Evaluation of a Treatment Package to Teach Children with Autism Spectrum Disorder to Tact Past Events

by

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Abstract

Speaking about past events is an important part of a functional verbal repertoire. Social interactions, personal safety, and academic success may be enhanced by learning to speak about past events. Unfortunately, children with language delays may have deficiencies in their ability to tact past events. Despite the importance of this skill, few studies have evaluated how to teach children to speak about past events. Experiment 1 evaluated the effectiveness of a treatment package to teach tacts of previously seen items with three children with autism spectrum disorder (ASD). The treatment package consisted of differential reinforcement, intraverbal and stimulus prompt fading, and an increasing delay between seeing an item and being asked “What was in the box?" All three participants reached mastery at a delay of 64 min. Two participants demonstrated generalization to novel items and locations. Experiment 2 evaluated components of the treatment package. The add-in component analysis found that stimulus-prompt fading is an important component of the treatment package and that differential reinforcement was not sufficient to teach delayed tacts. One participant did not meet mastery criterion after all components of the treatment package were implemented. The remaining two participants met mastery criterion at a 4 min delay and demonstrated generalization to novel items in novel locations after all of the components of the treatment package were implemented.

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Chapter 1: Literature Review

Behavior analysts who work with individuals with autism spectrum disorder (ASD) may focus on teaching verbal behavior, because ASD is characterized by deficits in communication (American Psychiatric Association, 2013). Verbal behavior is a category of operant behavior that includes communicative responses and the context in which each response occurs. Research and practice in verbal behavior takes a functional approach to language that focuses on the establishment and maintenance of verbal repertoires. This approach to language is based on Skinner's (1957) analysis of verbal behavior. Skinner broadly defined verbal behavior as behavior that is reinforced through the mediation of another person and suggested that the verbal community shapes and sustains verbal behavior.

Skinner (1957) describes specific verbal operants (e.g., tact, mand, echoic, and intraverbal) that are defined by their function (i.e., the conditions under which each response is most likely to occur and the consequences that maintain it). Antecedent conditions include discriminative stimuli and motivating operations, the presence of an audience, and the speaker's history of reinforcement under similar circumstances. Practitioners and researchers have used Skinner's taxonomy of verbal behavior as a framework to teach language. This approach to language instruction is often called the verbal behavior approach (Barbera & Rasmussen, 2007). There are several assessment tools (e.g., Partington, 2006; Sundberg, 2008) available to evaluate a learner's repertoire and to assist clinicians in developing verbal behavior programming. Verbal behavior programming focuses on teaching specific verbal operants: echoic, mand, tact, intraverbal, autoclitic, textual, and transcription. The verbal operants included in this study (echoic, intraverbal, and tact) will be defined and discussed in the following paragraphs.

Echoic

An echoic is a verbal operant in which a verbal response immediately follows a verbal stimulus and shares point-to-point correspondence and formal similarity with the stimulus (Skinner, 1957). For example, Golfeto and Souza (2015) taught prelingual children with cochlear implants to repeat the sentence "Juca is peeling the lemon" after hearing a computer provide a vocal model. In this example, the discriminative stimulus (S^D) and response share formal similarity because both are vocal ("Juca is peeling the lemon"). The point-to-point correspondence relates to the match between the sound of the stimulus and response. Point-to-point correspondence can also occur when a sign in sign language is repeated, because the stimulus and response share visual similarities. Echoics are maintained by generalized conditioned reinforcers. For example, a parent may deliver praise (e.g., "great job saying 'dada") after a child responds echoically.

Vocal imitation training is one approach to teaching echoic responding. During vocal imitation training, the clinician delivers reinforcers contingent on correct imitation of target vocal sounds. In some cases, the clinician may deliver reinforcers for successive approximations in the form of gradual steps toward the target vocal sound (i.e., shaping). For example, a clinician may provide access to a favorite ball after the child imitates the "b" sound. Following success with the "b" sound, the clinician may provide access only when the child echoes "ba" and eventually "ball." Previous researchers have used vocal imitation to establish echoic responding (Brigham & Sherman, 1968; Carroll & Klatt, 2008; Lovaas, Berberich, Perloff, & Schaeffer, 1966).

Another approach to echoic training is stimulus-stimulus pairing, which involves pairing target vocal sounds with established reinforcers. Through this stimulus-stimulus pairing procedure, the vocal sound becomes a conditioned reinforcer (e.g., Esch, Carr, & Grow, 2009;

Miguel, Carr, & Michael, 2002; Sundberg, Michael, Partington, & Sundberg, 1996) and vocalizations increase. However, the effects of stimulus-stimulus pairing on increasing target vocalizations have been inconsistent within and across studies (Esch et al., 2009).

Operant discrimination training can be used to teach echoics. During operant discrimination training, an auditory stimulus signals the availability of reinforcement. For example, Lepper, Petursdottir, and Esch (2013) reinforced each occurrence of arm raising following the presentation of a target vocalization (e.g., "goo") but not following the presentation of a non-target vocalization (e.g., "mee-muh"). The participants emitted more target vocalizations during operant discrimination training than in a control condition and a stimulus-stimulus pairing condition. Cividini-Motta, Scharrer, and Ahearn (2017) evaluated an assessment tool to identify the most effective echoic training procedure (vocal imitation training, a mand-model procedure, or stimulus-stimulus pairing) for individual learners. The assessment was effective in identifying the appropriate echoic training procedure for five of six participants. However, the most effective echoic training procedure varied across participants.

A strong echoic repertoire is important, because once a functional echoic repertoire is established, vocal models can be used to transfer control to additional operants, such as mands (e.g., Kodak & Clements, 2009), tacts (e.g., Bloh, 2008; Majdalany, Wilder, Smeltz, & Lipshultz, 2016), and intraverbals (e.g., Valentino, Shillingsburg, & Call, 2012). An individual who cannot echo a word would be unlikely to use that word in other contexts (Sundberg & Michael, 2001).

Intraverbal

The intraverbal is a verbal operant in which a verbal response is under the control of a previously presented verbal S^D and is maintained by a generalized conditioned reinforcer. Intraverbal responses do not share point-to-point correspondence with the verbal S^D (Skinner,

1957). In other words, an intraverbal occurs when a verbal stimulus such as "One, two, buckle my…" evokes a non-identical response such as "shoe." Intraverbals occur when singing songs, completing math equations, word associations, answering questions, and typical two-way conversations. For example, Vedora, Meunier, and Mackay (2009) taught a series of intraverbal responses to children with autism, including the response, "drink" to the question, "What do you do with a cup?" Intraverbals are important because much of our daily conversation is comprised of intraverbals. In fact, Sundberg (2008) suggested that typical adults emit thousands of intraverbals each day.

Tact

A tact is a verbal operant in which a response is occasioned by an object or event or property of an object or event (Skinner, 1957). In other words, tacts are verbal responses to nonverbal discriminative stimuli, such as physical objects, pictures, people, or events.

Tact Training

The goal of tact training is for an environmental stimulus (e.g., the presence of a flower) to evoke a verbal response (e.g., saying "flower). During typical tact training, the clinician presents a stimulus (commonly an object or a picture of an object; e.g., Arntzen & Almas, 2002). The clinician may provide a supplemental question (e.g., "What is it?") to prompt a tact response (e.g., Barbera & Rasmusssen, 2007; Sundberg & Partington, 1998; Wallace, Iwata, & Hanley, 2006) or provide no vocal cue (Partington, Sundberg, Newhouse, & Spengler, 1994). Some individuals may learn tacts more efficiently when a supplemental question is provided, while others may learn more quickly without a vocal prompt (Marchese, Carr, LeBlanc, Rosati, & Conroy, 2012). In addition to objects, clinicians can teach children to tact features of an item. For example, a child could learn to tact colors (e.g., red), parts of objects (e.g., wheels), and comparative size (e.g., big). Clinicians can teach tacts of other environmental stimuli, such as

sounds and textures (Hanney, 2012) and tacts of actions with the question, "What am I doing?" (Williams, Canerero, & Perez-Gonzalez, 2006). Typically, the correct response to a tact trial is saying or signing (Sundberg, Endicott, & Eigenheer, 2000) the word that corresponds to the environmental stimulus. For example, if the clinician held up a toy car, the correct response would be the word or sign "car."

During tact training, clinicians use prompts to increase the likelihood of a correct response. Clinicians may use echoic, receptive, or mand prompts during tact training. The most common prompt is an echoic prompt in which the clinician provides a vocal model (e.g., "car") of the correct response (e.g., Majdalany et al., 2016; Marchese et al., 2012). When using a receptive prompt, the clinician presents a listener discrimination (also referred to as receptive) trial (e.g., "touch the car") immediately before running a tact trial (Barbera & Kubina, 2005). Clinicians can use a mand prompt by presenting a tact trial for an item immediately after a child makes a request (mand) for that desired item (Barbera & Rasmussen, 2007). For example, a clinician may present a piece of candy that the child has just requested and ask, "What is it?"

Regardless of the form, prompts are gradually faded so that control is transferred from the prompt to the object itself. Most-to-least prompting (Barbera & Rasmussen, 2007) and progressive-time delay prompt fading (Majdalany et al., 2016) are commonly used in teaching tacts. These procedures typically involve presenting prompts immediately after the S^D is presented (i.e., a 0-s delay) and then gradually increasing the delay between the S^D and the prompt. For example, a clinician may present a picture of a car and say, "What is it? Car." The echoic prompt "car" increases the likelihood of the child answering correctly. In later sessions, the clinician would increase the delay between the presentation of the picture and the echoic prompt before completely removing the prompt.

During tact training, the clinician delivers a reinforcer after the child emits the correct tact. Reinforcement typically includes social praise (e.g., "that's right" or "great job"). Additional reinforcers (e.g., edibles, tokens, tangibles, activities) can be provided during acquisition and faded once the tact is mastered. If the child does not make a response or makes an incorrect response, the clinician frequently implements an error-correction procedure and provides a vocal model of the correct response (e.g., Arntzen & Almas, 2002; Carroll & Hesse, 1987; Marchese et al., 2012).

Tact training is an effective method for teaching individuals to label items, events, and their features. The current tact training literature has focused on teaching tacts when the nonverbal S^D (e.g., item, sound, texture) is present (e.g., Arntzen & Almas, 2002; Majdalany et al., 2016; Marchese et al., 2012). However, little research has evaluated how to apply these procedures when teaching someone to tact an item that is no longer present (delayed tacts).

Correspondence Training

When discussing events from the past or future, correspondence training may be helpful because it involves discussing an event before or after it occurs. During correspondence training, verbal behavior that is consistent with nonverbal behavior is reinforced (Baer, 1990). In other words, what the child says must match what the child does. There are two main forms of correspondence training. Say-do correspondence training involves reinforcing instances in which the child's behavior matches a statement the child previously made about his or her behavior (e.g., "Today I am going to ___."). For example, a client might say, "I am going to finish my math homework before I go outside to play." A clinician would provide a reinforcer if the child completed his math homework before going outside. Alternatively, in do-say correspondence training, verbal behavior that corresponds to previous behavior is reinforced. For example, Risley and Hart (1968) provided reinforcers when children's verbal reports about which toys

they played with matched their previous toy play. Although do-say correspondence training can improve the accuracy of reporting past events, it does not address how to teach children to talk about past events.

Working Memory and ASD

Cognitive psychology has produced myriad studies that evaluate memory in individuals with ASD. For a systematic review of research on memory in individuals with ASD, see Bordignon, Endres, Trentini, and Bosa (2015). Much of the research on individuals with ASD has focused on working memory (e.g., Kercood, Grskovic, Banda, & Begeske, 2014). Working memory refers to the ability to retain information over a delay and make a response based on that internal stimulus representation (Klingberg et al., 2005). Research on working memory in individuals with ASD has largely focused on identifying impairments in memory by comparing performance of individuals with ASD to typically developing individuals on a variety of memory tasks (e.g., Digit Span, visuospatial delayed matching-to-sample). Research examining working memory impairments in ASD has produced inconsistent effects (Bordignon, et al., 2015). However, a recent meta-analysis of working memory in ASD (Wang et al., 2017) suggested a significant impairment in working memory for individuals with ASD.

Although there is a wealth of research focused on identifying working memory impairments in children with ASD, there is limited research on methods to improve their working memory. A series of investigations on the effects of positive reinforcement on a working memory task performance with children with ASD found robust improvements on counting span (Baltruschat et al., 2011a), digit span backwards (Baltruschat et el., 2012), and complex span (Baltruschat et al., 2011b) tasks. The researchers provided access to preferred items or edibles contingent on accurate performance on the tasks. In each evaluation, participants demonstrated improvements with positive reinforcement that maintained after

reinforcement was discontinued (i.e., maintenance). High levels of performance also generalized to novel stimuli (e.g., letters that were not used during training; Baltruschat et al., 2011b).

Past Events and Behavior Analysis

Behavioral interpretations of remembering (Delaney & Austin, 1998; Palmer, 1991; Skinner, 1957) have described it as a complex behavior which likely entails a series of stimuli and responses that occur over a period of time. Experimental interpretations of remembering (e.g., White, 2001), suggest that remembering is a discrimination that occurs at the time of recall and that remembering is ruled by the same principles of discrimination and generalization as other behavior. Much of the experimental analysis of remembering examines forgetting functions (i.e., the accuracy of remembering decreases as the retention-interval duration increases) on delayed matching to sample tasks (e.g., White & Brown, 2014). Behavioral theories of remembering (e.g., Nevin, Davison, Odum, & Shahan, 2007; White & Brown, 2014; White & Wixted, 1999) offer quantitative predictions of forgetting functions that can account for an array of variables (e.g., reinforcement parameters, parameters of the of the sample stimulus). See White (2013) for a review of the experimental analysis of remembering and forgetting.

Behavior analysts have conducted relatively little research on speaking about past events. Skinner (1957) briefly discussed past events by saying, “the ability to respond verbally ‘to past events’ is acquired and acquired under explicit reinforcing contingencies arranged by the verbal community for just this purpose” (p. 142). Based on this interpretation, deficits in recalling past events may be due to errors in stimulus control (Delaney & Austin, 1998; Palmer, 1991; Skinner 1957) or an insufficient history of reinforcement (Shillingsburg, Carivequ, Talmadge, & Frampton, 2017). Behavioral research on recalling past events has focused on the use of prompts and reinforcement as a means to improve reporting past events.

Krantz, Zalenski, Hall, Frenske, and McClannahan (1981) taught two children with autism to answer questions about past events. Participants completed activities at home and at school. Parents asked the children about their school activities upon coming home and teachers asked about their home activities upon arriving at school. The student rehearsed the appropriate responses to questions about the completed activities for 10 min in the environment in which the behavior occurred (home or school). During rehearsal, the parent or teacher asked the child the targeted questions (e.g., "What did you do outside with your brother?"), provided vocal models for correct answers, and reinforced correct prompted responses. Written questions about the activities and the corresponding answers were placed in the child's backpack each day so correct answers could be reinforced. If the participant responded incorrectly or there was no answer within 3 s of the question, the parent or teacher said "no" and modeled the correct response (e.g., "Say Mr. Brown met me at the bus."). Correct responding to targeted questions increased for both participants. When the researchers removed the rehearsal component with one participant, correct responses temporary declined, then returned to high levels of correct responding. The researchers did not remove the rehearsal component with the other participant.

Mason, Davis, and Andrews (2015) taught one preadolescent and two adolescent boys with verbal repertoires scoring above level 3 in all domains of the Verbal Behavior Milestones Assessment and Placement Program (VB-MAPP; Sundberg, 2008) to answer questions about conversations with visitors. Visitors engaged in scripted conversations with each participant during which the visitors provided information about themselves (e.g., any pets they owned) and asked the participant questions (e.g., "Do you have any pets?"). Following these conversations, the experimenters asked the participants questions (e.g., "Who was that person to whom you were just speaking?" and "Can you tell me anything else about him?"). Participants received tokens (exchangeable for access to preferred items) for each visitor attribute they reported.

Participants provided more information about the visitor with the token-economy intervention. Two of three participants maintained high levels of performance during a two-week probe that included token reinforcement.

Shillingsburg et al. (2017) increased the accuracy with which children with ASD reported past behavior though response prompting, reinforcement, and prompt-fading procedures. At the start of the study, both children accurately reported their behavior immediately following an activity but failed to report past behavior (three activities that occurred at three separate locations) at end-of-day probes (following a 1- to 2.5-hr delay). For example, when asked what the child did in the book corner the correct response might be "read a book." The experimenters provided praise and edible items for correct responses to immediate and delayed probes. Following incorrect responses, the experimenters provided an echoic prompt (e.g., "say we read a book") for one participant and a tact prompt (a digital photo of the participant completing the activity) for the other participant. When incorrect responding at end-of-day probes continued for both participants, the researchers moved to a delay-fading condition where they provided additional opportunities to respond to probes during the delay. During additional probes, the experimenters asked the participant to recall a single activity. Following success with these additional probes, they gradually increased the duration between the probes from 15 min to 1 hr. Errors continued to occur on end-of-day probe during the delay-fading condition; thus, the researchers provided end-of-day probe practice trials to improve accurate responding for one participant. The end-of-day practice trials immediately followed the activities and mimicked the end-of-day probes (i.e., the participant was asked to recall all three activities). Prompting and error-correction were provided for incorrect responses during practice trials. For the other participant, the researchers gradually removed the immediate probes rather than removing them abruptly to increase the likelihood of correct responses to end-of-day probes. In the final phase

of the study (end-of-day probe only), both participants responded correctly to end-of-day probes without immediate probes or prompts.

While rehearsal and reinforcement have been successful in teaching children with advanced verbal repertoires to respond to questions about past events (Krantz, et al., 1981; Mason, et al., 2015; Shillingsburg et al., 2017), it is unclear how this repertoire is acquired in early learners with limited language skills. For example, with participants placing at level 2 (age equivalence 18 – 30 months) or below on the VB-MAPP (Sundberg, 2008). However, the acquisition of this repertoire could provide many benefits to the learner.

Much of our daily verbal behavior involves discussing objects or events that are no longer present (i.e., delayed tacts). In other words, past events regularly influence our verbal behavior. For example, when socializing with friends we may discuss what we did over the weekend or describe a movie we saw. Academic behavior also involves recalling past events (e.g., Hall, Jarrold, Towse, & Zarandi, 2015). For example, a social studies quiz requires students to recall previous readings or class discussions to answer the questions and earn points towards a high grade. Speaking about past events could also provide greater security. Parents may feel more comfortable if their child can report the activities he or she engaged in while the child was out of parental supervision. Safety concerns could be heightened by evidence that children with ASD and other developmental disorders may be at greater risk of abuse (Sevlever, Roth, & Gillis, 2013). Teaching children with language delays to tact past events has the potential to enrich their social interactions with family and peers, improve academic skills, and provide greater safety and security.

Despite the importance of speaking about past events, little research has been conducted on the acquisition of this skill. Furthermore, behavioral assessments do not explicitly assess this skill (e.g., Sundberg, 2008; Sundberg & Partington, 1998). Given the importance of a functional

repertoire of speaking about past events in developing social relationships and the direct implications for personal safety, establishing and evaluating procedures to teach delayed tacts to children with ASD is of substantial practical importance.

The purpose of the current study was to expand the literature on discussing past events by bridging the gap between labeling visible items and talking about items that were previously seen. Specifically, this study examined a treatment package to teach children to respond to a question about a previously seen item. Additionally, this study evaluated if the treatment package resulted in generalization to novel stimuli and environments. In Experiment 1, the experimenter used prompts, reinforcement, and an increasing intra-trial delay to teach participants to respond to the discriminative stimulus, "What was in the box?" by naming an item viewed previously. Experiment 2 evaluated the components of this treatment package through an add-in component analysis.

Chapter 2: Experimental Procedures

Evaluation of a Treatment Package to Teach Children with

Autism Spectrum Disorder to Tact Past Events

Behavioral interpretations of remembering (Delaney & Austin, 1998; Palmer, 1991; Skinner, 1957) have described it as a complex behavior which likely entails a series of stimuli and responses that occur over a period of time. Experimental interpretations of remembering (e.g., White, 2001), suggest that remembering is a discrimination that occurs at the time of recall and that remembering is ruled by the same principles of discrimination and generalization as other behavior. See White (2013) for a review of the experimental analysis of remembering and forgetting.

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Reinforcement in combination with response prompts and rehearsal has also successfully improved responding to past events. Krantz, Zalenski, Hall, Frenske, and McClannahan (1981) taught two children with autism to answer questions about past events. Participants completed activities at home and at school. Parents asked the children about their school activities upon coming home and teachers asked about their home activities upon arriving at school. The implementation of rehearsal, vocal models, and reinforcement increased correct responding to targeted questions for both participants. The researchers removed the rehearsal component with one participant. Correct responses temporary declined when rehearsal was discontinued, then returned to high levels of correct responding.

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delayed tacts could provide many benefits to the learner. Much of our daily verbal behavior involves discussing objects or events that are no longer present (i.e., delayed tacts). In other words, past events regularly influence our verbal behavior. For example, when socializing with friends we may discuss what we did over the weekend or describe a movie we saw. Academic behavior also involves recalling past events (e.g., Hall, Jarrold, Towse, & Zarandi, 2015). For example, a social studies quiz requires students to recall previous readings or class discussions to answer the questions and earn points towards a high grade. Speaking about past events could also provide greater security given that children with ASD and other developmental disorders may be at greater risk of abuse (Sevlever, Roth, & Gillis, 2013). Parents might feel more comfortable if their child can report the activities he or she engaged in while the child was out of parental supervision. Teaching children with language delays to tact past events has the potential to enrich their social interactions with family and peers, improve academic skills, and provide greater safety and security.

Despite the importance of speaking about past events, little research has been conducted on the acquisition of this skill. Furthermore, behavioral assessments do not explicitly assess delayed tacts (e.g., Sundberg, 2008; Sundberg & Partington, 1998). Given the importance speaking about past events in developing social relationships and the direct implications for personal safety, establishing and evaluating procedures to teach these skills to children with ASD is of substantial practical importance.

The purpose of the current study is to expand the literature on discussing past events by bridging the gap between labeling visible items and talking about items that were previously seen (delayed tacts). Specifically, this study examined a treatment package to teach children to respond to a question about a previously seen item and evaluated if the treatment package resulted in generalization to novel stimuli and environments. In Experiment 1, the experimenter

used prompts, reinforcement, and an increasing intra-trial delay to teach participants to respond to the discriminative stimulus, "What was in the box?" by naming an item viewed previously. Experiment 2 evaluated the components of this treatment package (differential reinforcement, intraverbal-prompt fading, and stimulus-prompt fading) through a component analysis.

Experiment 1: Evaluation of a Treatment Package

Method

Participants. Three children diagnosed with ASD participated. Pseudonyms were provided to protect the confidentiality of the participants. Ryan and Hughey were 7-year-old Hispanic males who received an average of 8-12 hours of ABA services in their homes. Robert was a 6-year-old African-American male who received ABA services in a clinic-based setting 40 hours a week. All three participants had programs that primarily focused on verbal behavior and social skills. Ryan's ABA programming included training on intraverbals, multiple-word echoic phrases, mands, tacts, gaining attention from others, and playing games with rules. Hughey's programs included training on intraverbals, tacts, and taking turns. Robert's programs included mands and tacts with noun-verb combinations, tacts of adjectives, four-syllable echoics, manding to peers, responding to peer mands, and responding to group instructions. All participants communicated vocally and used at least two-word sentences consisting of a noun and verb. All participants demonstrated the skills necessary to meet the requirements for completion of level two of the VB-MAPP intraverbal and tact assessment subtests (Sundberg, 2008). Specifically, participants were able to complete at least 25 fill-in-the-blank phrases, answer 25 different what questions, and tact at least 25 items when asked, "What's that?" None of the participants had a diagnosed visual or hearing impairment.

Setting and materials. Session locations varied across participants. Ryan's sessions took place at a dining room table in his home. Hughey's sessions were in his bedroom and

Robert's sessions were in a semi-private room (shared with one other client) at an ABA clinic. During the session, the therapist and participant sat at a table with at least two chairs. Some sessions included an additional trained data collector to collect interobserver agreement (IOA) and procedural integrity data. Session materials consisted of several small tangible items (e.g., toy food, animals, and vehicles). During the study, these items were placed in a transparent rectangular container (19 cm by 16.5 cm by 9 cm). During stimulus-prompt fading, the container was lined with paper of increasing levels of opacity (e.g., colored saran wrap, wax paper, construction paper). A trial consisted of one opportunity to respond to the question, "What was in the box?" Each session consisted of five trials. Sessions with long intra-trial delays (e.g., 32 min, 64 min) were conducted across days.

Response Measurement. Data on participant responses were collected on a trial-by-trial basis using paper-and-pencil data collection. A correct response was defined as a vocal response to the question, "What was in the box?" that corresponded to the item in the container (e.g., saying "cow" when the corresponding item was a toy cow). An incorrect response was defined as no vocal response within 10 s of the question or a vocal response that was inconsistent with the item in the container (e.g., saying "car" when the item in the container was a cow). The percentage of correct responses for each session was calculated by dividing the total number of correct responses by the total number of trials in the session (five) and multiplying the proportion by 100.

Interobserver Agreement and Procedural Integrity. Two trained observers independently recorded data during 38%, 39%, and 39% of sessions for Ryan, Hughey, and Robert, respectively. Trial-by-trial IOA (e.g., Cividini-Motta, Scharer, & Ahearn, 2016) was collected across phases (e.g., baseline, teaching, generalization probes). For each trial, the experimenter compared the responses of the two observers to evaluate if the observers agreed or

disagreed. An agreement was defined as both observers independently marking the same response (i.e., correct or incorrect). A disagreement was defined as two observers marking different responses. The total number of agreements was divided by the total number of agreements and disagreements and multiplied the proportion by 100 to obtain a percentage of agreement. Mean percentage agreement was 97% (range, 80%-100%) for Ryan, 100% for Hughey, and 99% (range, 80%-100%) for Robert.

An independent observer recorded procedural integrity data during 37% of sessions across conditions and participants. Therapist actions were evaluated and marked as correct (consistent with protocol) or incorrect. The observer recorded whether the therapist (1) presented the item and waited for the participant to look at the item; (2) asked "what is it?" or said "look" (based on condition); (3) waited for the appropriate delay; (4) presented S^D ("what was in the box?"); (5) showed participant the item in the container (except baseline); (6) provided differential reinforcement (except baseline); and (7) implemented correction procedure (if necessary). Procedural integrity was calculated by dividing the number of correct responses by the total number of opportunities for a response and multiplying the proportion by 100. Mean percentage procedural integrity was 99% across participants.

Pre-experimental Procedures

Preference assessment. The therapist conducted a multiple-stimuli without-replacement (MSWO) preference assessment (DeLeon & Iwata, 1996) with seven items to identify potential reinforcers. Brief-MSWOs (consisting of the top four items identified in the MSWO) were conducted before each session during baseline, teaching, and generalization probes. Highly preferred items were toy cars and figurines for Ryan; watching videos and drawing for Hughey; and access to a cellphone camera and a stuffed toy for Robert. One of the top two items

identified in the brief-MSWO were provided contingent on correct responding during the session.

Immediate tact assessment. Prior to initiating baseline trials, an immediate tact assessment was conducted to verify that participants could correctly tact the items included in baseline, teaching, and generalization trials. This helped to ensure that incorrect or absent responses were not a function of a deficient immediate tact repertoire. The assessment included 20 common objects that could fit inside the container (e.g., toy horse, small car, plastic apple). Each item was presented three times during the assessment. The therapist held the item in front of the participant and asked, "What is it?" Correct immediate tact responses were defined as saying the name of the item within 10 s. No response after 10 s or responses that were inconsistent with the displayed item (e.g., saying "ball" in the presence of an apple) were marked as incorrect. The therapist delivered a preferred tangible item (30-s access) following correct responses. Following an incorrect response, the therapist did not provide programmed consequences and moved to the next trial. Identical probe procedures were used to identify locations (e.g., sink, fridge, backpack) for the generalization probes. Items the participant tacted accurately on 100% of presentations were included in the study. Items varied across trials with 10 items in rotation during baseline and teaching sessions. Five additional items and five locations were used in the generalization assessment. See Table 1 for the items and locations used for each participant in baseline, teaching, and generalization probes.

Generalization Probes

Generalization probes consisted of five untrained questions (i.e., novel stimuli and environments). For example, "What was in the backpack?" or "What was in the bucket?" The generalization probes included target items and locations that were not used in teaching. The therapist prompted the participant to look at the item placed in the novel location. Following a

specified delay, the therapist asked the participant what item he saw. Generalization probes consisted of five trials with varying delays (one trial at 15 s, 1 min, 4 min, 16 min, and 64 min). Generalization probes were conducted during baseline and once the criterion for mastery was met.

Experimental Design

A noncontiguous multiple-baseline across-participants design was used to determine the effects of the teaching package on tacting past events (Kazdin, 1982). Visual inspection was used to evaluate the effects of the treatment. Levels of accuracy during baseline were visually compared to levels during and following teaching.

Procedures

Baseline. During baseline, a container lined with construction paper was placed on the table within 60 cm of the participant. The therapist held up the item and said “look.” Once the participant looked at the item, the therapist placed the item in the container and put the lid on the container. If the participant did not look at the item within 5 s, the therapist continued holding up the item and repeated the command, “look.” If the participant did not look following three prompts, the trial would have ended; however, this did not occur. The therapist placed the item in the container and placed a lid on the container. The closed container remained on the table throughout the trial. After the pre-determined duration elapsed, the therapist asked, "What was in the box?" The therapist did not provide programmed consequences for any correct or incorrect responses. During the delay, participants engaged in regular ongoing behavior-analytic programming targeting verbal behavior (e.g., intraverbals) and social skills (e.g., gaining adult’s attention). Praise and access to preferred items were provided following correct responses to regular program targets during the delay.

Baseline trials began with the presentation of the item and ended when the participant responded to the target question or if there was no response after 10 s. Baseline consisted of at least five sessions at a 15-s delay. Additional baseline probe trials occurred at the following delays: 30 s, 1 min, 4 min, 16 min, and 64 min presented in an ascending order. The delay began once the item was placed in the container and the lid was closed.

Teaching. The treatment package included programmed consequences following responding (differential reinforcement), stimulus-prompt fading, intraverbal prompt fading, and delay fading. Teaching trials began when the therapist placed the item inside the container. The closed container remained on the table throughout the trial. After the pre-determined duration elapsed (see intra-trial delay section below), the therapist asked, "What was in the box?" Following correct responses, the therapist showed the participant the item, said “You’re right! It was a [name of item],” and provided 30-s access to preferred items. Following an incorrect response, the therapist implemented an error-correction procedure. The therapist said, “It was a [name of item]” and revealed the item. The therapist repeated the question, “What was in the box?” while presenting the item as a tact prompt, waited for the participant to tact the item, and then placed the item back in the container. For trials with a delay of 2 min or less, the therapist used the same delay as the teaching trial. For trials with a delay greater than 2 min, a 2-min delay was used during the error-correction procedure. The therapist repeated this error-correction procedure until a correct response was made to the question “What was in the box?” If there was not a correct response after five attempts with the error-correction procedure, the trial ended and the therapist began a new trial.

Teaching began at a 15-s delay with a transparent container (the item in the container was visible) and a prompt to tact the item (i.e., the therapist asked, “What is it?” before placing the item in the container). As teaching progressed, both stimulus and intraverbal prompts were

faded as outlined below. Additionally, the delay between placing the item in the container and the question, "What was in the box" increased based on previous success.

Stimulus-prompt fading. Items were initially placed in a transparent container. The container was lined with paper of increasing levels of opacity across sessions (refer to Table 2). Step 1 was a transparent container (no lining). In step 2, a colored saran wrap lining was added to allow the participant to see the item inside the container, but not as clearly. In step 3, wax paper was applied to the interior of the container to make it more difficult to see the item inside the container. In step 4, a piece of opaque colored construction paper lined the container, making it impossible to see the item inside the container. The criterion for moving to the next step was two consecutive sessions at least 80% correct responding.

Intraverbal-prompt fading. An intraverbal prompt to tact the item ("What is it?") was provided during within-stimulus fading. During intraverbal prompting, the therapist held up the item and prompted the participant to tact the item before placing the item in the container. If the participant did not tact the item within 5 s, the therapist provided an echoic prompt (e.g., "Say ball"). The therapist provided brief verbal praise after correct tacts (e.g., "You're right that is a ball"). After two consecutive sessions at least 80% correct responses at the construction paper level (after within-stimulus fading), the therapist no longer provided an intraverbal prompt before placing the item in the container. The therapist recorded whether the participant emitted an audible tact of the item throughout the study.

Intra-trial delay fading. During within-stimulus and intraverbal-prompt fading, the delay between the presentation of the item and the intraverbal stimulus "What was in the box?" was 15 s. During delay fading, the delay increased in increments that doubled (30 s, 1 min, 2 min, 4 min, 8 min, 16 min, 32 min, 64 min). The criterion for increasing the delay was two consecutive sessions at least 80% correct responses. Once the criterion for increasing the delay

was met at a particular delay, the therapist probed forward (i.e., skipped the next delay interval) for a single trial. For example, once a participant met the mastery criterion for 15 s, a single probe occurred at 1 min. If the participant responded incorrectly at 1 min, teaching continued at 30 s. If the participant responded correctly at 1 min, additional probes were run at increasing delays until an incorrect response occurred. The arrangement of probes is displayed in Table 3. During the delay, the participant returned to activities that were part of their regular behavior-analytic services. Failure criterion for this study was 10 consecutive sessions at the same duration without any progress. Teaching ended for any participant who met this failure criterion.

Results and Discussion

Figure 1 displays the results for Ryan (top panel), Hughey (middle panel), and Robert (bottom panel). Ryan did not make a correct delayed tact during baseline at the 15-s delay. During the delay-probe session, he emitted one correct delayed tact during the 1-min delay trial. Ryan did not make a correct delayed tact to any generalization probes. Levels of correct responding increased slightly at the onset of training and were low and variable initially during training with the transparent container and intraverbal prompt before correct delayed tacts increased and reached mastery criterion (two consecutive sessions at/above 80% accuracy). High levels of correct responding maintained during the first stage of stimulus fading when the container was lined with saran wrap. Ryan's level of correct responding decreased to 40% for the first session when the container was lined with wax paper before increasing to 100% accuracy and meeting mastery criterion. He maintained high levels of correct delayed tacts during the opaque condition when the container was lined with construction paper and when intraverbals were removed. During the delay-fading phase, Ryan responded correctly to the probe at 1 min and 4 min before responding incorrectly to a probe at 16 min. Thus, sessions resumed with the 8-min delay. Correct delayed tacts decreased to moderate levels during the 8-

min delay condition for five consecutive sessions. When the delay was decreased to 4 min, his correct responding increased to 80% accuracy. When the training delay returned to 8 min, his levels of correct delayed tacts decreased initially before returning to mastery levels. Ryan responded correctly to a delayed tact probe at 32 min and began training at 64 min. Ryan met mastery criterion after two sessions at a 64-min delay. Ryan demonstrated generalization of delayed tacts across novel items when they were placed in a fridge, backpack, and sink at delays of 1 min, 4 min, and 64 min, respectively. He did not demonstrate generalization to novel items placed in a bag and under a blanket at 15-s and 16-min delays, respectively. In short, Ryan demonstrated moderate levels of generalization to novel items and locations.

Hughey (Figure 1, middle panel) did not emit any correct delayed tacts during baseline and generalization probes. Correct responding immediately increased and met mastery criterion levels during training with the transparent container and remained at high levels throughout the saran wrap and wax-paper conditions. During the opaque-container condition, correct responding decreased to 40% for two trials before returning to mastery levels. Responding remained at high levels when the intraverbal prompt was removed. Hughey responded correctly to probes at 1 min, 4 min, 16 min, and 64 min. Sessions continued at the 64-min delay. In the 64-min delay condition, Hughey's levels of correct delayed tacts were moderate and somewhat variable initially before increasing to 100% accuracy for two consecutive sessions. Hughey demonstrated generalization of delayed tacts across novel items when they were placed in a backpack, boot, bag, hat, and cup at delays ranging from 15 s to 64 min.

Robert (Figure 1, bottom panel) responded correctly to a single trial during baseline. He did not engage in any correct delayed tacts during delay and generalization probes. During training, his levels of correct responding quickly increased in the transparent-container condition and met mastery. Responding remained high when the container was covered in colored saran

wrap. Correct responding decreased to moderate to low levels before showing improvement and increasing to high mastery levels. Similarly, at the onset of opaque condition, levels of correct delayed tacts decreased before increasing to mastery criterion. Robert's performance remained high when the intraverbal prompts were removed. Robert correctly tacted a previously seen item during a 1-min probe and responded incorrectly to a 4-min probe before beginning the 2-min-delay condition. Robert's levels of correct delayed tacts were moderate and variable at the 2-min-delay before meeting mastery criterion after 13 sessions. Robert then responded correctly to an 8-min probe at and incorrectly to a 32-min probe. His levels of correct responding decreased to zero at the onset of the 16-min delay then became variable at low-to-moderate levels. Robert failed to meet mastery criterion after 22 sessions. The delay was decreased to 8 min and Robert's responding returned to mastery levels. This high level of correct delayed tacting continued at delays of 16 min and 64 min. Robert demonstrated generalization of delayed tacts across novel items when they were placed in a backpack, bucket, lunchbox, fridge, and bag at delays ranging from 15 s to 64 min.

The training package, consisting of stimulus and intraverbal prompt fading and differential reinforcement, successfully improved performance for all three participants at delays up to 64 min. These findings are consistent with previous literature indicating that differential reinforcement (Krantz et al., 1981; Mason, Davis, & Andrews, 2015; Shillingsburg et al., 2017) and fading procedures (Shillingsburg et al., 2017) can improve the accuracy of responses to questions about past events. Additionally, Hughey and Robert demonstrated generalization of delayed tacts to novel items and locations at mastery criterion levels. However, it is unclear which components of the training package were responsible for the improvements in correct responding.

Experiment 2 was an add-in component analysis (Ward-Horner & Sturmey, 2010) to evaluate whether some of the components of the treatment package (intraverbal and stimulus fading) are necessary for acquisition. To evaluate the sufficiency of differential reinforcement, the component analysis began by evaluating differential reinforcement independently (e.g., Krantz et al., 1981; Mason, Davis, & Andrews, 2015). Treatment package components were added if participants did not meet mastery criterion at a 4-min delay. Intraverbal prompts to immediately tact the item (i.e., asking "what is it?") were added if differential reinforcement did not promote successful acquisition of delayed tacts. If acquisition of delayed tacts did not occur in the differential reinforcement with intraverbal delay condition, stimulus-prompt fading was added to the treatment package. The stimulus-prompt fading component of the treatment package may require considerable effort and materials to conduct. If the package is successful without stimulus fading, it may be more efficient and cost effective to implement the treatment package without this component in a clinical setting. The purpose of Experiment 2 was to evaluate whether the treatment package could promote acquisition of delayed tacts without the inclusion of 1) stimulus-prompt fading and 2) intraverbal-prompt fading.

Experiment 2: Component Analysis

Method

Participants. Three children diagnosed with ASD participated in Experiment 2. Pseudonyms were provided to protect the confidentiality of the participants. Mikal was a four-year-old Asian male. Ty was a five-year-old Caucasian male. John was a four-year-old Caucasian male. All three participants received ABA services in a clinic-based setting 40 hours a week. Mikal's program targets included intraverbals, tacts of prepositions, and fluent responding (i.e., decreasing response latency following an S^D). Ty's program targets included intraverbals, tacts of prepositions, copying symbols, and responding to group instructions.

John's program included tacts, intraverbals, manding to peers, and appropriate toy play. All participants communicated vocally and used at least two-word sentences consisting of a noun and verb. All participants demonstrated the skills necessary to meet the requirements for completion of level two of the VB-MAPP intraverbal and tact assessment subtests. Specifically, the participants skill repertoires included intraverbals (at least 25 fill-in-the-blank phrases and 25 different what questions), and tacts (at least 25 items).

Setting and Materials. Sessions took place in a semi-private room in an ABA center. During the session, the participant and the therapist sat at a table with at least two chairs. During some sessions, an additional data collector was present to collect interobserver agreement and procedural integrity data. The materials consisted of several small tangible items (e.g., toy food, animals, and vehicles). During the study, these items were placed in a transparent rectangular container (19 cm by 16.5 cm by 9 cm). The container was lined with construction paper throughout Experiment 2 with the exception of the stimulus-prompt fading condition. During stimulus-prompt fading, the container was lined with paper of increasing levels of opacity (colored saran wrap, wax paper, construction paper). A trial consisted of one opportunity to respond to the question, "What was in the box?" Each session consisted of five trials.

Experimental Design

Visual inspection of a noncontiguous multiple-baseline across-participants design was used to determine the effects of treatment package components on the acquisition of delayed tacting. Levels of accuracy during baseline were visually compared to levels during teaching. Components of the teaching package (i.e., intraverbal prompts and stimulus prompts) were added to the training package once the participant met failure criterion (5 consecutive sessions without an increasing trend in correct responding).

Response Measurement. Data on participant responses were collected on a trial-by-trial basis using paper-and-pencil data collection. A correct response was defined as a vocal verbal response to the question, "What was in the box?" that corresponded to the item in the container. The percentage of correct responses for each session was calculated by dividing the total number of correct responses by the total number of trials in the session (five) and multiplying the proportion by 100.

Interobserver Agreement and Procedural Integrity. Interobserver agreement and procedural integrity were collected and calculated as outlined in Experiment 1. Two trained observers independently recorded data during 38%, 43%, and 35% of sessions for Mikal, Ty, and John, respectively. Mean percentage agreement was 98% (range, 80%-100%) for Mikal, 100% for Ty, and 100% for John. An independent observer recorded procedural integrity data during 35% of sessions across conditions and participants. Mean percentage procedural integrity was 100% across participants.

Pre-experimental Procedures

The preference and tact assessments were conducted as outlined in Experiment 1. The MSWO preference assessment results indicated the following highly preferred items: iPhone® games and an electronic toy for Mikal; toy figurines and puzzles for Ty; and videos and toy vehicles for John. Table 1 outlines the items and locations used in baseline, teaching, and generalization probes. Generalization probes followed the procedures in Experiment 1 with the exception that probes were run at 15 s, 30 s, 1 min, 2 min, 4 min for Experiment 2.

Procedures

Baseline. Baseline sessions were identical to Experiment 1. The therapist prompted the participant to look at an object up to three times before placing it in a container lined with construction paper. The container remained on the table during the delay and the child engaged

in activities that were consistent with his specific ABA program. After the assigned delay, the therapist asked, "What was in the box?" Baseline included at least five sessions at a 15-s delay and probes at 15-s, 30-s, 1-min, 2-min, and 4-min delays.

Differential reinforcement. This condition was identical to baseline with the addition of programmed consequences. Differential reinforcement was provided for correct delayed tacts following the question, "What was in the box?" Following correct responses, the therapist showed the participant the item in the box, said "You're right! It was a [name of item]," and provided 30-s access to preferred items. Following incorrect responses, the therapist revealed the item in the box and said, "It was a [name of item in the box]." The therapist then repeated the question, "What was in the box?" while presenting the item. The trial was then repeated at the programmed delay or a 2-min delay (whichever was shorter) until the participant made a correct response or the trial had been presented five times. Intraverbal and stimulus prompts were not provided in this condition.

Differential reinforcement with intraverbal prompt. If the participant met failure criterion with differential reinforcement, an intraverbal prompt was added to the teaching procedure (otherwise this condition was identical to the differential reinforcement condition). During this condition, the therapist held up the item and said, "What is it?" after the participant made eye contact with the item rather than saying, "Look." If the participant correctly tacted the item, the therapist said, "You're right" and placed the item in the container. If the participant emitted an incorrect tact or did not respond within 10 s of the question, the therapist said "It's a [name of item]. Say [name of item]." The therapist repeated this procedure until a correct prompted response occurred.

Differential reinforcement with stimulus prompts (John only). We introduced differential reinforcement with stimulus prompts if the participant immediately tacted the item

(after the therapist said "look") during 100% of trials in the differential reinforcement condition and did not meet mastery criterion with differential reinforcement alone. Stimulus prompts were identical to Experiment 1 (saran wrap, wax paper, construction paper). Teaching procedures were conducted as outlined in the differential reinforcement condition.

Differential reinforcement with intraverbal and stimulus prompts (Mikal and Ty). If participants did not acquire the skill with differential reinforcement with intraverbal prompts, stimulus prompts were added to the teaching procedure. Stimulus prompts were identical to Experiment 1 (saran wrap, wax paper, construction paper). Teaching procedures were conducted as outlined in differential reinforcement with intraverbal prompt condition. This condition included all the components of the treatment package evaluated in Experiment 1. The failure criterion for the study was 10 consecutive sessions at the same delay without improvement. Teaching ended for any participant who met this failure criterion.

Intra-trial Delay. Once acquisition criterion was met (two consecutive sessions at 80% correct or higher), the delay between the presentation of the item and the intraverbal stimulus "What did you see?" increased in increments that double (15 s, 30 s, 1 min, 2 min, 4 min). The criterion for increasing the delay was two consecutive sessions at 80% correct or higher. As in Experiment 1, the therapist probed forward (i.e., skipped the next delay interval) for a single trial once the criterion for increasing the delay had been met at a particular delay.

Results and Discussion

Figure 2 displays the results of the component analysis for Mikal (top panel), Ty (middle panel), and John (bottom panel). Mikal's levels of correct responding were near zero throughout baseline. During the differential-reinforcement condition, correct delayed tacts increased, but levels were highly variable and decreased to low levels at the end of this phase. Intraverbal prompts were added and his levels of correct delayed tacts remained low initially before

performance increased to moderate levels. Stimulus prompts were added, and Mikal responded correctly during 100% of trials with the transparent container and when the container was lined in colored saran wrap. Levels of correct responding initially decreased to low levels when the container was lined with wax paper. Levels of correct responses increased after five sessions and Mikal met mastery criterion. Mikal's responding was moderate and variable in the opaque-container condition (*M* = 58% correct). Although his responding improved from baseline, he did not meet mastery requirements and met the failure criterion for the study after 13 sessions.

Ty (Figure 2, middle panel) had low levels of correct delayed tacts during baseline (*M* = 11.4%) and no correct delayed tacts during delay and generalization probes. During the differential-reinforcement condition, Ty met mastery criterion at the 15-s delay after five sessions. Ty responded correctly to probes at 1 min and 4-min delays. His levels of correct delayed tacts during the 4-min training were variable with a decreasing trend across the phase. When intraverbal prompts were added, levels of correct delayed tacting became more stable, but remained at moderate levels. Correct responding immediately increased to mastery criterion levels when the transparent container was introduced and remained high when the container was lined with colored saran wrap. When the wax-paper condition was introduced, his levels of correct delayed tacts initially decreased to 60% before increasing and meeting mastery criterion. Levels of correct delayed tacts remained high when the intraverbal prompts were removed. Ty demonstrated generalization to novel items placed in a bag, lunchbox, backpack, bucket, and cup at delays that ranged from 15 s to 4 min.

During baseline, John's (Figure 2, bottom panel) levels of correct delayed tacts were low and somewhat variable (*M* = 15.6% correct). He responded correctly to one trial during the delay probe (at a 1-min delay) and to one trial in the generalization probe (when the item was placed in a bag at a 15-s delay). John's level of correct responding immediately increased and

reached mastery criterion levels at 15 s in the differential-reinforcement condition. He responded incorrectly to a probe at 1 min and began training at 30 s. John's level of correct delayed tacting reached mastery after three sessions. John responded incorrectly to a probe at 2 min, but immediately met mastery at 1 min with training. He then responded incorrectly to a probe at 4 min; however, with training, he met mastery criterion at the 2-min delay after five sessions. During training at the 4-min delay, performance remained below mastery criteria and did not show an increasing trend after six sessions. Intraverbal prompts were not added for John because he immediately tacted the item following the instruction "look" for 100% of trials in the differential-reinforcement condition. When stimulus prompts were added to the treatment package, levels of correct responding increased and reached mastery level and remained high throughout the transparent container and colored saran-wrap conditions. When the wax-paper condition was introduced, correct responding decreased to low levels. His performance improved and became more variable before reaching mastery criterion. When the stimulus prompts were removed (container was opaque and lined with construction paper), his responding became highly variable. The delay was then decreased to 2 min. Levels of correct delayed tacts remained highly variable during the 2-min delay condition, but increased to mastery at the end of the phase. Levels of correct delayed tacts remained at 100% correct when the delay was increased back to 4 min. John demonstrated generalization of delayed tacts across novel items when they were placed in a bag, lunchbox, backpack, and bucket at delays ranging from 15 s to 2 min, but responded incorrectly when a novel item was placed in a cup at a delay of 4 min.

Although Ty and John made advancements up to 4 min in the differential reinforcement condition, none of the participants met mastery criterion during differential reinforcement or differential reinforcement with an intraverbal-prompt conditions. Ty met mastery criterion for delayed tacts at a 4-min delay after all of the treatment components (differential reinforcement,

intraverbal-prompt fading, and stimulus-prompt fading) were included in the package. John mastered delayed tacting with differential reinforcement and stimulus prompts. However, John's responding only met mastery criterion after decreasing the delay from 4 min to 2 min then returning to 4 min in the differential reinforcement with stimulus-prompts condition. The complete treatment package was not successful for Mikal. Anecdotally, Mikal often engaged in an echoic response to the question ["what was in the box?"] by repeating the word "box." This echoic responding may have interfered with his acquisition of tacting previously seen items.

In summary, the differential-reinforcement component was not sufficient to teach delayed tacts at 4 min. Differential reinforcement in combination with intraverbal prompts was also insufficient at teaching delayed tacts. When stimulus prompts, intraverbal prompts, and differential reinforcement were used in combination, Ty and John met mastery criterion at a 4-min delay. Ty and John demonstrated generalization to novel items and locations at mastery criterion level (similar to the generalization observed with Hughey and Robert in Experiment 1). Stimulus prompts appear to be the necessary component. However, we are unable to rule out the behavioral effects of component combinations and sequence effects due to the limitations of the add-in component analysis design. We recommend that clinicians seeking to teach delayed tacts include all of the components of the treatment package (i.e., Experiment 1).

General Discussion

Despite the importance of teaching children with ASD to talk about past events, little research has evaluated procedures to establish this repertoire. Previous studies used response prompts and reinforcement to increase tacts of past events in children with advanced verbal repertoires (e.g., Krantz et al., 1981; Shillingsburg et al., 2017). The current study extends previous literature by using a treatment package that included differential reinforcement, stimulus prompts, intraverbal prompts, and delay fading to teach children to tact a previously

seen item. Participants mastered delayed tacting at a delay of 64 min in Experiment 1 (Ryan, Hughey, and Robert) and 4 min in Experiment 2 (Ty and John). The current study also extends the literature by evaluating generalization to novel items and locations.

The goal of this intervention was to establish a generalized repertoire of speaking about previously seen items. We programmed for generalization by alternating between 10 different items during training. Thus, the correct response to the question "what was in the box?" was different for each trial in a session. During generalization probes, four of five participants (Hughey, Robert, Ty, and John) demonstrated high levels of correct delayed tacts of novel items and locations following mastery and one participant (Ryan) demonstrated moderate levels of generalization. Generalization is an important goal of treatment intervention because it means that future targets will not need to be directly taught. Therefore, promoting generalization can save valuable clinical time. Future research should evaluate generalization of delayed tacts across people (e.g., caregivers) and environments (e.g., home, school) and generalization to activities (e.g., "What did you do outside?")

The use of differential reinforcement is supported by previous research on recalling past events (e.g., Krantz et al., 1981; Mason, Davis, & Andrews, 2015; Shillingsburg et al., 2017). For example, Mason, Davis, and Andrews (2015) increased the number of visitor attributes participants reported following a conversation when tokens were provided for each reported attribute. Additionally, differential reinforcement is a common component of standard verbal-behavior procedures (e.g., tact training, intraverbal training). In the component analysis, differential reinforcement was evaluated in the absence of stimulus and intraverbal prompts. Two of the participants progressed up to a 4 min delay with only differential reinforcement, but they did not meet the mastery criterion after five (John) and eight (Ty) sessions in the differential

reinforcement condition. This suggests that differential reinforcement alone is not sufficient to teach delayed tacts at delays of 4 min or longer.

Intraverbal prompts were also included in the treatment package. Intraverbal prompts (e.g., "What is it?") are commonly used in tact training when the item is present (e.g., Barbera & Rasmusssen, 2007; Sundberg & Partington, 1998; Wallace, Iwata, & Hanley, 2006). The purpose of the intraverbal prompt in the current study was to increase the likelihood that the participant would overtly tact (audibly label) the item before the item was placed in the container. Overtly tacting the item may provide additional stimuli (e.g., a verbal auditory stimulus) that could promote later recall. Overtly tacting the item also ensures that the participant attended to the relevant stimulus (i.e., observing response). It remains unclear however if immediate tacts enhance performance on delayed tacts. Table 4 displays the percentage of trials in which participants in Experiment 1 immediately (before the item was placed in the container) tacted the item. Ryan demonstrated high levels of immediate tacts following the instruction "look" during baseline. Hughey demonstrated moderate levels of immediate tacts and Robert rarely tacted the item during baseline. Intraverbal prompts ("what is it?") were provided during prompt levels 1-4 and removed at prompt level 5. After intraverbal prompts were removed, Ryan, Hughey, and Robert demonstrated high levels of immediate tacts. The treatment package in Experiment 1 increased the likelihood of immediate tacts for all three participants. However, it is not clear if the intraverbal prompt component or some other component (e.g., stimulus prompts or differential reinforcement) of the treatment package was responsible for the increase in immediate tacts. Table 5 displays the percentages of trials in which participants immediately tacted the item in Experiment 2. Mikal demonstrated moderate levels of immediate tacts during baseline and differential reinforcement. Mikal met failure criterion for the study before intraverbal prompts were removed. Ty demonstrated moderate

levels of immediate tacts during baseline. During the differential reinforcement condition, in which no intraverbal prompts were provided, Ty's immediate tacts increased to moderately high levels. This demonstrates that intraverbal prompts may not be necessary to increase immediate tacts. After intraverbal prompts were removed, Ty immediately tacted the item on 100% of trials. Intraverbal prompts were not evaluated with John because he immediately tacted the item during each trial of baseline and differential reinforcement. We were unable to assess the effects of intraverbal prompts for Mikal and John. It is possible that individuals with a strong history of tact training may spontaneously tact items when a therapist holds it up and says "look" (e.g., John and Ryan). In these cases, the inclusion of an intraverbal prompt ("what is it?") may not be indicated. Based on the high rates of immediate tacts during baseline for Ryan and John, it appears that overtly tacting the item before it was placed in the box was not sufficient for establishing delayed tacts. Future research should evaluate whether overt immediate tacts are necessary for acquisition of delayed tacts with individuals who do not readily tact the item.

The component analysis in Experiment 2 determined that differential reinforcement is not sufficient for teaching tacts at delays over 2 min. Differential reinforcement in combination with intraverbal prompts was not also not sufficient to produce the acquisition of delayed tacts. The add-in component analysis design did not allow us to determine the necessity of differential reinforcement or intraverbal prompts. Stimulus prompts seem to be a necessary component, but we are unable to rule out component combinations (e.g., stimulus prompts combined with differential reinforcement) and sequence effects because the components were presented in the same order across participants in order to maintain experimental control in the multiple-baseline design (Ward- Horner & Sturmey, 2010). To evaluate the sufficiency of stimulus prompts, future researchers should counterbalance the component analysis in the current study by first evaluating stimulus prompts independently.

Mikal did not meet mastery criterion even after all of the treatment components were added. The order of components introduced in the component analysis may have contributed to his failure to master the skill by establishing a history of incorrect responding. Anecdotally, Mikal often responded to the question "What was in the box?" by echoing the word "box." It is possible that Mikal responded echoically during training due to a strong history of echoic prompts used in tact and intraverbal training. Ryan and Robert also responded by echoing "box" or "in the box" during baseline; however, they stopped responding echoically after the treatment package (including stimulus prompts) was introduced. In contrast, Mikal continued to respond echoically to some trials throughout the study. Mikal's history of incorrect responding to the S^D during the baseline, differential-reinforcement, and differential- reinforcement with intraverbal-prompt conditions could have interfered with acquisition. Introducing stimulus prompts (i.e., tact prompts) earlier in treatment may have reduced errors and prevented a strong history of responding echoically to the target S^D. Alternatively, a failure to identify powerful reinforcers or a deficit in Mikal's skill repertoire could have impeded acquisition. The prerequisite skills necessary for acquiring delayed tacting have not been identified and provide an avenue for future research.

This study extends previous literature by including stimulus prompts in teaching children to tact previously seen items. By nature, there are limited prompts available to clinicians when teaching individuals to talk about items that are no longer visible. Echoic response prompts (i.e., vocal models) are easily provided but may produce rote responding. The stimulus-fading component of the treatment package provided a tact prompt (the item was visible in the transparent container and to a lesser extent in the saran wrap and wax paper prompt levels). By using stimulus-prompt fading, we established the desired response (i.e., labeling the item in the box) and gradually removed the prompts until the item was no longer visible. The stimulus

prompts were designed to transfer stimulus control from the tact prompt (the visible item) to the relevant controlling stimuli (i.e., the previously seen item and the discriminative stimulus, "what was in the box?").

The treatment package also included delay fading. Shillingsburg et al. (2017) incorporated delay fading into their procedures to teach two children with ASD to report past behavior. They provided additional opportunities to respond to the target discriminative stimulus in the interval between the immediate and end-of-day probes (following a 1- to 2.5-hr delay). These practice trials began at a 15-min delay and were gradually increased (20, 25, 30, 35, 40, 45, and 60 min) once a participant responded with 100% accuracy to an end-of-day probe. This allowed for additional opportunities to practice responding and decreased the delay between opportunities to respond. In the current study, delays began at 15 s and increased to 4 min (Experiment 2) and 64 min (Experiment 1). Delays increased upon participant success at previous delays. Additionally, participants in the current study could advance to longer delays by responding correctly to forward probes (see Table 3). This allowed for a personalized treatment approach for the participants. For example, Hughey was able to progress from a 15-s delay to a 64-min delay rapidly by responding correctly to forward probes. John, however, never responded correctly to a forward probe and completed training at each delay interval. By individualizing the training delays based on previous success, we were able to reduce the amount of time necessary for Hughey to reach mastery criterion while minimizing errors for John. In a clinical setting, this delay fading with a probe forward design could help reduce valuable treatment time for clients, while also working to minimize errors.

There are several limitations to the current study. One limitation is that we did not systematically collect data on the types of errors that participants made. Data on the types of errors (e.g., echoic responding, naming an item from a previous trial) that participants made

could have informed modifications to the procedures. For example, if participants regularly responded by tacting the item from a previous trial, this might suggest proactive interference. Proactive interference occurs when events that occur before a trial interfere with responding on a trial (Bigelow & Poremba, 2013). Previous literature on proactive interference on memory tasks in animals (e.g., Bigelow & Poremba, 2013; Edhouse & White, 1988; Maki, Moe & Bierley, 1977; Roberts & Kraemer, 1982) suggests that changes to the intertrial intervals (time elapsed between trials) may affect proactive interference and therefore correct responding. Another limitation is that due to the schedule restraints of the participants' availability we were unable to maintain specific intertrial intervals. Future research may evaluate the effects of different intertrial intervals and provide guidance on optimizing these intervals.

This study provides clinicians with treatment procedures to teach children with ASD to tact previously seen items. The results of Experiment 1 suggest that children who score below level 3 of the VB-MAPP (Sundberg, 2008) can learn to tact previously seen items using differential reinforcement, stimulus and intraverbal prompts, and delay fading. None of the participants in Experiment 2 met mastery criterion at a 4-min delay until all of the components were added to the treatment package. It is possible that stimulus-prompt fading is necessary for some individuals to master delayed tacts at longer delays but further analysis is needed. Additionally, therapists can work on other clinical targets during the delay period. This allows for efficient use of valuable clinical hours. The use of a delay fading with probe forward design can also minimize the amount of clinical time necessary to acquire this valuable skill.

Overall, the treatment package consisting of prompts and differential reinforcement was effective at increasing correct responding to questions about previously seen items for Ryan, Hughey, Robert, Ty, and John. These findings are similar to previous research on teaching children with ASD to recall past events (Krantz et al., 1981; Mason, Davis, & Andrews, 2015;

Shillingsburg et al., 2017) and consistent with the interpretation that deficits in recalling past events may be due to errors in stimulus control or an insufficient history of reinforcement (Delaney & Austin, 1998; Palmer, 1991; Shillingsburg et al., 2017; Skinner 1957). The treatment package established a generalized ability to tact previously seen items in children with ASD. Future research should further investigate the components of the treatment package to determine their necessity and sufficiency.

References

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders (5th ed.).* Washington DC: Author.

Arntzen, E., & Almas, I. K. (2002). Effects of mand-tact versus tact-only training on the acquisition of tacts. *Journal of Applied Behavior Analysis, 35,* 419-422. doi:10.1901/jaba.2002.35-419

Baer, R. A. (1990). Correspondence training: Review and current issues. *Research in Developmental Disabilities, 11,* 379-393. doi:0891-422/90

Baltruschat, L., Hasselhorn, M., Tarbox, J., Dixon, D. R., Najdowski, A. C., Mullins, R. D., & Gould, E. R. (2011a). Addressing working memory in children with autism through behavioral intervention. *Research in Autism Spectrum Disorders, 5,* 267-276. doi:10.1016/j.rasd.2010.05.008

Baltruschat, L., Hasselhorn, M., Tarbox, J., Dixon, D. R., Najdowski, A. C., Mullins, R. D., & Gould, E. R. (2011b). Further analysis of the effects of positive reinforcement on working memory in children with autism. *Research in Autism Spectrum Disorders, 5,* 855-863. doi:10.1016/j.rasd.2010.09.015

Baltruschat, L., Hasselhorn, M., Tarbox, J., Dixon, D. R., Najdowski, A. C., Mullins, R. D., & Gould, E. R. (2012). The effects of multiple exemplar training on a working memory task involving sequential responding in children with autism. *The Psychological Record, 62,* 549-562. doi:10.1037/t54175-00

Barbera, M. L., & Kubina, R. M. (2005). Using transfer procedures to teach tacts to a child with autism. *The Analysis of Verbal Behavior, 21*, 155-161. doi:10.1007/bf0339017

Barbera, M. L., & Rasmussen, T. (2007). *The verbal behavior approach: How to teach children with autism and related disorders*. London: Jessica Kingsley Publications.

Bigelow, J., & Poremba, A. (2013). Auditory proactive interference in monkeys: The roles of stimulus set size and intertrial interval. *Learning and Behavior, 41*, 319-332. doi:10.3758/s13420-013-0107-9

Bordignon, S., Endres, R. G., Trentini, C. M., & Bosa, C. A. (2015). Memory in children and adolescents with autism spectrum disorder: A systematic literature review. *Psychology & Neuroscience, 8*, 211- 245. doi:10.1037/h0101059

Brigham, T. A., & Sherman, J. A. (1968). An experimental analysis of verbal imitation in preschool children. *Journal of Applied Behavior Analysis, 1,* 151-160. doi:10.1901/jaba.1968.1-151

Carroll, R. J., & Hesse, B. E. (1987). The effects of alternating mand and tact training on the acquisition of tacts. *The Analysis of Verbal Behavior, 5,* 55-65. doi:10.1007/bf03392820

Carroll, R. A., & Klatt, K. P. (2008). Using stimulus-stimulus pairing and direct reinforcement to teach vocal verbal behavior to young children with autism. *The Analysis of Verbal Behavior, 24,* 135-146. doi:10.1007/bf03393062

Cividini-Motta, C., Scharrer, N., & Ahearn, W. H. (2017). An assessment of three procedures to teach echoic responding. *The Analysis of Verbal Behavior*, *33*, 41-63. doi:10.1007/s40616-016-0069-z

Edhouse, W. V., & White, K. G. (1988). Sources of proactive interference in animal memory. *Journal of Experimental Psychology; Animal Behavior Processes, 14*, 56-70. doi:10.1037/0097-7403.14.1.56

Esch, B. E., Carr, J. E., & Grow, L. L. (2009). Evaluation of an enhanced stimulus-stimulus pairing procedure to increase early vocalizations of children with autism. *Journal of Applied Behavior Analysis, 42,* 225-241. doi:10.1901/jaba.2009.42-225

Golfeto, R. M., & Souza, D. G. (2015). Sentence production after listener and echoic training by prelingual deaf children with cochlear implants. *Journal of Applied Behavior Analysis, 48,* 363-375. doi:10.1002/jaba.197

Hall, D. Jarrold, C., Towse, J. N., & Zarandi, A. L. (2015). The developmental influence of primary memory capacity on working memory and academic achievement. *Developmental Psychology, 8,* 1131-1147. doi:10.1037/a0039464

Hanney, N. M. (2012). *Teaching children with autism to tact stimuli from auditory and tactile sensory modalities* (Unpublished master's thesis). Auburn University, Auburn, AL.

Kazdin, A. E. (1982). *Single-case research designs*. New York: Oxford University Press.

Kercood, S., Grskovic, J. A., Banda, D. & Begeske, J. (2014). Working memory and autism: A review of the literature. *Research in Autism Spectrum Disorders, 8*, 1316-1332. doi:10.1016/j.rasd.2014.06.011

Klingberg, T., Fernell, E., Olesen, P. J., Johnson, M., Gustaffson, P., Dahlstrom, K., Gillberg, C. B., Forssberg, H., & Westerberg, H. (2005). Computerized training of working memory in children with ADHD-A randomized, controlled trial. *Journal of the American Academy of Child and Adolescent Psychiatry, 44,* 189-233. doi:10.1097/oooo4583-200502000-00010

Krantz, P. J., Zalenski, S., Hall, L. J., Fenske, E. C., & McClannahan, L. E. (1981). Teaching complex language to autistic children. *Analysis and Intervention in Developmental Disabilities, 1,* 259-297. doi:0891-4222/90

Lepper, T. L., Petursdottir, A. I., & Esch, B. E. (2013). Effects of operant discrimination training on the vocalizations of nonverbal children with autism. *Journal of Applied Behavior Analysis, 46,* 656-661. doi:10.1002/jaba.55

Lovaas, O. I., Berberich, J. P., Perloff, B. F., & Schaeffer, B. (1966). Acquisition of imitative speech in schizophrenic children. *Science, 151,* 705-707. doi:10.1126/science.151.3711.705.

Majdalany, L., Wilder, D. A., Smeltz, L., Lipschultz, J. (2016). The effect of brief delays to reinforcement on the acquisition of tacts in children with autism. *Journal of Applied Behavior Analysis, 49,* 411-415. doi:10.1002/jaba.282

Maki, W. W., Moe, J. C., & Bierley (1977). Short-term memory for stimuli, responses, and reinforcers. *Journal of Experimental Psychology; Animal Behavior Processes, 13*, 156-177. doi:10.1037/0097-7403.3.2.156

Marchese, N. V., Carr, J. E., LeBlanc, L. A., Rosati, T. C., & Conroy, S. A. (2012). The effects of the question "what is this?" on tact-training outcomes of children with autism. *Journal of Applied Behavior Analysis, 45,* 539-547. doi:10.1901/jaba.2012.45-539

Mason, L. L., Davis, D., & Andres, A. (2015). Token reinforcement of verbal responses controlled by temporally removed verbal stimuli. *Analysis of Verbal Behavior, 31,* 145-152. doi:10.1007/s40616-015-0032-4

Miguel, C. F., Carr, J. E., & Michael, J. (2002). The effects of a stimulus-stimulus pairing procedure on the vocal behavior of children diagnosed with autism. *The Analysis of Verbal Behavior, 18,* 3-13. doi:10.1007/bf03392967

Nevin, J. A., Davison, M., Odum, A. L., & Shahan, T. A. (2007). A theory of attending, remembering, and reinforcement in delayed matching to sample. *Journal of the Experimental Analysis of Behavior, 88*, 285-317. doi:10.1901/jeab.2007.88-285

Partington, J. W. (2006). *The assessment of basic language and learning skills – revised (ABLLS_R).* Walnut Hill, CA: Behavior Analysts Inc.

Partington, J. W., Sundberg, M. L., Newhouse, L., & Spengler, S. (1994). Overcoming an autistic child's failure to acquire a tact repertoire. *Journal of Applied Behavior Analysis, 27,* 733-734. doi:10.1901/jaba.1994.27-733

Richter, K. M., Modden, C., Eling, P., & Hildebrandt, H. (2015). Working memory training and semantic structuring improves remembering future events, not past events. *Neurorehabilitation and Neural Repair, 29*, 33-40. doi:10.1177/1545968314527352

Risley, T. R., & Hart, B. (1968). Developing correspondence between the non-verbal and verbal behavior of preschool children. *Journal of Applied Behavior Analysis, 1,* 267-281. doi:10.1901/jaba.1968.1-267

Roberts, W. A., & Kraemer, P. J, (1982). Some observations of the effects of intertrial interval and delay on delayed matching to sample in pigeons. *Journal of Experimental Psychology; Animal Behavior Processes, 8*, 342-353. doi:10.1037/0097-7403.8.4.342

Sevlever, M., Roth, M. E., & Gillis, J. M. (2013). Sexual abuse and offending in autism spectrum disorders. *Sexuality and Disability, 31,* 189-200. doi:10.1007/s11195-013-9286-8

Shillingsburg, M. A., Cariveau, T., Talmadge, B., & Frampton, S. (2017). A preliminary analysis of procedures to teach children with autism to report past behavior. *Analysis of Verbal Behavior, 32,* 275-282. doi:10.1007/s40616-017-0085-7

Skinner, B. F. (1938). *The behavior of organisms.* New York: Appleton-Century-Crofts.

Skinner, B. F. (1953). *Science and human behavior.* New York: Macmillan.

Skinner, B. F. (1957). *Verbal behavior.* New York: Appleton-Century-Crofts.

Sundberg, M. L. (2008). *Verbal behavior milestones assessment and placement program: A language and social skills assessment program for children with autism or other developmental disabilities.* Concord, CA: AVB press.

Sundberg, M. L., Michael, J. Partington, J. W., & Sundberg, C. A. (1996). The role of automatic reinforcement in early language acquisition. *The Analysis of Verbal Behavior, 13,* 21-37. doi:10.1007/bf03392904

Sundberg, M. L., Endicott, K. & Eigenheer, P. (2000). Using intraverbal prompts to establish tacts for children with autism. *The Analysis of Verbal Behavior, 17,* 89-104. doi:10.1007/bf03392958

Sundberg, M. L., & Partington, J. W. (1998). *Teaching language to children with autism or other developmental disabilities.* Pleasant Hill, CA: Behavior Analysts, Inc.

Tarbox, J. Madrid, W. Aguilar, B. Jacobo, W. & Schliff, A. (2009). Use of chaining to increase complexity of echoics in children with autism. *Journal of Applied Behavior Analysis, 42,* 901-906. doi:10.1901/jaba.2009.42-901

Valentino, A. L., Shillingsburg, M. A., & Call, N. A. (2012). Comparing the effects of echoic prompts and echoic prompts plus modeled prompts on intraverbal behavior. *Journal of Applied Behavior Analysis, 45,* 431-435. doi:10.1901/jaba.2012.45-431

Vedora, J. Meunier, L., & Mackay H. (2009). Teaching intraverbal behavior to children with autism: A comparison of textual and echoic prompts. *The Analysis of Verbal Behavior, 25*, 79-86. doi:10.1007/bf03393072

de Vries, M., Prins, P. J.M., Schmand, B. A., & Guerts, H. M. (2015). Working memory and cognitive-flexibility training for children with an autism spectrum disorder; A randomized controlled trial. *Journal of Child Psychology and Psychiatry, 56,* 566-576. doi:10.1111/jcpp.12324

Wallace, M. D., Iwata, B. A., & Hanley G. P. (2006). Establishment of mands following tact training as a function of reinforcer strength. *Journal of Applied Behavior Analysis, 39,* 17-24. doi:10.1901/jaba.2006.119-04

Wang, Y., Zhang, Y., Liu, L., Cui, J., Wang, J., Shum, D., Amelsvoort, T., & Chan, R. (2017). A meta-analysis of working memory impairments in autism spectrum disorders. *Neuropsychological Review, 27*, 46-61. doi:10.1007/s11065-016-9336-y

Ward-Horner, J. & Sturmey, P. (2010). Component analyses using single-subject experimental designs: A review. *Journal of Applied Behavior Analysis, 43*, 685-704. doi:10.1901/jaba.2010.43-695

White, K. G., & Brown, G. S. (2014). Forgetting from short-term memory in delayed matching to sample: A reinforcement context model. *Comparative Cognition & Behavior Reviews, 9*, 1-16. doi:10.3819/ccbr.2014.90001

White, K. G. (2001). Forgetting functions. *Animal Learning and Behavior, 29*, 193-207. doi:10.3758/bf03192887

White, K. G. (2013). Remembering and forgetting. In G. J. Madden, V. W. Dube, T. D. Hackenberg, G. P Hanley, & K. A. Lattal (Eds.), *APA handbook of behavior analysis: Vol. 1. Methods and principles* (pp. 441-437). Washington, DC: American Psychological Association. doi:10.1037/13937-018

White, K. G., & Wixted, J. T. (1999). Psychophysics of remembering. *Journal of the Experimental Analysis of Behavior, 71*, 91-113. doi:10.1901/jeab.1999.71-91

Williams, G., Canerero, J. J., Perez-Gonzales, L. A. (2006). Generalization of tacting actions in children with autism. *Journal of Applied Behavior Analysis, 39,* 233-237. doi:10.1901/jaba.2006.175-04

Yoon, S., & Bennett, G. (2000). Effects of a stimulus-stimulus pairing procedure on conditioning vocal sounds as reinforcers. *The Analysis of Verbal Behavior, 17,* 75-88. doi:10.1007/bf03392957

Table 1

Items and Locations Used During Teaching and Generalization

Participant	Teaching Items		Generalization Items	Generalization Locations
Ryan	Fish	Pizza	Car	Bag
	Cow	Tiger	Horse	Fridge
	Banana	Carrot	Apple	Backpack
	Pig	Elephant	Tiger	Blanket
	Strawberry	Broccoli	Helicopter	Sink
Hughey	Apple	Elephant	Fish	Backpack
	Helicopter	Banana	Broccoli	Boot
	Cow	Firetruck	Tiger	Bag
	Pizza	Pig	Ice cream	Hat
	Bus	Carrot	Bus	Cup
Robert	Cat	Horse	Banana	Backpack
	Orange	Carrot	Alligator	Bucket
	Car	Giraffe	Pig	Lunchbox
	Zebra	Pizza	Ice cream	Fridge
	Grapes	Cow	Lion	Bag
Mikal	Horse	Giraffe	Cat	Backpack
	Ice cream	Corn	Pizza	Bucket
	Cookie	Motorcycle	Pig	Trashcan
	Tree	Spider	Banana	Bag
	Cow	Apple	Truck	Lunchbox
Ty	Apple	Garbage truck	Giraffe	Bag
	Lion	Alligator	Ice cream	Lunchbox
	Pizza	Broccoli	Tree	Backpack
	Frog	Cat	Car	Bucket
	Police car	Banana	Horse	Cup
John	Cow	Grapes	Lion	Bag
	Firetruck	Fish	Ice cream	Lunchbox
	Pizza	Watermelon	Tree	Backpack
	Pig	Penguin	Horse	Bucket
	Car	Carrot	Alligator	Cup

Table 2

Prompt Fading Steps

Step	Prompt Level
1	Clear box with intraverbal prompt
2	Saran wrap with intraverbal prompt
3	Wax paper with intraverbal prompt
4	Construction paper with intraverbal prompt
5	Construction paper without intraverbal prompt

Table 3

Duration of Delays for Probes and Teaching

Step	Delay	Delay of Next Probe	Teaching Delay Following Incorrect Probe Response
1	15 s	1 min	30 s
2	30 s	2 min	1 min
3	1 min	4 min	2 min
4	2 min	8 min	4 min
5	4 min	16 min	8 min
6	8 min	32 min	16 min
7	16 min	64 min	32 min
8	32 min		64 min
9	64 min		

Table 4

Percentage of Trials Participants Immediately Tacted the Item for Experiment 1

Participant	Baseline	After intraverbal prompts were removed
Ryan	80%	90%
Hughey	71%	100%
Robert	9%	98%

Table 5

Percentage of Trials Participants Immediately Tacted the Item for Experiment 2

Participant	Baseline	Differential Reinforcement	After intraverbal prompts were removed
Mikal	66%	65%	n/a
Ty	49%	76%	100%
John	100%	100%	n/a

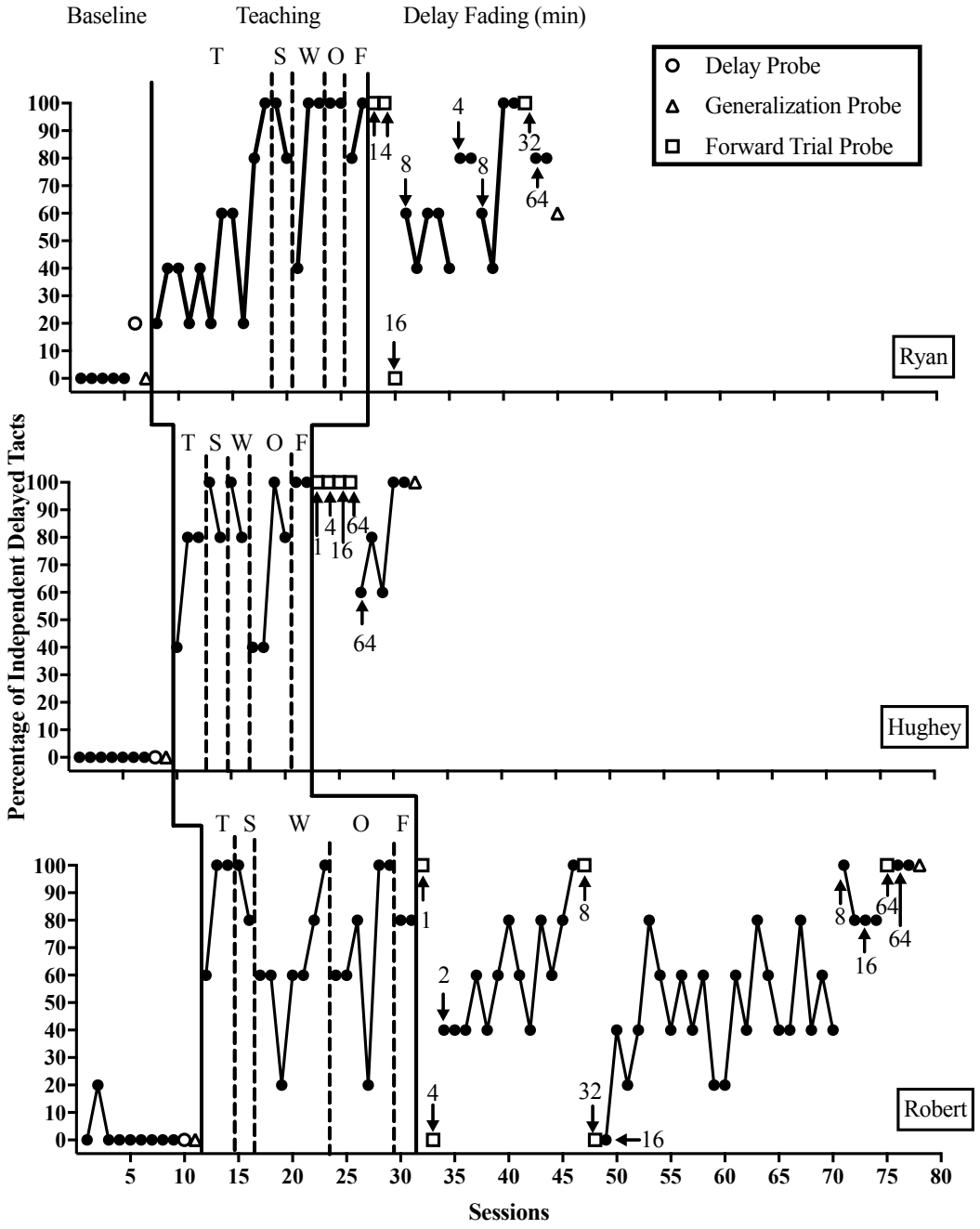

Figure 1. Percentage of independent delayed tacts during baseline, teaching, delay fading, and generalization probes for Ryan, Hughey, and Robert. T refers to transparent box with intraverbal prompt. S refers to saran wrap with intraverbal prompt. W refers to wax paper with intraverbal prompt. O refers to opaque box with intraverbal prompt. F refers to final phase (all prompts removed).

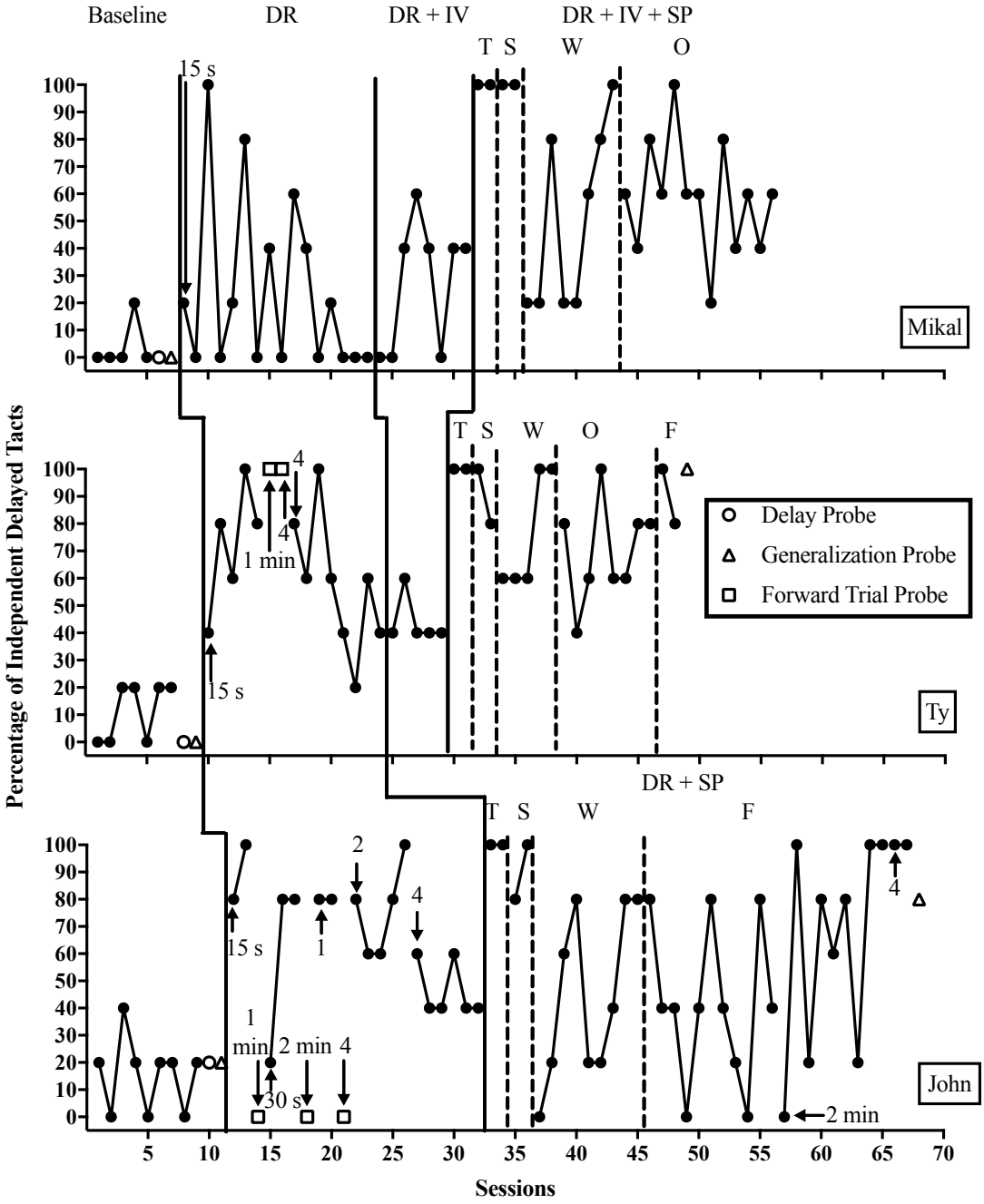

Figure 2. Percentage of independent delayed tacts during baseline, differential reinforcement (DR), differential reinforcement with intraverbal prompts (DR + IV), differential reinforcement with intraverbal prompts and stimulus prompts (DR + IV + SP), differential reinforcement with stimulus prompts (DR + SP) and generalization probes for Mikal, Ty, and John. T refers to transparent box. S refers to saran wrap box. W refers to wax paper box. O refers to opaque box. F refers to final phase (all prompts removed).