An Evaluation of Discrete-Trial and Secondary Target Instruction Procedures on Olfactory Tact Acquisition for Children with Autism Spectrum Disorder

Michael R. Toto

A Dissertation Submitted to the Faculty of

The Chicago School of Professional Psychology

In Partial Fulfillment of the Requirements

For the Degree of PhD in Applied Behavior Analysis

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Abstract

Teaching individuals to tact visual stimuli has often been the focus of research on tact acquisition. Children with autism spectrum disorder (ASD), however, may have difficulty learning tacts of nonvisual stimuli (e.g., gustatory, olfactory, tactile). As a result, the purpose of the current study was to expand the literature on tact training and secondary target instruction by evaluating the effects of discrete-trial procedures that involved either immediate echoic prompts, prompt delay, or an error correction procedure on the acquisition of olfactory tacts with children diagnosed with ASD.

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Chapter 1: Nature of the Study

Humans learn through a variety of senses. We learn through what we see, hear, taste, smell, and touch (Greer & Longano, 2010). However, accurately identifying what we see, hear, taste, smell, or touch may be difficult for children with autism spectrum disorder (ASD). To date, it remains unclear what the most effective teaching strategies are for children with ASD to accurately identify more than what they visually see (Dass et al., 2018). Being able to accurately identify more than what they see allows children with ASD to use all their senses to correctly interpret information around them. When children with ASD can better interpret differing nonverbal stimuli (e.g., the smell of pizza) it allows them to experience the world in a much more dynamic, meaningful way (e.g., asking a peer what kind of pizza they prefer).

Therefore, the nature of the study was to select a sense other than sight and investigate the most effective teaching procedures for children with ASD to accurately identify (or name/label) them. The sense of smell was chosen, as the ability to identify what children with ASD smell can have important health and safety implications. With the limited research devoted to accurately identifying what children with ASD can smell, the nature of the current study was to also investigate the influence of additional teaching stimuli on their ability to categorize (e.g., identifying the smell of pizza but also recognizing that pizza smells yummy).

Background

When a response is evoked by a nonverbal stimulus such as an event or object it is often characterized as a *tact* (Skinner, 1957). A tact is a type of verbal operant controlled by a nonverbal stimulus and is typically maintained by nonspecific social reinforcement (Skinner, 1957). For example, a child may tact (or label) a horse if in the presence of a horse the child says "horse." Generalized conditioned reinforcement is then at least partially responsible for the maintenance of learned tacts (Skinner, 1957). Through incidental interactions with their environment, children will typically learn an array of tacts (Shafer, 1995). Children with ASD may acquire tacts at a lower rate and with greater difficulty of generalization (Sundberg & Partington, 1998). Fortunately, discrete-trial instruction (DTI) has been instrumental in effectively teaching tacts to children with ASD (Partington et al., 1994). A collection of research evaluating the effects of DTI on the acquisition of tacts has predominantly focused on teaching visual tacts. Consequently, there has been a gap in research in teaching individuals to tact stimuli of other sensory modalities (e.g., teaching individuals to tact what they smell, touch, hear, and taste). Teaching children to tact olfactory stimuli can be instrumental in increasing important and appropriate behaviors. For example, consider teaching safety skills, a child may recruit help upon smelling smoke. This would be beneficial over waiting until the child saw the smoke, which may entail a more dangerous situation. From a social perspective, a child may smell pizza in the school cafeteria and say to their friend, “I can’t believe we’re having pizza today!” This is an example of an appropriate social exchange that could benefit children with ASD when making friends. All things considered, research should determine what teaching procedures are as effective and efficient at teaching tacts of nonvisual stimuli.

Dass et al. (2018) targeted olfactory tact acquisition in children with ASD. The researchers evaluated the effects of a discrete-trail instruction procedure that involved echoic prompts, prompt delays, and specific error correction procedure toward their primary targets. They also folded in multiple exemplar training and included secondary target stimuli within the consequence portion of their learning trials. The authors found that each participant acquired the olfactory tact (and category tact), and those same participants demonstrated generalization across category tacts. A major limitation to their study was that verbal stimuli were not faded within their final step of tact training, leaving the response under potential multiple control.

Carr and LeBlanc (2019) focused on teaching tacts of stimuli in other sensory domains as well. In their study, two participants with ASD were taught to tact auditory stimuli under two different arrangements: isolated and compound. The isolated presentation included auditory stimuli without visual cues, while the compound presentation involved auditory stimuli with visual cues. The researchers found that compound stimulus presentation was more effective than isolated presentations. Essentially, the presence of the visual stimulus facilitated stimulus generalization. The authors note that behavior analysts should extend the literature on effective teaching procedures for teaching tacts of various sensory stimuli, including olfactory stimuli. The key, they highlight, is identifying teaching procedures that prevent faulty stimulus control.

When teaching visual tacts to children with ASD, Majdalany et al. (2014) compared massed-trial instruction to distributed-trial instruction and task interspersal. The researchers' six participants were taught to tact shapes of countries using all three teaching methods. The investigators wanted to conclude with teaching presentation revealed the quickest rate of tact acquisition. Five of their six participants acquired the visual targets using the massed-trial condition before the other two conditions. When analyzing efficiency, their massed-trial instruction sessions were approximately 60% shorter than sessions in the other teaching conditions. The researchers noted that future research should examine the most effective instructional methods across various sensory stimuli.

Problem Statement

Research devoted to teaching children with ASD how to effectively tact olfactory stimuli is extremely limited (Dass et al., 2018). If practitioners hope to develop comprehensive and well-rounded learners, then children with ASD should be taught across more than one sense. Unfortunately, the problem remains in identifying the most effective teaching procedures to teach children with ASD to tact these nonvisual stimuli. Researchers are also largely unaware of how secondary target instruction (i.e., additional verbal stimuli during teaching trials) can help increase and improve the learning outcomes of children with ASD. The current study has aimed to address this research gap in hopes that future curriculum for children with ASD can start to incorporate more multisensory learning opportunities.

Purpose of the Study

The purpose of the current study was to extend upon the sparse literature on olfactory tact acquisition. Specifically, the purpose was to evaluate the effects of different teaching procedures and secondary target instruction on the acquisition of olfactory tacts for children with ASD. The associated findings of the current study will help determine which teaching procedures are more effective, whether the influence of secondary target instruction is meaningful, and how future programming for children with ASD could be adjusted to include the acquisition of nonvisual tacts.

For three children with ASD in their home setting, data were collected across three different teaching procedures to determine if the rate of olfactory tact acquisition was greater in one teaching condition than the others. Data were also collected to determine which olfactory tact(s) were mastered, which teaching procedure was responsible for its mastery, and if olfactory tacts could be maintained and generalized across each of the three participants.

Research Questions and Hypotheses

Research Question 1: When comparing three different teaching conditions (e.g., echoic, prompt delay, and error correction) on the acquisition of olfactory tacts, will one teaching condition prove to be most effective?

$H_1$1: The error-correction teaching condition will be most effective in teaching olfactory tacts.

$H_2$1: The echoic teaching procedure will be least effective in teaching olfactory tacts.

Research Question 2: Will secondary target instruction affect the acquisition of category tacts?

$H_1$2: Secondary target instruction will affect the acquisition of category tacts for some, not all, of the participants.

Research Question 3: Will olfactory tacts of oil-saturated cotton balls be generalized to real items?

$H_1$3: Some olfactory tacts will be generalized to real items.

Research Question 4: Will mastered olfactory tacts be maintained once teaching conditions have ended?

$H_1$4: Some, not all, olfactory tacts will be maintained once teaching conditions have ended.

Definition of Key Terms

Abstract tact. Identifying an object or event that is nonvisual (e.g., saying “pizza” when smelling pizza).

Concrete tact. Identifying an object or event that is visual (e.g., saying “pizza” when seeing a pizza).

Olfactory tact. Identifying an object or event through only the sense of smell (e.g., saying "strawberry" after smelling a strawberry).

Secondary target instruction. Additional verbal stimuli during teaching trials (e.g., "Yes, strawberry smells fruity!").

Significance of the Study

The findings of the current study bear significance on developing comprehensive curriculum of children with ASD that includes multisensory teaching opportunities. Fine-tuning curriculum for children with ASD to include various modalities of learning directly impacts teachers and practitioners within teams of special education and applied behavior analysis. Although future research will certainly be required, the findings of the current study provided useful information as to how nonvisual tacts can efficiently be taught to children with ASD, and how secondary target instruction can be embedded within multisensory teaching opportunities to maximize learning. By extension, knowing how to effectively teach tacts of nonvisual stimuli may also provide practitioners with potential next steps within a learner's repertoire (e.g., building a child's listener response skills). For example, if a child with ASD can accurately tact the smell of smoke, they could then be taught what action needs to be taken thereafter (e.g., leave the home immediately) to significantly improve their health and safety.

Summary

Research devoted to tacts and tact training has extensively relied on visual tacts (or concrete tacts). Little is known on the most effective teaching strategies to teach tacts of nonvisual stimuli (or abstract tacts). Although teaching visual tacts to children with ASD is an important component of their growth and development, humans have the capability of learning through more than just one isolated sense. By expanding what researchers know about a child's capacity to learn through various senses, researchers provide opportunities to refresh and polish evidence-based practices. The implications of teaching children with ASD across their senses could be vast, as it could impact their social development, academic achievement, self-help skills, safety awareness, and health.

Chapter 2 will investigate the current literature on tacts, tact training, olfactory tacts, and secondary target instruction. In addition, Chapter 2 will discuss the current success of various teaching procedures such as echoic prompting, prompt-delay, and error-corrections. Chapter 3 will outline the current study's research design and how the methodology was used to investigate the different teaching conditions on the acquisition of olfactory tacts. Chapter 4 will illustrate the current study's clinical results and findings, while Chapter 5 will summarize the findings, outline the conclusions, and discuss future recommendations.

Chapter 2: Review of the Literature

A review of the relevant literature yields important information regarding tacts, tact training, secondary target instruction, abstract tact training (e.g., olfactory tacts), and various teaching procedures (e.g., echoic prompts, prompt delay, error correction). Robust literature has been devoted to tact, tact training, and the various teaching procedures, with a growing body of literature dedicated to secondary target instruction. Abstract tact training, however, has received little attention within peer-reviewed journals. For children with ASD, such information plays a vital role in the overall discussion of what research has previously confirmed, but also what has yet to be found effective. To date, the collected literature reveals the current research gaps that provide opportunities for future researchers to fill.

Tacts and Tact Training

Skinner (1957) originally outlined that a tact is a response evoked by nonverbal stimuli such as events, objects, or properties of each. Typically, children learn tacts through every day, natural, or incidental interactions with their environment. Children with ASD, however, may struggle with acquiring tacts, and if tacts are acquired than children with ASD may not acquire them at the same rate as their typical-developing counterparts. Therefore, children with ASD often require specialized instruction to learn, maintain, and extend their tact repertoire. Skinner emphasized that the tact is the most important of verbal operants due to how a tact provides opportunities for listeners to provide reinforcement to the speaker, which can then be a catalyst for additional verbal behavior. Through interactions between the speaker and listener, a child with ASD who demonstrates a tact creates further exposure to other verbal behavior. It is important that listeners not only address the visual tact skill set of speakers, but also pay close attention to the nonvisual tact skill set (e.g., speakers that label objects or events through senses other than sight).

Tact training protocols are common within language interventions for children with ASD. Specifically, Sundberg and Partington (1998) highlighted that a core feature of interventions for children with ASD should be tact training in order to develop tact relations. In 2003, Lovaas outlined that tacts (and tact relations) could be more aptly classified as expressive labels. A typical trial of tact training would include an adult holding up a picture (or a real object), asking the child with ASD to identify the picture or object, wait for the child's response, and then provide the child with praise if they are able to correctly identify the picture or object.

A common recommended practice is to include a supplemental question such as, "What is it?" during teaching trials for tacts across any sensory modality. But, any supplemental question should not be a defining feature of a tact relation, and prior research has suggested that including such questions could impede tact acquisition. Marchese et al. (2012) compared tact training with and without supplemental questions. Two of their four participants with ASD acquired tacts much more efficiently in the object-only condition, but the other two participants acquired tacts more efficiently in the "object + question" condition. Interestingly, during maintenance tests, all four participants emitted tacts at end-of-training levels with no differential effect observed between training conditions. The researchers noted that learners may be prone to stimulus control errors when acquiring tacts of any sensory stimuli. They emphasized that a verbal question could be a supplemental source of control if it is not the primary source of control (and does not impede maintenance in its absence). The authors highlighted that future research should investigate if supplemental questions would interfere with subsequent acquisition of other responses to questions across stimuli.

Stevens et al. (2011) attempted to teach tacts to two young male children with pervasive developmental disorders. To decrease the likelihood that the tacts would be developed outside of the study, the researchers chose the pictorial targeted tacts of avocado, garlic, and marmot. With an alternating treatments design and multiple baselines across each participant, the researchers presented the visual stimulus paired with the question, “What is it?” Upon correct responses, participants either received a token, a token paired with behavior-specific praise, or a token paired with general praise. Echoic prompts (e.g., “That’s garlic”) was the consequence for incorrect responses. Results indicated that visual tacts were acquired similarly across each of three teaching conditions.

Sundberg et al. (1990) attempted to teach tacts to two adult males with brain injuries in addition to significant verbal deficits. The researchers used three-dimensional objects that were relevant to each participant prior to their accidents which results in brain injury. With a multiple baseline design, tact training included researchers holding the target object in front of each participant while asking, “What is it?” Echoic prompts along with a mild “no” were provided by the researchers if researchers received either no response from the participants or incorrect responses. Echoic prompts were gradually faded from full word to initial sound of each target stimuli. Both participants acquired all target tacts during the tact training protocol.

Tacting through sign language has also been investigated. Wallace et al. (2006) taught tacts through sign language to three adults diagnosed with intellectual disabilities. Various leisure items ranging from highly preferred to low preferred were the targeted stimuli (e.g., books, musical toys, bubbles). Using a multiple baseline design across participants, the researchers implemented a tact training protocol where they presented each item to the participant paired with the question “What is it?” Correct responses (i.e., the sign for the items presented) were followed by a preferred edible item delivered to the participant. Incorrect responses (and no response) were met with the researcher demonstrating and modeling the correct sign for the presented target. If the participant did not imitate the model, the researcher physically guided the participant to form the correct sign for the presented target. Across each participant and across both high and low preferred leisure items results indicated that all tacts were acquired.

Four preschool-aged children with language delays were the participants of a tact training study by Twyman (1996). Two participants were male and other two participants were female. Everyday leisure activities encompassed the targeted stimuli (e.g., puzzles, Legos, PlayDoh) and the participants were required to tact various properties of each stimulus (e.g., large, whole). A reversal design allowed tact training to include a presented object (e.g., whole puzzle) along with a nonexample of the presented object (e.g., part of a puzzle). The researcher would then point to the presented object and verbally label it (e.g., "whole puzzle"). Once the participant correctly imitated the tact within three consecutive opportunities, the researcher would present the example stimulus with the nonexample stimulus and waited for the participant to provide the correct tact. Praise paired with access to an unrelated activity was provided contingent on correct responses, while incorrect responses were followed by the absence of praise and access to an unrelated activity. Once tact training was complete, each of the four preschool-aged participants acquired the tacts of the stimulus properties.

A 7-year-old male multiply diagnosed with intellectual disability and ASD was the participant of Barbara and Kubina (2005). The researchers attempted to teach three sets of tacts to the participant through common objects (e.g., household items) using a multiple baseline design across responses. Tact training protocols included presenting the target stimulus within an array directly in front of the participant while instructing the participant to point the target stimulus. If the participant pointed to the correct item, the researcher held up the item and replied, “Yes, what is it?” Failing to respond or responding incorrectly led the researcher to provide an echoic prompt to the participant. Once the participant vocally imitated the researcher in correctly tacting the item, the researcher again replied, “Yes, what is it?” and waited for the participant to provide a correct, independent response. Through these teaching procedures the participant acquired all sets across each set of stimuli.

Using a multiple-probe design across responses, Sigafoos et al. (1989) implemented tact training via a picture exchange system with three adults diagnosed with intellectual disabilities. Each participant was familiar with effectively utilizing a picture exchange system; therefore, the researchers used that modality to teach the participants to tact real food items, drink items, and common utensils. When each participant was shown the target stimulus and asked, “What is this?” the participant was expected to select the correct corresponding picture card from a folder of various picture cards. If a correct response was provided within 10 s the researcher provided descriptive verbal praise (e.g., “You got it, that’s a fork!”). If the participant did not respond or responded incorrectly, the researcher’s consequence included physically guiding the participant to select the correct picture card from their folder. Results indicated that each participant mastered the ability to accurately tact each target stimuli.

Nuzzolo-Gomez and Greer (2004) addressed tact training with four children diagnosed with ASD ranging in age from 6–9 years old. Using a multiple-probe across participants design, the researchers targeted adjective-object pairs of stimuli (e.g., large cup, second box). With an array of three objects placed in front of the participant, the researcher would point to a target stimulus with the participant expected to vocally tact the item (e.g., “Small cup”). If the participant did not respond or responded incorrectly, the researcher would provide an echoic prompt (e.g., “That’s the large cup”) and then present the next target. All correct imitative responses from the participants were followed by praise and the delivery of a token. The tact training protocols allowed each participant to acquire each of the targeted stimuli.

Marchese et al. (2012) implemented a tact training protocol with four children with ASD that ranged in age from 6–8 years old. The researchers selected common objects such as toys, books, and a hat to serve as the presented stimuli. Using an adapted alternating treatments design embedded in a nonconcurrent multiple baseline design across participants, the researchers either presented the stimuli and asked, “What is it?” or they presented the object without the question. Across both treatment conditions, the researchers waited 3 s for a response and correct responses from the participants were followed by verbal praise paired with a preferred item. Incorrect responses and no responses from the participants yielded an echoic prompt from the researcher (e.g., “Book”). Results indicated that the presentation of the object with the question, “What is it?” was more effective for two out of four participants, while the remaining two participants tacted stimuli more effectively when the object alone was presented.

Previous tact training studies that focus on visual stimuli appear too common within the research literature. The studies discussed have predominately used 2-D or 3-D visual targets during their tact training teaching conditions. But, to improve the language development for children with ASD, Sundberg and Partington (1998) advised that advanced tact training incorporate other sensory modalities such as addressing auditory, olfactory, gustatory, and tactile tacts.

Abstract Tact Training

Tacting visual stimuli has often been the focus of tact acquisition research for children with ASD. As mentioned, evaluating procedures for teaching nonvisual stimuli (i.e., abstract tacts) is important as well. One such abstract tact would be olfactory tacts, or the ability to identify stimuli through the sense of smell only. Dass et al. (2018) focused on the acquisition of olfactory tacts through a discrete-trial teaching procedure with three children diagnosed with ASD that incorporated echoic prompts, a constant prompt delay, and an error correction procedure. Teaching procedures were not separated into different teaching conditions to determine which teaching component were more effective than the others. The researchers also embedded secondary target instruction within their learning trials. Following the teaching trials, the researchers found that all three participants acquired each of their assigned olfactory tacts, acquired each of their assigned category tacts (e.g., “Strawberry smells fruity”), and demonstrated generalization and maintenance during the 2- and 4-week probes.

Outside of olfactory tact training, Hanney et al. (2019) taught auditory tacts to two children with ASD under two different stimulus-presentation arrangements: isolated, in which the auditory stimuli were presented in absence of visual cues, and compound, in which the presentation of auditory stimuli was paired with visual cues. Researchers discovered that the compound stimulus presentation was a more effective teaching procedure than presenting the stimuli in isolation.

Although McKeel and Matas (2017) did not specifically target abstract tacts, the researchers did utilize the promoting the emergence of advanced knowledge (PEAK) equivalence module to teach adults with ASD visual, gustatory, and auditory relations. Specifically, a transitivity program utilizing the gustatory sensory modality was implemented in which the relationship of gustatory stimuli to a visual picture was trained. Then, the visual picture to a spoken word was trained. Once the participants achieved mastery criterion, the researchers tested the participants to determine whether derived relations occurred following training. The participants were able to derive the new relations without direct training. The results highlighted that stimulus equivalence (by way of gustatory sensory modality) could be trained outside of just verbal to visual stimuli or visual to visual stimuli.

Discrete-Trial and Secondary Target Instruction

DTI is an effective teaching method that individualizes and simplifies instruction to enhance learning (Smith, 2001). Specifically, for children with ASD, DTI can be pivotal to teaching new skills, new forms of behavior, and new discriminations (Smith, 2001). But, DTI is not without its criticisms. For instance, many researchers argue that when children are taught under highly structured conditions it may inhibit their ability to generalize their skills to naturalistic conditions (Smith, 2001). To combat this criticism, DTI can include multiple exemplar training so that programming is continually focused on generalization. Multiple exemplar training allows numerous exemplars of a particular target stimulus with the aim of increasing generalization across categories (Greer & Longano, 2010). In relation to tact instruction, multiple exemplar training has been found to establish generalized repertoires while promoting novel responses for children with ASD (Miguel & Kobari-Wright, 2013). But, multiple exemplar training has yet to determine if it can enhance the emergence of olfactory stimuli (i.e. nonvisual stimuli).

In terms of efficiency, the intervention duration should be taken into consideration (Ingvarsson & Hollobaugh, 2011). Presenting additional targets, also known as secondary targets, during learning trials has been proven effective in increasing efficiency within DTI programing (Reichow & Wolery, 2011). Historically, the secondary target is stated by the experimenter while the primary targets lead to differential consequences (i.e., prompts and reinforcers). These secondary targets are often acquired but the primary targets remain directly taught. For example, Vladescu and Kodak (2013) taught primary tact targets (e.g., dog) within learning trials for four children with ASD but also presented secondary tact targets (e.g., cat) in the antecedent or consequence portion of the learning trials. Results demonstrated that the majority of participants acquired the secondary targets in both the antecedent and consequent events of learning trials.

Similarly, Loughrey et al. (2014) studied the effects of secondary target instruction but the curricular domains were different. For example, if the primary target was a picture of a "microwave" the secondary target were statements related to the features or functions of the "microwave" (e.g., "It makes food warm"). These secondary target statements were always presented in the consequence portion of the learning trial. During probes, the participants were asked questions related to the feature or function (e.g., "Tell me what a microwave does?") but only one participant responded correctly without direct teaching. Relatedly, Loughrey et al. first taught listener responses (e.g., "Touch the cashew") but then presented categorical statements consequentially (e.g., "A cashew is a nut"). When presented with the picture of the cashew and asked, "Cashew is a ___" the participants' responses increased without the need for direct teaching. The studies illustrated that embedding secondary targets into learning trials may increase the acquisition of the secondary targets (Loughrey et al., 2014).

Nottingham et al. (2017) studied the effects of presenting multiple secondary targets within learning trials for two children with ASD. The researchers compared four differing conditions: presenting a secondary target in the antecedent and consequence of trials, presenting two secondary targets in the consequence of trials, presenting one secondary target in the consequence of each trial, and trials in which no additional secondary targets were presented. Both participants acquired the majority of secondary targets, and researchers concluded that presenting one or multiple secondary targets per trial, regardless of location, increased the efficiency of their instruction.

Outside of secondary target instruction, researchers have also closely investigated the effects of echoic prompts, prompt delay, and error correction procedures on the acquisition of skills with ASD. For instance, Vedora et al. (2009) compared textual prompts to echoic prompts to increase intraverbal behavior and found that textual prompts were more effective in building intraverbal responses in children with ASD. Valentino et al. (2012) compared echoic prompts to echoic prompts paired with sign language and concluded that echoic prompts paired with sign language resulted in faster acquisition of intraverbal behavior. Interestingly, Leaf et al. (2016) compared the effectiveness of echoic prompts (and prompt fading) to multiple-alternative prompts and concluded that both teaching procedures were more effective than a no-intervention control condition in teaching tacts to children with ASD. Textual prompts were also found to be more effective than echoic prompts in teaching a 6-year-old boy with ASD intraverbal behavior (Finkel & Williams, 2002).

Prompt delay teaching procedures have also been closely examined. Vedora and Barry (2016) attempted to teach receptive labeling to two teenagers with ASD and found that prompt delay teaching procedures was effective (although one participant required a procedural modification). O'Neill et al. (2018) compared the effectiveness of three different prompt delay conditions (2-s or 5-s constant delay and 5-s progressive delay) on the acquisition of discrimination tasks with four individuals with ASD and found that the progressive prompt delay teaching condition was most effective in reducing learner errors. Pesantez (2012) compared total communication teaching procedures to prompt delay teaching procedures in the acquisition of intraverbal behavior to three children with ASD and discovered no clinically relevant differences between the two conditions.

Finally, although error correction procedures take various forms with varying levels of intrusiveness, the effectiveness of error correction procedures have also been widely investigated. Barbetta et al. (1993) found that an active student response in which students were required to emit a correct response following a teacher model was more effective as an error correction procedure compared to an error correction procedure in which the teacher modeled the correct answer but did not require the student to repeat it (i.e., no-response instruction). A multiple-response repetition condition (as an error correction procedure) was found to be more effective than a single-response repetition condition in teaching children with ASD sight words. While error correction procedures have been generally found to be effective in skill acquisition, children with developmental disabilities tend to be idiosyncratic in terms of the most efficient error correction procedure (Cariveau et al., 2019). An error correction procedure largely known as demonstration simply entails a therapist demonstrating the correct response. Interestingly, the demonstration error correction procedure was found to be the most efficient procedure across three comparative studies, while the active student response error correction procedure was found to be the most efficient strategy for five participants across three studies (Carroll et al., 2015, 2018; Kodak et al., 2016). Again, regarding error correction procedures, what largely separates demonstration from active student responding is the response requirement in the active student responding condition.

The purpose of the current study was to extend literature on secondary target instruction and tact training. This was accomplished by evaluating the effects of discrete-trial procedures that involved either immediate echoic prompts, prompt delay, or an error correction procedure on the acquisition of olfactory tacts with children diagnosed with ASD.

Chapter 3: Research Design and Method

The purpose of the current study was to extend the literature on olfactory tact acquisition. Specifically, the purpose was to evaluate the effects of various teaching procedures and secondary target instruction on the acquisition of olfactory tacts for children with ASD. The associated findings of the current study help determine which teaching procedures are more effective, whether the influence of secondary target instruction is meaningful, and how future programming for children with ASD could be adjusted to include the acquisition of nonvisual, abstract tacts. In this chapter, several key areas will be described in greater detail: participants, setting and materials, dependent variable, interobserver agreement, experimental design, and procedures.

Participants

Inclusion criteria included participants that ranged in age from 3–8 years of age, had a current diagnosis of ASD, and demonstrated a “strong” labeling and verbal imitation repertoire. Exclusion criteria included children with allergies to strong scents. Ultimately, the study included three participants who ranged in age from 6–8 years old. All participants were diagnosed with ASD, and the diagnosis was verified through parent-provided documentation. According to documentation provided by the parents (e.g., school-based speech and language evaluations), all participants could readily tact visual stimuli (e.g., “That’s a dog!”) by having at least 50 visual labels and the ability to verbally imitate at least 10 different three-word utterances. Children with allergies to strong scents did not participate in the study.

Each participant attended full day public school in which they received special education services including consultation from a board-certified behavior analyst. One participant, George, was an 8-year-old male that had a school-based behavior support plan aimed at reducing and replacing his motor stereotypy and noncompliance. John was also an 8-year-old male; however, he did not have a formal school-based behavior support plan to reduce or replace the presence of challenging behaviors. Paul, a 7-year-old male, did not engage in any challenging/interfering behaviors that warranted school-based interventions. Each family reported that their child was familiar with discrete trial instruction and received some form of discrete trial instruction throughout their school day. All three families identified themselves as Caucasian.

A recruitment flyer was posted in several locations (e.g., libraries, coffee shops) and included my contact information. A mother of a local parent support group contacted me via email and expressed interest. The mother provided the email addresses of two other mothers who were also interested in participating in the study, as all three mothers were members of the same local parent support group. All three mothers requested to meet with me as a group, at which time informed consent was reviewed and secured with each mother.

Setting and Materials

Sessions occurred in the homes of each participant. Each home contained a variety of toys as well as child-sized tables and chairs. The home environments were mostly free of distractions (e.g., television, siblings, pets). All sessions across participants were conducted either in their basements or in their living rooms. Session materials included datasheets, pencils, glass bottles containing scented-oil-saturated cotton balls, actual foods that related to the scented oils, a glass bottle containing coffee beans, a token board, and condition-specific discriminative stimuli (e.g., three different colored cards that represented the three different teaching conditions). The scent categories were selected based on what humans can commonly discriminate among categories of scents (e.g., fruity, stinky, yummy, citrusy). Each category included four target items (e.g., the fruity category included strawberry, coconut, watermelon, cherry) for a total of 16 target tacts.

Tables 1–2 depict the categories and specific targets, as well as which targets were assigned to the various conditions for all participants. Table 1 depicts the four categories of scents and the identified scents within each category. The fruity scents were strawberry, watermelon, coconut, and cherry. The citrusy scents were lemon, orange, lime, and grapefruit. The stinky scents were blue cheese, garlic, vinegar, and nail polish. The yummy scents were popcorn, bubblegum, pizza, and chocolate. Table 2 depicts the item tacts that were assigned to John during each teaching condition. John's echoic condition consisted of strawberry, lemon, blue cheese, and popcorn. John's prompt delay condition consisted of watermelon, orange, garlic, and bubblegum. Finally, John's error correction condition consisted of coconut, lime, vinegar, and chocolate. Paul's echoic condition consisted of coconut, lime, vinegar, and chocolate. Paul's prompt delay condition consisted of strawberry, lemon, blue cheese, and popcorn. Finally, Paul's error correction procedure consisted of watermelon, orange, garlic, and bubblegum. George's echoic condition consisted of watermelon, orange, garlic, and bubblegum. George's prompt delay condition consisted of coconut, lime, vinegar, and chocolate. Finally, George's error correction procedure consisted of strawberry, lemon, blue cheese, and popcorn.

Dependent Variable and Measurement

The dependent variable was defined as the percentage of trials with correct responses to item tacts and the cumulative number of mastered tacts. *Correct independent responses* were defined as the participant verbalizing the accurate tact within 5 s of the discriminative stimulus (S^D). *Correct prompted responses* were defined as the participant verbalizing the accurate tact immediately following an echoic prompt. *Incorrect responses* were defined as the participant verbalizing an inaccurate tact or not responding within 5 s of the S^D. At the end of each session the number of correct responses was divided by the number of trials and multiplied by 100, providing an overall percentage correct of item tacts. All scent targets had a mastery criterion of 100% correct responses across two consecutive probe sessions.

Interobserver Agreement and Treatment Integrity

Data were collected for 33% of sessions across conditions by a secondary observer to calculate interobserver agreement (IOA). Trial-by-trial IOA was calculated, and an agreement was defined as the secondary observer and myself scoring the same response during a single trial. At the end of the session the number of agreements was divided by the total number of trials and multiplied by 100. The overall agreement between myself and secondary observer across all sessions was 95.7%. The IOA for John was 96.8% (93.4%–100%). The IOA for Paul was 94.2% (89.1%–100%). The IOA for George was 96.2% (94.3%–100%).

A procedural integrity checklist was used by the secondary observer to collect data on my behavior to ensure proper implementation. A task analysis was developed for each procedure, and the secondary observer checked each step that was implemented correctly. At the end of the session the number of steps implemented correctly was divided by the total number of steps and multiplied by 100. Treatment integrity was collected for 33% of sessions across teaching conditions and participants. Overall treatment integrity was 95.4% (92.8%–97.5%). Treatment integrity for John was 96.1%. Treatment integrity for Paul was 97.5%. Treatment integrity for George was 92.8%

Experimental Design

An alternating treatments design was used to evaluate the effects of immediate echoic prompts, prompt delay, and error correction on tacting olfactory stimuli. The effects of such procedures were compared to a baseline condition in which all training procedures were absent. The alternating treatments design allowed interventions to be compared across participants, and to analyze the effects of teaching conditions across participants. The alternating treatment efficiently compared intervention effectiveness by measuring the differences in responding between the three teaching conditions.

After baseline, the three teaching conditions (e.g., echoic, prompt delay, error correction) were alternated in a quasi-random fashion such that no condition was implemented more than twice consecutively. After the first session, a concurrent-chains procedure was implemented in which the participant chose the order in which conditions were conducted. The concurrent-chains procedure included an initial and terminal link. The *initial link* included the presentation of the colors associated across the different conditions. The participant selected a color. The colors were the discriminative stimuli for each teaching condition. Yellow represented the echoic teaching condition, blue represented the prompt delay condition, and red represented the error correction condition. The *terminal link* included the implementation of the session using the procedures which corresponded with the color selected in the initial link. Following that session, another initial link was implemented with the remaining colors representing the conditions not yet conducted.

Procedures

I conducted each session, and sessions for each participant occurred approximately every other day across a 3-week period. Each condition was between 30 and 45 min in duration. The number of trials within each teaching condition was not the same, yet each teaching condition had at least 25 total trials but no more than 35 total trials. Throughout the study, no participant went more than 2 consecutive days without a teaching condition.

Baseline

Baseline was conducted to ensure that each participant could not tact the target scents. Each of the 16 scents were presented twice in a glass bottle which contained a scented-oil-saturated cotton ball. I presented each scent by bringing the bottle approximately 2 cm from the participant's nose and asked, "What is it?" (to occasion the item tact) followed by, "How does it smell?" (to occasion a category tact). Correct and incorrect responses were not reinforced. To minimize the likelihood of scent carryover, a 15-s intertrial interval between scents was used in which coffee beans were presented to the participant to serve as a neutralizing scent. Once stable responding was established, one scent from each category was assigned to each of three teaching conditions (for a total of four scents per teaching condition).

Probe Sessions

Before any of the three teaching sessions occurred on a given day, a pre-session probe was first conducted which included two trials per scent with no programmed consequence. It was conducted across all participants to measure their accuracy of target identification before the participant selected a teaching condition. Each scent was presented in a glass bottle which contained a scented-oil-saturated cotton ball. I presented each scent by bringing the bottle approximately 2 cm from the participant's nose and asked, "What is it?" (to occasion an item tact). Correct and incorrect responses were not reinforced. A 15-s intertrial interval between scents was used.

Teaching

Once the presession probe was completed, the assigned teaching condition began. During all teaching conditions (e.g., echoic, prompt delay, and error correction) a secondary target instruction was provided following a correct response. The secondary target included a categorical tact for the targeted scent. For example, for the strawberry scent, the praise statement for a correct response was "Yes, strawberry smells fruity!" The participant was not required, in any teaching condition, to repeat the secondary target. During all teaching conditions a correct response earned the participant a token, and at the end of the session tokens were traded for preferred items/activities. Prompts were not faded within teaching trials across teaching conditions to ensure that each teaching condition remained constant in its implementation.

Echoic

During the echoic condition, I immediately prompted the correct response following the S^D. To increase stimulus control, I allowed the participants to smell the scent again. A correct prompted response was followed by a token paired with verbal praise. After the echoic prompt was delivered, to embed secondary target instruction, I provided a secondary target praise statement (e.g., "Yeah, strawberry smells fruity!"). The participant was not required to vocally imitate the secondary target praise statement. An incorrect response did not result in a token, verbal praise, or secondary target statement.

Prompt Delay

During the prompt delay condition, I waited 5 s to provide the echoic prompt. If the participant responded correctly, a token paired with verbal praise with the secondary target was delivered. If the participant responded incorrectly within 5 s, I did not provide any feedback but still provided the echoic prompt at 5 s. To increase stimulus control, I allowed the participants to smell the scent again.

Error Correction

During the error correction condition, I waited 5 s to provide the echoic prompt. If the participant responded correctly a token paired with verbal praise with the secondary target was delivered. If the participant responded incorrectly or did not respond within 5 s, an error correction procedure trial was presented. An error correction trial included re-presenting the scent and S^D, providing the participant with an immediate prompt, and requiring the participant to imitate the prompt. To increase stimulus control, I allowed the participants to smell the scent again. After the imitated response, I delivered a token paired with verbal praise along with the secondary target.

Maintenance

Five days after the last teaching condition a maintenance session was conducted with each participant. Procedures during the maintenance session were identical to those in baseline except the maintenance session only included the four scents that were targeted during the error-correction teaching condition (as the error-correction teaching condition was the last teaching condition across each participant).

Categorial Probe

Following the maintenance session, category tacts were measured as the experimenter presented each scent by bringing the bottle approximately 2 cm from the participant's nose and asked, "What is it?" (to occasion the item tact) followed by, "How does it smell?" (to occasion a category tact).

Real Item Probe

Five days after the last teaching condition a real item probe was conducted with each participant. Procedures during the real item probe were identical to those in maintenance except the real item probe used real objects instead of scented-oil-saturated cotton balls and participants were asked to close their eyes. Once their eyes were closed, a real object was brought approximately 2 cm from the participant's nose and asked, "What is it?" (to occasion an item tact). Participants were discouraged from touching the real object, as touching the real object could have provided them with additional cues of what the object was.

Social Validity

Two procedures were conducted to measure social validity. An empirical evaluation of participant preference was conducted throughout the study, while a subjective evaluation of parent preference was conducted at the end of the study.

Participant Preference

After the first session, a concurrent-chains procedure was implemented in which the participant chose the order in which conditions were conducted to determine participant preference. The concurrent-chains procedure included an initial and terminal link. The *initial link* included the presentation of the colors associated across the different conditions. The participant selected a color. The colors were the discriminative stimuli for each teaching condition. Yellow represented the echoic teaching condition, blue represented the prompt delay condition, and red represented the error correction condition. The *terminal link* included the implementation of the session using the procedures which corresponded with the color selected in the initial link. Following that session, another initial link was implemented with the remaining colors representing the conditions not yet conducted.

Parent Preference

Each parent watched every session in real time; however, one parent was temporarily absent during one session for approximately 15 min. At the end of the study, a social validity survey was provided to the parents to rate the treatment conditions. The different teaching conditions were described by the discriminative stimuli (e.g., colors) used within the session. For example, the echoic condition was represented by yellow, so for the parent social validity survey, it was described as the “yellow” session. The parents completed a subjective survey regarding their child’s responding, perceived preference, and the parent’s preference for the different teaching conditions.

Chapter 4: Findings

The following chapter will review the results of the study, specifically how the acquisition of olfactory tacts (and secondary target statements) was acquired across participants throughout the three teaching procedures. Maintenance and real item probe results across participants will be outlined as well, in addition to guardian and participant preference results.

Results

Figure 1 illustrates the cumulative number of mastered item tacts across each participant. John did not master any scents within the echoic teaching condition or the prompt delay teaching condition. However, John mastered two scents during the error correction teaching condition: coconut and chocolate. Coconut was mastered on Session 13 and chocolate was mastered on Session 14. Paul did not master any scents within the echoic teaching condition or the prompt delay teaching condition. However, Paul mastered the scent of bubblegum during the error correction teaching condition on Session 14. On Session 14, George mastered the scent of blue cheese during the error correction teaching condition. Like his counterparts, George did not master any scents during the echoic teaching condition or prompt delay teaching condition.

Figure 2 depicts the correct independent responses across teaching conditions and participants. No acquisition occurred during baseline measures with John. John's average score during probe sessions was 10% and ranged from 0%–21%. John's percentage of correct item tacts improved across probe sessions. John's average percentage of correct independent responses during the prompt delay condition was 20% and ranged from 17%–22%. John's average percentage of correct independent responses during the error correction condition was 40% and ranged from 33%–54%. John's performance improved throughout the error correction teaching condition. Paul's performance during baseline ranged from 6–9% accuracy in correctly tacting scents. Paul’s average score during probe sessions was 9% and ranged from 0%–38%. Like John, Paul’s percentage of correct item tacts improved across probe sessions. Paul’s average percentage of correct independent responses during the prompt delay condition was 18% and ranged from 14%–22%. Paul’s average percentage of correct independent responses during the error correction condition was 30% and ranged from 25%–41%. Like John, Paul’s performance improved throughout the error correction teaching condition.

No acquisition occurred during baseline measures for George. George’s average score during probe sessions was 8% and ranged from 0%–38%. Like his counterparts, George’s percentage of correct item tacts improved across probe sessions. However, George engaged in frequent motor stereotypy (e.g., hand puppeteering) that appeared to impact his overall attending skills across each teaching condition. George’s average percentage of correct independent responses during the prompt delay condition was 14% and ranged from 10%–17%. Finally, George’s average percentage of correct independent responses during the error correction condition was 29% and ranged from 21%–42%. Like his counterparts, George’s performance improved throughout the error correction teaching condition.

Figure 3 represents the correct prompted responses across each teaching condition and participant. John’s average percentage of correct prompted responses during the echoic condition was 92% and ranged from 87%–95%. John’s average percentage of correct prompted responses during the prompt delay condition was 24% and ranged from 10%–33%. John’s average percentage of correct prompted responses during the error correction condition was 26% and ranged from 15%–40%. Paul’s average percentage of correct prompted responses during the echoic condition was 82% and ranged from 79%–85%. Paul’s average percentage of correct prompted responses during the prompt delay condition was 61% and ranged from 57%–66%.

Paul’s average percentage of correct prompted responses during the error correction condition was 44% and ranged from 28%–60%. George’s percentage of correct prompted responses during the echoic condition was 48% and ranged from 42%–57%. George’s average percentage of correct prompted responses during the prompt delay condition was 22% and ranged from 18%–26%. George’s average percentage of correct prompted responses during the error correction condition was 29% and ranged from 20%–35%.

Figure 4 illustrates the percentage of incorrect responses across teaching conditions and participants. John’s average percentage of incorrect responses during the echoic condition was 8% and ranged from 5%–13%. John’s average percentage of incorrect responses during the prompt delay condition was 57% and ranged from 50%–68%. John’s average percentage of incorrect responses during the error correction condition was 34% and ranged from 14%–52%. John’s incorrect responses decreased throughout the error correction condition. John’s average number of incorrect responses during probe sessions was 15.3 and ranged from 11–19. John’s average number of no responses was 6.2 and ranged from 5–8. John’s total number of errors decreased across probe sessions.

Paul’s average percentage of incorrect responses during the echoic condition was 18% and ranged from 15%–21%. Paul’s average number of incorrect responses during probe sessions was 14.5 and ranged from 10–17. Paul’s average number of no responses was 7.2 and ranged from 4–10. Paul’s total number of errors neither increased nor decreased across probe sessions. Paul’s average percentage of incorrect responses during the error correction condition was 25% and ranged from 15%–40%. Paul’s incorrect responses increased throughout the error correction condition. Paul’s average percentage of incorrect responses during the prompt delay condition was 21% and ranged from 17%–26%. George’s average percentage of incorrect responses during the echoic condition was 52% and ranged from 43%–58%. George's average percentage of incorrect responses during the prompt delay condition was 64% and ranged from 59%–67%. George's average percentage of incorrect responses during the error correction condition was 42% and ranged from 23%–59%. Like John, George's incorrect responses decreased throughout the error correction condition. George's average number of incorrect responses during probe sessions was 10.2 and ranged from 5–14. George's average number of no responses was 11.8 and ranged from 4–19. George's total number of errors increased across probe sessions.

Figure 5 depicts secondary target imitation across teaching conditions and participants. John's average percentage of secondary target imitation during the echoic condition was 12% and ranged from 8%–16%. John's average percentage of secondary target imitation during the prompt delay condition was 12% and ranged from 8%–18%. John's average percentage of secondary target imitation during the error correction condition was 21% and ranged from 14%–29%. John's imitation of secondary targets increased slightly throughout the error correction condition.

Paul's average percentage of secondary target imitation during the echoic condition was 20% and ranged from 16%–24%. Paul's average percentage of secondary target imitation during the prompt delay condition was 25% and ranged from 22%–28%. Paul's average percentage of secondary target imitation during the error correction condition was 25% and ranged from 17%–33%. Paul's imitation of secondary targets also increased slightly throughout the error correction condition.

George's average percentage of secondary target imitation during the echoic condition was 5% and ranged from 4%–8%. George's average percentage of secondary target imitation during the prompt delay condition was 8% and ranged from 5%–9%. George's average percentage of secondary target imitation during the error correction condition was 10% and ranged from 5%–15%.

Figure 6 illustrates the percentage of correct independent item tacts during the maintenance session across participants. When a maintenance session was conducted 5 days after the last teaching condition, John maintained both the coconut item tact and the chocolate item tact. However, John's percentage of correctly tacting the scent of lime was 0%, and his percentage of correctly tacting the scent of vinegar was 50%. John's percentage of correctly tacting both watermelon and orange was 0%. Paul's percentage of correctly tacting bubblegum was 50%, as was his percentage of correctly tacting garlic (50%). When presented with garlic scent, Paul replied "stinky" in 50% of trials. When presented with the bubblegum scent, Paul replied "yummy" in 50% of trials as well. George maintained the ability to correctly tact the scent of blue cheese but scored 50% on correctly tacting the scent of strawberry and popcorn. George's percentage of correctly tacting the scent of lemon was 0%.

Figure 7 depicts the correct independent category tacts across participants. Target scents were presented and asked, "How does it smell?" When presented with the coconut scent John replied "fruity" in 50% of trials. When presented with the vinegar scent John replied "stinky" in 100% of trials. When presented with the chocolate scent John replied "yummy" in 50% of trials. Paul provided a correct independent category tact in 50% of trials for both stinky and yummy. George did not provide any correct categorial tacts when presented with his target scents.

Figure 8 represents the percentage of correct independent item tacts with real items during the real item probe session across participants. John correctly tacted real vinegar in 50% of trials but scored 0% on correctly tacting the remaining real items (e.g., real coconut, real lime, and real chocolate). During the real item probe, Paul correctly tacted real bubblegum in 100% of trials but scored 0% on correctly tacting his remaining real items (e.g., real watermelon, real orange, and real garlic). George correctly tacted real blue cheese in 100% of trials and real lemon in 50% of trials. George scored 0% on correctly tacting his remaining real items (e.g., real strawberry and real popcorn).

Figure 9 illustrates the cumulative participant preference throughout teaching sessions across each participant. Both John and George selected the echoic teaching condition three times, the prompt delay condition three times, and the error correction condition two times. At the conclusion of the study, John reported that he preferred the prompt delay condition more than the other two teaching conditions while George reported that he preferred the error correction teaching condition. Paul selected each teaching condition evenly (i.e., selected each of the three teaching conditions three times). At the conclusion of the study, Paul reported that he preferred the prompt delay condition more than the other two teaching conditions while George reported that he preferred the error correction teaching condition. Two out of the three participants may have ultimately preferred the prompt delay teaching condition more than the other two teaching conditions because the prompt delay teaching condition frequently evoked laughter in the participants. For example, I may have inadvertently provided "expectant stares" to the participant during the prompt delay condition, and those "expectant stares" frequently evoked laughter.

Table 3 depicts the satisfaction scores and belief in effectiveness recorded by the guardians of the three participations. Each of the three teaching conditions were rated on a 7-point Likert scale from 1 (*very unsatisfied*) to 7 (*very satisfied*). Overall, the prompt delay teaching condition (blue) was rated the highest. The echoic teaching condition scored an average of 4.6 (range 4–6), the prompt delay teaching condition scored an average of 6.3 (range 6–7), and the error correction teaching condition scored an average of 4.3 (range 4–5). When asked if the different teaching conditions affected their child's responding, two out of three guardians reported "agree" while one guardian reported "slightly agree." When asked if the secondary target instruction affected their child's responding, one guardian reported "strongly agree," one guardian reported "agree," and one guardian reported "slightly disagree." All three guardians reported that they believed their children learned better in one teaching condition than the others. In addition, all three guardians reported that they believed their children enjoyed one teaching condition more than the others. Finally, when asked what their favorite teaching condition was, two guardians reported the prompt delay condition as their favorite while one guardian reported the error correction condition.

Chapter 5: Summary, Conclusions, and Recommendations

The purpose of the current study was to determine the effects of discrete-trial and secondary target instruction procedures on the acquisition of olfactory tacts with children with ASD. Specifically, three different teaching procedures were evaluated (e.g., echoic, prompt delay, error correction), each with embedded secondary target instruction (e.g., "Right, strawberry is fruity"), to determine which teaching condition led to greater acquisition of children with ASD expressively labeling various scents. Except for Dass et al. (2018), previous research has predominately focused on teaching tacts of visual stimuli. But, it is important that children with ASD learn to tact stimuli that impact their other senses. To my knowledge, this is the second study to investigate the effects of teaching procedures on olfactory tact acquisition.

Overall, all three participants correctly tacted a higher percentage of scents during the error correction teaching condition as compared to baseline scores and other teaching conditions (e.g., echoic and prompt delay). Collectively, only four scents were mastered across all three participants (e.g., chocolate, coconut, bubblegum, blue cheese) and occurred during the error correction teaching condition. The error correction procedure may have been the most effective of the teaching conditions due to errorless teaching component of immediately prompting the correct response and then requiring the participant to imitate the prompt (Cariveau et al., 2019). This error correction component was not present among the other two teaching conditions.

Regarding secondary target instruction, John was the only participant to score 100% in identifying the category tact for a particular scent (e.g., vinegar). Interestingly, vinegar was not one of the two item tacts that John mastered (e.g., chocolate and coconut). Conversely, George mastered the item tact of blue cheese but scored 0% on expressing its category tact of "stinky." Overall, no participant who mastered their item tact also mastered their corresponding category tact. These variable findings of secondary target instruction are consistent in some respects with the findings of Dass et al. (2018), but this current study examined the effects of three separate teaching procedures whereas Dass et al. used a treatment package that consisted of echoic prompts, prompt delay, and error correction procedures. Like the findings of Dass et al., this study highlighted that behavior-analytic training procedures (e.g., error-correction procedures) are effective for teaching tacts of olfactory stimuli and that embedded secondary target instruction can result in the emergence of categorical tacts of olfactory stimuli for children with ASD. The participants had different histories with different target stimuli, and those histories could result in category tacts that shift over continued exposure. For example, a child may initially report that pizza smells stinky but after further exposure report that the same pizza smells yummy. These shifts in categorical tacts could be the result of its relation to reinforcement (i.e., the secondary target statement occurred in close proximity to token delivery). It is important to note that the three participants in this study had well-established tacting repertoires, and that having such a strong repertoire may be a critical prerequisite skill for developing nonvisual, abstract tacts (e.g., olfactory tacts).

A recommendation for future research by Dass et al. (2018) was to evaluate generalization to novel stimuli (e.g., tacting the scent of real lemons). This current study addressed that recommendation during the real item probe across each participant, yet the percentage of accuracy was low (i.e., ranging from 8–25%). Accurately tacting real items may have been weak due to how the oil-scented cotton balls differ in smell compared to the real item. For example, real popcorn may have a distinctively different scent compared to popcorn scented oil. Another recommendation by Dass et al. that was addressed in this study was the duration of instructional sessions. Across each teaching condition, each instructional session was 30–40 min in duration. This helped ensure that the amount of teaching trials and opportunities to acquire olfactory tacts were relatively equal across each of the teaching conditions.

Future research may also want to consider having the olfactory tact be the secondary target within trials that aim to teach a tact visually. For instance, researchers could present a picture of a strawberry, teach participants to label it as a strawberry, and embed secondary target instruction of a strawberry scent. Then, researchers could test if the presence of the scent alone evokes an expressive tact (e.g., “That smells like strawberry!”). Essentially, several teaching configurations should be closely examined in future research across a variety of abstract tacts (e.g., olfactory, auditory, tactile).

When reflecting on the low number of mastered item tacts across participants and teaching conditions, what may have hindered progress and mastery was the number of targeted scents within each teaching condition. Each teaching condition had four different target scents, which means that 12 scents were always in acquisition across most of the study. Therefore, future research may want to limit the number of olfactory tacts in acquisition (i.e., two olfactory tacts per teaching condition instead of four) so that participants have a greater likelihood of making adequate progress toward tact mastery.

There are several limitations to the study that should be discussed. Primarily, this study was conducted amidst a COVID-19 pandemic, and one common symptom related to COVID-19 is a significant loss of someone’s sense of smell. Fortunately, throughout the study and to date, no participant or immediate family member of a participant has tested positive for COVID-19. What is unknown, however, is if one of the family members or participants had COVID-19 but was not demonstrating detectable symptoms (e.g., fever). Therefore, any of the three participants could have had undiagnosed COVID-19 which may have impacted their sense of smell.

Fortunately, there were differences in participant responding per teaching condition and particular scents were mastered, so it is unlikely that COVID-19 impacted the acquisition of olfactory tacts across participants.

Second, due to the nature of alternating treatments (and different teaching conditions therein), a potential carryover effect could have occurred. For instance, if a participant had just experienced the echoic teaching condition in which they were immediately prompted with the correct response, and then the next teaching condition was the error correction condition, the participant may have expected to be immediately prompted with the correct response during the error correction condition. In addition, participants could have “carried over” their responses to other teaching conditions regardless of the presented scent. To control for potential carryover effects, participants had to select a color before a teaching session began and the colors served as discriminative stimuli for the teaching condition they were about to experience.

Third, the study was designed to be conducted over a 2-week period, and most teaching sessions did not occur over consecutive days. If sessions occurred over consecutive days, participants could have demonstrated greater acquisition of olfactory tacts or could have mastered additional tacts within different teaching conditions. As a result, the current study may be more reflective of the participants’ ability to retain olfactory tacts as opposed to being more reflective of efficacy of teaching conditions. Future research should consider implementing teaching conditions over consecutive days and extending the study past a 2-week period, all to control for confounding variables (e.g., smelling items outside of teaching sessions) and to determine how long participants must be in specific teaching conditions to master, maintain, and generalize their olfactory tacts.

Fourth, some of the scents might be considered more common than other scents. For example, outside of teaching sessions, participants could have been olfactorily exposed to strawberry, watermelon, cherry, orange, popcorn, bubblegum, pizza, and chocolate. Scents such as those are perhaps more common to children than blue cheese, nail polish, vinegar, and garlic. Therefore, future research should consider having guardians track what scents their children could have encountered outside of teaching sessions so that researchers can measure a potential correlation between smelling scents outside of teaching sessions and the acquisition of targeted olfactory tacts. Additionally, some scents could be considered more potent than others (e.g., nail polish, vinegar, blue cheese) which could lead some participants to master (and maintain) those item tacts quicker than less potent scents (e.g., coconut, chocolate). As a result, future research should ensure that targeted scents are similar in potency so that results are more reflective of differing teaching conditions.

There are some clinical implications from the current study that future research should additionally consider. First, although this study demonstrated that an error-correction procedure evoked the greatest tact success, future research should continue to compare the effects of different teaching procedures (and secondary target instruction) on the acquisition of olfactory tacts, gustatory tacts, kinesthetic tacts, and auditory tacts. Although all teaching procedures will likely include formal training trials and natural environment teaching procedures, researchers should not assume that the teaching procedures should be similar across all senses largely due to stimulus control. For example, what controls our ability to accurately tact auditory stimuli is different from what controls our ability to accurately tact what we touch, taste, see, and smell. Blocking off the other senses to increase stimulus control and comparing the effects of different verbal antecedent stimuli (e.g., “What do you taste?”, “What do you hear?”) require further investigation as well. If an error-correction procedure proves to be consistently more effective across teaching a variety of abstract tacts, then future research should conduct component analyses to determine which components of an error-correction procedure are most salient and required.

Second, verbal antecedent stimuli were not faded during this study as recommended by Sundberg and Partington (1998) to increase stimulus control of the nonverbal antecedent stimulus (i.e., the scent). Fading any additional stimulus such as verbal antecedent stimuli provide researchers with greater assurance and confidence that a single, salient stimulus (i.e., the scent) is controlling the participant's verbal tact (i.e., "That's bubblegum!"). To avoid responses being multiply-controlled, future research should consider systematically fading verbal antecedent stimuli within teaching conditions. But, perhaps the most significant of clinical implications is considering what children with ASD will do once they acquire nonvisual, abstract tacts. Smelling vinegar and immediately tacting it as "vinegar" is just one step toward securing someone's safely and health. Future research must investigate not only the most effective methods to teach nonvisual tacts, but how the acquisition of nonvisual tacts relates to listener responses (e.g., smelling vinegar and refraining from drinking it by putting it away). Simply put, a child with ASD may be able to accurately tact the smell of smoke but if a successful tact does not lead to observable and actionable listener responses (e.g., finding an adult, leaving the immediate area, yelling for help) then the field of behavior analysis is failing to qualitatively improve the lives of clients in meaningful ways.

Although several limitations are noted, tacting olfactory stimuli could give us important insight into the development of verbal behavior, relational frames, and the expansion of language repertoires. According to relational frame theory, human language and cognition are relational abilities (Cullinan & Vitale, 2010). In other words, humans respond relationally to stimulus events (e.g., smelling popcorn) by additional contextual cues and social convention (e.g., eating popcorn while watching a movie, hearing kernels being popped, etc.). Terms such as popcorn or buttery may be participating in a frame of coordination (e.g., yummy food) but they also participate in a frame of difference with other categories (e.g., snacks, vegetables, salty food). Regarding olfactory tacting, abstraction was occurring in this study in which participants were expected to tact a single property of a stimulus (i.e., the scent of a food item). If a human is attempting to tact or label what they smell, then they must rely on their relational frames to correctly identify the smell. Future research should consider examining how teaching children across various senses could expand their relational frames to significantly increase their language development.

In conclusion, as the second known study to teach olfactory tacts and the first study to measure the acquisition of olfactory tacts across various teaching conditions, this study should be considered another step on a tall ladder toward teaching children with ASD the most effective ways to tact nonvisual, abstract stimuli. The goal is to yield comprehensive, well-rounded learners; therefore, incorporating multisensory teaching strategies (e.g., auditory, gustatory, tactile) deserves ongoing investigation. This study has clinical implications for future research and for developing robust programming for children with ASD beyond mere visual stimuli. This study indicates behavior-analytic training that embeds error-correction teaching procedures (with secondary target instruction) is effective in teaching item tacts and category tacts of olfactory stimuli. It is the responsibility of researchers to discover the most efficient interventions to improve the abstract tact repertoire of children with ASD and related disorders.

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Table 1

Category Tacts and Associated Item Tacts

	Fruity	Citrus	Stinky	Yummy
Item Tacts	Strawberry	Lemon	Blue Cheese	Popcorn
	Watermelon	Orange	Garlic	Bubblegum
	Coconut	Lime	Vinegar	Pizza
	Cherry	Grapefruit	Nail Polish	Chocolate

Note. Item tacts for each category of scents (Dass et al., 2018).

Table 2

Item Tact Assignment

	Echoic Condition	Prompt Delay Condition	Error Correction Condition
John	Strawberry	Watermelon	Coconut
	Lemon	Orange	Lime
	Blue Cheese	Garlic	Vinegar
	Popcorn	Bubblegum	Chocolate
Paul	Coconut	Strawberry	Watermelon
	Lime	Lemon	Orange
	Vinegar	Blue Cheese	Garlic
	Chocolate	Popcorn	Bubblegum
George	Watermelon	Coconut	Strawberry
	Orange	Lime	Lemon
	Garlic	Vinegar	Blue Cheese
	Bubblegum	Chocolate	Popcorn

Note. Assigned item tacts per teaching condition across each of the three participants.

Table 3

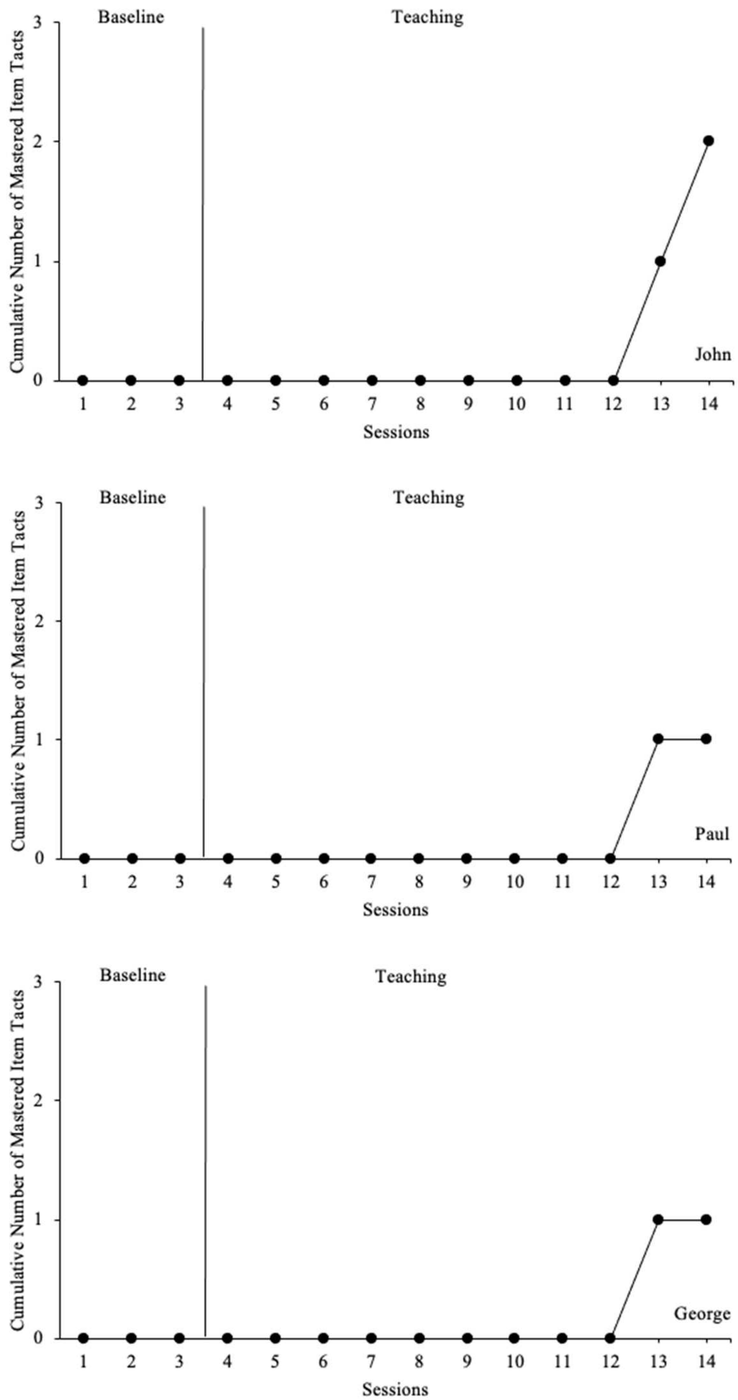
Social Validity Survey Results

	John's Guardian	**Paul's Guardian**	**George's Guardian**
Echoic (Yellow) Condition Satisfaction	6	4	4
Prompt Delay (Blue) Condition Satisfaction	7	6	6
Error Correction (Red) Condition Satisfaction	5	4	4
Different Teaching Conditions Affected Responded	6	6	5
Secondary Target Instruction Affected Responding	7	6	3

Note. Ratings on the social validity survey completed by the participants' guardians. A rating of a 7 represents "very satisfied" or "strongly agree" while a rating of 1 represents "very unsatisfied" or "strongly disagree".

Figure 1

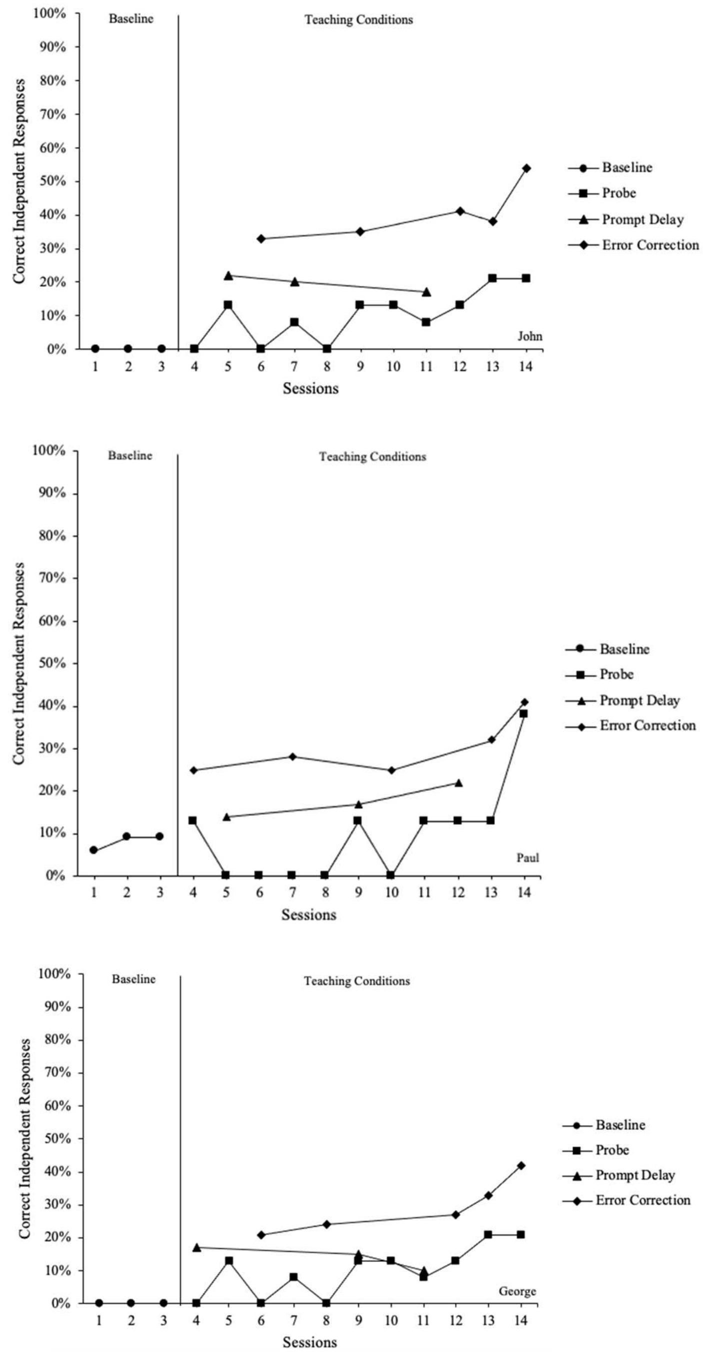
Cumulative Number of Mastered Item Tacts



Note. The cumulative number of mastered item tacts across each participant.

Figure 2

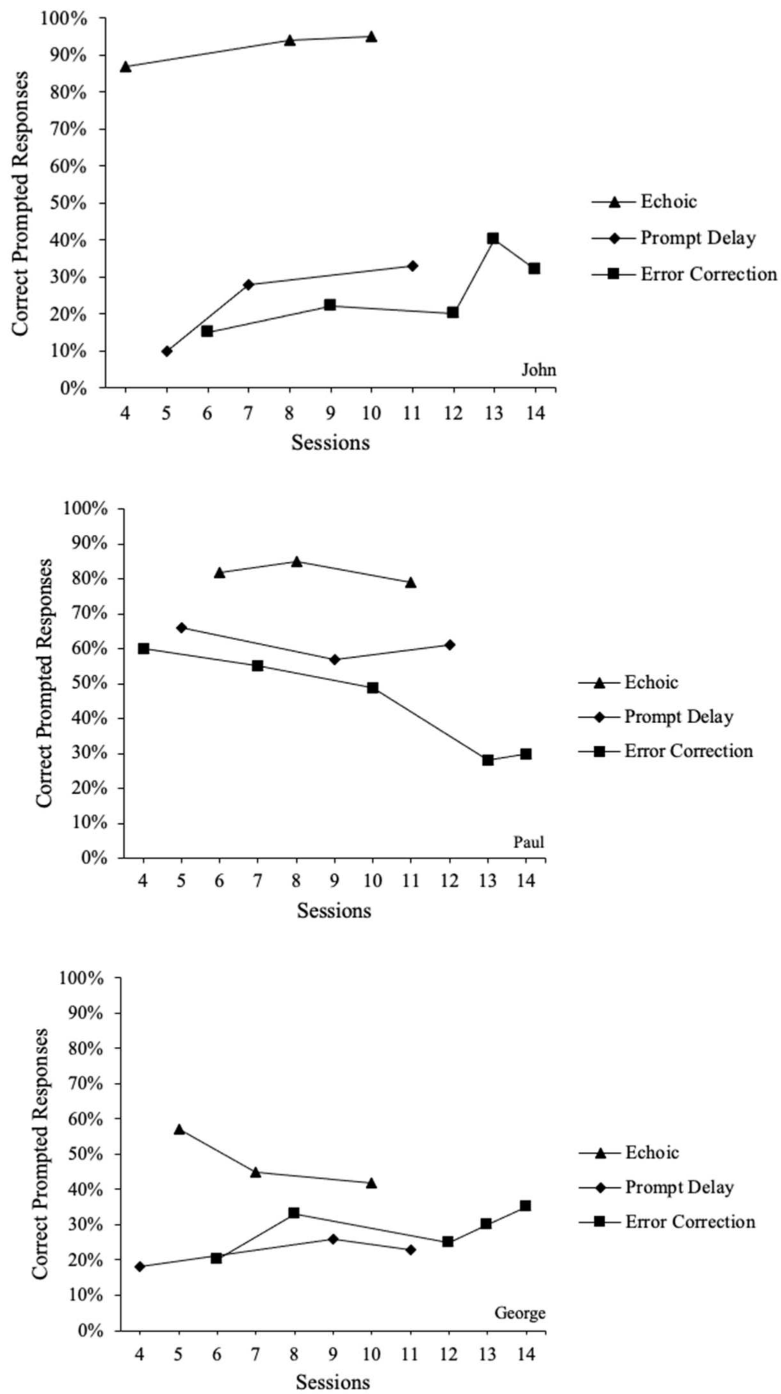
Correct Independent Responses



Note. The percentage of correct independent responses across each teaching condition and participant. There were no correct independent responses during the echoic teaching condition due to the immediate echoic prompt that was provided.

Figure 3

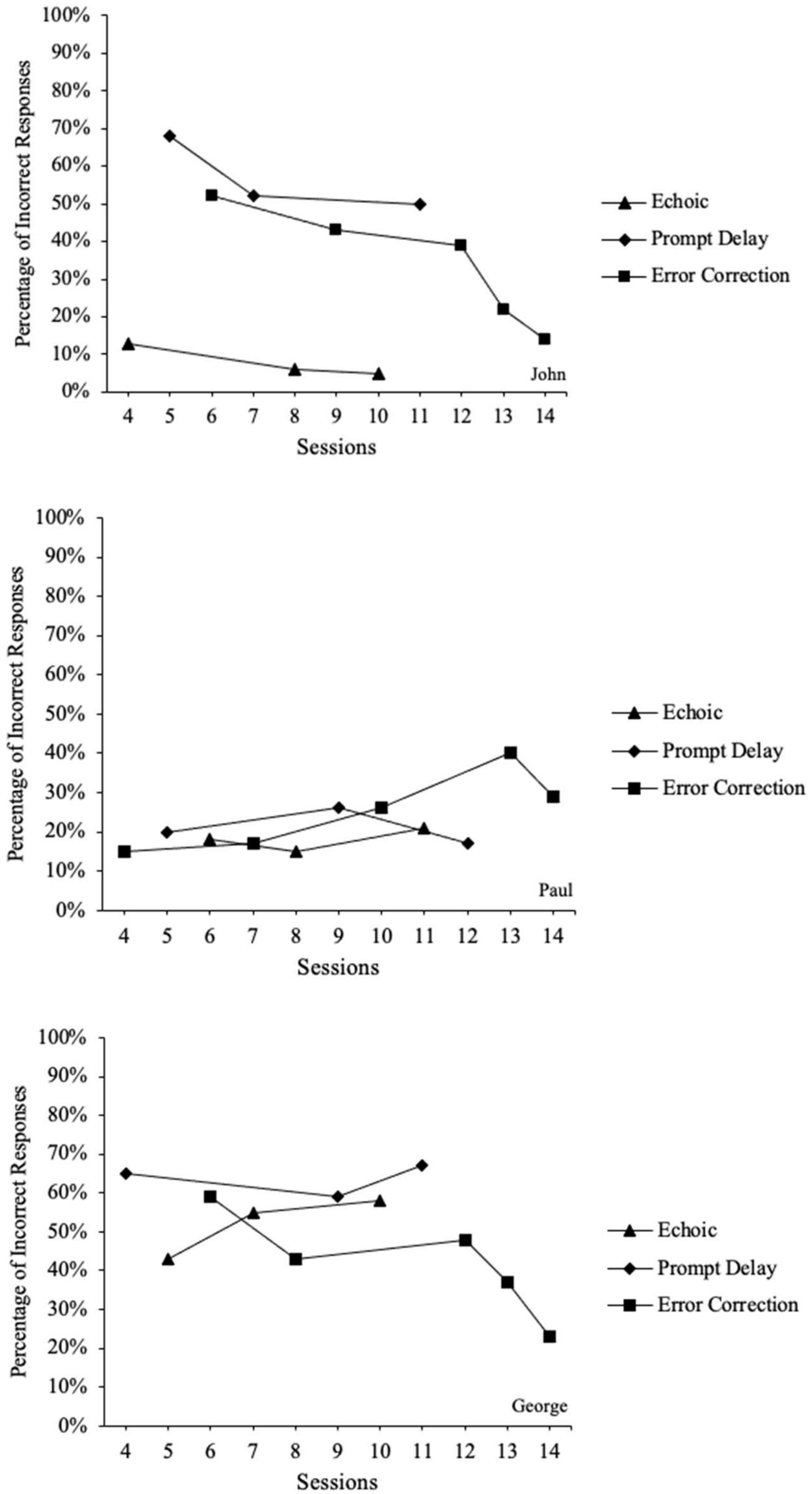
Correct Prompted Responses



Note. The percentage of correct prompted responses across each teaching condition and participant.

Figure 4

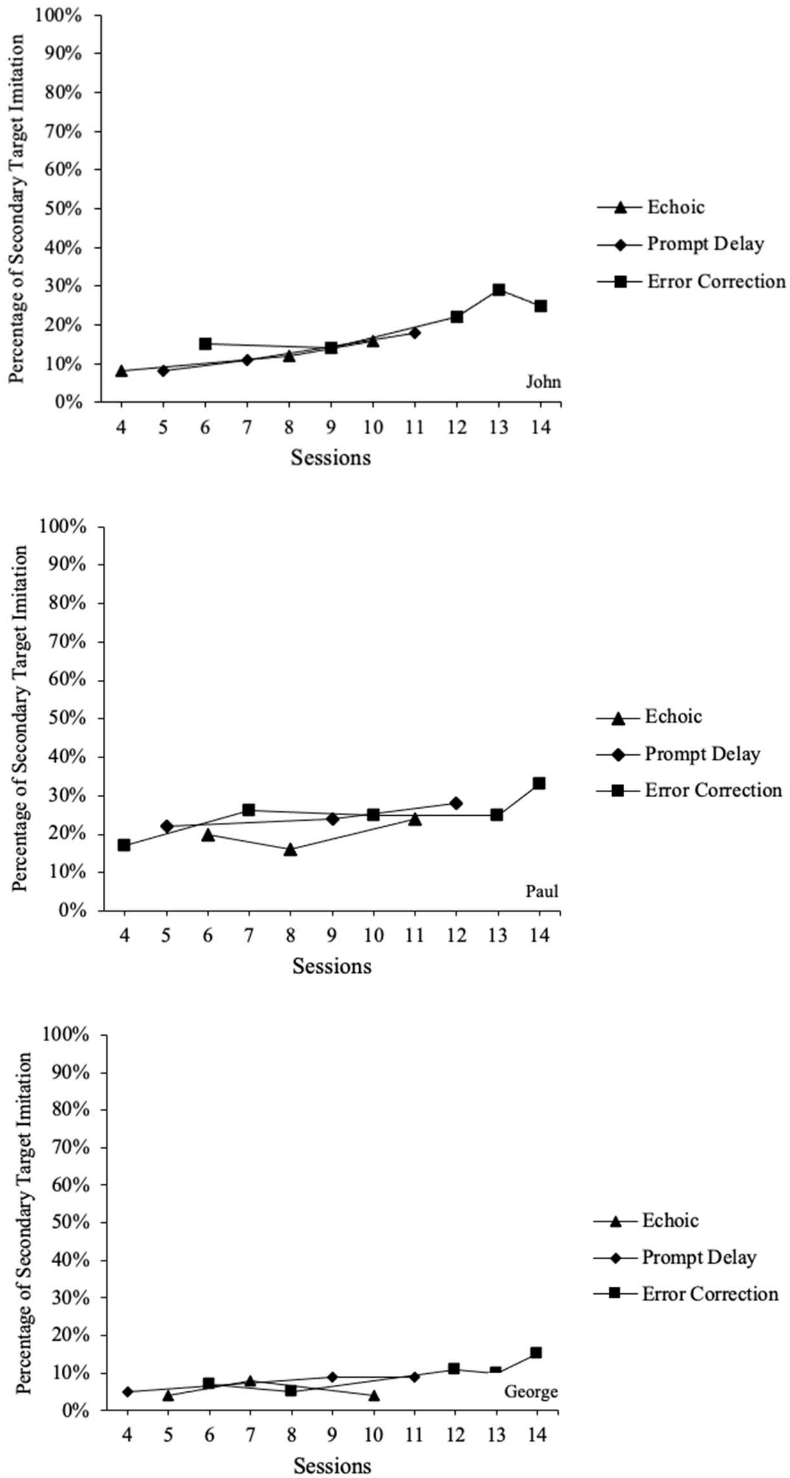
Incorrect Responses



Note. The percentage of incorrect responses across each teaching condition and participant.

Figure 5

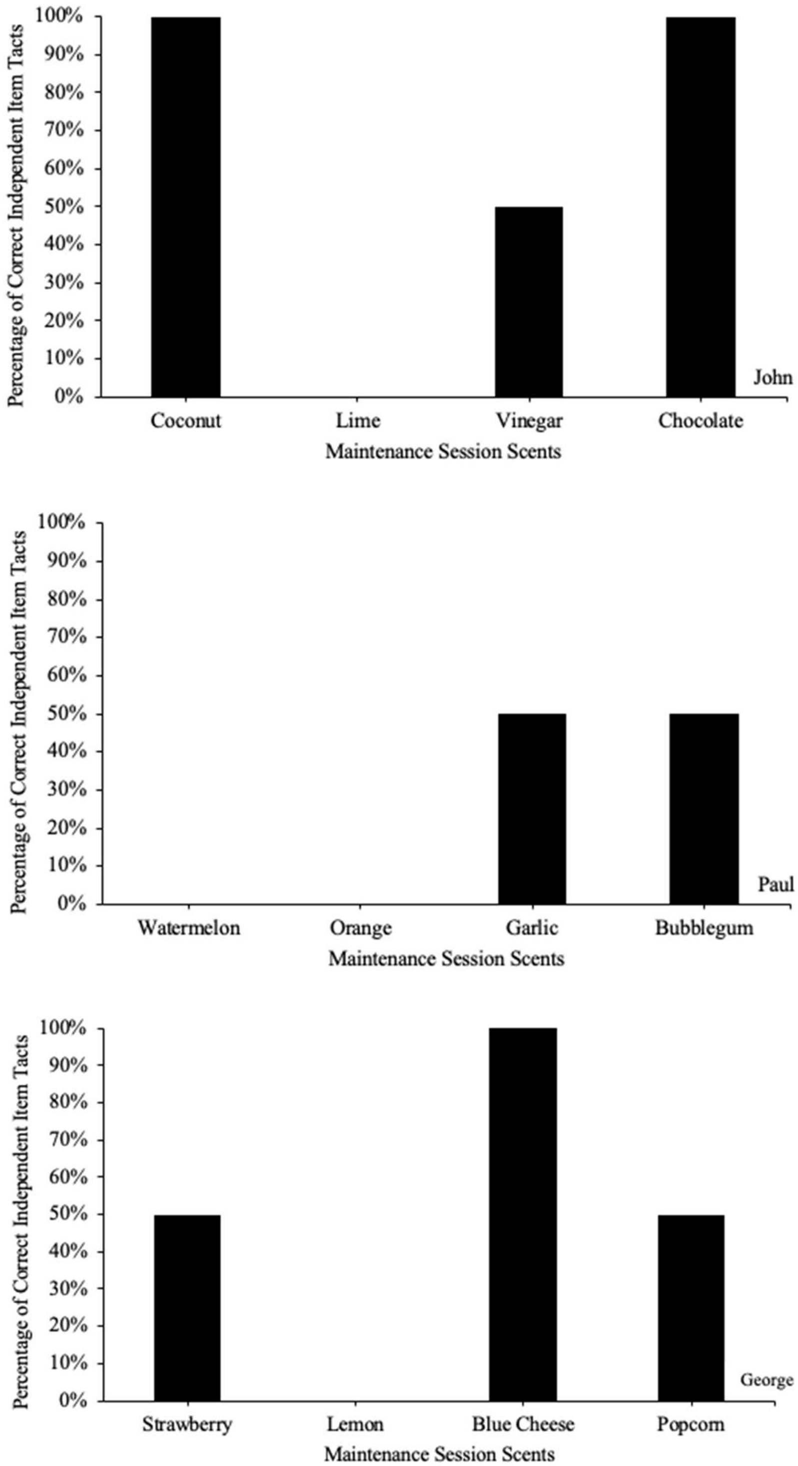
Secondary Target Imitation



Note. The percentage of secondary target imitation across each teaching condition and participant.

Figure 6

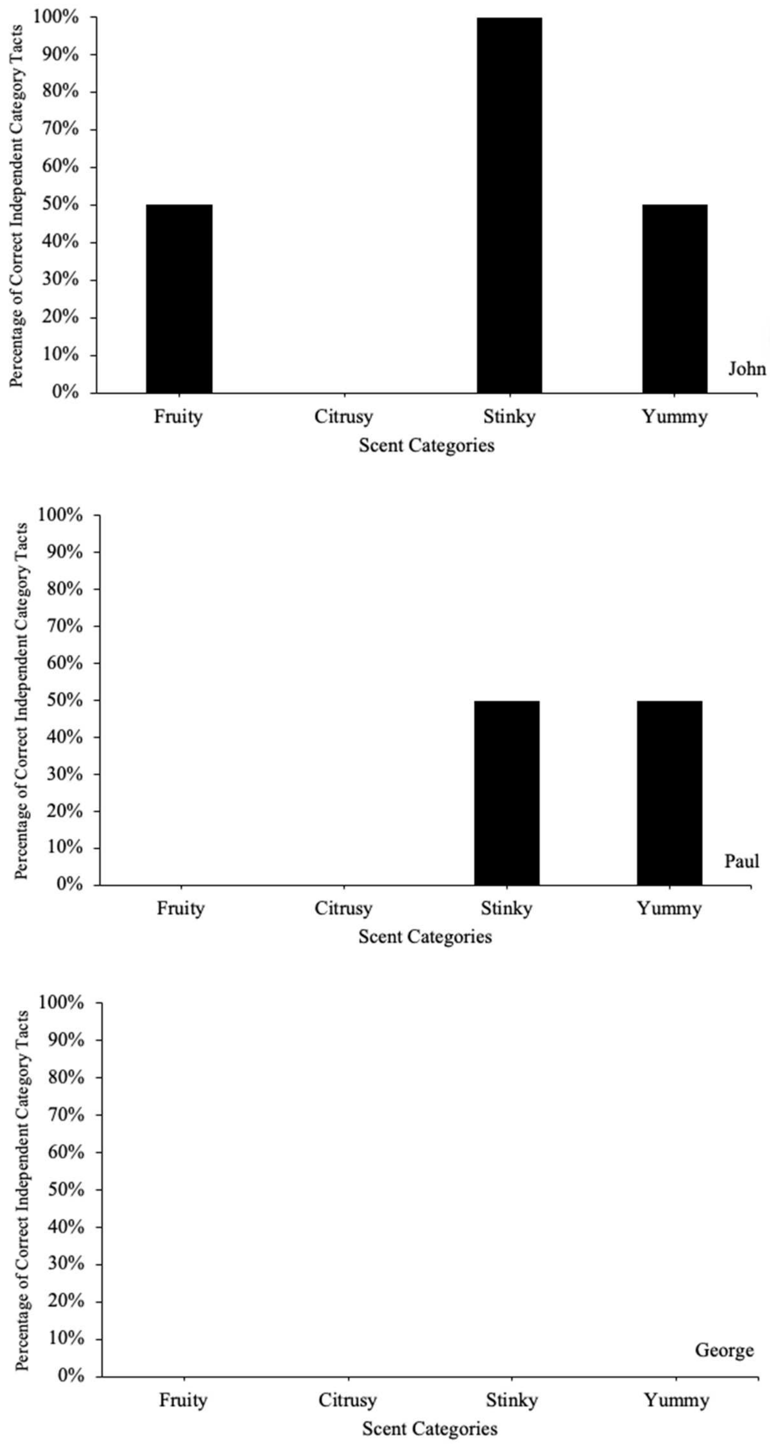
Maintenance: Correct Independent Item Tacts



Note. The percentage of correct independent item tacts during the maintenance session across each participant.

Figure 7

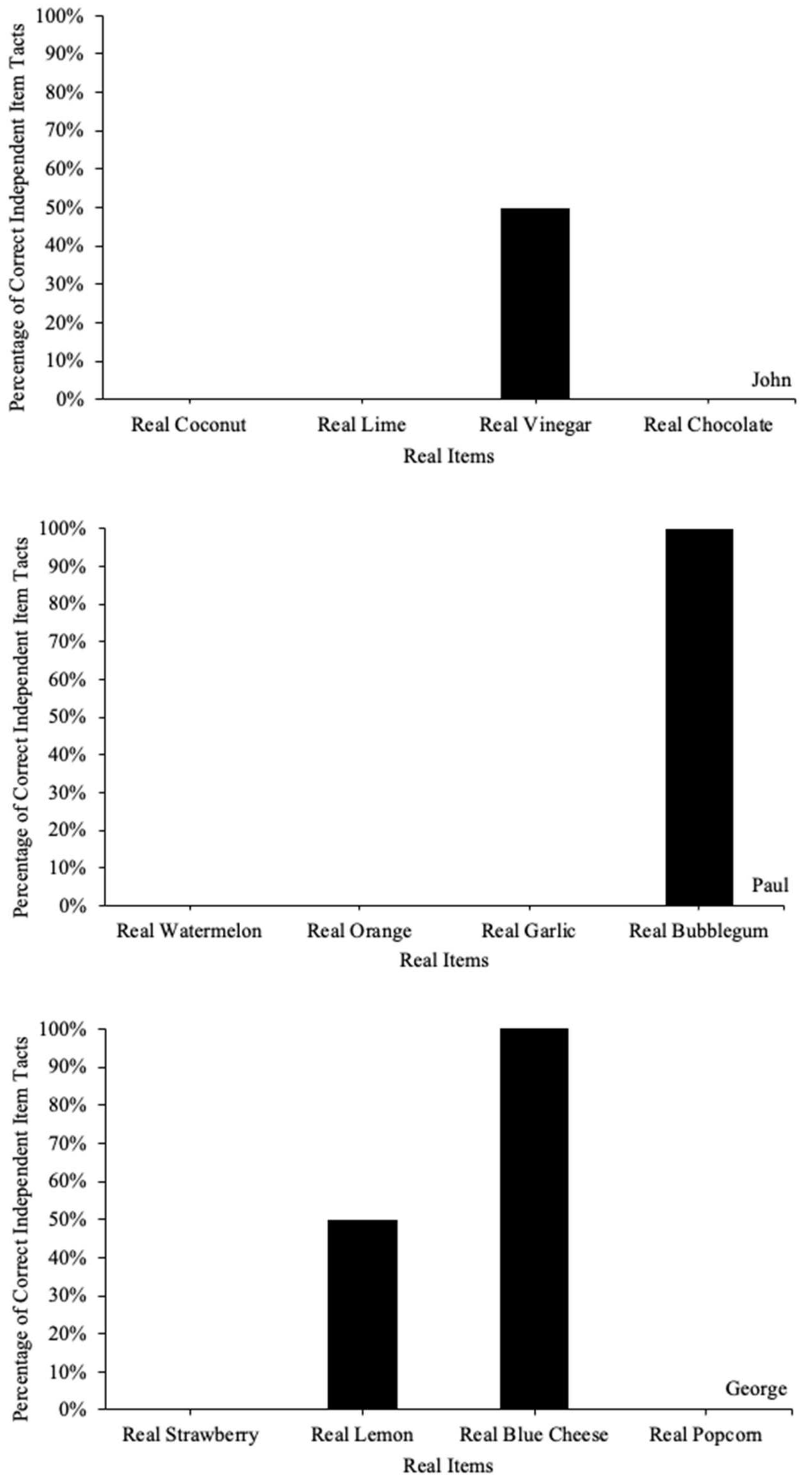
Correct Independent Category Tacts



Note. The percentage of correct independent category tacts across each participant.

Figure 8

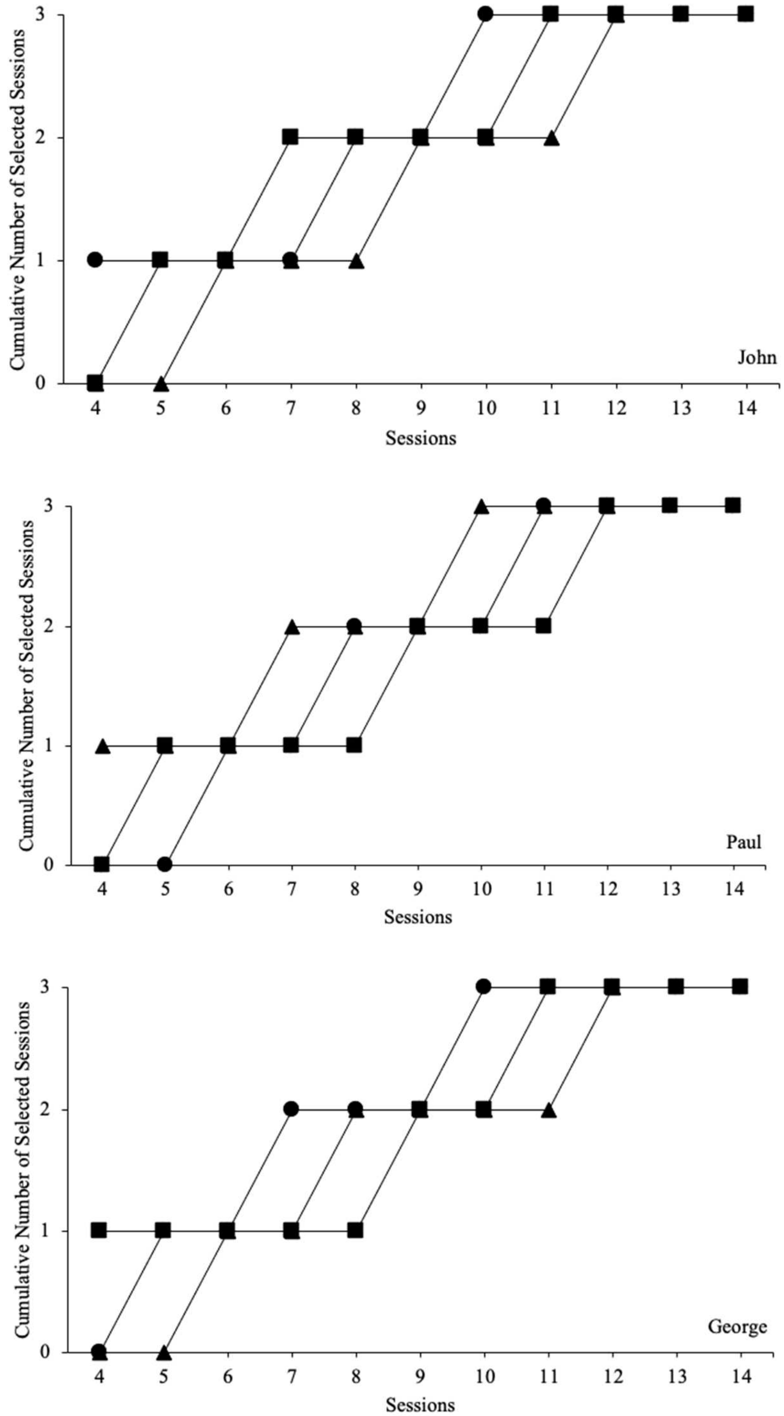
Real Item Probe



Note. The percentage of correct independent item tacts during the real item probe across each participant.

Figure 9

Participant Preference



Note. The cumulative record of the teaching condition that was selected first across each participant. The closed circle represents the echoic condition, the closed square represents the prompt delay condition, and the closed triangle represents the error correction condition.