refused
17.	COLOR 2	COLOR 1	Refused
18.	COLOR 5	COLOR 6	Refused
19.	COLOR 4	COLOR 2	Refused
20.	COLOR 1	COLOR 7	Refused
21.	COLOR 1	COLOR 4	Refused
22.	COLOR 7	COLOR 2	Refused
23.	COLOR 4	COLOR 6	Refused
24.	COLOR 4	COLOR 1	Refused
25.	COLOR 2	COLOR 7	Refused
26.	COLOR 3	COLOR 5	Refused
27.	COLOR 6	COLOR 7	Refused
28.	COLOR 5	COLOR 2	Refused
29.	COLOR 4	COLOR 3	Refused
30.	COLOR 6	COLOR 1	Refused
31.	COLOR 5	COLOR 4	Refused
32.	COLOR 7	COLOR 6	Refused
33.	COLOR 3	COLOR 1	Refused
34.	COLOR 5	COLOR 7	Refused
35.	COLOR 2	COLOR 4	Refused
36.	COLOR 1	COLOR 5	Refused
37.	COLOR 3	COLOR 6	Refused
38.	COLOR 4	COLOR 7	Refused
39.	COLOR 2	COLOR 5	Refused
40.	COLOR 7	COLOR 1	Refused
41.	COLOR 3	COLOR 4	Refused
42.	COLOR 5	COLOR 3	Refused
# Chosen 1st	COLOR 1= COLOR 2 = COLOR 3 = COLOR 4= COLOR 5= COLOR 6 = COLOR 7=		

APPENDIX L

BASELINE TRIAL EXAMPLE

APPENDIX M

WITHIN-STIMULUS PROMPT EXAMPLE



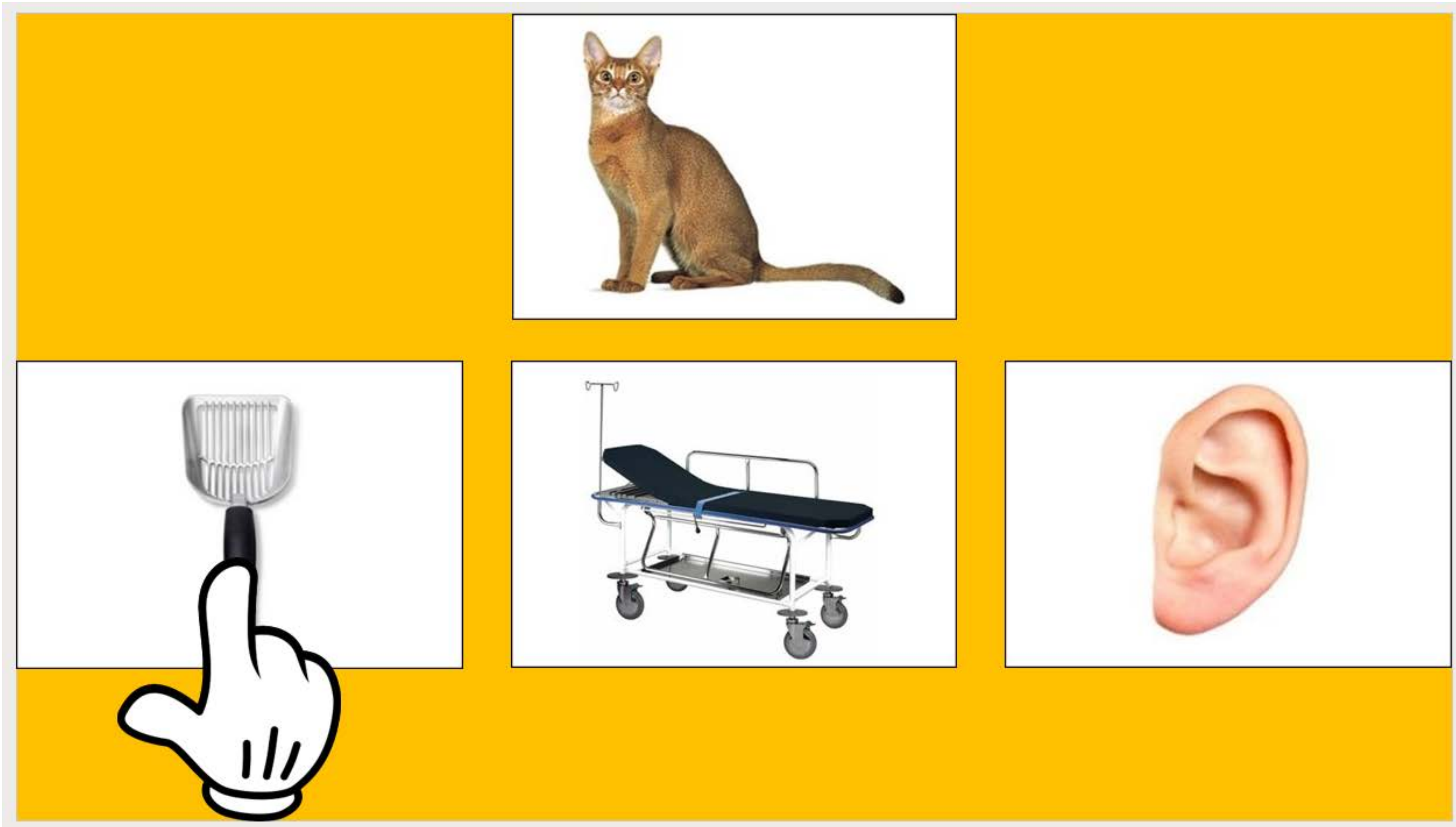
Note. In this example, keyboard is the S+. The top image depicts the keyboard teetering to the right, and the bottom image depicts the keyboard teetering to the left. Teetering back and forth continued for the entire 5-s response interval.

Note. In this example, flippers are the S+. The top image depicts the flippers teetering to the right, and the bottom image depicts the flippers teetering to the left. Teetering back and forth continued for the entire 5-s response interval.

APPENDIX N

EXTRA-STIMULUS PROMPT EXAMPLE

Note. In this example, pot is the S+.



Note. In this example, litter scoop is the S+.

APPENDIX O

PROMPT ASSESSMENT BASELINE DATA SHEET

VERSION 1 Child: ____ BT: ____ Session #:____ Condition:_____ Date: _______ Primary/Reli

Trial	LEFT	MIDDLE	RIGHT	Unprompted. Resp.	CB	Interfering Behavior
1.	***A***	B	C	+ / - / NR	+ / -	+ / -
2.	***B***	C	A	+ / - / NR	+ / -	+ / -
3.	A	***C***	B	+ / - / NR	+ / -	+ / -
4.	B	***A***	C	+ / - / NR	+ / -	+ / -
5.	C	A	***B***	+ / - / NR	+ / -	+ / -
6.	***C***	B	A	+ / - / NR	+ / -	+ / -
7.	C	B	***A***	+ / - / NR	+ / -	+ / -
8.	B	A	***C***	+ / - / NR	+ / -	+ / -
9.	A	***B***	C	+ / - / NR	+ / -	+ / -

VERSION 2 Child: ____ BT: ____ Session #:____ Condition:_____ Date: _______ Primary/Reli

Trial	LEFT	MIDDLE	RIGHT	Unprompted. Resp.	CB	Interfering Behavior
1	C	A	***B***	+ / - / NR	+ / -	+ / -
2	B	***A***	C	+ / - / NR	+ / -	+ / -
3	***C***	A	B	+ / - / NR	+ / -	+ / -
4	***B***	C	A	+ / - / NR	+ / -	+ / -
5	C	***B***	A	+ / - / NR	+ / -	+ / -
6	***A***	C	B	+ / - / NR	+ / -	+ / -
7	A	***C***	B	+ / - / NR	+ / -	+ / -
8	C	B	***A***	+ / - / NR	+ / -	+ / -
9	B	A	***C***	+ / - / NR	+ / -	+ / -

VERSION 3 Child: ____ BT: ____ Session #:____ Condition:_____ Date: _______ Primary/Reli

Trial	LEFT	MIDDLE	RIGHT	Unprompted. Resp.	CB	Interfering Behavior
1	B	***C***	A	+ / - / NR	+ / -	+ / -
2	***B***	C	A	+ / - / NR	+ / -	+ / -
3	C	***A***	B	+ / - / NR	+ / -	+ / -
4	***C***	B	A	+ / - / NR	+ / -	+ / -
5	B	C	***A***	+ / - / NR	+ / -	+ / -
6	C	A	***B***	+ / - / NR	+ / -	+ / -
7	A	***B***	C	+ / - / NR	+ / -	+ / -
8	***A***	B	C	+ / - / NR	+ / -	+ / -
9	B	A	***C***	+ / - / NR	+ / -	+ / -

VERSION 4 Child: ____ BT: ____ Session #:____ Condition:_____ Date: _______ Primary/Reli

Trial	LEFT	MIDDLE	RIGHT	Unprompted. Resp.	CB	Interfering Behavior
1	***B***	A	C	+ / - / NR	+ / -	+ / -
2	A	B	***C***	+ / - / NR	+ / -	+ / -
3	A	***B***	C	+ / - / NR	+ / -	+ / -
4	***A***	B	C	+ / - / NR	+ / -	+ / -
5	***C***	A	B	+ / - / NR	+ / -	+ / -
6	A	C	***B***	+ / - / NR	+ / -	+ / -
7	B	***C***	A	+ / - / NR	+ / -	+ / -
8	C	***A***	B	+ / - / NR	+ / -	+ / -
9	B	C	***A***	+ / - / NR	+ / -	+ / -

Note. Gray colored rows indicate trials after which reinforcement was provided for appropriate session behavior.

APPENDIX P

PROMPT ASSESSMENT DATA SHEET

VERSION 1 Child: ____ BT: ____ Session #:____ Condition:_____ Date: _______ Primary/Reli

Trial	LEFT	MIDDLE	RIGHT	Unprompted Response	Prompt Response	CB	Interfering Behavior
	C	B	A	+ / - / NR	+ / - / NR	+ / -	+ / -
	B	A	C	+ / - / NR	+ / - / NR	+ / -	+ / -
	C	***A***	B	+ / - / NR	+ / - / NR	+ / -	+ / -
	B	***C***	A	+ / - / NR	+ / - / NR	+ / -	+ / -
	A	C	***B***	+ / - / NR	+ / - / NR	+ / -	+ / -
	A	B	C	+ / - / NR	+ / - / NR	+ / -	+ / -
	A	B	***C***	+ / - / NR	+ / - / NR	+ / -	+ / -
	B	C	***A***	+ / - / NR	+ / - / NR	+ / -	+ / -
	C	***B***	A	+ / - / NR	+ / - / NR	+ / -	+ / -

VERSION 2 Child: ____ BT: ____ Session #:____ Condition:_____ Date: _______ Primary/Reli

Trial	LEFT	MIDDLE	RIGHT	Unprompted Response	Prompt Response	CB	Interfering Behavior
	A	C	***B***	+ / - / NR	+ / - / NR	+ / -	+ / -
	B	***C***	A	+ / - / NR	+ / - / NR	+ / -	+ / -
	A	C	B	+ / - / NR	+ / - / NR	+ / -	+ / -
	B	A	C	+ / - / NR	+ / - / NR	+ / -	+ / -
	A	***B***	C	+ / - / NR	+ / - / NR	+ / -	+ / -
	C	A	B	+ / - / NR	+ / - / NR	+ / -	+ / -
	C	***A***	B	+ / - / NR	+ / - / NR	+ / -	+ / -
	A	B	***C***	+ / - / NR	+ / - / NR	+ / -	+ / -
	B	C	***A***	+ / - / NR	+ / - / NR	+ / -	+ / -

VERSION 3 Child: ____ BT: ____ Session #:____ Condition:_____ Date: _______ Primary/Reli

Trial	LEFT	MIDDLE	RIGHT	Unprompted Response	Prompt Response	CB	Interfering Behavior
	B	***A***	C	+ / - / NR	+ / - / NR	+ / -	+ / -
	B	A	C	+ / - / NR	+ / - / NR	+ / -	+ / -
	A	***C***	B	+ / - / NR	+ / - / NR	+ / -	+ / -
	A	B	C	+ / - / NR	+ / - / NR	+ / -	+ / -
	B	A	***C***	+ / - / NR	+ / - / NR	+ / -	+ / -
	A	C	***B***	+ / - / NR	+ / - / NR	+ / -	+ / -
	C	***B***	A	+ / - / NR	+ / - / NR	+ / -	+ / -
	C	B	A	+ / - / NR	+ / - / NR	+ / -	+ / -
	B	C	***A***	+ / - / NR	+ / - / NR	+ / -	+ / -

VERSION 4 Child: ____ BT: ____ Session #:____ Condition:_____ Date: _______ Primary/Reli

Trial	LEFT	MIDDLE	RIGHT	Unprompted Response	Prompt Response	CB	Interfering Behavior
	B	C	A	+ / - / NR	+ / - / NR	+ / -	+ / -
	C	B	***A***	+ / - / NR	+ / - / NR	+ / -	+ / -
	C	***B***	A	+ / - / NR	+ / - / NR	+ / -	+ / -
	C	B	A	+ / - / NR	+ / - / NR	+ / -	+ / -
	A	C	B	+ / - / NR	+ / - / NR	+ / -	+ / -
	C	A	***B***	+ / - / NR	+ / - / NR	+ / -	+ / -
	B	***A***	C	+ / - / NR	+ / - / NR	+ / -	+ / -
	A	***C***	B	+ / - / NR	+ / - / NR	+ / -	+ / -
	B	A	***C***	+ / - / NR	+ / - / NR	+ / -	+ / -

APPENDIX Q

PROMPT ASSESSMENT WITH ERROR CORRECTION DATA SHEET

VERSION 1 Child: ____ BT: ____ Session #:____ Condition:_____ Date: _______ Primary/Reli

Trial	LEFT	MIDDLE	RIGHT	Unprompted Response	Prompt Response	Error Correction	CB	Interfering Behavior
	A	B	C	+ / - / NR	+ / - / NR		+ / -	+ / -
	B	C	A	+ / - / NR	+ / - / NR		+ / -	+ / -
	A	***C***	B	+ / - / NR	+ / - / NR		+ / -	+ / -
	B	***A***	C	+ / - / NR	+ / - / NR		+ / -	+ / -
	C	A	***B***	+ / - / NR	+ / - / NR		+ / -	+ / -
	C	B	A	+ / - / NR	+ / - / NR		+ / -	+ / -
	C	B	***A***	+ / - / NR	+ / - / NR		+ / -	+ / -
	B	A	***C***	+ / - / NR	+ / - / NR		+ / -	+ / -
9.	A	***B***	C	+ / - / NR	+ / - / NR		+ / -	+ / -

VERSION 2 Child: ____ BT: ____ Session #:____ Condition:_____ Date: _______ Primary/Reli

Trial	LEFT	MIDDLE	RIGHT	Unprompted Response	Prompt Response	Error Correction	CB	Interfering Behavior
1.	C	A	***B***	+ / - / NR	+ / - / NR		+ / -	+ / -
2.	B	***A***	C	+ / - / NR	+ / - / NR		+ / -	+ / -
3.	***C***	A	B	+ / - / NR	+ / - / NR		+ / -	+ / -
4.	***B***	C	A	+ / - / NR	+ / - / NR		+ / -	+ / -
5.	C	***B***	A	+ / - / NR	+ / - / NR		+ / -	+ / -
6.	***A***	C	B	+ / - / NR	+ / - / NR		+ / -	+ / -
7.	A	***C***	B	+ / - / NR	+ / - / NR		+ / -	+ / -
8.	C	B	***A***	+ / - / NR	+ / - / NR		+ / -	+ / -
9.	B	A	***C***	+ / - / NR	+ / - / NR		+ / -	+ / -

VERSION 3 Child: ____ BT: ____ Session #:____ Condition:_____ Date: _______ Primary/Reli

Trial	LEFT	MIDDLE	RIGHT	Unprompted Response	Prompt Response	Error Correction	CB	Interfering Behavior
1.	B	***C***	A	+ / - / NR	+ / - / NR		+ / -	+ / -
2.	***B***	C	A	+ / - / NR	+ / - / NR		+ / -	+ / -
3.	C	***A***	B	+ / - / NR	+ / - / NR		+ / -	+ / -
4.	***C***	B	A	+ / - / NR	+ / - / NR		+ / -	+ / -
5.	B	C	***A***	+ / - / NR	+ / - / NR		+ / -	+ / -
6.	C	A	***B***	+ / - / NR	+ / - / NR		+ / -	+ / -
7.	A	***B***	C	+ / - / NR	+ / - / NR		+ / -	+ / -
8.	***A***	B	C	+ / - / NR	+ / - / NR		+ / -	+ / -
9.	B	A	***C***	+ / - / NR	+ / - / NR		+ / -	+ / -

VERSION 4 Child: ____ BT: ____ Session #:____ Condition:_____ Date: _______ Primary/Reli

Trial	LEFT	MIDDLE	RIGHT	Unprompted Response	Prompt Response	Error Correction	CB	Interfering Behavior
1.	***B***	A	C	+ / - / NR	+ / - / NR		+ / -	+ / -
2.	A	B	***C***	+ / - / NR	+ / - / NR		+ / -	+ / -
3.	A	***B***	C	+ / - / NR	+ / - / NR		+ / -	+ / -
4.	***A***	B	C	+ / - / NR	+ / - / NR		+ / -	+ / -
5.	***C***	A	B	+ / - / NR	+ / - / NR		+ / -	+ / -
6.	A	C	***B***	+ / - / NR	+ / - / NR		+ / -	+ / -
7.	B	***C***	A	+ / - / NR	+ / - / NR		+ / -	+ / -
8.	C	***A***	B	+ / - / NR	+ / - / NR		+ / -	+ / -
9.	B	C	***A***	+ / - / NR	+ / - / NR		+ / -	+ / -

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