BUILDING PLAY SKILLS USING VIDEO MODELING AND MATRIX TRAINING

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ABSTRACT

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Children with autism spectrum disorder (ASD) often lack fundamental play skills, which can aid development with social, language, and imitation skills (Boutot, Guenther, & Crozier, 2005). The purpose of this study was to extend previous literature that successfully combined video modeling and matrix training. Matrix training is an efficient way of teaching that encourages generalization without direct teaching of some skills. In this study, play actions were selected from a 2D, 6x6 matrix to teach play skills to 3 to 5-year-old children with a diagnosis of ASD. Play actions were made up of different toy kitchen foods and play actions within a play kitchen setting (e.g. rinse the carrot and cut the pear). Using a multiple probe design across behaviors, the play actions were taught using video modeling and other play actions from the matrix were later assessed for recombinative generalization. Overall, matrix training was effective for producing recombinative generalization, although additional training was required for 1 out of the 3 participants.

Keywords: Autism, play skills, matrix training, generalization

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

KEY TO SYMBOLS AND ABBREVIATIONS

®	Registered Trademark
ASD	Autism Spectrum Disorder
EBP	Evidence-Based Practice
EIBI	Early Intensive Behavioral Intervention
IOA	Interobserver Agreement
MSWO	Multiple Stimulus Without Replacement
PECS	Picture Exchange Communication System
PI	Procedural Integrity
VB-MAPP	Verbal Behavior Milestones Assessment and Placement Program

Introduction

Autism Spectrum Disorder (ASD) is a developmental disability significantly affecting verbal and nonverbal communication and social interaction with traits including repetitive activities or stereotyped movements (American Psychiatric Association, 2013). For children with ASD, play skills may not emerge due to stereotypic behaviors and limited interest in their environment. Play skills, such as functional play with toys and pretend play, generally emerge around the age of 18 months and become more complex by the time a child is ready for preschool (McCune-Nicolich, 1981). A lack of appropriate play skills can impact peer relationships, independence, and other critical development skills like language, social competence, fine and gross motor skills, confidence, and emotional control (Boutot, Guenther, & Crozier, 2005). To address these deficits among children with ASD, play skills have been frequently targeted in both research and early intervention programs.

Play Skills

Play skills are a fundamental part of early childhood development because they provide opportunities to develop social, language, and other important skills. Children with ASD who have limited play skills may play with toys in repetitive or stereotypic ways. A variety of procedures have been used to teach a range of play skills to children with ASD. Some of these approaches include discrete trial training (Eason, White, & Newson, 1982), backwards chaining (Edwards, Landa, Frampton, & Shillingsburg, 2018), or differential reinforcement of appropriate behavior (Nuzzolo-Gomez, Leonard, Ortiz, Rivera, & Greer, 2002). More naturalistic approaches to teaching play skills include pivotal response training (Stahmer, 1999) and reciprocal imitation training (Ingersoll & Schreibman, 2006) which uses imitation, direct reinforcement, interaction between the teacher and student, and response prompting with a constant time delay (Barton, Choi, & Mauldin, 2019). Video modeling is another evidence-based practice that has demonstrated success in teaching a range of play skills, which encourages independence and generalization.

Video Modeling

Video modeling is a type of instruction that involves observational learning and imitation after watching a model of a target behavior in a video. It's possibly advantageous due to the fact that the student can observe both the antecedent and consequences for a desired target behavior, which provides an opportunity for the student to learn why and when to perform a certain behavior (Ploog, 2010). It's also effective in that it provides a discrete opportunity to observe target skills without distractions from one's immediate environment, as videos can be edited to remove extraneous variables (MacDonald, Sacramone, Mansfield, Wiltz, & Ahearn, 2009). With video modeling, one also has the ability to quickly model many different target skills, which provides the opportunity for swift acquisition and generalization (Charlop & Millstein, 1989). Video modeling has been used to successfully teach a variety of play skills, such as play sequences (D'Ateno, Mangiapanello, & Taylor, 2003) and pretend play (MacDonald, Clark, Garrign, & Vangala, 2005; MacDonald et al., 2009).

In a study conducted by MacDonald and colleagues (2005), preschoolers with ASD were taught pretend, scripted play with multiple play sets (i.e., baking, grocery, tea party sets) using video modeling. All participants demonstrated an increase in scripted pretend play; however, limited novel narration and play was observed. In a similar study conducted by MacDonald and colleagues (2009), video modeling was used to teach reciprocal pretend play to children with ASD. Two pairs of children, each pair involving one child with a diagnosis of ASD and one without, were shown video models demonstrating a scripted sequence of pretend play. Each video model contained 14-17 scripted actions and vocalizations to go along with three different play sets. Results showed that after the introduction of a video model, there was an increase in scripted vocalizations and actions for each participant. However, there was a lack of generalization of play actions to novel play materials and settings. While video modeling has proven effective when it comes to teaching play skills to children with ASD, the lack of novel responding with different stimuli may be addressed by combining it with generative approaches, such as matrix training.

Matrix Training

Matrix training is a tactical approach to instruction where some skills are taught and others skills may emerge due to the prior teaching of similar target skills (Ross, 2017). The skills that are not directly taught are later assessed for recombinative generalization (Curiel, Sainato, & Goldstein, 2018), which demonstrates generalization across stimuli and actions without direct teaching. A matrix is developed using two kinds of stimuli, such as two actions (e.g., underline and circle) on one axis and two pictures (e.g., apple and fish) down the other axis, resulting in four total possible behavior combinations within one matrix. In this instance, the four possible behavior combinations within the matrix would be underline apple, circle fish, circle apple, and underline fish. The two play actions down the diagonal of the matrix (e.g., underline apple and circle fish) are taught while the remaining two (e.g., circle apple and underline fish) are tested for recombinative generalization. Matrix training is effective if all four behavior combinations emerge after only teaching the two trained behavior combinations. Matrix training has been successful in teaching language skills such as instruction following (Axe & Sainato, 2010; Kohler & Mallot, 2014), tacting (Pauwels, Ahearn, & Cohen, 2015), as well as mand-model procedures (Nigam, Schlosser, & Lloyd, 2006). Matrix training has also been used to teach various play skills to individuals with ASD.

MacManus, MacDonald, and Ahearn (2015) utilized matrix training combined with video modeling to teach three preschool aged children with ASD pretend play with various play sets. Researchers created 3-min video models demonstrating 30-40 scripted actions and 30 scripted vocalizations selected from a 3D matrix. Results indicate that scripted vocalizations and actions did not increase until video modeling was introduced and that video modeling used with matrix training had an effect on sequences of scripted generalized pretend play. Although results of this study are promising, the complex play sequences taught using a 3D matrix make it difficult to replicate with participants who have little to no verbal or play skills.

Video modeling combined with matrix training has demonstrated that generalization across play sequences and stimuli is possible. However, few studies have examined the use of a simple, 2D matrix to teach basic play skills to children with ASD. Therefore, the purpose of this study was to extend current research on using video modeling and matrix training to understand how a simpler, 2D matrix could also have success in teaching play skills to children with ASD. More specifically, the study examined the use video modeling and matrix training to teach pretend play actions to young children with ASD who had little to no verbal skills or functional play skills using a less complex matrix. This research study will address the following research questions:

1. Does video modeling lead to the acquisition of pretend play with play food among young children with ASD?
2. Does matrix training facilitate the generalization of play actions across play food items?

Method

Participants

Three preschool children between the ages of 3 and 5 with a diagnosis of ASD were selected for this study. All participants attended an early intensive behavioral intervention (EIBI) program where they received one on one behavior therapy for approximately 30 hours a week. All participants were previously instructed in the clinical setting using a 10-strip conditioned reinforcement system, meaning each participant had to earn 10 tokens to access a terminal reinforcer. All participants were on level 4 of The Picture Exchange Communication System (PECS ®; Charlop-Christy et. al, 2002), which means they were able to request items by placing an "I want" icon and a picture icon of a item on a sentence strip and hand it to a communication partner. Participants met the following inclusion criteria: ability to attend to a video for at least 15 s and the ability to follow simple one-step directions or imitation targets. Participants were also chosen based on the presence of stereotypic or repetitive play and overall lack of functional play during independent free time, which indicated they may benefit from this intervention.

Maddie was a 5-year-old girl who had 2 years of previous early intensive behavior intervention therapy. Maddie's score on the Verbal Behavior Milestones Assessment and Placement Program (VB-MAPP, Sundberg, 2008) at the time of the study was 84.5 with level 2 scores (18-30 months) in imitation (9.5) and play (8.5). Maddie was vocal and was able to engage with many closed ended play activities (e.g. block building, puzzles, shape sorters), but only engaged in open ended activities (e.g. doll or animal figures, train tracks, picnic set) when play actions were modeled or reinforcement was available from an adult.

Ben was a 4-year-old boy who had 2 years of previous early intensive behavior intervention therapy with little previous video modeling history. Ben's VB-MAPP (Sundberg, 2008) score was 61.5 with level 2 scores (18-30 months) in imitation (7) and play (9). Ben was highly echoic and could engage in many close ended activities (e.g. magnetic blocks, puzzles, ring stackers) and mainly engaged in open ended activities (e.g. train tracks, arts and crafts, baby dolls) when modeled by an adult.

Charlie was a 3-year-old boy who has had 8 months of early intensive behavior intervention therapy and had no previous history with video modeling. Charlie's VB-MAPP (Sundberg, 2008) score was 9.5 with level 1 scores (0-18 months) in imitation (1.5) and play (2.5). Charlie was non-vocal and enjoyed reading books with adults and peers, could complete 8-10-piece puzzles, build with blocks, and play with toy cars. Charlie was currently being taught various closed ended play activities (e.g. shape sorter, ring stacker) within the clinical setting using a conditioned 10-strip token board.

Settings and Materials

Baseline, training, and probe sessions were conducted in an empty classroom that had a few tables and chairs and a small play area with the materials used in the study. The participant and researcher were the only ones present during all sessions. Sessions took place in an open play area in front of a play kitchen. Videos were shown on an Apple iPad (first generation) in front of the play kitchen. Play materials consisted of a play kitchen, which had a stove, oven, and sink, as well as a plastic pan, knife, plate, fork, and various pretend food items. The play materials were only available during research sessions and were chosen based on the observation of typically developing children in a preschool classroom engaging with similar materials during a free play period. All sessions were recorded using a video camera so that a second observer could record procedural integrity and interobserver agreement data at a later time. During training sessions, a 10-strip token reinforcement system was used to reinforce every correct, independent play action. The token boards were previously conditioned by the participants' behavior technicians for regular instruction within the therapeutic setting.

Dependent Variable

The dependent variable was the percentage of correct, independent play actions with food items completed during each session. There was a total of six trained play actions chosen from a 6x6 matrix and 30 untrained play actions for a total of 36 play actions (see Table 1). The horizontal axis of the matrix contained actions while the vertical axis contained food items. These two axes were combined to form the play actions with food items. Trained play actions were defined as play actions that were targeted for direct training. The matrix was divided into three submatrices, each containing two trained play actions. Submatrix 1 included the trained play actions rinse the carrot and cut the grapes. Submatrix 2 consisted of the trained play actions bake the pepper and cook the strawberry. Trained play actions from submatrix 3 included serve the corn and eat the potato. Operational definitions of each the play actions are provided in Table 2. Untrained play actions were defined as responses that were not targeted for training, but were tested for recombinative generalization during probes (e.g., play actions that were outside the diagonal of the matrix). For example, rinse the pear was a play action that was not down the diagonal of the matrix and therefore not taught during training sessions, but was tested for recombinative generalization during probes. The number of correct play actions was converted to a percentage by dividing the number of play actions independently completed by the total number of response opportunities for that session and multiplying by 100.

Table 1. Matrix containing play actions.

	Cut	Rinse	Bake	Cook	Serve	Eat
Carrot						*
Grapes		1			*	
Pepper				*		
Strawberry			*	2		
Corn		*			3	
Potato	*					3
	Submatrix 1		Submatrix 2		Submatrix 3	

Table 2. Operational Definitions of Play Actions.

Set	Play Action	Operational Definition
A	Rinse	Picking up the fruit or vegetable and holding it under it under the faucet for a count of 1 one thousand then picking up the towel and rubbing the fruit or vegetable ("drying") for a count of 1 one thousand
A	Cut	Picking up the knife and cutting the fruit or vegetable in half
B	Bake	Putting the fruit or vegetable on the baking sheet, opening the oven, and placing both items in the oven
B	Cook	Picking up the frying pan and putting it on the stove, then picking it up the fruit or vegetable and putting it in the frying pan
C	Serve	Placing the fruit or vegetable in the ladle and setting the fruit or vegetable in the bowl
C	Eat	Picking up the fruit or vegetable on the plate and taking at least one pretend bite of the fruit or vegetable

Interobserver agreement (IOA). The first author was the primary facilitator and data collector throughout the study. A graduate student was trained to be a secondary data collector by watching videos of the target behaviors until reaching 80% agreement levels with the first author. The secondary observer collected IOA data by watching videos of previously completed sessions. IOA was derived by using point-by-point agreement (Cooper, Heron, & Heward, 2007) for each behavior was to derive a percentage of agreement. Using this strategy, each play action was scored as an agreement or disagreement between the researcher and secondary observer. The percentage of agreements was attained by dividing the total number of agreements by the total number of agreements plus disagreements and multiplying by 100%. IOA was assessed for at least 30% of training and probe sessions for each participant. For Maddie, mean IOA for probe sessions was 97% (range, 96 to 98%) and 100% for training. For Ben, mean IOA was 96% (range, 93 to 98%) and 98% (range, 97 to 100%) for probe and training sessions, respectively. For Charlie, mean IOA score for probe sessions was 98% (range, 94 to 100%) and 96% (range, 70 to 100%) for training sessions.

Experimental Design

A multiple probe design with probe conditions (Gast & Ledford, 2018) across behaviors replicated across participants was used to evaluate the effectiveness of video modeling on the acquisition of play skills. All 36 possible behavior combinations (e.g., trained and untrained play actions) were initially probed under baseline conditions for all participants. Following baseline, video models for submatrix 1 were introduced for the participant until the mastery criteria was met. Mastery criteria for trained play action from each submatrix was 8 out 10 correct responses (80%) for consecutive sessions. To prevent the mastery of one trained play action but not the other within each submatrix, each participant had to receive a 4 out of 5 for each play action within a 10-trial block to score at least an 80%. Once this criterion was met for the first behavior, all 36 play action combinations were probed under baseline conditions. Following these probes, video models were then applied to trained play actions from the second submatrix and so on until all behaviors were trained and final probes were conducted for all participants.

Procedure

Probe sessions. The first three sessions of this study served as a baseline to assess each participant's pretend play skills with toys from the matrix prior to intervention. To begin probe sessions, the participant was brought to the play kitchen and told, "It's time to play," and the two or three items needed to complete the play action were placed in front of the participant. The participant was given 10 s to complete the play action. After 10 s, regardless of whether or not the participant performed the play action, they were told, "Play is all done," and the materials were cleared from the play kitchen area and the next trial was presented until all 36 possible play actions were probed. Probes began by first assessing the six trained play actions followed by a 30 s break for the participant. After the 30 s break, the ten untrained play actions from submatrix

1 were assessed followed by a 30 s break. Next, the six trained play actions were probed a second time, a 30 s break was provided, and then the untrained play actions from submatrix 2 were probed. This pattern continued until all untrained play actions were probed one time each and the trained play actions were probed three times (see Appendix A). Reinforcer breaks were provided to align with current classroom practices during individualized instruction time and to encourage responding from the participant throughout the session. During these breaks, the participants were given access to a reinforcer (e.g. edibles, toys) chosen prior to the start of the session through a brief multiple stimulus without replacement (MSWO) preference assessment (DeLeon & Iwata, 1996). To ensure untrained play actions were presented in a random order across probe sessions, an online random generator was used to create different versions of probe data sheets for each probe session (See Appendix A). No prompting or reinforcement was provided to participants for correct or incorrect responding during probe sessions. Regardless of whether emergent learning of untrained play actions was demonstrated during probe sessions, training of play actions continued down the diagonal of the matrix as the effects of recombinative generalization may not emerge until the majority of trained play actions have been targeted.

Training. Video models were used to teach participants the trained play actions from three submatrices. Within each training session, the two trained play actions from the corresponding submatrix were alternated within a 10-trial block so that each play action was trained a total of five times within each session (see Appendix B). Trials contained the teaching of one play action began with the instruction, “It’s time to watch a video” and then the participant was shown a 3-5 s video model, which demonstrated one play action. In each video, a female adult said to the female adult participant, “It’s time to play” and then the adult participant performed the play action, such as rinsing a carrot under the play sink. Once the participant finished watching the video, the participant was given the toy items needed to complete the play action demonstrated in the video. Along with instruction, “It’s time to play,” these food items served as the controlling stimuli for what play action to complete. The participant was then given 5 s to initiate a response after the instruction was given and a total of 10 s to complete a response from when the instruction was given. If the participant correctly completed the play action, he or she was reinforced with a token and social praise. If an error or no response occurred after the direction to begin play was given, the trial was scored as incorrect, and the participant was directed to re-watch the video model by the instruction, “Let’s watch the video again.” Once the participant re-watched the video, a full manual prompt was given by the researcher to complete the play action. No feedback or reinforcement (token) was given and teaching continued by beginning the next trial. Once the participant earned all 10 tokens on the token board, he or she received a reinforcer that was selected from the MSWO preference assessment. No materials other than the ones necessary to complete the presented play action were available during training sessions. If the participant performed two consecutive sessions at 0% responding for a trained play action, graduated guidance (Demchak, 1990) was used during the next session. The full physical prompt was provided immediately after the participant had watched the video model and was given the instruction, “It’s time to play.” The physical prompts were faded out trial by trial within one session so that by the last trial, the participant performed the last trial independently.

Additional training. Additional training was conducted if recombinative generalization did not emerge after the trained play actions from all three submatrices were taught to mastery. To conduct additional training, play actions were selected from the opposite diagonal of the matrix (See Table 1). From submatrix 1, the addition training targets included cut the potato and rinse the corn. From submatrix 2, the additional training targets included bake the strawberry and cook the pepper. From submatrix 3, the additional training targets included serve the grapes and eat the carrot. Video models were created for the six additional trained play actions. Additional training was conducted in the same manner as in intervention, but started with the additional trained play actions from submatrix 3 (eat the carrot and serve the grapes). After the mastery of additional trained play actions for each submatrix, a probe was conducted to assess for recombinative generalization and training continued down the opposite diagonal until all additional training targets were taught.

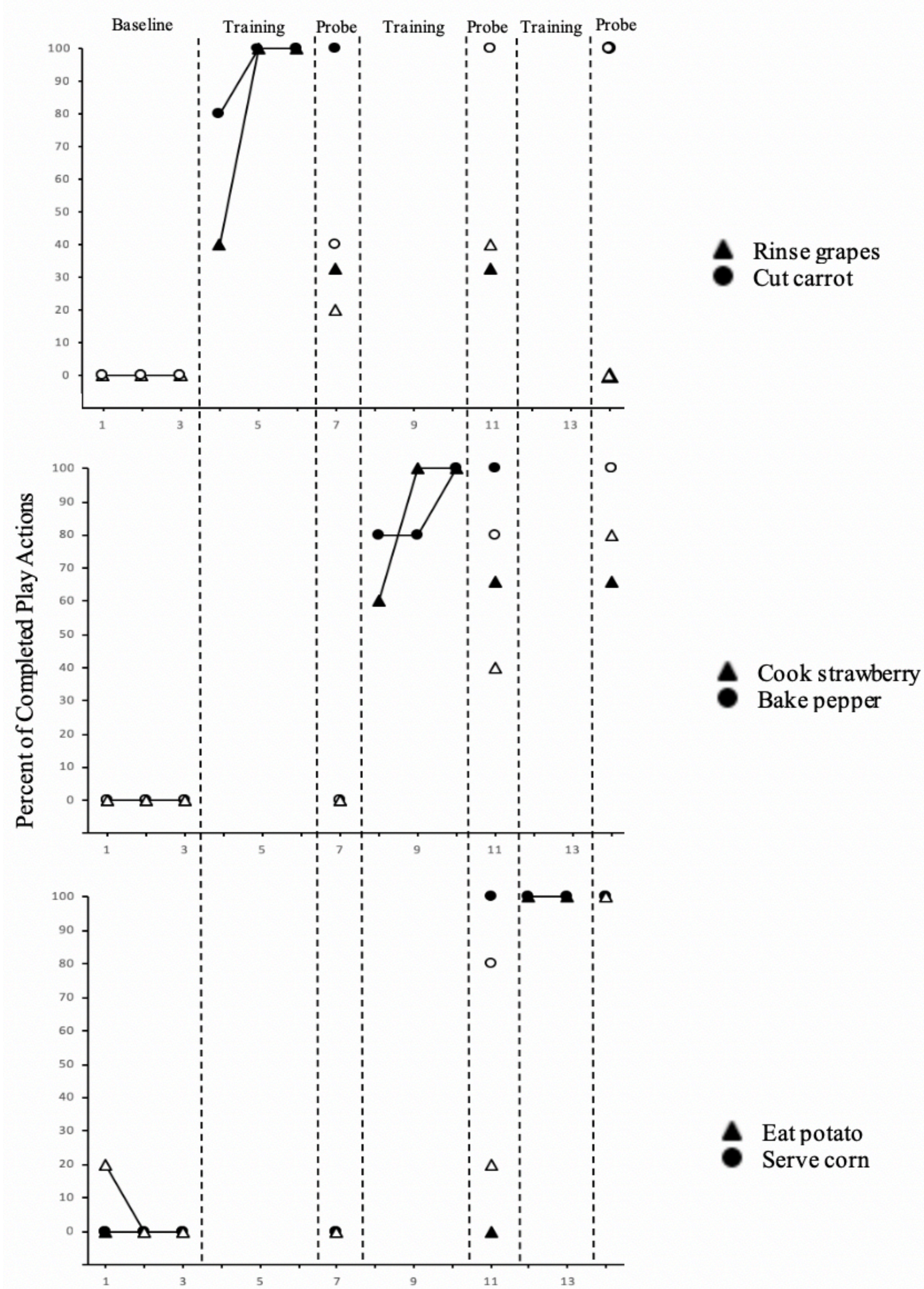
Procedural Integrity

A procedural integrity (PI) checklist with seven operationally defined training steps for both probe and training sessions was created by the first author to assess the extent to which all aspects of the intervention were implemented correctly or incorrectly on a trial by trial basis. Appendix C contains the PI checklist for probe sessions and Appendix D includes the PI checklist for training sessions. Data was collected by a graduate student who was trained by the researcher to assess PI by watching recorded videos of sessions. PI was calculated for at least 30% of all probe and training sessions for each participant. For Maddie, mean PI for probe sessions was 98% (range, 97 to 98%) and 100% for training sessions. For Ben, mean PI was 96% (range 93 to 98%) and 99% (range, 97 to 100%) for probe and training sessions, respectively. For Charlie, mean PI for probe sessions was 100% and 99% (range, 96 to 100%) for training sessions.

Results

Maddie's results are displayed in Figure 1. During baseline, Maddie demonstrated 20% correct responding. Maddie mastered the trained play actions from the first submatrix within three training sessions with a mean of 93% independence (range, 80 to 100%) for the trained play action cut carrot and a mean of 80% independence (range, 40 to 100%) for the trained play action rinse grapes. During the first probe session, Maddie demonstrated 40% recombinative generalization for the untrained play action cut (open circle) and 20% recombinative generalization for the untrained play action rinse (open triangle). Within training for the second submatrix, Maddie demonstrated a mean of 93% independence (range, 80 to 100%) for the trained play action bake pepper and a mean of 87% independence (range, 60 to 100%) for cook strawberry. After the second probe session, results showed that Maddie had 80% recombinative generalization for the untrained play action bake and 40% recombinative generalization for the untrained play action cook from the second submatrix. Results from the same probe showed an increase in recombinative generalization for untrained play actions from the first submatrix with 100% recombinative generalization for the untrained play action cut and 40% recombinative generalization for the untrained play action rinse. Training for the third submatrix was completed in two sessions with a mean of 100% independence for both serve corn and eat potato. During the final probe, Maddie demonstrated 29 of the 36 total behaviors from the matrix (81% independence). Overall, there was 70% recombinative generalization (e.g., 21 out of 30 untrained targets) demonstrated by Maddie.

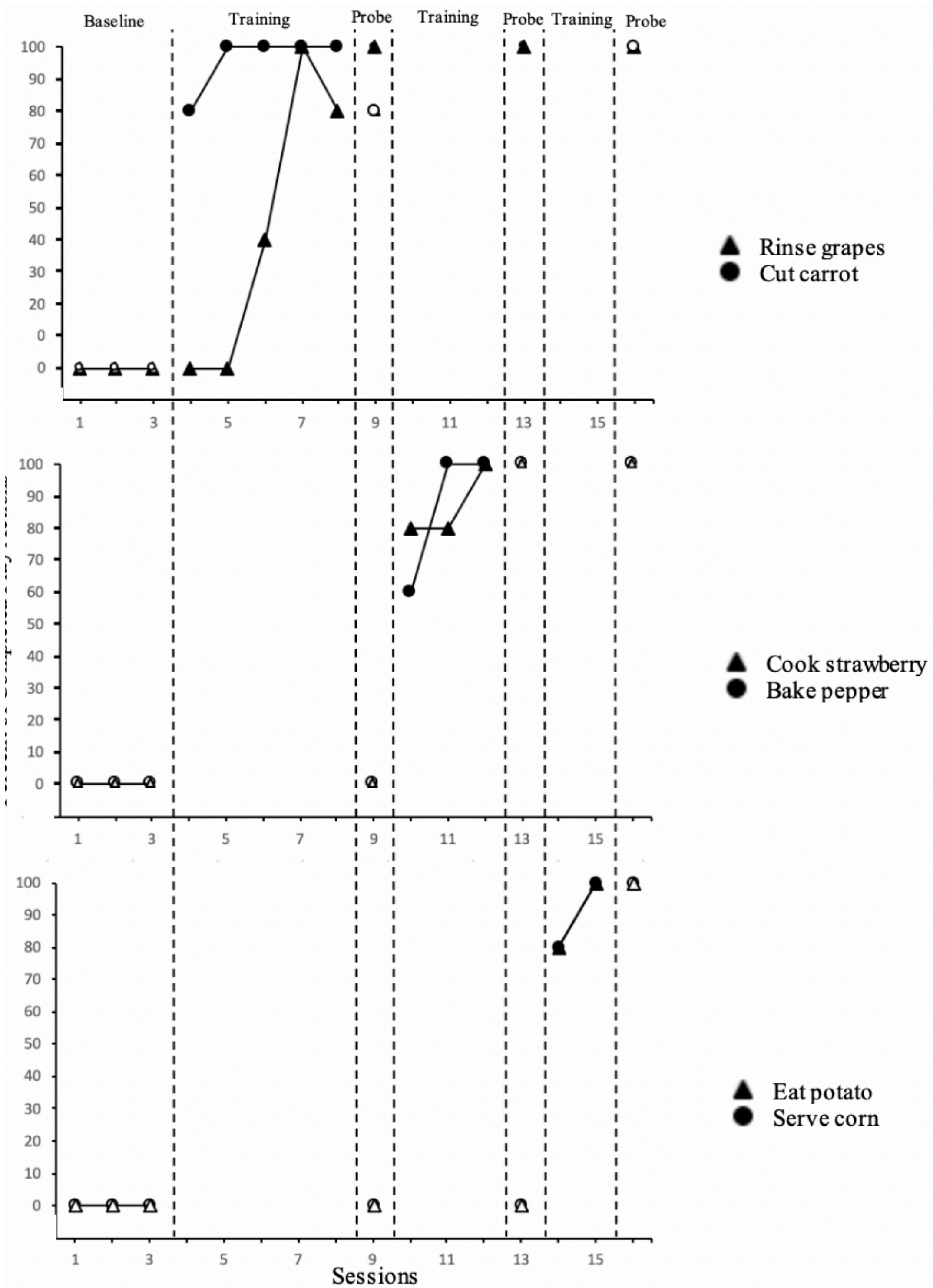
Figure 1. Percentage of Completed Play Actions (Maddie).



Open shapes represent untrained play actions and closed shapes represent trained play actions.

Results for Ben are shown in Figure 2. In baseline, Ben did not demonstrate any play actions from the matrix. During training for the first submatrix, Ben completed the play action cut carrot with 100% independence but completed the play action rinse grapes with 0% accuracy. After two sessions at 0% independence for the play action rinse grapes, graduated guidance was introduced for one session. After additional training was complete, Ben demonstrated a mean of 96% (range, 80 to 100%) independence for the trained play action cut carrot and a mean of 44% independence (range, 0 to 100%) for the trained play action rinse grapes. In the probe following training for the first submatrix, Ben demonstrated 80% recombinative generalization for both untrained play actions rinse (open triangle) and cut (open cirlce). Ben mastered the trained play actions from the second submatrix in three sessions showing a mean of 87% (range, 60 to 100%) independence for bake pepper and a mean of 87% (range, 80 to 100%) independence for cook strawberry. During the second probe, Ben demonstrated 100% recombinative generalization for the untrained play actions in both the first and second submatrix. Last, Ben mastered the trained play actions from the third submatrix in two sessions showing a mean of 90% independence (range, 80 to 100%) for serve corn and a mean of 90% independence (range, 80 to 100%) for eat potato. After all six trained play actions were mastered, Ben showed 100% independence and 100% recombinative generalization, demonstrating all 36 play actions from the matrix.

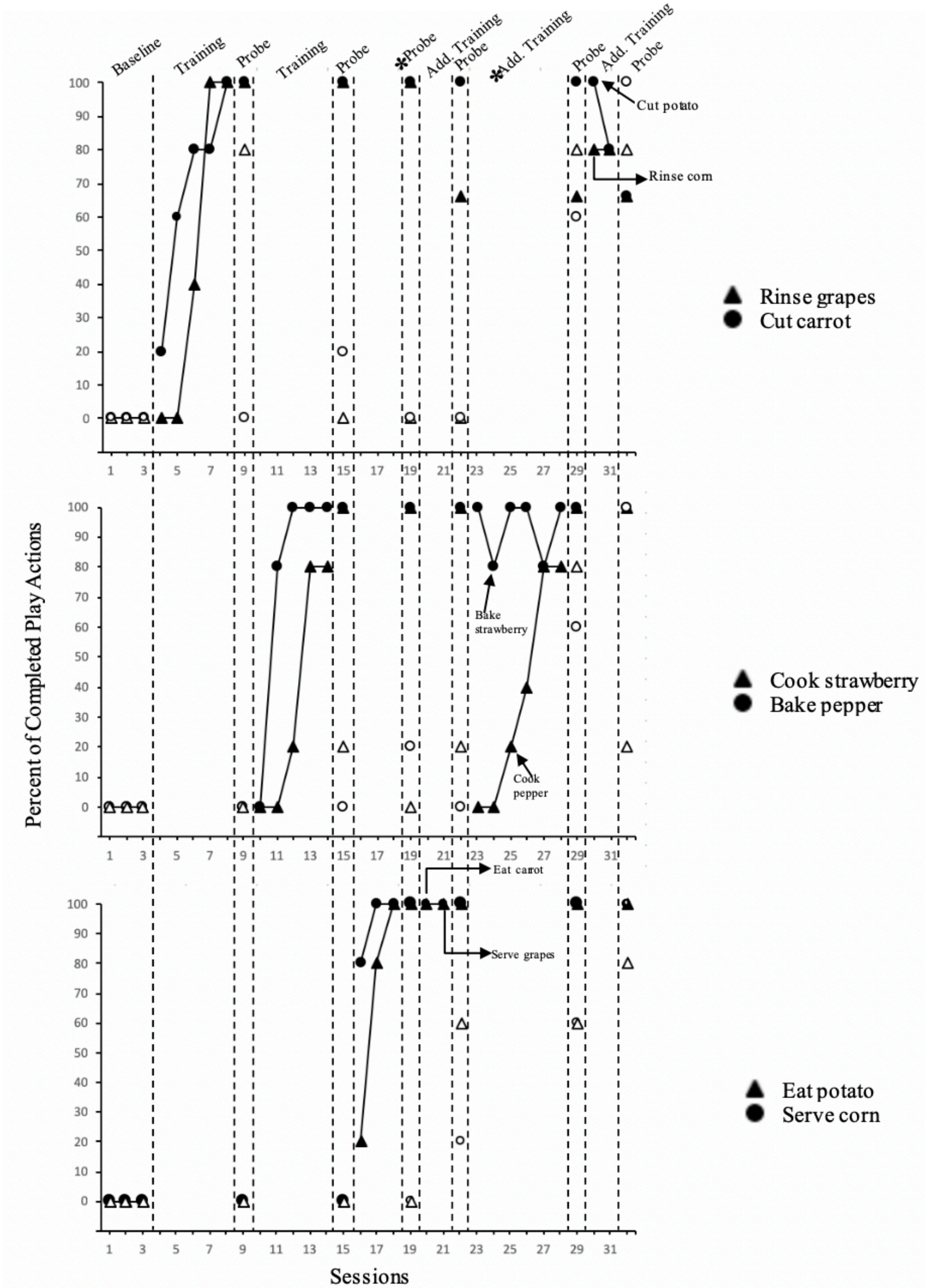
Figure 2. Percentage of Completed Play Actions (Ben).



Open shapes represent untrained play actions and closed shapes represent trained play actions.

Charlie's results are presented in Figure 3. During baseline, Charlie did not perform any of the play actions. During training for the first submatrix, graduated guidance was implemented for the trained play action rinse grapes after two sessions at 0% responding. After training was complete, Charlie demonstrated a mean of 68% independence (range, 20 to 100%) for cut the carrot and a mean of 44% independence (range, 0 to 100%) for rinse grapes. During the first probe, Charlie demonstrated 0% recombinative generalization for the untrained play action cut (open circle) and 80% recombinative generalization for the play action rinse (open triangle). Training for the second submatrix was completed in five training sessions with graduated guidance introduced for the trained play action cook strawberry in the third training session. Charlie showed a mean of 76% independence (range, 0 to 100%) for the trained play action bake pepper and a mean of 36% independence (range, 0 to 80%) for the play action cook strawberry. During the second probe, Charlie demonstrated 0% recombinative generalization for the untrained play action bake and 20% for the untrained play action cook. Training for the third submatrix was completed in three sessions with a mean of 93% independence (range, 80 to 100%) for the trained play action serve corn and a mean of 67% (range, 20 to 100%) for eat potato. During the third probe, Charlie showed a total of 17% recombinative generalization (e.g., 5 out of 30 untrained play actions) across the entire matrix. Due to this low percentage of recombinative generalization, additional training was conducted for Charlie. After training the six additional play actions from the opposite of the diagonal, Charlie demonstrated 20 of the 24 untrained play actions that were not trained, which was 83% recombinative generalization. Overall, Charlie independently completed 27 of the 36 (75%) total play actions from the matrix.

Figure 3. Percentage of Completed Play Actions (Ben).



Open shapes represent untrained play actions and closed shapes represent trained play actions.

Discussion

The purpose of this study was to extend current research using video modeling and matrix training to understand how a 2D matrix could have success in teaching play skills to young children with ASD. Overall, matrix training was effective for producing recombinative generalization, although additional training was required for one out of the three participants. This is consistent with previous literature by using matrix training to efficiently and successfully teach a range of skills to individuals with ASD (Axe & Sainato, 2010; Frampton, Wymer, & Hansen, 2016; Kohler & Mallot, 2014). More specifically, this study demonstrated similar results consistent with previous literature by using video modeling and matrix training to teach play skills to individuals with of ASD (MacManus et. al, 2015). The results of this study extend the previous literature by using a simpler 2D matrix to teach generalized play skills to a wider range of learners with little to no verbal or play skills.

Video modeling seemed to increase the efficiency of instruction for teaching play skills. Maddie mastered trained play actions from both the first and second submatrix within three sessions and mastery criterion was reached within two sessions for the third submatrix. For Ben, the number of training sessions required to master the trained play actions decreased across each submatrix. Similar results were observed for Charlie, who mastered the play actions from the third submatrix faster than the first two; however, Charlie required additional prompting and training to reach mastery and demonstrate recombinative generalization of skills. Previous research has shown that video modeling can lead to a rapid rate of acquisition of skills, with future targeted behaviors often acquired faster than the first (Charlop-Christy, Le, & Freeman, 2000). Efficiency of instruction can be beneficial in a variety of educational settings by decreasing instructional time required to master skills. This is also important when it comes to teaching play skills because of the abundance of naturally occurring learning opportunities that can occur with play skills once they are learned. Some of these opportunities include social skills, fine and gross motor skills, and language skills (Boutout, et. al, 2005). Specifically, play skills similar to those taught within this study could be used in a pretend play area with peers in an inclusive setting for both typically and children with a diagnosis of ASD. Learning functional play skills may also decrease stereotypic or repetitive play with toys (Nuzzolo-Gomez et al., 2002) and eventually help integrate a child with ASD into an inclusive setting.

Matrix training procedures may be particularly useful in EIBI programs as a way to maximize learning outcomes in a time and resource efficient manner. Recombinative generalization was demonstrated for two out of three participants after training on the six training targets, whereas one participant required additional training for recombinative generalization to occur. Maddie mastered the trained targets fairly quickly, but recombinative generalization did not immediately emerge. With the exception of the play action rinse, Maddie's recombinative generalization greatly increased after mastering the trained play actions from the second submatrix and then again in the final probe. This is consistent with previous literature where some participants may take longer to generalize learned skills because they are still learning the routine that matrix training teaches by combining the stimuli along the diagonal of the matrix (Ross, 2017). Although Ben required physical prompting for the play action rinse from the first submatrix, recombinative generalization occurred during the first probe session and reliably increased as additional trained play actions were mastered across the matrix. This demonstration of stimulus control is consistent with results from previous literature where as more trained play actions were taught, the skills transferred to untrained play actions within the matrix (MacManus et al., 2015; Nigam et al., 2006). These findings are beneficial because it demonstrates that by teaching a few simple play skills, additional combinations of play skills can be acquired without direct teaching. Since individuals with ASD struggle to generalize learned skills and directly teaching every possible combination of play action can be time consuming, matrix training may be an efficient way to teach young children with ASD to use a range of pretend play skills.

Charlie eventually demonstrated recombinative generalization after additional training of play actions from all three submatrices. This is consistent with previous literature where additional training was needed for some participants to bring responding under stimulus control and demonstrate recombinative generalization (Axe & Sainato, 2010; Kohler & Mallot, 2014). Additional training may have been necessary for Charlie due to a couple of factors. First, there were planned and unplanned breaks (i.e., holidays or snow days) that resulted in several weeks of missed therapy. For example, there were 2 weeks between Charlie's last training session and third probe, which may be one explanation for the initial lack of recombinative generalization. It is also possible that these breaks in therapy resulted in graduated guidance being implemented for some of the play actions in the additional training phase. Second, Charlie's VBMAPP scores in imitation and play skills were in the Level 1 range and Charlie also had no previous video modeling history. Previous research has shown a performance correlation of successfully using video modeling when participants were able to imitate actions with objects after a 3s delay (MacDonald, Dickson, Martineau, & Ahearn, 2015). It is possible Charlie may have benefited from some kind of pre-teaching for in-vivo imitation to improve his imitation skills or ability to follow one or two step directions. Last, the mastery criterion used in this study may have affected Charlie's ability to generalize play actions during probe sessions. Although 80% independence or higher across two sessions is a standard mastery criterion, Charlie's mean performance for each of the three submatrices was often below 80%. As additional play actions were taught, Charlie's mean performance increased and the number of training trials decreased, meaning video modeling was effective in teaching play skills for Charlie, but he may have benefited from more exposure to the teaching procedure. It is possible that with additional trials or intervention sessions Charlie may have demonstrated greater mastery of the skill, which could allow for greater recombinative generalization.

Overall, there were three main limitations that affected this study. One limitation for participants was the fine motor skills required to complete some of the play actions. For example, for the play action cut, some participants had difficult with the skill with round foods (e.g. potato or pepper). The participants would have to keep the round food item from rolling off of the kitchen counter while trying to cut the food item in half. An initial assessment for pre-requisite skills, like fine motor abilities, should be assessed or taught before teaching certain play actions to set participants up for success. Another option would be to select play actions that do not have the same requirements for fine motor abilities. A second limitation may have been the operational definitions used in the study. For the two participants who did not demonstrate 100% of the skills in the final probe, they often attempted to complete the skill, but did not complete it in a way that aligned with the operational definition. For example, Maddie only demonstrated 27 out of 36 play actions from the matrix, partially because she did not independently complete any of the rinse play actions. Maddie attempted to rinse each food item, but only wiped off the item with a towel and did not hold the item under the faucet. Similarly, Charlie only completed half of the play action cook by putting the food item in the pan, but not placing it on the stove. One way to address this concern could be to increase the mastery criterion during training sessions to allow for additional opportunities to demonstrate the skill correctly and access additional reinforcement prior to probe sessions. Another limitation of this study was the packaged intervention approach used to teach the play actions. While video modeling was the primary independent variable, error correction, physical prompting, and reinforcement were also used. The researchers felt it was necessary to include all of these components in order to align with current practices in each participant's therapy; however, a component analysis would be necessary to determine which variable was responsible for change in responding among participants.

Future research should examine methods to apply matrix training into a more naturalistic way of teaching such as reciprocal imitation training (Ingersoll & Schreibman, 2006), natural intervention (Amsbary & AFIRM Team, 2017), or play sequence video modeling (MacManus et. al, 2015) with a simple 2D matrix. In the current study, the discrete trial format and built in reinforcement may have created rigid performance of the play actions, potentially limiting the participants' ability to use the skills in a natural play environment. Teaching the play actions from a matrix in a natural play sequence may help address this issue along with video fading within training sessions so the participants learn to perform the play action without any kind of instruction or prompt. Next, future research may consider potential methods to decrease the length of probe sessions. Probe sessions for the large 6x6 matrix generally lasted 30-50 minutes for each participant, which is not always feasible in educational settings. Breaking down the 6x6 matrix into a series of smaller 3x3 matrices (Kohler & Mallot, 2014) could help solve this issue by having fewer play actions to probe during each probe session. Using smaller matrices would also make it easier to probe play actions using more naturalistic approaches because there would be fewer play actions to assess at one time.

Overall, this study expands current research on the use of video modeling and matrix training to teach play skills to children with ASD. While there were many variables used within this intervention, video modeling combined with a simple 2D matrix training was effective in producing generalized play skills across participants who had less language and play skills than represented in previous literature. Future research should address the limitations and suggestions from this study to expand on using matrix training to teach play skills so that more learning opportunities are available for students with ASD through play.

APPENDICES

APPENDIX A:

Probe Session Data Sheet

Probe 1 Data Sheet

Date: Participant ID: Researcher:

Diagonal Play Actions 1	
Target	**+ or -**
Cook Strawberry	
Eat Potato	
Cut Grapes	
Rinse Carrot	
Bake Pepper	
Serve Corn	

Non-Diagonal Actions 1	
Target	**+ or -**
Rinse Corn	
Rinse Strawberry	
Rinse Carrot	
Cut Pepper	
Cut Grapes	
Cut Potato	
Cut Strawberry	
Rinse Pepper	
Rinse Potato	
Cut Corn	

Diagonal Play Actions 2	
Target	**+ or -**
Bake Pepper	
Cook Strawberry	
Eat Potato	
Serve Corn	
Rinse Grapes	
Cut Carrot	

Non-Diagonal Actions 2	
Target	**+ or -**
Cook Grapes	
Cook Pepper	
Bake Grapes	
Cook Carrot	
Bake Potato	
Bake Carrot	
Cook Corn	
Bake Strawberry	
Cook Potato	
Bake Corn	

Diagonal Play Actions 3	
Target	**+ or -**
Rinse Grapes	
Cut Carrot	
Cook Strawberry	
Bake Pepper	
Serve Corn	
Eat Potato	

Non-Diagonal Actions 3	
Target	**+ or -**
Serve Grapes	
Serve Pepper	
Eat Pepper	
Serve Potato	
Eat Carrot	
Eat Strawberry	
Eat Grapes	
Serve Carrot	
Eat Corn	
Serve Strawberry	

APPENDIX B:

Submatrix 1 Training Session Data Sheet

Training Session Data Sheet

Submatrix 1

Date:	
Play Action	+ or -
Cut carrot	
Rinse grapes	
Cut the carrot	
Rinse grapes	
Cut the carrot	
Rinse grapes	
Cut the carrot	
Rinse grapes	
Cut the carrot	
Rinse grapes	
% Independent:	

Date:	
Play Action	+ or -
Rinse grapes	
Cut the carrot	
Rinse grapes	
Cut the carrot	
Rinse grapes	
Cut the carrot	
Rinse grapes	
Cut the carrot	
Rinse grapes	
Cut the carrot	
% Independent:	

Date:	
Play Action	+ or -
Cut the carrot	
Rinse grapes	
Cut the carrot	
Rinse grapes	
Cut the carrot	
Rinse grapes	
Cut the carrot	
Rinse grapes	
Cut the carrot	
Rinse grapes	
% Independent:	

APPENDIX C:

Probe Session Procedural Integrity Data Sheet

Page 1 of procedural integrity datasheet for probe sessions. This data sheet continued to 48 trials so each trial of the probe session was assessed for the seven aspects of the procedure listed above.

Probe Session Procedural Integrity

Researcher	
Participant ID	
Date	
Set	
Session Type	Probe

Pre-Session Components	**+ or -**
Play materials in arms reach of researcher	
Video model (iPad) in arms reach of researcher	
Area clear of extra toys or people in play area	

Probe Session																		
+ = Occurred **-** = Did not occur	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Sd, "Ready," given to gain attending from participant																		
Sd, "It's time to play," told to participant																		
Only two items placed in play area when Sd is given																		
10 s given for the participant to complete the play action																		
Toys are cleared after 10 s																		
No reinforcement or feedback given for correct responses																		
Probes were ran in order according to the corresponding randomized data sheet																		

APPENDIX D:

Training Session Procedural Integrity Checklist

Training Session Procedural Integrity

Researcher	
Participant ID	
Date	
Set	
Session Type	Training

Pre-Session Components	**+ or -**
Play materials in arms reach of researcher	
Video model (iPad) in arms reach of researcher	
Area clear of extra toys or people in play area	

Training Session										
+ = Occurred **-** = Did not occur	1	2	3	4	5	6	7	8	9	10
Participant brought to play kitchen										
Participant given the Sd, “It’s time to watch a video,” before shown the video model										
Sd, “It’s time to play,” is given within three seconds of the end of the video model										
The participant is given 10 s to complete a response										
If an error or no response occurred, error correction was implemented										
Reinforcement for participant delivered as described in procedures										
Alternated target behavior										

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