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A Parent-Mediated Intervention to Teach a Generalized Repertoire of Auditory Tacts to a Child with Autism

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A PARENT-MEDIATED INTERVENTION TO TEACH A GENERALIZED REPERTOIRE OF AUDITORY TACTS TO A CHILD WITH AUTISM

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Abstract

Tact is the most important verbal operant (Skinner, 1957) due to the uniqueness of stimulus control and its role in facilitating acquisition of another verbal (e.g., mands, intraverbals) and nonverbal (i.e., listener) operants (Sundberg, 2015). Teaching tacts to children with ASD and the research on this area, however, are largely focused on visual stimuli. Teaching tacts of auditory stimuli to children with ASD is important as they constantly experience various auditory stimuli (e.g., vehicles, pets, machines, music) in the natural environment. Adding auditory and other nonvisual tacts to tact repertoire increases its effectiveness (Sundberg & Partington, 1998). Furthermore, teaching auditory tacts help children with visual impairment who do not respond to visual stimuli (Sundberg & Partington, 1998). Despite the importance of teaching auditory tacts to children with ASD, only one study examined it (i.e., Hanney et al., 2019).

This study aimed to examine the effectiveness of using SPOP and MET on the number of auditory tacts for a child with ASD, generalization to untrained stimuli, maintenance of auditory tacts for one week following the last postintervention probes, and the social significance of the intervention from the perspective of the participant and her parent.

To examine the effectiveness of SPOP and MET, a multiple-probe design across stimulus sets (Horner & Baer, 1978) was used. The data revealed that the intervention package had a modest effect as the functional relation between the intervention and number of correct tacts existed among some, but not all, target tacts. Similarly, generalization and maintenance were limited to some target tacts. The participant and her parent were generally satisfied, but the procedure was difficult to the parent. It is important to note that the study was limited to one participant. Therefore, the findings may not generalize to other learners with ASD.

Acknowledgements

I would like to express my sincere gratitude to the chair and the members of my graduate advisory committee, Dr. Joshua Baker, Dr. Joseph Morgan, Dr. Wendy Rodgers, and Dr. Tiberio Garza, for their continuous guidance and support throughout this project.

Dedication

I dedicate this work to my parents and brothers. I greatly appreciate their continuous prayers, support, and encouragement.

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Chapter One: Introduction

This chapter presents an overview about autism spectrum disorder (ASD), verbal behavior, and interventions used to teach tacts to children with ASD. Thereafter, the chapter discusses the research problem the present study aims to investigate, how conceptual framework was built, the purpose of study, its significance, and research questions. The chapter concludes with the potential delimitations and definitions of key terms.

Autism Spectrum Disorder

Characteristics of Children with ASD

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder which appears early in a child's life and is characterized by impaired social communication and interaction as well as restricted, repetitive, and stereotyped patterns of activities, behaviors, and interests (American Psychiatric Association, 2013). As per the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5; APA, 2013), the restricted, repetitive, and stereotyped patterns of activities, behaviors, and interests include: a) stereotyped or repetitive motor (e.g., hand flapping), vocal (e.g., echolalia), or object use (e.g., lining up objects), and b) insistence on sameness and inflexibility for change in routine, or ritualistic verbal or nonverbal patterns.

Language and Communication Deficits in Children with ASD

The social communication and interaction deficits seen in children with autism include a) social-emotional reciprocity, b) nonverbal communication (e.g., eye contact), and c) developing, maintaining, and understanding relationships (e.g., making friends) (APA, 2013).

Social-emotional reciprocity is an individual's ability to take part in back-and-forth social interaction between two or more people (Schwartz et al., 2021). For example, someone says thank you when a friend makes a compliment about their clothes. Social-emotional reciprocity requires the child's awareness of emotional and interpersonal cues of others, appropriate interpretation of those cues, appropriate responding to cues after interpreting them, and the motivation to take part in social interactions (Constantino et al., 2003). Deficits in social-emotional reciprocity among children with autism include the following range of deficits: 1) atypical social approach; 2) failure of mutual (i.e., back-and-forth) conversation; 3) reduction in interest, emotional, or affective sharing; and 4) failure to start or respond to social exchanges (APA, 2013).

Nonverbal communication involves using eye contact, body movements, and gestures when interacting with others. Typically developing newborns learn to use the nonverbal means of communication (e.g., vocalizations, eye gaze, prelinguistic gestures) in their first year of life (Trevarthen & Hubley, 1978). Nonverbal communication deficits among children with ASD may involve the disintegration of verbal and nonverbal communication and the poor use of eye contact, body language, using and understanding gestures, facial expressions, and nonverbal communication (APA, 2013).

Relationships are vital in a child's life. There is an evidence that making and maintaining friendships in classrooms is correlated with increased school acceptance and performance (Ladd, 1990). Children with ASD, however, have difficulties in developing, maintaining, and understanding relationships. These difficulties may include a range of challenges from difficulties in altering behavior to suit different social situations, sharing pretend play with others, or in building friendships to lack of interest in their peers (APA, 2013).

Language impairments are not within the diagnostic criteria of ASD (APA, 2013). The literature, however, indicates that some children with autism have linguistic impairments that go beyond social communication deficits. These impairments fall under four categories: a) phonology, b) syntax, c) morphology, and d) semantics. It is important to note that the language abilities of children with ASD are largely heterogenous (Wittke et al., 2017). Impairments across these four categories have been reported in literature.

Phonology is the system of speech sounds. For example, the consonant /p/ is aspirated when it occurs in the beginning of the word (e.g., pan), but it is unaspirated when it occurs after a voiceless alveolar sound (e.g., span). Typically developing children make errors in their speech known as *phonological processes*. Children with ASD may show similar errors, but they can demonstrate atypical errors as well. For example, Cleland et al. (2010) analyzed the speech of 69 children with ASD. They found phonological errors were generally similar to developmental phonological processes seen in typically developing children. However, they also noticed some non-developmental distortions (e.g., nasal emission) similar to those seen in adolescents with ASD in earlier experiments, suggesting that those errors are persistent. *Syntax* refers to combining words to form meaningful sentences. The sentences individuals with ASD produce are generally simpler and include less variable syntactic structures than sentences structured by typically developing speakers (Kelley, 2011). *Morphology* refers to combining parts of words (i.e., morphemes) to form meaningful words. Morphemes are classified into free and bound. For example, the word "school" is a free morpheme because it gives a meaning when it stands alone, while a bound morpheme such as "pre" and "the plural s" has no meaning unless it is added to a free morpheme. Thus, adding a bound morpheme (e.g., pre, plural "s") to a free morpheme (e.g., school) will result in meaningful words (e.g., schools, preschool, preschools). While evidence of morphological errors among children with ASD is not clear (Tek et al., 2014), there is some evidence that some children with ASD tend to emit some morphological errors such as deleting articles, past tense, and progressives (Bartolucci et al., 1980). *Semantics* refer to the meanings of words and their combinations in a language. There is no clear evidence whether semantics among children with ASD follow the same developmental milestones as in typically developing children but at a slower rate or they fall outside the expected range of development (Kelly, 2011). There is some evidence, however, that some individuals with ASD demonstrate semantic difficulties such as slower semantic classification (i.e., indicating which words fall under a particular category, Dunn et al., 1999) and reduced lexical fluency (i.e., word generation; Turner, 1999).

Verbal Behavior

Introduction

In 1937 B. F. Skinner developed the term *operant conditioning* to identify the process in which human and animal behaviors are controlled by their consequences (i.e., reinforcement). For example, when someone switches on the light and gets the light as a consequence. That consequence (i.e., the light) shapes the behavior. In other words, the person will switch on the light again in future. However, when the light bulb stops giving this consequence because it is burned out, then the person will not switch it on. Skinner also used *operant conditioning* to explain how humans acquire language. That is, Skinner hypothesized that language acquisition is similar to the process of learning any other behavior. For example, an early vocal behavior of infants such as crying is reinforced by receiving attention from caregivers. Skinner developed the term *verbal behavior* to refer to language. Reinforcement of verbal behavior is mediated by another person, and this is what distinguishes verbal and nonverbal behaviors. That is, reinforcement of verbal behavior is mediated by other people (i.e., listeners), whereas nonverbal behavior is reinforced through a direct contact with the physical environment (e.g., switching the light on; Skinner, 1957).

Skinner's Analysis of Verbal Behavior

Verbal operants are the fundamental units of Skinner's analysis of verbal behavior. Verbal operant is the functional relationship between the antecedents that precede and evoke response (i.e., motivating operations, discriminative stimuli, nonverbal behavior), the response itself, and its consequence (Sundberg & Michael, 2001). Skinner (1957) identified five verbal operants: four primary and one secondary. The primary verbal operants are: 1) *mand*, 2) *tact*, 3) *intraverbal*, and 4) *echoic*, whereas the secondary verbal operant is *autoclitic*. Each verbal operant is identified by the functional relation between the operant and its antecedents and consequences. Hence, each verbal operant is identified by its function rather than its topography (i.e., form). It is important to note that the structural classification of language (e.g., nouns, verbs) is not rejected in Skinner's analysis of verbal behavior (Sundberg, 2008). Skinner's analysis considers the structure but also focuses on what evokes (i.e., function) the verbal operants (Sundberg, 2008). Skinner further analyzed verbal behavior into functional units known as verbal operants.

Verbal Operants

A mand is a verbal operant that is evoked by motivating operations. Motivating operations are events that either increase or decrease the value of consequences. Events that increase the value of consequence are known as establishing operations (EOs), whereas events that decrease the value of consequence are known as abolishing operations (AOs). For example, thirst is an establishing operation because it increases the value of water. Thus, requesting water will more likely occur when the person is thirsty. Mand*s* are reinforced by specific reinforcement. For example, the mand "water" is reinforced by receiving a glass of water. Hence, a mand directly benefits the speaker (Skinner, 1957).

A tact is a verbal operant evoked by nonverbal stimuli. These nonverbal stimuli can be external such as visual (e.g., pictures), auditory (e.g., environmental sounds), olfactory (i.e., scents), gustatory (i.e., taste), and tactile (i.e., texture), or internal such as feelings (e.g., happiness, pain). Unlike mand, tact is reinforced by nonspecific (i.e., generalized) reinforcement. For example, saying "water" as a tact (e.g., labeling a picture of water) is reinforced by acknowledgement or praise, whereas saying "water" as a mand (i.e., request it when thirsty) is reinforced by receiving a glass of water.

An intraverbal is a verbal operant that is evoked by a verbal stimulus with no similarity between the stimulus and response (Skinner, 1957). In other words, the stimulus and the intraverbal response do not comprise the same letters or sounds (Sundberg & Michael, 2001). For example, the stimulus "How are you?" and the intraverbal response "I am well" contain different words. Similar to tacts, an intraverbal is reinforced by non-specific reinforcement.

An echoic is a verbal operant that is evoked by a similar verbal stimulus. For example, saying "bird" upon hearing another speaker says "bird". Hence, the echoic response contains the same units of the verbal stimulus unlike intraverbals which do not match their verbal stimuli. Similar to tacts and intraverbals, echoics are reinforced by nonspecific reinforcement.

An autoclitic is a verbal operant that helps with clarifying or altering the effectiveness of other verbal behaviors on listeners (Skinner, 1957). For example, the mand "water" is modified by the autoclitic "please" which adds some politeness to the request.

Interventions to Teach Verbal Behavior to Children with ASD

Applied Verbal Behavior Approach

Applied verbal behavior (AVB; Sundberg & Michael, 2001) refers to using Skinner's analysis of verbal behavior in language programming and training for children with autism and other developmental disabilities who demonstrate language delays. Unlike traditional language interventions which focus on the topography (i.e., structure), AVB approach focuses on the function of verbal operants (LeBlanc et al., 2006). Because mand directly benefits the speaker, AVB programs usually begin with this operant (Sundberg & Partington, 1998). Practitioners using AVB approach usually make environmental arrangements to evoke responses such as mands (LeBlanc et al., 2006). For example, to teach the mand "toy", the practitioner places the toy in a visible but inaccessible place. To teach a new verbal operant, the practitioner uses the antecedents that evoke a strong verbal operant in eliciting a new one (LeBlanc et al., 2006). For example, to evoke the intraverbal "airplane" when asked, "What transport means flies?", the practitioner uses the picture of airplane which evokes the mastered tact "airplane". The previous example shows how a stimulus typically used to evoke mand was used to facilitate another verbal operant (i.e., intraverbal). The practitioner, however, gradually fades this prompt out in order to evoke an intraverbal response that is solely controlled by the verbal response, "What transport mean flies?". In AVB, verbal operants are usually taught in an interspersed manner. This technique is known as *mixed verbal behavior* (Mixed VB; Sundberg & Partington, 1998). For example, the practitioner delivers the juice box to the child who spontaneously emits the mand *juice* but has not acquired the same response as a tact yet. This mand trial is immediately followed by a tact trial in which the practitioner holds up the juice box and asks, "What is it?" in order to evoke the response "juice" as a tact rather than a mand. Applied verbal behavior is not the only approach to teach tacts. There are other approaches such as stimulus pairing observation procedure (SPOP; Smyth et al., 2006) and multiple exemplar training (MET; Stokes & Baer, 1977).

Interventions to Teach Tacts

Different interventions have been used successfully to teach tacts to children with autism such as antecedent arrangements (e.g., Cengher & Fienup, 2020), intensive instruction (i.e., Pistoljevic & Greer, 2006), teaching tacts in a play-based context (e.g., Duenas et al., 2019), teaching tacts concurrently with other verbal operants (e.g., Kodak & Clements, 2009), augmentative alternative communication (e.g., Lorah & Parnell, 2017), adult attention (e.g., Eby & Greer, 2017), matrix training (Jimenez-Gomez et al., 2019), SPOP (Smyth et al., 2006), and MET (Stokes & Baer, 1977).

Stimulus Pairing Observation Procedure

Stimulus Pairing Observation Procedure (SPOP; Smyth et al., 2006), previously known as respondent-type responding (Leader et al., 1996), is a procedure based on the concept that novel (i.e., untaught) skills can be acquired merely when stimuli are paired. For instance, the tact "car" can be taught by pairing the visual stimulus (e.g., toy car) with the auditory/verbal stimulus (i.e., teacher says car). Previous studies (e.g., Solares & Fryling, 2019) found that children with ASD acquired tacts when visual and auditory stimuli were paired.

Multiple Exemplar Training

Multiple exemplar training (MET) is a procedure based on the concept of teaching *sufficient exemplars* (Stokes & Baer, 1977) of stimuli during training. For example, the teacher uses pictures of different types of birds (e.g., dove, sparrow, crow) to teach the tact "bird". This approach is specifically important for children with ASD due to a common learning problem among this population known as *overselectivity* (Lovaas et al., 1971). That is, children with ASD tend to focus on specific features of stimulus rather than the whole stimulus. For example, a child with autism may pay more attention to the lights of a car rather than whole structure. Accordingly, the child may not identify different exemplars of cars when introduced. Involving parents in intervention is important for facilitating stimulus generalization as they provide exemplars other than practitioners can do in a contrived setting. For example, parents can use the flowers in the garden to give multiple exemplars of colors being taught at a therapy setting.

Involvement of Families of Children with ASD in Intervention

Involving families of children with ASD in intervention is very helpful for both children and families. For instance, involving families in early intensive behavioral intervention (EIBI) enhances this intervention both quantitively and qualitatively, improves generalization outcomes of EIBI, decreases parental stress, and increases parental coping (Machalicek et al., 2014). The child- and parent-related outcomes of family involvement have been reported in literature.

Child-related Outcomes

Previous experiments (e.g., Shire et al., 2015) indicated that social engagement among children with ASD can increase when parents are involved. Interestingly, the study of Shire et al. (2015) indicated that merely observing the interventionists implementing the intervention was variably effective in teaching parents some interventional strategies. Previous research (e.g., Loughrey et al., 2014) show that children with ASD can also successfully learn verbal operants (i.e., mand) when their parents implement the intervention. A systematic review of 12 studies (i.e., McConachie & Diggle, 2007) also showed that communicative behaviors and interaction styles between children with ASD and their parents improve when parents are involved in intervention.

McConachie & Diggle (2007) systematically reviewed 12 studies. In these experiments, different parent-implemented interventions for young children with autism ranging in age from 1-6 years were examined. In this review, the researchers found that involving parents in intervention was helpful in improving the communicative behaviors of children, increasing maternal awareness about autism, improving communication and interaction styles between parents and their children.

Parent-related Outcomes

Involving parents in intervention benefit them as well. Previous studies showed that involving parents in interventions for children with ASD helps with stabilizing parental stress (Estes et al., 2014) and decreasing psychological symptoms such as depression (McConachie & Diggle, 2007), anxiety, and insomnia (Tonge et al., 2006). It is important to note that the impact of involving parents in intervention on parental stress is not necessarily large. For instance, in a recent systematic review and meta-analysis of 9 experiments reported in 11 studies, Tarver et al. (2019) found that parent-implemented intervention had a small effect on the parental stress. Although small the research suggested, the intervention effect on parents of children with ASD is still encouraging.

Statement of the Problem

Tacts are evoked by nonverbal stimuli. These stimuli are either visual (e.g., pictures), auditory (e.g., environmental sounds), olfactory (e.g., flower smells), gustatory (e.g., food taste), tactile (e.g., clothing texture), or internal (e.g., pain). Most research, however, is focused on tacts evoked by visual stimuli. A systematic literature review of 18 studies on tact instruction for young children with ASD shows that only one study addressed nonvisual (i.e., auditory) stimuli. Furthermore, parents were included in implementing tact instruction in one study only despite the importance of family involvement in interventions for children with ASD. Last, most research teams in the aforementioned review did not use multiple exemplars of stimuli to evoke tacts. Using multiple exemplars of the stimuli is especially important for children with ASD as they have a difficulty with stimulus generalization due to *overselectivity* (Lovaas et al., 1971). For example, a child with ASD who says “car” in response to a picture of car shows difficulty with stimulus generalization if they do not show the same response in response to an actual car.

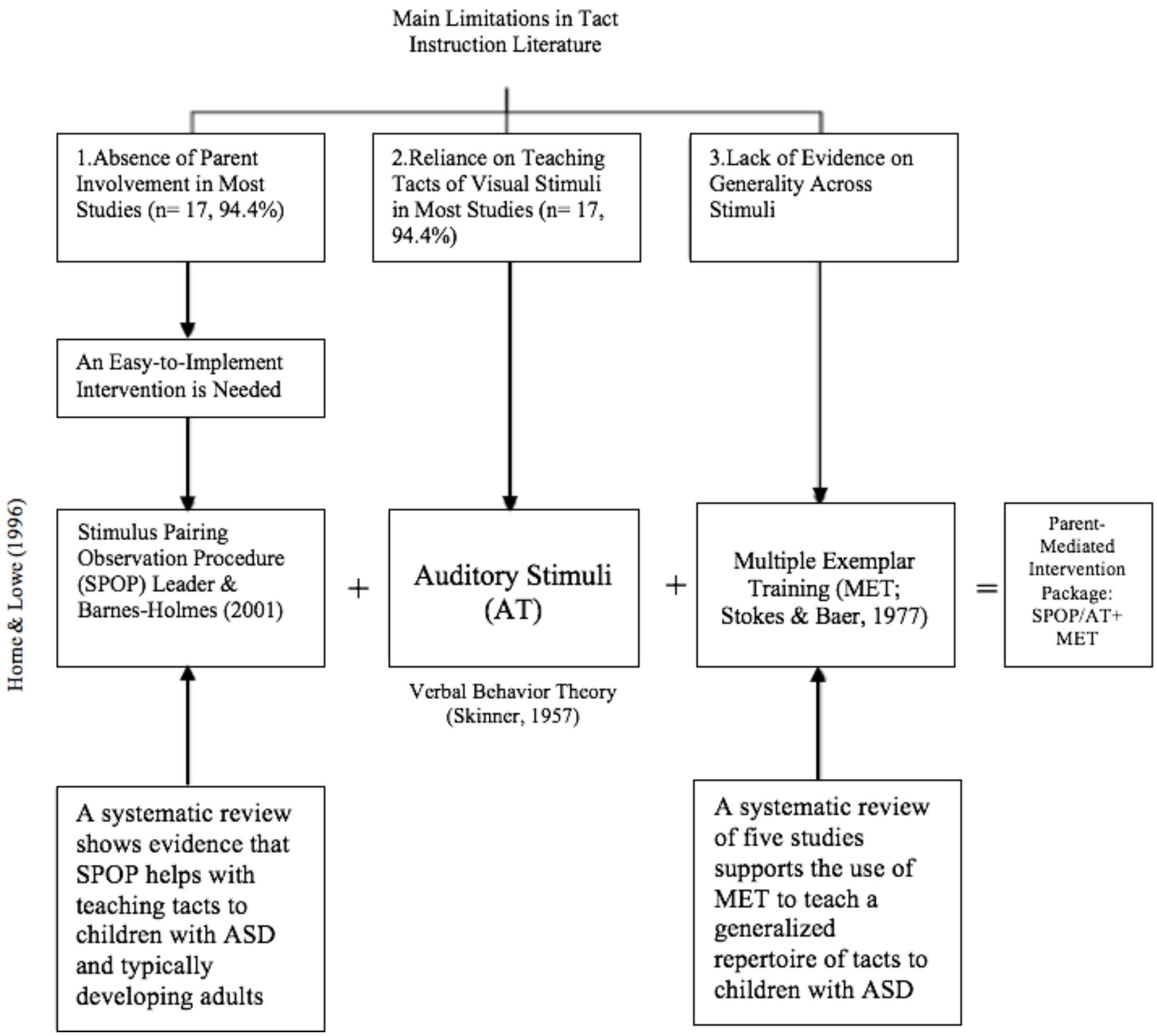
In sum, there is a dire need for an intervention for young children with ASD that can be implemented easily by parents, addresses nonvisual tacts, and facilitates stimulus generalization by using multiple exemplars of stimuli.

Conceptual Framework

The conceptual framework of the study (see Figure 1) is based on the systematic reviews of tact instruction for young children with ASD, multiple exemplar training, and stimulus pairing observation procedure (SPOP). It is also based on theories, related literature, and contextual factors.

Figure 1

Conceptual Framework



As mentioned previously, the systematic review of 18 studies on teaching tacts to young children with ASD identified several limitations in the reviewed literature. Three of these limitations were 1) absence of parent involvement in implementing these interventions, 2) overreliance on teaching tacts of visual stimuli, and 3) limited evidence on generality of acquired tacts across novel stimuli.

Involving parents in implementation of interventions for children with ASD is important for generalization and the overall success (Burrell & Borrego, 2012; Koegel & Koegel, 2006; Symon, 2001). Involving parents may also help with generalization as they use stimuli and contexts (e.g., gardening tools, bath time) that do not exist in clinical and instructional settings. Not all parents and caregivers have previous experience with interventions. Therefore, it is important to choose an easy-to-implement intervention to enhance the acceptability and continuity of use (Carter & Wheeler, 2019). SPOP (Leader & Barnes-Holmes, 2001) is a viable option due to its ease of use and the evidence of its effectiveness in teaching different skills to children with ASD such as tact*s* (e.g., Solares & Fryling, 2019), matching-to-sample (e.g., Takahashi et al., 2011), and intraverbals (e.g., Vallinger-Brown & Rosales, 2014). A systematic review of five experiments (see Chapter 2) shows evidence that SPOP helps with teaching tacts to children with ASD and typically developing adults. Implementing SPOP involves pairing two stimuli simultaneously (e.g., visual-auditory, visual-visual). The following is an example of pairing visual-auditory stimuli: The therapist holds up a picture and names it without asking the child to emit any response. It is believed that SPOP is easy to implement because no response is required of the child during implementation. Prompts, reinforcement, error correction, and data collection are neither required of the instructor during implementation. Data collection, however, is required only during probes that precede and follow SPOP implementation. Furthermore, SPOP is compatible with naming theory of Horne & Lowe (1996). In other words, naming theory implies that the child typically acquires naming as both a speaker and a listener when he is exposed to both the environmental stimulus and its label. For example, when the child sees a bird and someone tacts it, the child will acquire the name “bird” as a speaker and listener. That is, he will tact (i.e., speaker) the bird when he sees it again and will point to it (i.e., listener) when he hears the tact “bird”. Accordingly, teaching tacts by pairing environmental objects or events with their names is consistent with how children typically acquire naming as per the theory of Hone & Lowe (1996).

The second main limitation in the reviewed literature is the overreliance on visual stimuli when teaching tacts. Seventeen of the 18 research teams used visual stimuli to evoke tacts with or without verbal prompts (e.g., What is this?). Auditory stimuli were selected due to theoretical and contextual factors. The theoretical factor is the definition of tact in the verbal behavior theory of Skinner (1957). According to Skinner (1957), tact can be evoked by objects, events, or their properties. This implies that stimuli which evoke tacts go beyond visuals (e.g., pictures, manipulatives); they include a broader range of nonvisual stimuli such as sounds, scents, textures, and tastes. The contextual factors behind choosing auditory stimuli is the frequent exposure to various auditory stimuli throughout the day (e.g., appliances, pets, vehicles, music). In addition, a tact repertoire is considered effective when it includes tacts controlled by both visual and nonvisual stimuli (Sundberg & Partington, 1998). For example, a less effective tact repertoire of a child with autism or developmental delay might include the tact “bird” when a picture of bird is presented but this tact will not be evoked when a bird tweeting is presented alone (i.e., sound only). Teaching auditory tacts is also important for children with visual impairment (Sundberg & Partington, 1998).

A third limitation in the current research on tact interventions is lack of evidence on generality of the acquired tacts across novel stimuli. Assessing and programming stimulus generalization among children with autism is necessary due to the difficulty they experience in responding to multiple exemplars of stimuli. A systematic review of five experiments in which MET was used to teach tacts found that teaching multiple exemplars of visual stimuli was generally effective to teach generalized tact repertoires to children and adolescents with ASD.

Purpose of the Study

This study aims to examine the efficacy of a parent-implemented intervention package consists of MET and SPOP on acquisition of the auditory tacts for a young child with ASD. Specifically, it aims to examine a) the impact of this package on the number of correct tacts of auditory stimuli, b) the effectiveness of teaching multiple exemplars of auditory stimuli in establishing a repertoire of auditory tacts that are generalized across novel stimuli, c) the maintenance of auditory tacts for one week following the last postintervention probe, and d) the social significance of the intervention package from the perspectives of parents and their children.

Significance

This study aims to examine the effectiveness of using SPOP and MET on the number of auditory tacts. To date, teaching auditory tacts to children with ASD was examined in one study only (i.e., Hanney et al., 2019). Teaching auditory tacts is important for the following reasons: 1) children are frequently exposed to various auditory stimuli (e.g., appliances, music, pets, vehicles), 2) tact repertoire is considered effective when it includes tacts controlled by both visual and nonvisual stimuli (Sundberg & Partington, 1998), and 3) teaching auditory tacts is important for children with visual impairment (Sundberg & Partington, 1998). While the literature emphasizes the importance of parent involvement in early intervention for children with ASD (e.g., Machalicek et al., 2014), parents were not involved in the vast majority of research on tact instruction for young children with ASD as indicated by a systematic review of

18 studies (see Chapter 2). However, the intervention package, which is designed for the present study, was completely implemented by the parent of the participant. What distinguishes this intervention package is the ease of use for both parents and their children. That is, responses are only required of the child during the probes that precede and follow the intervention, and no response is required during implementation. Prompts, reinforcement, error correction, and data collection are neither required of the parent during implementation. Data collection, however, is required only during probes that precede and follow implementation of SPOP. Although some previous studies support the use of SPOP in teaching tacts to children with autism through pairing of auditory-visual stimuli, no research conducted to date on the effectiveness of pairing auditory-auditory stimuli on teaching auditory tacts to children with autism.

In sum, the present study contributes to tact instruction literature by introducing a parent-implemented intervention package to teach a generalized repertoire of auditory tacts to young children with ASD.

Research Questions

Research Question One:

Will the parent-mediated SPOP+MET intervention increase the number of correct tacts of auditory stimuli in a child with autism?

Research Question Two:

Will the participant tact different exemplars of original stimuli?

Research Question Three:

Will the participant maintain the tacts she will acquire one week following the last postintervention probe?

Research Question Four:

Will the participant and her parent support the social validity of SPOP+MET intervention?

Delimitations

The following are four delimitations of the present study:

1. The present study included one kindergartener with ASD. The findings may not be replicable to older or younger children with ASD or those with other disabilities.
2. The intervention package in the present study was implemented completely by a parent at home setting. Accordingly, the findings may not generalize to other change agents (e.g., teachers) and settings (e.g., school).
3. There are distractors at home settings that are difficult to control as in clinical and educational settings such as TV, phones, siblings walking through, and appliances.
4. The procedures in the present study were designed to teach auditory tacts by pairing two auditory stimuli together. Accordingly, the results may not generalize to other types of nonvisual tacts (e.g., olfactory, gustatory).

Definitions

Auditory Tact. A form of tact in which the speakers label the sounds they hear such as doorbells, fire alarms, musical instruments, vehicles, pets, etc.

Autism Spectrum Disorder. Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder, appears early in the child's life, and characterized by impaired social communication and interaction, restricted, repetitive, and stereotyped patterns of activities, behaviors, and interests (American Psychiatric Association, 2013).

Autoclitic. A verbal operant that helps with clarifying or altering the effectiveness of other verbal behaviors on listeners (Skinner, 1957). For example, the mand "water" is modified by the autoclitic *"please"* which adds some politeness to the request.

Discriminative stimulus. Discriminative stimulus is the stimulus that is recurrently associated with occurrence of a particular response and delivery of reinforcement contingent on that response. Hence, reinforcement is withheld when the same response occurs in absence of the discriminative stimulus.

Echoic. An echoic is a verbal operant that is evoked by a similar verbal stimulus (Skinner, 1957). For example, saying "bird" upon hearing another speaker says "bird".

Intraverbal. An intraverbal is a verbal operant that is evoked by another verbal stimulus (Skinner, 1957). For example, saying "good" upon hearing another speaker says, "how are you?"

Impure Tact. A form of tact in which verbal response is controlled by multiple sources of control. For example, labeling the pain to the physician is controlled by the event (i.e., pain) and the verbal stimulus (e.g., how are you feeling today?).

Gustatory Tact. A form of tact in which the speakers label what they taste (e.g., sweet, sour).

Mand. A mand is a verbal operant that is evoked by motivating operations. For example, the mand "food" is evoked by hunger.

Morphology. Combining parts of words (i.e., morphemes) to form meaningful words. For example, combining the morpheme "paper" with the morpheme "the plural s" to form a meaningful word "papers".

Multiple Exemplar Instruction. Multiple exemplar instruction refers to interspersing novel and mastered exemplars across various verbal operants (Sidener et al., 2010). For example, running an interverbal trial by asking a child who likes football "what is your favorite sport?" That trial is followed by a tact trial in which the teacher holds up a picture of football and asks, "what is this?".

Multiple Exemplar Training. Multiple exemplar training (MET) is a procedure based on the concept of teaching *sufficient exemplars* (Stokes & Baer, 1977) of stimuli used in training.

Naming. Naming is a capability that involves responding to stimuli as a speaker (i.e., tact) and as a listener (e.g., pointing, selecting, turning toward) (Horne & Lowe, 1996).

Olfactory Tact. A form of tact in which speakers label what they smell. For example, saying "lavender" when smelling the perfume that a scented candle makes.

Operant Conditioning. The process in which human and animal behaviors are controlled by their consequences (i.e., reinforcement).

Phonology. The system of speech sounds. For example, the consonant /p/ is aspirated when it occurs in the beginning of the word (e.g., pan), but it is unaspirated when it occurs after a voiceless alveolar sound (e.g., span).

Phonological Processes. Patterns of speech errors made by typically developing children in their first years of development. The most processes are stopping (e.g., ban for fan), gliding (e.g., wain for rain), and cluster reduction (e.g., top for stop).

Pure Tact. A form of tact in which events or objects are the only stimuli of a verbal response. For example, children in a science class say "alligator" because they see an alligator. If the teacher, however, points to the alligator and asks, "what is it?" then the tact that children make is impure because it is elicited by the animal (i.e., alligator) and the verbal stimulus "what is it?".

Reinforcement. Reinforcement is the consequence that intensifies, strengthens, maintains, or increases the future occurrence of the preceding response.

Response Generalization. Generating new responses that serve the same function of the original response. For example, after learning to say “hi” to greet others, children use untaught words to greet others such as “hey” or “hello”.

Semantics. The meanings of words and their combinations in a language.

Stimulus Generalization. Demonstrating the same response to stimuli that share some characteristics. For example, to say “balloon” in response to balloons varying in colors and sizes.

Stimulus Pairing Observation Procedure. Stimulus Pairing Observation Procedure (SPOP; Smyth et al., 2006), previously known as respondent-type responding (Leader et al., 1996), is a procedure based on the concept that novel (i.e., untaught) skills can be acquired merely when stimuli are paired.

Syntax. Combining words to form meaningful sentences. For example, to combine a noun (e.g., Jason), a verb (e.g., loves), and an object (e.g., football) in the correct order to form a meaningful sentence (e.g., Jason loves football).

Tact. A tact is a verbal operant evoked by nonverbal stimuli. Nonverbal stimuli controlling tacts can be external such as visual, auditory, olfactory, gustatory, and tactile, or internal such as feelings (e.g., happiness, pain).

Tactile Tact. A form of tact in which the speakers label the things or textures they experience by the sense of touch.

Verbal Operant. Verbal operant is the fundamental unit of Skinner’s analysis of verbal behavior. Skinner (1957) identified five verbal operants: Four primary and one secondary. The primary verbal operants are: 1) mand, 2) tact, 3) intraverbal, and 4) echoic, whereas the secondary verbal operant is autoclitic. Each verbal operant is identified by the functional relation between the operant and its antecedents and consequences.

Visual Tact. A form of tact in which the speakers label what they see (e.g., pictures, objects).

Chapter Two: Literature Review

This chapter aims to synthesize and evaluate the literature on interventions to teach tact, multiple exemplar training, and stimulus pairing observation procedure used to teach young children with ASD. This chapter includes three systematic reviews: One for tact interventions, one for multiple exemplar training, and one for stimulus pairing observation procedure. Each systematic review starts with an overview and description of search process followed by a summary of each study and concludes with a discussion of the literature.

Tact is a verbal operant evoked by a nonverbal stimulus (e.g., visual, tactile) and maintained by nonspecific reinforcement delivered by the listener. For instance, when a child emits the tact "car", this response is controlled by the sight of a car and maintained by acknowledgement or praise made by their parent. According to Skinner (1957), tact is the most important operant due to the uniqueness of its stimulus control. That is, tact is controlled by the entire physical environment (e.g., objects, sounds, scents, movements) unlike other verbal operants, which are controlled by a motivating operation such as hunger or thirst (i.e., mand) or verbal stimuli (i.e., intraverbal, echoic). In addition, the importance of tacts stems from their role in facilitating acquisition of another verbal (e.g., mands, intraverbals) and nonverbal (i.e., listener) operants (Sundberg, 2015). For example, learning the response "key" as a tact helps the speaker emits the response "where is my key?" as a mand when the key is missing. Furthermore, learning the response "key" as a tact will help the speaker emits it as an intraverbal response when asked "What do you need to lock the door?" Teaching the speaker to emit the response "key" as a tact will also help with emitting listener response such as pointing to the key or searching for it when someone asks for help to find his key. Tact training may also help with facilitating social behavior (Sundberg, 2015). For instance, making a compliment such as "nice shirt" requires having the tacts "nice" and "shirt" in the speaker's verbal repertoire. Describing special or complex events such as pain, happiness, sadness, comfort, and discomfort requires tacting too (Sundberg, 2015). Tacting autoclitic helps with providing the listener with unknown information about events (Sundberg, 2015). For example, saying "few oranges left" gives the listener an indication about the quantity of oranges. Tact is a component of a broader capability known as naming (Horne & Lowe, 1996). That is, naming involves responding to stimuli as both a speaker (i.e., tact) and a listener (e.g., pointing, selecting, turning toward). For example, naming a spoon involves tacting it upon seeing it (i.e., saying "spoon") and pointing to it when asked, "point to spoon." There is an evidence that acquisition of tacts facilitates the emergence of receptive repertoire among typically developing children (Lowe et al., 2002).

Interventions Used to Teach Tacts to Young Children with ASD: Systematic Review I

Systematic Review I: Overview

Typically developing children are known to acquire speaker and listener components of naming incidentally without explicit teaching (Fiorile & Greer, 2007). For example, when a parent points to a bird and says "bird," the child acquires the name "bird" as both a speaker and a listener without explicit teaching methods such as prompting. Children with ASD, however, have difficulty with incidental acquisition of the naming capability in natural settings (Olaff et al., 2017). Accordingly, children with ASD need more explicit teaching of the two components of naming: tact and listener behavior.

In addition to the need for explicit teaching, there is a need to begin teaching of verbal behavior (e.g., tacts) and other developmental domains to children with ASD at an early age to capitalize on the neural plasticity of young children's brains (Sullivan et al., 2014). Early intervention for young children with autism produces moderate-to-large effects in critical domains such as communication and socialization (Landa, 2018).

In addition to the aforementioned benefits of learning tacts, learning this verbal operant is also necessary for academic achievement (LeBlanc et al., 2009). Furthermore, there is an evidence that tact training helps with reducing vocal stereotypies (i.e., repeating vocalizations that are nonfunctional or outside the context) (Guzinski et al., 2012) and palilalia (i.e., delayed repetition of vocalizations emitted by others; Karmali et al., 2005) among learners with ASD. There is some evidence, although conflicting, that tact training facilitates emergence of other verbal and nonverbal operants such as mands (e.g., Wallace et al., 2006), intraverbals (e.g., Conine et al., 2021), listener behavior (e.g., Miguel & Kobari-Wright, 2013), and categorization (i.e., selecting the correct category from a multi-stimulus array, Miguel & Kobari-Wright, 2013).

Unfortunately, teaching tacts to young children with ASD is not without barriers. That is, tact is reinforced by nonspecific reinforcement (Skinner, 1957). This reinforcement typically occurs in the form of social attention, praise, facial expressions, smile, or acknowledgement. For example, when a child says “airplane” upon seeing it, their mother reinforces this response by acknowledging it (e.g., Yes! That’s an airplane). Social stimuli do not serve as positive reinforcers for many young children with ASD (Axe & Laprime, 2017; LeBlanc et al., 2009). Accordingly, acquisition of tacts will be limited (Axe & Laprime, 2017). In addition, teaching generalized and maintained repertoires of tacts to young children with ASD can be difficult, as learners with autism are known to have difficulties with generalizing and maintaining the skills they acquire (Gunning et al., 2019; Neely et al., 2016). This is particularly important for tact instruction, as tacts should be emitted in different contexts and for an extended period of time. For example, emitting the tact “airplane” should not be solely controlled by a single toy airplane used in instruction. Instead, the tact “airplane” should be emitted upon seeing or hearing both real and toy airplanes.

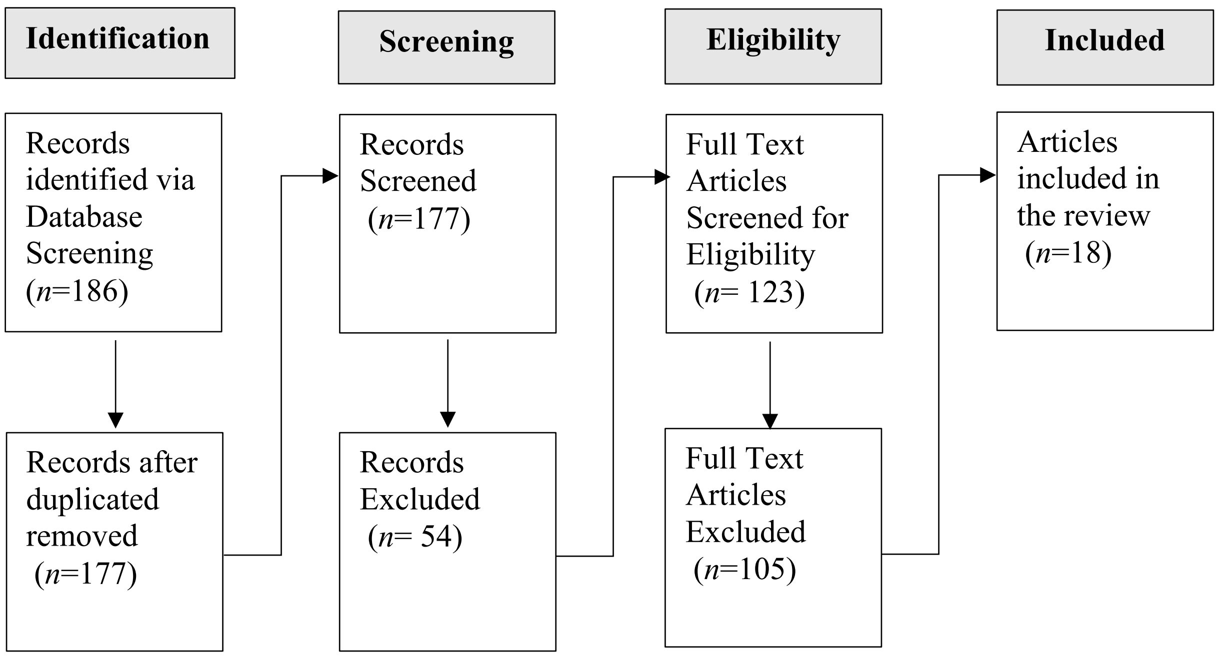
Due to the aforementioned importance of tact instruction for young children with autism and the barriers that may limit acquisition of this verbal operant, this review aims to synthesize the existing literature about tact instruction for young children with ASD. Specifically, it aims to answer the following questions: 1) What types of intervention used to teach tacts to young children with ASD? 2) What is the efficacy of these interventions in teaching tacts to young children with ASD? 3) What types of tacts were addressed in these interventions? 4) What are the outcomes of acquisition, generalization and maintenance? 5) What stimuli were used to evoke tacts in these interventions? 6) What consequences were used to reinforce the learned tacts? 7) Is the social validation of target behaviors, interventions, and outcomes supported? 8) In what settings were these interventions implemented? 9)Who was involved in implementation? and 10) What are the characteristics of tact repertoires and learning histories of participants?

Systematic Review I: Search Process

A four-step process (see Figure 2) was followed to locate and review studies that examined interventions to teach tacts to young children with ASD. The first step is *identification*. This step included conducting a combined electronic search using two keywords: “autism” and “tact”. The databases were: Academic Search Premier, Education Full Text, ERIC, and PsychINFO. The following filters were applied in the combined search: English, scholarly (peer-reviewed) journals, and published between 1957 and 2021. The year 1957 was selected because it is the year when B.F. Skinner developed *Verbal Behavior Theory*. After removing duplicates, this search resulted in 177 articles. The second step was *screening*. During this step, the records were screened to verify their relevance to the topic of the research by reading the title and abstract of each record. This step resulted in excluding 54 records. The third step was *eligibility* in which 123 records were screened in full to determine eligibility. Records were considered eligible if they met the following inclusion criteria: 1) published in English, 2) experimental research, 3) included participants with ASD, 4) examined explicit instruction of tacts or their emergence following training on other verbal operants, and 5) participants ranged from zero to 59 months. This process resulted in 18 records. The last step was reviewing and summarizing these 18 records in one matrix. The matrix included the following information about each record: a) purpose and/or research questions, b) characteristics of participants, c) implementer, d) experimental design, e) experimental settings, f) materials, g) dependent variables, h) type of tact (i.e., pure, impure), i) independent variable, j) treatment procedures, k) type of consequence (i.e., reinforcement), l) findings, m) generalization, n) maintenance, o) social validity, and p) limitations.

Figure 2

Four-Step Search Process



Systematic Review I: Results

The reviewed studies were categorized into six interventions: Teaching tacts in a play-based context, intensive instruction, antecedent arrangements, teaching tacts concurrently with other verbal operants, AAC-based tact training, and other interventions.

Systematic Review I: Strand I: Teaching Tacts in a Play-Based Context

Two research teams examined the effects of teaching verbal operants such as tacts and mands in play-based contexts. The intervention was delivered by the experimenter in the first study (Duenas et al., 2019), whereas parents were trained on delivering instruction to their children in the second study (Pisman & Luczynski, 2020).

Using a multiple probe across behaviors design, Duenas et al. (2019) examined the effect of tact instruction embedded into play activities on acquisition and maintenance of tacts for three four-year-old preschoolers with autism. The three participants were attending a program for early intensive behavior intervention (EIBI). The tact repertoire of the three participants ranged from tacting 25 to 60 items and actions as measured by *Verbal Behavior Milestones Assessment and Placement Program* (VB-MAPP; Sundberg, 2008). The age equivalence of both the auditory comprehension and the expressive language for the three participants ranged from 14 to 17 months as measured by *Preschool Language Scale*, 5th Ed. (PLS-5; Zimmerman et al., 2011). To teach target tacts, the experimenter used three-dimensional items that were used in potentially preferred play activities. The experiment took place at the same building in which participants attended the EIBI program, but not in the same room where instruction typically occurs. The dependent variable was the percentage of correct tacts that were emitted independently within 5 s of introducing the stimulus.

Interobserver agreement scores (IOA) that were collected in one third of all experimental sessions for the three participants ranged from 85% and 100%. Baseline condition involved three routines that were similar to those in early childhood settings. These routines were: a) taking toys out, b) playing with, and c) cleaning up the toys. Taking toys out involved hiding each toy in a plastic egg. The experimenter prompted the participant to open the egg, then waited 5 s for the participant to emit a tact. During play, the experimenter held up one of the items and asked a question (e.g., What is it?). During cleaning up, the experimenter handed one of the items to the participant or allowed for picking up and waited 5 s for the participant to emit a spontaneous tact. During baseline, no consequences followed either correct or incorrect responses. During the intervention, the experimenter followed the same procedures of baseline except the vocal models that followed the 5-s time delay, social praise for correct responses, and error correction for incorrect responses or if no response made within 5 s of the stimulus. Error correction involved repeating the vocal model and waiting 5 s for the participant to echo the tact. The intervention was removed for each participant when the mastery criterion was met. Two weeks following the termination of intervention, a maintenance probe was conducted in which the experimenter accompanied each child to lockers located outside the room in which the intervention was implemented. These lockers contained the same items that were used during instruction. Evaluating the maintenance of the acquired tacts was not the only purpose of this probe. It also aimed to determine if participants could transfer the tacts to novel context. No prompts or praise was delivered during the maintenance probe. Social validity of intervention was evaluated by asking educators who were experienced in preschool education to watch a video of regular tact instruction using discrete trial instruction (DTI) and another video of tact instruction embedded into play activity. The teachers used a 7-point Likert scale to rate each instructional strategy.

Data collected during intervention show that the three participants demonstrated a rapid acquisition of tacts. Maintenance data that were collected for two participants show that tacts were maintained after 2 weeks of terminating the intervention. No maintenance probe was conducted for the remaining participant. Social validity ratings for tact instruction embedded into play activity were higher than those for regular tact instruction using DTT. This suggests that embedding tact instruction into play activities is more favorable for preschool teachers and this strategy fits well into early childhood settings. The study encompasses two possible limitations. First, the verbal stimulus “What do you call this?” is possibly not a question that children typically ask when they play. Second, the results may not generalize to learners who demonstrate a better responding when instructors use reinforcers that are more powerful than praise (e.g., tangibles).

Using a concurrent multiple-probe design across behaviors, Pisman & Luczynski (2020) investigated the effects of behavior skills training (BST) on parents' integration of four components: Parallel play, child-directed interaction, and teaching of tacts and mands. The participants were two children ranging in age from 3 to 4 years and their mothers. The two children were able to produce spontaneous speech prior to the experiment. The materials used throughout the experiment were toys and manipulatives. The experiment took place at clinic and participants' homes. The experimenters measured two types of dependent variables: Child-related and parent-related. Dependent variables related to child behavior were the percentage of correct tacts and mands. They also involved vocalizations produced during play session measured using partial interval recording. Parent-related behaviors included parallel play, less desirable behaviors (e.g., redirecting play), and child-directed interaction (e.g., praise). The experimenters also measured the procedural integrity by calculating the percentage of components implemented correctly per each opportunity.

The experimenters assessed the children's preference toward toys and activities. They also assessed echoics, tacts, and mands for the two children to verify that they could not echo or emit any of the target responses prior to intervention. The experimenter used BST to train the two mothers on integrating parallel play, child-directed interactions, and teaching tacts and mands. Teaching tacts involved training the mothers on placing their hands over their children's hands and/or toys and waiting for them to look at them or the toy. Thereafter, the mothers pointed to that toy and asked, "What is it?". Correct independent or prompted tact responses resulted in praise and continuation of play. Incorrect or missing response within 5 s of the question in the second remedial trial resulted in resuming play with no further procedures. In-vivo training was conducted with the experimenter only (i.e., no children) and with children. The mothers recorded implementation at home and sent the videos to the experimenter for evaluation. Generality of teaching procedure was assessed by asking the mothers to teach new responses in new settings and using new toys. The parents were also asked to conduct a minimum of three sessions every week to assess maintenance. Interobserver agreement and procedural fidelity were measured. The experimenter also assessed the social validity of the intervention program by surveying the mothers.

The results of the experiment were as follows: First, the percentages of correct tacts and mands were zero during baseline for both participants. Second, the percentage increased significantly after introducing the intervention. Third, the mothers demonstrated the generality and maintenance of teaching methodology they learned as they were able to deliver them at home using new stimuli and without direct help from the experimenter for almost a month. Fourth, the mean percentage of IOA for the dependent variables ranged from 82% to 100%, whereas the mean of procedural fidelity for BST and in-vivo training for the two mothers ranged from 92% to 100%. Fifth, the two mothers were satisfied with the procedures as per social validity survey. A possible limitation of the study is the limited efficiency of intervention. That is, not all parents have the time to make frequent visits to the clinic to receive training as in this study (i.e., 16-22 visits). Therefore, the authors encouraged researchers to study more efficient options to deliver caregiver training such as remote and group training.

Systematic Review I: Strand II: Intensive Instruction

Two research teams examined the effects of intensive instruction of tacts (i.e., 100 learn units a day) on increasing impure tacts and mands in non-instructional settings. Pistoljevic &

Greer (2006) used a delayed multiple probe design across participants to evaluate the effects of intensive tact teaching on acquisition of pure tacts and mands in non-instructional setting for three preschoolers with autism. The participants ranged in age from 42 to 49 months. The experimenters assessed the preexisting repertoires of the participants using *The International Curriculum and Inventory of Repertoires for Children* (CABAS®; Greer & McCorkle, 2003). They found that the four participants could mand and tact items using autoclitic frames (e.g., it's a, I want). However, all three participants demonstrated a few pure tacts that were solely controlled by nonverbal stimuli in settings other than the classroom (e.g., play area). The experiment was conducted in the same preschool the participants attended. To teach tacts, the experimenters used a total of 80 pictures distributed into four sets numbered from 1 to 4. Each set was composed of five 4-picture categories (e.g., transportation, food). A multiple exemplar training (MET) was implemented as participants were exposed to different presentations of the same item. The dependent variables were the number of pure mands and tacts that were solely evoked by the nonverbal stimuli (i.e., no questions) and emitted in three non-instructional contexts: 1) transition, 2) lunchtime, and 3) free play.

Interobserver agreement and fidelity were measured in 18% of intensive tact instruction sessions. The percentage of agreement between the two observers was 100% across the three participants. Prior to and following intensive tact instruction on each set, the experimenters observed each participant for five minutes in each non-instructional setting (e.g., lunchroom) to collect data on pure tacts and mands. Intensive instruction involved adding 100 tact learn units to the daily learning activities of each participant. In each tact learn unit, the experimenter presented the stimulus (i.e., picture), waited 3 s for the student to respond, and delivered a praise if the student emitted the correct tact. Incorrect responses were corrected by modeling the tact vocally. Echoing the vocal model was not followed by praise as in independent tacts. Mastering each set of pictures was required before the subsequent set was introduced.

Pretest and posttest data indicate that the three participants demonstrated an increase in their pure tacts and mands in the non-instructional contexts after receiving intensive tact instruction. However, there are two potential limitations. Only one participant received intensive tact instruction on the four sets. The remaining two participants received instruction on one to two sets only. It is believed that exposing these two participants to more sets would enhance their acquisition of pure tacts and mands. Second, the numbers of pure tacts and mands that the participants acquired are not comparable to those emitted by children who do not have developmental disabilities due to absence of normative data.

Using a delayed multiple baseline design, Lydon et al. (2009) replicated the study of Pistoljevic & Greer (2006) to examine the effects of intensive tact instruction on three verbal operants at non-instructional contexts. These operants were tacts, mands, and conversational units. The two participants were three- and four-year-old. They were both diagnosed with autism and attended a school adopting a behavior analytic approach. Prior to the experiment, the participants were emitting an average of 20-30 pure tacts per a school day. To teach target tacts, the experimenters used five sets of picture cards. Each set consisted of five categories (e.g., clothes, foods). The five sets included the same categories, but the stimuli were different. The intensive instruction took place at the classroom, while pre- and post-instruction probes were conducted at three non-instructional contexts. These contexts were lunchroom, hallways, and play area. The dependent variable was the number of pure tacts, mands, and conversational units emitted during 15-min probes.

Pre-instruction probes were conducted in the aforementioned non-instructional contexts. A total of five post-instructional probes were conducted for each participant. The post-instruction probes were conducted following mastery on each set. During these probes, pure tacts were reinforced by a generalized non-specific reinforcement (i.e., praise). As in the study of Pistoljevic & Greer (2006), 100 tact learn units were added to the daily learning activities of each participant. During instruction, correct pure tacts were followed by a nonspecific reinforcement. Failure to emit the pure tact within 3 s of presenting the stimulus or emitting incorrect response resulted in error correction. The experimenters also measured the percentage of IOA. The percentage of IOA ranged from 95 to 100%.

The findings were as follows: First, the number of pure tacts emitted in non-instructional contexts increased significantly for the two participants after mastering each set of stimuli. Second, no significant increase was observed in the number of pure mands and conversational units. A possible limitation of the study is lack of significant increase in pure mands following intensive tact instruction as in the study of Pistoljevic & Greer (2006). The authors suggested that mands and conversational units did not increase significantly due to shortness of pre- and post-instructional probes. In other words, there were no establishing operations (EOs) or the opportunities to initiate a conversation were very limited. Anyways, this claim requires further investigation.

Systematic Review I: Strand III: Antecedent Arrangements

Different antecedent arrangements were used to teach tacts to young children with ASD. These arrangements included adding and removing the verbal stimulus “What is it?” (Lalonde et al., 2020), using auditory stimuli to evoke tacts **(**Hanney et al., 2019), withholding social attention prior to tact instruction (i.e., Cengher & Fienup, 2020), evoking tacts by presenting high- and low-preferred items (i.e., Davis et al., 2012), using pictures with and without backgrounds to elicit tacts (i.e., Mitteer et al., 2020), and behavioral momentum (i.e., Kelly & Holloway, 2015) in which easier responses (i.e., high probability) were introduced prior to more difficult ones (i.e., low probability).

Lalonde et al. (2020) used a repeated acquisition design to investigate the effects of tact instruction with and without the verbal stimulus “What is it?” on acquisition and generalization of tacts in non-instructional contexts for three children with ASD. The participants ranged in age from 42 to 44 months and they all had been receiving 30 h of EIBI per week at the outset of the experiment. The three participants underwent two assessments: VB-MAPP (Sundberg, 2008) and PLS-5 (Zimmerman et al., 2011). The overall scores of VB-MAPP indicated that the tact repertoires among the three participants ranged from 4 and 20 common items. The overall age equivalents (i.e., auditory comprehension, expressive language) on PLS-5 for the three participants ranged from 17 to 26 months. All sessions were conducted at a research room. To teach and probe target tacts, the experimenters used four sets of three-dimensional stimuli. Tokens and preferred items were used as reinforcers, whereas pretend-play objects were used for generalization probe (i.e., play context). The dependent variable was the percentage of tacts emitted both correctly and independently within 6 s of presenting the object.

Before tact training began for each set, the experimenters probed tacts in the play-based activity to verify whether participating children could tact the objects in that context or not. Each participant received two types of tact training sessions: 1) with question “What is it?”, and 2) without question. Each session was conducted at the table and consisted of 12 trials. The two types of tact training were separated by a short break. In both types of tact training, the experimenter used vocal prompts that were delayed progressively on a predetermined criterion until faded completely. Following tact training, the experimenter probed tacts in a play-based activity to determine the extent to which the participants generalized the tacts they acquired to non-instructional context. It is of interest to note that generalization probe was conducted in the same instructional room, but on the floor. Maintenance sessions were conducted after four weeks of post-training probe for the fourth set. These sessions aimed to determine the extent to which the participants could maintain and generalize the tacts they acquired to both instructional and noninstructional contexts and under two conditions: 1) with question, 2) without question. Interobserver agreement and treatment integrity were measured on 51% and 33% of sessions, respectively. The mean percentage of IOA for the three participants ranged from 94.7% to 98.5%. The mean percentage of instructional steps implemented correctly during instruction and play-based probes were 96.2% and 99%, respectively

The findings of the experiment were as follows: First, tact training with and without question "What is it?" were both effective in acquisition of tacts. However, two participants demonstrated faster acquisition when the question was asked. Second, all participants demonstrated generalization of the tacts they acquired in non-instructional context. However, one participant could not demonstrate generalization of tacts for one stimulus set. The authors suggested that increasing the exposure of that participant to objects in the non-instructional context may have enhanced her generality outcomes. Third, the three participants demonstrated maintenance of the tacts they acquired under both conditions. However, the percentage of correct and independent tacts emitted during maintenance probe was higher for all three participants when the question "What is it?" was used. However, the study has two potential limitations. First, the experimenters could not control for the potential carryover effect due to the experimental design used in the study. Second, the play-based activity in which the experimenter conducted generalization probe was not completely natural. That is, the experimenter held up the object and waited for the participant to emit a tact response.

Using an adapted alternating treatments design embedded within a nonconcurrent multiple baseline design across participants, Hanney et al. (2019) compared the effectiveness of two arrangements to teach auditory tacts to two 3-year-old children with autism. These two arrangements were isolated and compound. Isolated arrangement included presenting the auditory stimulus only, whereas the compound arrangement included presenting both the auditory and visual stimuli simultaneously. The two participants already had repertoires of 150-200 tacts of items and actions. They also had strong echoic repertoires. They were both able to echo multisyllabic words, as measured by VB-MAPP (Sundberg, 2008). The experimenters used a laptop and external speakers to deliver auditory stimuli in the isolated arrangement. They used sound-generating toys in the compound condition. The experiment took place at a therapy room located in a preschool building. The dependent variable was the percentage of correct tacts that were evoked by the auditory and/or visual stimulus and questions such as "What sound do you hear?" and "What it is?".

During baseline, the experimenter asked the participant "What sound do you hear?". The question was followed by the auditory stimulus (e.g., laugh). The tact was recorded as correct if it was emitted within 3 s of presenting the auditory stimulus and if it corresponded the sound. Correct tacts were not followed by any form of reinforcement. Tact training started with the isolated arrangement which was similar to baseline except the consequences of correct and incorrect responses. Correct responses were followed by praise and access to highly preferred item, whereas incorrect and missing responses were followed by repeating the question and a vocal model of the correct tact. During the compound arrangement, the experimenter followed the same procedure of the isolated arrangement except the format in which the auditory stimulus was presented. The auditory stimuli were generated by toys (e.g., tiger) that were visible to the child. To assess generalizability and maintenance of auditory tacts, the experimenters conducted follow-up probes one and two weeks following the termination of training. During these probes, the sounds of the isolated arrangement were presented with toys to assess the generalizability to compound stimuli. Similarly, the sounds of the items that were used during the compound arrangement were presented without toys to assess generalizability to isolated stimuli. Last, they presented the toys of both arrangements without sounds to determine if auditory and visual tacts interfered. One participant demonstrated interference. Therefore, the experimenters decided to conduct mixed training for that participant. During mixed training, new toys were presented randomly with and without sounds.

The experimenters noticed that both visual and auditory tacts were acquired with no interference after mixed training for one participant. This finding suggests that mixed training has the potential to prevent any possible interference of auditory and visual tacts. On other hand, the other participant who did not receive mixed training was able to demonstrate mastery of auditory tacts with the compound arrangement only.

Cengher & Fienup (2020) examined the effects of manipulating the motivating operations by withholding social attention prior to teaching session on acquisition of tacts in three preschoolers with ASD. The experimenters used an adapted alternating treatment design. The participants ranged in age from three to four years old. Prior to the experiment, the participants were able to emit five to 10-word sentences vocally, basic intraverbals, generalized echoic responses, and a tact repertoire of 300 tacts. All sessions took place in a quiet room in a preschool. The experimenters used pictures. These pictures illustrated social interactions (e.g., talking, tickling) between the experimenter and a child. They also created pictures illustrated the experimenter and the child had no social interaction (i.e., control card). Tact stimuli were six cards illustrating different colors (e.g., yellow, orange). Toys that are played both solely and jointly (e.g., action figures) were also used. The dependent variables were matching pictures with the modeled social interactions, the number of social consequences (e.g., tickles) the participants selected, and percentage of correct tacts in each condition (i.e., presession attention, no attention, control). Tact responses were recorded as correct if the student stated the color within 5 s of presenting the card. To measure the efficiency of each condition, the experimenters calculated the number of sessions required to reach the mastery per condition, the mean percentage of erred response, and cumulative duration of instruction for each condition.

The experimenters assessed the participants' social interaction preference by asking them questions such as "Do you want clapping or high fives?". The participants had to state the names of their preferred social interactions and point to or place their hands over the pictures illustrating their preference within 5 s of the question. The experimenter ranked the social interactions by the number of times each one was selected from the highest to the lowest. Prior to intervention, the experimenter conducted two tact probes: one in English and one in a foreign language (i.e., Japanese, Spanish). The purpose of English probe is to ensure that the participants could tact the colors in English, whereas the purpose of the foreign language probe is to ensure that participants could not tact the target colors in Japanese or Spanish prior to manipulations. Tact training and maintenance probes were preceded by one of three conditions: (a) presession attention (PA), (b) no presession attention (NPA), and (c) control. The PA condition lasted 15 minutes. During this condition, each participant was invited to choose one toy and play with it. During play, the experimenter was delivering the participants' preferred social interaction (e.g., tickling, clapping) on a 20 s-fixed interval schedule of reinforcement. As its name implies, the NPA was similar to PA except delivering any form of social interaction during the 15-min session. However, the experimenter was giving neutral responses to the participants if they asked questions. In control condition, tact probes were not preceded by the 15-min play session as in PA and NPA. Participants were asked to tact two colors in a foreign language during the control condition. Correct tacts were followed by a smile, acknowledgement, and a preferred social interaction (e.g., clapping). Incorrect responses were not followed by any procedure (e.g., error correction). Tact training started after PA and NPA conditions only. After the 15-min play session in PA and NPA conditions, all toys were removed, and tact training started. Tact training procedures were identical to tact probes except the error correction (i.e., verbal prompt) which followed the incorrect responses. Maintenance probes were conducted two- and four-weeks following mastery of each set of pictures in the respective conditions. To confirm that the mastered responses had the function of tact, a functional analysis was conducted by alternating tacts from PA and NPA with stimuli of control condition. The research team measured the percentage of IOA and treatment integrity. The percentage of IOA across the four conditions ranged from 92% to 100%, whereas treatment integrity ranged from 87% and 100%.

Data on acquisition of tacts in a foreign language for the three participants showed that NPA was more efficient (i.e., fewer sessions to mastery) than PA condition. Two participants showed high levels of tacts at maintenance probes in the two conditions, while the remaining participant demonstrated maintenance at NPA only because PA tacts were not probed. No maintenance probe for PA tacts was conducted for that participant because he could not reach mastery in that condition. The causal relationship between acquisition of target tacts and manipulations of motivating operations was confirmed as the percentage of correct responses remained zero in control condition for the three participants. The results of the experiment supported the claim that manipulating the motivating operations by limiting access to social reinforcement (i.e., deprivation) prior to instruction increases the momentary value of this type of reinforcer, thus tact training will be more efficient (i.e., fewer sessions to mastery). Anyways, the study has some potential limitations. First, the authors believe that implementing errorless learning would have resulted in fewer errors than error correction procedures implemented during tact training. Second, each condition consisted of pictures only. The authors believed that having two stimuli per condition brought the response under the control of the negative stimulus rather than the color. For example, it is possible that participants labeled the red card because the blue card was absent, not because the red card was presented.

Using multielement design, Davis et al. (2012) taught tacts of high-preferred (HP) and low-preferred (LP) items to a 4-year-old child with autism and examined the effect of tact training on emergence of mands. Prior to the experiment, the participant had about 5 to 10 tacts and a generalized echoic repertoire. To teach the target tacts, the experimenters used two items that were identified in preference assessment. These two items were the most and the least preferred toys. The experiment took place at speech therapy room. The dependent variables were the percentages of independent tacts and mands. The tact response was recorded as correct if it was emitted within 5 s of the question “What is it?” without any vocal model from the experimenter.

During each baseline session, the experimenter ran either 10 trials with either the HP or the LP item. The experimenter held up the item and simultaneously asked the participant “What is it?”. Correct responses were followed by praise, whereas incorrect tacts were not followed by any procedure (e.g., error correction). During tact training, the experimenter followed the same procedures of baseline except the vocal models that followed the question and the error correction procedures. Vocal models were systematically delayed following predetermined criteria. Error correction involved repeating the question and modeling the correct response. Training continued until the participant reached the mastery criteria for both HP and LP toys. Following the mastery of target tacts, the experimenter conducted mand test. During mand test, the experimenter measured the percentage of correct mands for HP and LP toys in two conditions: (a) satiation (i.e., access granted to the HP and LP items) and (b) deprivation (i.e., access to the HP and LP items was withheld for 2-3 days). Percentage of interobserver agreement across 32% of baseline and training sessions of tacts ranged from 80% to 100%.

Baseline data indicated that the participant did not emit any independent tact prior to intervention. The percentage of independent tacts started to increase only after tact training was initiated. The participant reached mastery for the HP and LP items. On the other hand, the authors noticed that mands for the HP and LP toys did not emerge following tact training. Mands for these two toys increased only when tact trials were conducted immediately before the mand test. However, the authors were not sure if emergence of mands occurred because of presession tact trials. They suggested verifying the causal relationship by withdrawing the presession tact trials, then running the mand test to determine if percentage of independent mands will decline after the withdrawal of presession tact trials.

Using an adapted alternating treatment design, Mitteer et al. (2020) compared the effects of tact instruction using pictures with and without background on rate of acquisition and generality in four children with autism. The participants ranged in age from 3 to 4 years. They all had tact repertoires such as body parts, common items prior to the experiment. Tact instruction was carried out by the experimenters. To teach target stimuli, they used pictures of animals with and without background. To test generalization stimuli, the experimenters used videos, figurines, and images. The experiment took place at clinic for three participants, whereas the remaining participant received tact instruction at home. The main dependent variable was the percentage of correct tacts. Tact response was recorded as correct if it was emitted within 5 s of presenting the stimulus. The experimenters also calculated the number of sessions to mastery in each condition and percentage of stimuli mastered during generalization phase.

To determine the reinforcers delivered at the end of each teaching sessions, the experimenters conducted a brief preference assessment at the outset of the session. They also conducted an echoic assessment prior to instruction to confirm that all participants could echo the target tacts. Teaching started with presenting an immediate echo after presenting the stimulus. Echoic prompts were faded into delayed vocal models. The experimenters provided positive reinforcement for both correct and prompted responses. During differential reinforcement condition, the experimenter praised the correct responses and ignored the incorrect ones. To test generality of tacts, the experimenters used three images, figurines, and videos per each stimulus. The experimenters also assessed generalizability of target tacts to moving animals by accompanying the participants to a zoo. The experimenters pointed to the target animals and asked each participant “What is it?”. The experimenters measured interobserver agreement (IOA) on 20 to 44% of sessions for the four participants. The mean percentage of IOA for the four participants was 100%.

The research team found that pictures with and without backgrounds had similar effects on the rate of acquisition and generality. The experimenters, however, were pointing to the target stimulus during instruction. Accordingly, it is unknown if pointing facilitated the acquisition of target tacts. Another possible limitation of the study is the tacts that participants possessed prior to the experiment and the previous learning histories. The authors recommended that future researchers compare the effects of pictures with and without background for children with varying verbal behavior profiles and tact learning histories. In addition, they recommended examining the effect of pointing to the target stimulus during tact instruction on the rate of acquisition requires further investigation.

Using a multiple baseline design across stimulus sets, Kelly & Holloway (2015) investigated the effects of behavioral momentum on acquisition and fluency outcomes of tacts. Behavioral momentum is a procedure used to increase both accuracy and speed of responding by introducing the responses that require less effort (i.e., high probability) prior to more effortful ones (i.e., low probability). The participants were three preschoolers with ASD ranging in age from 42 to 59 months. All three participants had been receiving EIBI 5 days a week at the outset of the experiment. The age equivalent scores on PLS-4 (Zimmerman et al., 2002) for three participants ranged from 2.1to 3.6. The experiment took place at a small room within preschool building, whereas postintervention probes were conducted at the participants' classrooms. The experimenter used flashcards to teach and probe tacts. The dependent variables were accuracy, retention, endurance, stability, and application. Accuracy is the total number of correct and incorrect tacts. Tact was considered correct if it was emitted independently within 3 s of presenting the visual stimulus. Retention is the ability of each participant to maintain a high level of tacting after four weeks of reaching mastery criteria. Endurance is the participant's ability to stay engaged in the instructional activity for three minutes. Stability is the participant's ability to maintain high level of tacting in presence of distractors (e.g., video, other students) after reaching mastery criteria. Application is the participant's ability to apply what was learned to novel stimuli. During application probe, the experimenter used different exemplars of the mastered stimuli. Number of tacts per minute the measure used for these five dependent variables.

The learners usually control the instruction in behavioral momentum. Therefore, the participants were trained on self-management of the visual stimuli prior to baseline probe. This training involved teaching the participants how to pick up a picture card from the left side of the table, tact it, then put it to the right side. The mastery criterion was set at 30 to 35 correct tact per minute. During baseline, the participants viewed different picture cards. The experimenters used cards that were incorrectly tacted as low-probability stimuli. During the behavioral momentum training, the experimenter presented 20 previously mastered pictures (i.e., high probability). The participants tacted these pictures then received 1-min training on the low-probability stimuli. The experimenter recorded the number of correct and incorrect tact per minute for each set of stimuli. During training, the experimenter was only reinforcing on-task behaviors rather than correct responses. Similarly, incorrect tacts were not corrected immediately during the 1-min training. Incorrect tacts were corrected during the corrective feedback. During corrective feedback, the experimenter modeled the correct tact vocally and asked the participant to repeat the response. The experimenter then represented the same stimuli and waited for the participant to tact it correctly without a vocal model. Mastery of target stimuli was followed by 1-min retention (i.e., 4-week follow-up), stability, and application. Unlike the aforementioned probes, the endurance probe lasted three minutes. The experimenters also measured the percentage of IOA for three participants on 30% of the experimental sessions. The mean IOA for three participants was 98.5%.

The research team found that the three participants increased the number of correct tacts per minute during the behavioral momentum training. However, their performance was variable.

The first participant met the mastery criteria for the three sets and maintained that high level of tact on the 4-week retention probe. The second participant met and maintained the mastery criteria for two of the three target sets. The third participant increased the number of correct tacts per minute but could not reach the mastery criterion across the three sets. However, she maintained the same level of tacting on the retention probe. A possible limitation of the study is setting the same mastery criterion for the three participants. The authors recommended future researchers to individualize mastery criteria when investigating the effects of behavioral momentum training.

Systematic Review I: Strand IV: Teaching Tacts Concurrently with Oher Verbal Operants

Tacts were taught concurrently with other verbal operants (e.g., mands, echoics) by three different procedures: Mixed training (i.e., Kodak & Clements, 2009; Sidener et al., 2010)**,** transfer procedures (i.e., Dell'Aringa et al., 2021), and multiple exemplar instruction (MEI; Fiorile & Greer, 2007)**.** These studies were summarized in the subsequent paragraphs.

Two research teams (i.e., Kodak & Clements, 2009; Sidener et al., 2010) investigated the effects of mixed training on acquisition of tacts among young children with ASD. Mixed training is a procedure in which more than one verbal operant is concurrently taught for the same response. For example, an instructor contrives the EOs to elicit the vocal response "Apple" as a mand and asks the question "What is it?" at another opportunity to elicit the same target as a tact.

Kodak & Clements (2009) used a reversal design embedded in a multiple baseline design across verbal operants to investigate the effects of concurrent echoic training on acquisition of tacts and mands in a 4-year-old child with autism. The participant's preexisting verbal behavior repertoire was not thoroughly described. The authors mentioned that the participant rarely engaged in verbal behavior prior to experiment. The experiment took place at the therapy room in which the participant typically received early intervention services. To teach target tacts and mands, the participant's therapist used juice, music, and cookie. The dependent variable was the percentage of correct vocalizations (i.e., tacts, mands). The correct vocalization was recorded as prompted or unprompted. The vocalization was recorded unprompted if it was emitted within 5 s of presenting the stimulus, or after 5 s of delivering the prompt. The vocalization was recorded as prompted when the participant emitted the response within 5 s of delivering the vocal prompt.

A preference assessment was conducted at the onset of experiment to identify four highly preferred items. Mands were baselined first. During mand baseline, the therapist held up one preferred item and waited the participant for 5 s to emit the correct mand. A vocal prompt in the form of question "What do you want?" was delivered if 5 s elapsed and correct mand was made. Correct mands resulted in access to the manded item, whereas incorrect or missing ones were not followed by any procedure (e.g., error correction, vocal prompt). The therapist followed the same procedures during training except stating the name of the item if the participant did not answer the question "What do you want?". Tacts were also baselined. During tact baseline, the therapist placed the item in the participant's lap or hand and waited for 5 s. The therapist pointed to the item and asked, "What is it?" if the 5 s elapsed and no response was made. Tacts emitted within 5 s of asking the question were verbally praised. Incorrect or missing responses were not followed by any procedure. The therapist followed the same procedures during tact training except the vocal prompt that was delivered when 5 s elapsed and no correct tact was made in response to the question "What is it?". Tact and mand training sessions were preceded by echoic training. Echoic training did not involve any of the three target items. During this training, the therapist presented the echoic prompt (e.g., "cookie") and waited the participant for 5 s to emit a response. Absence of correct response within 5 s resulted in repeating the prompt with addition of the word “say” before the item name. Correct vocalizations that followed the first or the second prompt resulted in praise and access to one preferred item. The experimenters measured the percentage of IOA. The percentage of IOA was 100% for the three responses: Juice, music, and cookie.

The findings of the experiment were as follows: First, the percentage of correct vocalizations was zero for three responses during baseline probed. Second, the percentage of unprompted correct vocalizations was near to baseline level when tact and mand training were not preceded by echoic training. Third, the percentage of unprompted tacts increased significantly only when mand and tact sessions were preceded by echoic training. Fourth, the participant maintained the high level of unprompted tacts and mands after the removal of echoic training. The authors suggested that increasing echoic prompts during tact and mand sessions might have increased the percentage of unprompted responses without echoic training. However, this claim requires further investigation. The study has two possible limitations. First, it included one participant only. Second, the authors could not determine if unprompted target responses would have increased if tact and mand sessions continued without combining them with echoic training.

Sidener et al. (2010) investigated the effects of mixed training on acquisition of tacts and mands among young children with and without autism through three experiments. The first experiment involved comparing tact-only training, mand-only training, and mixed training among three typically developing children. In this experiment, the experimenters found that mixed training was not superior to mand and tact instruction when conducted alone. The second experiment involved a direct replication of a previous study (i.e., Carroll & Hesse, 1987) with typically developing participants. In the study of Carroll & Hesse (1987), the mixed training (i.e., mand-tact) was more efficient than tact-only instruction. In other words, fewer trials were required to teach tacts during mixed training than tact-only instruction. However, contrasting results were obtained in the second experiment of Sidener et al. (2010). That is, tact instruction alone was more efficient than mixed training for two typically developing children. Sidener et al. (2010) suggested that mixed training was not more efficient because the reinforcing value of the task the participants were required to accomplish was low. Therefore, they conducted the third experiment with a 4-year-old preschooler with autism to determine the facilitative effects of mixed training on acquiring tacts or mands using an adapted alternative treatment design. The age equivalent score for this participant on the Expressive Vocabulary Test (EVT; Williams, 1997) was less than 21 months. The verbal repertoires (e.g., tact, echoic) the participants had at the onset of the experiment was not described. The experiment took place at his home. The experimenters used toys to teach target tacts and mands. To reinforce correct responses, they used edibles identified through preference assessment. The dependent variable was the number of sessions required to reach mastery for tacts and mands. The mastery criterion for tacts and mands was to emit the response correctly in 4 out of 5 trials across two consecutive sessions. The experimenters required the first trial to be correct.

The experiment involved three randomly ordered conditions: 1) Tact-only instruction, 2) Mand-only instruction, and 3) Mixed training. Assessment of EOs preceded the introduction of each condition to ensure that highly preferred items are used during instruction. Mand-only instruction involved presenting the highly preferred item or placing it in a bag to elicit a pure response. During this condition, trials were interspersed with receptive discrimination trials. Emitting the correct mand resulted in accessing the item for 30 s and a praise. During tact-only instruction, tact and receptive discrimination trials were presented alternately. It is important to note that receptive identification trials were not relevant to target tacts and mands. They were brought from unmastered receptive identification targets, such as letters and numbers. Correct tacts evoked in response to the question “What is this?” were followed by a praise and consuming the preferred edible. The experimenters used progressive time delay in introducing verbal prompt for mand and tact trials. Mixed training involved an alternation of trials (i.e., tact, mand). The experimenters also measured the percentage of IOA and treatment integrity. The mean percentage of IOA and treatment integrity were 98% and 99%, respectively.

The findings of the experiment were as follows: First, the mixed training was not superior to tact-only or mand-only training. For example, the mixed training was faster in reaching mastery criterion for tacts in the first stimulus set. Mixed and tact-only training, however, were equally fast in reaching mastery criterion in the second set. Second, tact-only training was slightly faster in the third stimulus set. The experiment has four possible limitations. First, frequent discontinuation of training. Second, the multiple distractors at the participant’s home. Third, the varying preference toward items used in mand-training. Fourth, changing the experimental setting in between two stimulus sets due to fire at the participant’s house.

Dell’Aringa et al. (2021) compared the effectiveness of transfer procedure and non-transfer procedure to teach two-component tacts to three 4-year-old children with ASD, using a multielement design. The verbal behavior for the three participants was evaluated using VB-MAPP (Sundberg, 2008). The scores of VB-MAPP indicated that each participant was able to tact a minimum of 100 different tacts, emit one- and two-word mands, and some basic intraverbals (e.g., fill in blanks). Instruction was carried out by ABA therapists who were familiar to the participants. The dependent variable was the percentage of correct tacts. The tact was recorded as correct if it was emitted within 3 s of presenting the corresponding picture and the question “What’s happening?”. To teach target tacts, the therapists used two sets (i.e., A, B) of nine pictures for two participants. Each set consisted of three subsets of pictures. Each subset was assigned to one of the following conditions: (a) control, (B) transfer, and (c) nontransfer. For the remaining participant, the therapists used one set only (i.e., set A). The experiment took place at a clinic for behavioral-analytic therapy.

Potential reinforcers were determined by preference assessment. To identify the two-word tacts that participants could not emit independently, the therapists conducted pretest using 50 picture cards. Pretest was followed by baseline in which the three experimental conditions were alternated. During baseline probes, the therapist held up the picture and asked, “What’s happening?”. Correct responses emitted within 3 s of the question were praised, while incorrect and missing responses were not followed by any procedure (e.g., error correction). The therapists conducted tact training in two rapidly alternating conditions: transfer and nontransfer. During the transfer condition, the therapist held up the picture, asked the question “What’s happening”, and immediately modeled the two-word tact. This was immediately followed by a transfer trial in which the therapist repeated the question “What’s happening?” and gave the participant a 3-s opportunity to emit the tact. Correct responses were praised and followed by access to an edible of the participant’s choice. Incorrect and missing responses were followed by error correction procedures. The immediate vocal model which followed the first presentation of the question “What’s happening” was systematically delayed. During nontransfer trials, the therapists held up the picture and asked the question. Nontransfer trials followed the aforementioned procedures except the transfer trials. Control condition was similar to baseline probes. That is, no tact instruction occurred during this condition. Maintenance probes similar to baseline were conducted 6- and 7-weeks following the termination of tact training for two participants. No maintenance probe conduced for the remaining participant. The experimenters surveyed the therapists who implemented tact instruction to assess the preference, ease, and efficiency of transfer and non-transfer procedures. They also measured the percentage of IOA and fidelity of implementation. The percentage of IOA ranged from 75% and 100% across the three participants. Second, the fidelity of implementation ranged from 94% and 100%.

Findings of this experiment were as follows: First, social validity ratings indicated that most therapists preferred transfer trials. However, most of them believed that non-transfer trials were easier and faster. Second, transfer and non-transfer trials were both effective in increasing the percentage of correct tacts for the three participants. Third, the maintenance probes that were conducted for two participants indicated that tacts acquired during transfer and non-transfer trials were maintained 6- and 7-weeks following the termination of intervention. Fourth, the difference between the number of sessions required to reach mastery in each condition was negligible. This means that transfer procedures are effective in teaching tacts, but they are not necessarily more efficient than non-transfer procedures. The study encompasses three possible limitations. First, the target two-word tacts included common words (e.g., baby, cats) that participants probably exposed to outside the experimental setting. Accordingly, the exposure to common words has probably confounded the changes in the dependent variable (i.e., percentage of correct tacts). Second, the small number of participants. Third, the lack of control over the previous exposure to transfer or non-transfer procedures. In other words, the experimenters were not sure if the recent exposure to transfer or non-transfer procedures has facilitated acquisition of tacts or not.

Fiorile and Greer (2007) used a multiple probe design across participants to examine the effect of intensive multiple exemplar instruction (MEI) on the two components of naming: Listener (i.e., pointing) and speaker (i.e., impure tacting) responses, after introducing tact training alone to four toddlers with ASD. The four participants ranged in age from 24 and 28 months. At the onset of the experiment, all four participants were unable to name three-dimensional items. To teach naming, the experimenter used unfamiliar hardware (e.g., bolts). The experiment was conducted at participants' homes. The dependent variables were the listener (i.e., pointing) and speaker (i.e., impure tacts) components of naming. The impure tacts were the responses controlled by the visual stimulus (i.e., three-dimensional item) and the question (e.g., "what is this?")

Before tact training began, the experimenter probed naming, visual matching, pointing, and impure tacts. Thereafter, the experimenter taught the participants pure tacting until mastery. Following pure tact training, the experimenters probed the two components of naming: pointing and impure tacts. The MEI was initiated for the four participants across the first and second sets because no one demonstrated the two components of naming on the aforementioned probe. However, one of the participants did not require MEI for the third set because the two components of naming were high after tact training alone. The MEI involved alternate introduction of impure tact and listener (i.e., pointing) trials. The MEI continued until mastery. Thereafter, naming was probed for each participant. Generality of naming to novel stimuli was also assessed. The experimenters also measured the percentage of IOA for the four participants. The mean percentage of IOA for the four participants ranged from 98% to 100%.

The following were the findings of the experiment. First, pure tact training alone was not enough to develop naming repertoire for two to three sets of stimuli across the four participants. It is of interest to note that listener and impure tacts increased after pure tact training, but mastery criterion was not met for both type of responses. Naming is a two-component skill. Therefore, the authors required mastery of both components. For example, the number of correct listener responses (i.e., pointing) for one participant on the first set was 6 out of 18 trials. On the other hand, the number of correct impure tacts for the same participant were 16 out of 18. Accordingly, MEI was introduced because mastery was met for only one half of naming (i.e., impure tacts). However, MEI was not needed for the third set for the same participant because the criterion was met for both components of naming repertoire after tact training alone. Second, naming was generalized to novel stimuli after MEI. The results indicate the MEI was superior to tact instruction alone in developing untaught components of naming: listener (i.e., pointing) skills and impure tacts. A possible limitation of the study is uncertainty regarding the extent to which participants were able to demonstrate naming repertoire for stimuli other than those utilized in the experiment, such as two-dimensional stimuli and printed materials. The authors recommended future researchers to examine the generalization of naming repertoire across various types of stimuli.

Systematic Review I: Strand V: AAC-Based Tact Training

Tacts were taught to young children with autism who use high-tech speech generating devices (SGDs) in two studies. These studies were summarized in the subsequent paragraphs.

Lorah & Parnell (2017) used a multiple baseline across participants design to examine the effects of time delay combined with full physical prompt on acquisition and maintenance of tacts in three preschoolers with ASD who used speech generating devices (SGD) primarily to communicate with others. The three participants ranged in age from 42 to 50 months. They all had a limited tact repertoire as measured by VB-MAPP (Sundberg, 2008). The dependent variable was the percentage of correct tacts. The instructors who implemented tact training were also enrolled at master's program in Applied Behavior Analysis (ABA). To teach the target tacts, the instructors used iPad™, a flipbook story, and an augmentative and alternative communication (AAC) application (i.e., *Proloquo2Go*™). All experimental sessions took place at a preschool in the same area where learning activities (e.g., circle time) typically occurred.

During baseline probe, the instructor turned to the page that illustrated the target stimulus and waited the participant for 5 s to emit the tact. The response was recorded as correct if the participant pressed on the icon that displayed on iPad™ and corresponded to the target stimulus within 5 s of the presenter turning to the page. Correct responses were followed by praise, whereas incorrect or missing responses were not followed by prompt or error correction. Tact training was similar to baseline except full physical prompt the instructor presented when the participant could not emit the correct response within 5 s of reaching the page was delivered. Maintenance probes similar to baseline were conducted for two participants following the termination of instruction. No maintenance probe conducted for the remaining participant due to time limitation. Percentage of IOA and treatment integrity were also collected. The percentage of both IOA and treatment integrity was 100%.

The findings of the experiment were as follows: First, percentage of independent tacts remained zero during baseline across the three participants. Second, the percentage of correct tacts for at least one stimulus increased only when tact training was introduced for the three participants. However, one participant could reach the mastery criterion for the two target stimuli. Third, these two participants for whom maintenance probes were conducted demonstrated maintenance of the acquired tacts. The study encompasses four potential limitations. First, failure to reach mastery criterion in one participant was due to time constraint. The authors believed that conducting extra sessions would have enhanced the performance of that participant. Second, the high variability of maintenance data for one participant. Third, the experimenters did not assess the generalizability of the acquired tacts across novel contexts. Fourth, absence of social validity data from the implementers and the caregivers.

Speech generating devices (SGDs) were also used in another study to teach tacts. Using an alternating treatment design, Ferris & Fabrizio (2009) compared the effectiveness of vocal models generated by an SGD and those emitted by teachers on the rate of acquisition of tacts for a 4-year-old child with autism. The participant attended a preschool and received home-based behavior analytic services, speech and language therapy, and occupational therapy. He also used an SGD (i.e., Vantage™) to communicate with others. The participant's home program included instruction on listener skills and different verbal operants (e.g., mand, tact) with and without his SGD. Tact training throughout the experiment was carried out by tutors at the participant's home. To teach target tacts, they used the SGD and picture cards. The dependent variables were the rate of correct and incorrect tacts emitted per minute. Tacts were recorded as correct if they were vocally emitted within 2 s of the tutor presenting the stimulus and they corresponded to the picture presented.

Two conditions were alternately and randomly introduced throughout the experiment. The first condition was error correction emitted by the tutor, while the second condition was the error correction generated by an SGD. During the first condition, the tutor presented the visual stimulus and waited the participant for 2 s to respond. Incorrect or missing responses were followed by representing the stimulus and vocally modeling the tact. Echoing the tact resulted in access to a preferred item or activity. After consuming the item or finishing the activity, the tutor reintroduced the stimulus and asked the participant to name it. The participant's responses were differentially reinforced by allowing longer access to his preferred activities and larger pieces of the favorite snacks when the tact was emitted in response to the question and the visual stimulus only without vocal model (i.e., impure tact). The second condition (i.e., error correction generated by an SGD) was similar to the first except the source of vocal model. In other words, the tutor pressed on the symbol that corresponded to the visual stimulus to generate a vocal model from the SGD following incorrect or missing tact response.

Data collected throughout the experiment showed that vocal models emitted by the tutor were more effective than those generated by the SGD as indicated by the rate of correct tacts emitted per minute in each condition. The experimenters also noticed that rate of incorrect tacts emitted per minute did not decrease during the condition in which vocal models were generated by the SGD. On the other hand, the rate of incorrect tacts emitted per minute decreased to zero in the final week of the experiment during the condition in which vocal models were emitted by the tutors. The authors suggested that vocal models generated by the SGD were less effective than those emitted by the tutor because the participant did not have a history of responding to artificial speech. They also speculated whether training the participant on responding to the artificial speech generated by the SGD prior to the experiment would have made the vocal models the device produced more effective. Accordingly, this is considered a potential limitation of the study.

Systematic Review I: Strand VI: Other Interventions

This section includes a summary of two studies in which tokens and adult attention (i.e., Eby & Greer, 2017) and matrix training (Jimenez-Gomez et al., 2019) were used to teach tacts to young children with ASD.

Eby & Greer (2017) compared the effects of using tokens and adult attention on emission of tacts in natural settings for children with and without disabilities using an alternating treatment design. The study included a total of four children. Two of them were typically developing, whereas the remaining two participants had disabilities; one had pervasive developmental disorder-not otherwise specific (PDD-NOS) and one had a nonspecific disability. The child with PPD-NOS was 45 months old at the outset of the study. The scores of expressive communication and auditory comprehension the participant with PDD-NOS received on *PLS–4* (*Zimmerman* et al., 2002) were 112 and 110, respectively. The age equivalents for these two scores were not mentioned. The same participant had a tact repertoire with autoclitics prior to the experiment. The experiment took place at three settings: 1) a play area within a classroom, 2) at one of the tables at the same classroom, and 3) the hallway. Different toys were available at play areas and tables. There were bulletin boards in the hallways decorated with colorful themes (e.g., trees). Plastic chips in different colors were used to reinforce tact responses during token condition. The dependent variable was the frequency of tacts emitted during the experimental sessions.

Each session lasted five minutes. Two conditions were alternated in these sessions: adult attention and tokens. During adult attention condition, the experimenter delivered a vocal praise. During token condition, the experimenter delivered plastic chips following emission of tacts without any vocal praise. The experimenter also refrained from responding vocally to questions or mands the participants made during tact condition to avoid social reinforcement. The experimenters also measured IOA in 11 to 44% of sessions for each participant. The mean IOA for the participant with ASD was 93.8%.

The research team found that the frequency of tacts during the adult attention condition was higher than token condition for the participant with ASD and the remaining three children. However, the experimenters noticed that the effect of adult attention on emission of tacts was smaller in the two children with disabilities as compared to the remaining participants who were typically developing. The study has two possible limitations. First, the increase in frequency of tokens was possibly due to carryover effects that were not controlled in the experiment. Second, the tacts that the participants emitted during structured play were usually directed to self (i.e., self-talk) rather than adults or peers. That is, the listeners during structured play were the speakers themselves. The experimenters suggested that this could explain the variability in tacts emitted during structured play. Third, the noise-generating toys the participants played with during free play. The experimenters suggested that these toys probably reduced the participants' willingness to speak during free play.

Jimenez-Gomez et al. (2019) used a multiple probe design across submatrices to examine the effect of matrix training on developing recombinative generalization of tacts in three toddlers with ASD. Matrix training is an intervention procedure in which stimuli are assigned to rows and columns. The intersection of these rows and columns creates new combinations of targets. For example, the matrix might include rows of subjects (e.g., boy, girl) and columns of verbs (e.g., running, drawing). The initial targets in this matrix are “boy running” and “girl drawing”. Upon reaching the mastery criterion for these two targets, the learner will demonstrate novel combinations such as “boy drawing” and “girl running”. The participants in the experiment were three toddlers under the age of 3 years. The participants had been receiving EIBI at the onset of the experiment. At the outset of the study, all three participants had tacts and strong echoics as measured by VB-MAPP (Sundberg, 2008). The experimental sessions took place at the same room in which participants typically received their EIBI services. To tech the target tacts and probe the generalization stimuli, the experimenters used a variety of toys and figurines. The main dependent variable was the percentage of correct tacts. The target tacts were combinations of nouns and verbs. A tact was recorded as correct if it was emitted within 5 s of presenting the stimulus and included both the accurate name and verb.

A baseline probe was conducted to determine the items that were selected as initial targets. The experimenters excluded stimuli that were tacted correctly in more than 60% of trials during baseline probe. Training involved presenting the item (e.g., airplane) and performing an action (e.g., flying) while asking the question "What is it doing?". The experimenters provided immediate vocal prompts that were delayed systematically depending on predetermined criteria. Correct tacts resulted in reinforcement (i.e., praise and preferred item), whereas the incorrect ones were followed by error correction. Upon mastery of each submatrix, the experimenter tested the generality to responses that were not included in the initial training. Remedial training was delivered if recombinative generalization was not observed in some stimuli. Training was initiated again for the submatrix B. Generalization probe was also conducted for stimuli of submatrix B that were not included in initial training. The same procedures were followed for matrix 2. The experimenters calculated the percentage of IOA for two participants. The percentage of IOA for those two participants ranged from 96.25% to 100%.

The research team found that all participants demonstrated recombinative generalization upon demonstrating mastery of initial targets. However, the authors were not sure if highly preferred items have facilitated acquisition for two participants or not. For example, there were two participants who demonstrated faster acquisition of target stimuli in the second matrix which involved more preferred items.

Systematic Review I: Discussion and Summary of Results

Efficacy of Interventions

The findings of the reviewed studies suggest that all 43 participants acquired or increased tacts successfully. However, the participants varied in their performance. Some participants demonstrated an increase in tacts after receiving the instruction, but they could not reach mastery (e.g., Kelly & Holloway, 2015; Lorah & Parnell, 2017). Research teams that compared two or more manipulations made different conclusions about the superiority of particular interventions. For example, Kodak and Clements (2009) found that mixed training was superior to tact-only training. On the other hand, Sidener et al. (2010) found that mixed training was not superior to tact-only training. However, it is not possible to determine if confliction of findings exists across all comparative studies due to the limited number of studies included in this review. For instance, Eby and Greer (2007) found that adult attention was more effective than tokens in increasing tacts for a child with ASD. However, it was not possible to verify whether other research teams made similar or different conclusions because it is the only experiment in this review in which adult-mediated social and nonsocial reinforcers were compared.

Target Tacts

Tacts evoked solely by nonverbal stimuli are known as *pure tacts*, whereas those evoked by a combination of verbal and nonverbal stimuli are known as *impure tacts*. Teaching pure tacts is important, as typically developing speakers tact the visual and nonvisual events without a verbal stimulus such as “What is this?” However, Sundberg and Partington (1998) warned against the complete fading of verbal stimuli during tact instruction because impure tacts occur in natural environments as well. For example, a science teacher evokes impure tacts when she points to a picture of a crocus and asks, “What flower is this?” In this review, five research teams (27.78%) addressed pure tacts only, 9 teams addressed impure tacts (50%), and four teams addressed both pure and impure tacts. Accordingly, it is unknown if participants in experiments in which pure tacts were solely taught could emit these tacts when a verbal stimulus is used. Similarly, it is unknown if participants who learned impure tacts could emit them when nonverbal stimuli were presented alone. One of the four studies (i.e., Lalonde et al., 2020) in which both pure and impure tacts were taught, involved a comparison of tact acquisition with and without verbal stimulus. Lalonde et al. (2020) found that both conditions were effective in increasing tacts. Due to the limited number of participants in Lalonde et al.'s experiment, further comparisons are needed to confirm if these two conditions are both effective in teaching tacts.

Generalization and Maintenance

Generality of behavior change is one of the seven dimensions of ABA (Baer et al., 1968). Generality of behavior change is confirmed when the target behavior is emitted across time (i.e., maintenance), environments, and responses (Baer et al.,1968; Stokes & Baer, 1977). Generality across time (i.e., maintenance) means to continue demonstrating the behavior after the withdrawal of intervention. Generality across environments means to demonstrate the learned behavior in settings other than the instructional settings. For example, a child greets peers in the hallway and cafeteria after they learn how to greet peers in the classroom. Generality across responses means to demonstrate responses that are functionally equivalent to the target response. For example, the child demonstrates different ways to greet peers (e.g., hey, hello) after learning one form of response (e.g., hi). While all participants successfully increased their tacts during the reviewed experiments upon receiving different manipulations, it is unknown if all participants were able to generalize the acquired tacts across novel settings, people, and stimuli. Similarly, it is unknown if all participants were able to maintain the acquired tacts for an extended period of time after the dismissal of intervention. Ten research teams (55.56%) only reported generalization outcomes. However, none of these teams assessed generality of tacts across the three facets of generalization: Time, environment, and responses. These ten research teams measured generalization of tacts across novel settings/contexts (n= 6), stimuli (n= 5), and novel combinations of familiar stimuli (n= 1). Therefore, generality in these ten experiments was partially confirmed. Overall, generalization outcomes were positive with some variability among participants in some studies (e.g., Hanney et al., 2019; Lalonde et al., 2020). It is important to note that generality of tacts was not confirmed in some studies because generalization probes were conducted after the intervention only (e.g., Duenas et al., 2019; Kelly & Holloway, 2015). Measuring generalization of response before intervention is the only objective way to verify that the performance of learners after intervention is a generalized outcome (Cooper et al., 2007). It is of interest to note that experiments in which verbal stimuli were used to evoke impure tacts did not include a variety of questions throughout the experiment. Therefore, it is unclear if the participants would emit the impure tacts they acquired when the same visual stimulus is presented but a novel question is asked (e.g., "What is it?" Instead of "What's this?"). In addition, only one research team (Jimenez-Gomez et al., 2019) assessed and planned for response generalization. Because of this gap, it is unclear if participants in most studies could emit multiple exemplars of the responses they learned (e.g., airplane, aircraft, jet). In terms of generality across time (i.e., maintenance), follow-up probes were conducted in 8 studies only. These probes varied from 1 to 7 weeks. Overall, the outcomes of maintenance were positive.

Stimuli Used to Evoke Tacts

Seventeen studies (94.4%) used visual stimuli (e.g., pictures, objects) to elicit tacts, whereas nonvisual (i.e., auditory) stimuli were used to elicit tacts in one study (i.e., Hanney et al., 2019). Visual items are not the only stimuli of tacts. Tacts can also be elicited by objects, events, or their properties (Skinner, 1957). These events can be visible (e.g., pictures) or invisible (e.g., sounds, pain, scent). Due to the limited research on nonvisual tacts, it is unclear if procedures used in most experiments included in this review are also effective in teaching nonvisual tacts.

Consequences

As mentioned earlier, teaching tacts to children with ASD can be difficult because tacts are reinforced by social non-specific stimuli which do not serve as reinforcers for many children with ASD (Axe & Laprime, 2017; LeBlanc et al., 2009). Apparently, tacts were not solely reinforced by social stimuli in all experiments as Skinner's definition of tact (Skinner, 1957) implies. Social reinforcers such as praise, clapping, and acknowledgement were used as the only consequences for correct tacts in 8 (44.4%) of the 18 reviewed studies. Social reinforcers were combined with access to preferred items, activities, or edibles in seven (38.9%) experiments. One research team (i.e., Fiorile & Greer, 2007) did not specify how correct tacts were reinforced. Another research team (i.e., Eby & Greer, 2017) compared adult attention with delivering plastic chips upon emitting correct tacts and they found that more tacts were emitted when adult attention was given. Interestingly, Kelly & Holloway (2015) made reinforcement available only for on-task behaviors during the behavioral momentum. That is, no reinforcement followed the correct tacts. The reinforcement used for on-task behavior has probably contributed to the increase in tacts. Overall, using either social reinforcers alone, or a combination of social and nonsocial (e.g., tangibles) reinforcers were effective in increasing tacts. However, it is unclear which of the following arrangements is the most effective in establishing, maintaining, and generalizing tact repertories among young children with autism: a) social reinforcers only, b) a combination of social and nonsocial (e.g., tangible) reinforcers, and c) tangible reinforcers only. Further comparative studies similar to Eby and Greer (2007) are needed to examine the efficacy and efficiency of each arrangement.

Social Validity

Evaluating social validity of interventions is important to determine the extent to which the intervention is acceptable from the consumer's perspective. The social validity assessments are important to determine the level to which the intervention is viable (Schwartz & Baer, 1991). That is, the consumers are less likely to continue using the intervention in future if it does not satisfy them (e.g., difficult to implement, time-consuming, expensive). Social validity data are necessary to make changes to the intervention or to change the consumers' opinion about it (Schwartz & Baer, 1991). In this review, however, social validity was evaluated in three studies only. Social validity data were collected from educators not involved in implementation (i.e., Duenas, 2019), parent implementers (i.e., Pisman & Luczynski, 2020), and therapist implementers (i.e., Dell'Aringa et al., 2021). None of the three research teams evaluated the three facets of social validation: a) acceptability of treatment package, b) social significance of target behaviors, and c) importance of intervention outcomes (Wolf, 1978). Social validity assessments in these three studies were mainly focused on assessing the acceptability of intervention procedures. However, the social validity survey in Pisman and Luczynski's study (2020) addressed the change in parents' interaction with their children as an indirect outcome of the training package. It is important to note that none of these studies assessed social validity from the perspective of children who received tact instruction.

Settings

Two thirds (*n*= 12) of the reviewed studies were conducted in natural settings (e.g., home, preschool), whereas the remaining six experiments were conducted in clinical (*n*= 5) and research (*n*=1) settings. It is unknown if participants in these six experiments demonstrated the acquired tacts across natural settings (e.g., home) and agents (e.g., parents) as children with ASD have difficulties with generalization (Gunning et al., 2019; Neely et al., 2016).

Implementers

Eleven studies (61.1%) were conducted by experimenters. Parents were involved in implementation in one study only, despite the important role that families can play in learning. Family involvement facilitates generalization and the overall success of intervention (Burrell & Borrego, 2012; Koegel & Koegel, 2006; Symon, 2001). Six studies were conducted by instructors or therapists. The qualifications and background of those instructors and therapists were not reported in most experiments.

Tact Repertoires of Participants and Their Learning Histories

The majority of participants (*n*= 29, 67.4%) were familiar with behavior analytic procedures and verbal behavior contingencies prior to experiments. The learning histories of those participants have possibly facilitated acquisition of tacts. Hence, it is unclear if the same interventions would result in comparable outcomes when used with children who were not familiar with behavior analytic procedures. The remaining participants (*n*= 14, 32.6%) were either: a) had no behavior analytic services prior to experiment, b) enrolled in early intervention programs, received speech therapy, or attended classrooms for children with developmental disabilities but it is unclear if the services they received were behavior analytic, or c) their previous learning histories were not described.

More than two thirds of participants (*n*= 30, 69.7%) either had tact repertoires or histories of tact instruction prior to tact instruction. Some participants had repertoires of 100-300 tacts (e.g., Cengher & Fineup, 2020) prior to tact instruction. It is possible that tact repertoires of these participants and/or previous attempts to teach tacts have facilitated acquisition of new tacts.

Accordingly, it is unclear if these interventions are also effective for learners with extremely limited or absent tact repertoires. The remaining participants (*n*= 13, 30.2%) either had no tacts or naming capability, or their tact repertoires at the outset of the experiments were not reported.

Systematic Review I: Conclusion and Future Directions

This systematic review found that different arrangements were successful in teaching tacts to 43 young children with ASD. However, the reviewed literature encompasses some limitations. It is important to address the following limitations in future research: 1) measuring the generality of acquired tacts prior to and following tact instruction across the three facets of generalization identified by Stokes & Baer (1977), 2) teaching multiple stimulus and response exemplars, 4) examining the efficacy of teaching nonvisual (e.g., auditory, tactile) tacts, 5) future research should evaluate the three facets of social validation identified by Wolf (1978), and 6) more research on interventions implemented by natural agents (e.g., families) and in natural settings (e.g., home).

Using Multiple Exemplar Training to Teach Tacts and Naming to Children with ASD: Systematic Review II

Systematic Review II: Overview

In the previous systematic review, it was found that only 5 (28%) studies measured generality across novel stimuli. One research team (Hanney et al., 2019) measured generality across novel combinations of familiar stimuli. While measuring generality across novel stimuli prior to and after instruction is necessary, and the only way, to verify that intervention has resulted in generalization (Cooper et al., 2007), attempts to facilitate generalization during instruction should be made. This is especially important for children with ASD due to a common learning problem among this population known as *overselectivity* (Lovaas et al., 1971).

Overselectivity refers to demonstrating a narrow attending pattern (Dube et al., 2016), or a limitation in the number of stimuli or features of stimuli a learner pays attention to and learns (Dube & Wilkinson, 2014). For example, if the learner is being taught to discriminate between a red chicken and frog, the learner will probably fail to identify a white chicken in future because he focused on redness of feathers rather than the whole physical features of the chicken (e.g., comb, beak). One way to increase the number of stimuli that elicit the target behavior for learners with autism is *multiple exemplar training* (Stokes & Baer, 1977). This training involves teaching *sufficient exemplars* of the stimulus. This is especially important for tact instruction, as stimuli include a wide variety of features (e.g., sport car, sedan car, hatchback car). Generalization involves another facet known as *response generalization* (Cooper et al., 2007; Kazdin, 1994; Skinner, 1953). Response generalization refers to generating new responses that serve the same function of the original response. For example, emitting equally functional responses (e.g., cat, kitty, kitten) when a picture of cat is presented.

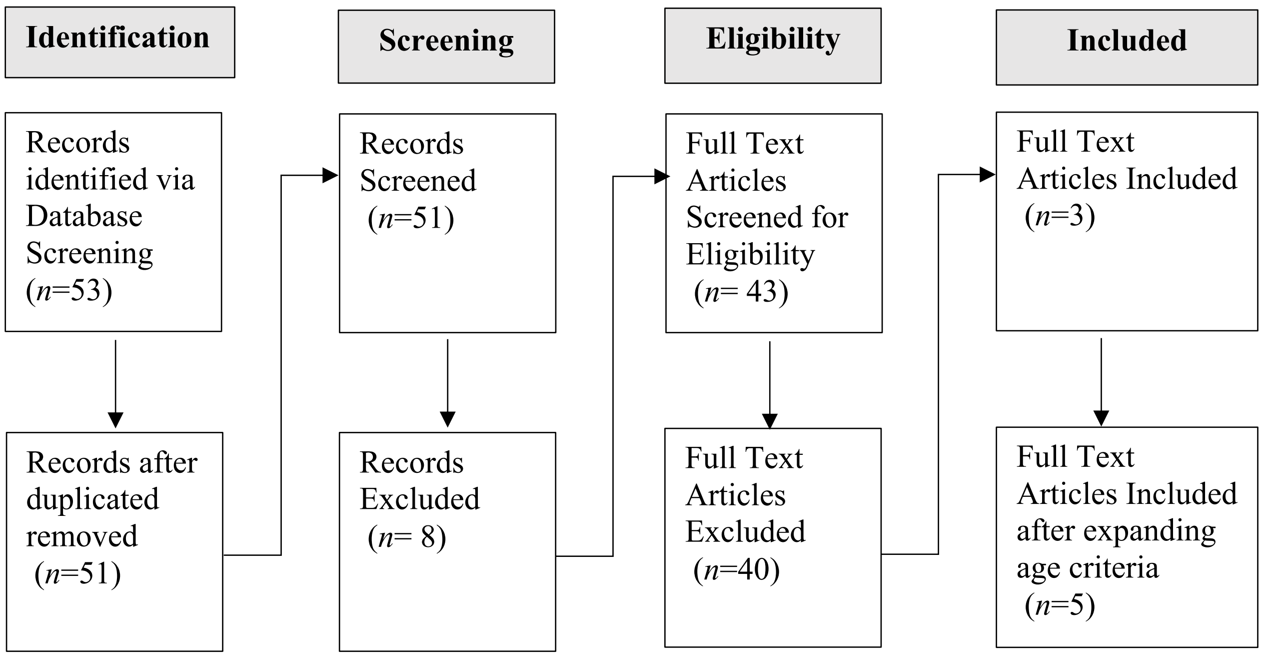
In the previous systematic review, a few experiments involved explicit teaching of multiple exemplars of stimuli. One research team only (i.e., Jimenez-Gomez et al., 2019) measured and planned for response generalization. Due to the importance of establishing a generalized tact repertoire and the small number of reviewed studies in which MET was incorporated with tact instruction, further evidence on the efficacy of this training is needed. The present systematic review aims to synthesize research in which MET was used in tact instruction for young children with ASD. Specifically, it aims to answer these two questions: 1) what MET arrangements were made to enhance stimulus and response generalization of tacts to young children with ASD? and 2) what are the outcomes of acquisition, generalization and maintenance in the reviewed literature?

Systematic Review II: Search Process

A four-step process (see Figure 3) was followed to locate and review studies in which multiple exemplar training was used to teach tact to children with ASD. The first step is *identification*. This step included conducting a combined electronic search using the following keywords: *"multiple exemplar training"* and "*autism*" or "*ASD*" or "*autism spectrum disorder*" or "*asperger's*" or "*asperger's syndrome*" or "*autistic disorder*" or "*aspergers*". The combined databases were: Academic Search Premier, Education Full Text, ERIC, and PsychINFO. The following filters were applied in the combined search: English and scholarly (peer-reviewed) journals. After removing duplicates, this search resulted in 51 articles. The second step was *screening*. During this step, the records were screened to verify their relevance to the topic of the research by reading the title and abstract of each record. This step resulted in including 43 records. The third step was *eligibility* in which the 43 records were screened in full to determine eligibility. Records were considered eligible if they met the following inclusion criteria: 1) published in English, 2) experimental research, 3) included participants with ASD, 4) examined multiple exemplar training on acquisition of tacts or naming, and 5) participants raged from zero to 59 months. This process resulted in 3 records. Due to the small number of records, the age criterion was extended to 18 years. This resulted in two additional records. The last step was reviewing and summarizing these 5 records in one matrix. The matrix involved the following information about each record: A) purpose and/or research questions, B) characteristics of participants, C) implementer, D) experimental design, E) experimental settings, F) materials, G) dependent variables, H) type of tact (i.e., pure, impure), I) independent variable, J) treatment procedures, K) type of consequence (i.e., reinforcement), L) findings, M) generalization, N) maintenance, O) social Validity, and P) limitations.

Figure 3

Four-Step Search Process



Systematic Review II: Results

The reviewed studies were categorized into three themes: 1) Multiple Exemplar Training (MET), 2) Multiple Response Exemplar Training (MRET), and 3) Serial vs. Concurrent MET.

Systematic Review II: Strand I: Multiple Exemplar Training

Dass et al. (2018) used an adapted alternating treatment design to examine the effect of a treatment package consisted of echoic prompts, prompt delay, error correction, addition of secondary targets, and MET on the acquisition of olfactory tacts, emergence of category matching, emergence and generalization of category tacts. The participants were three children with ASD ranged in age from 5 to 6 years. Prior to the experiment, all three participants had robust tact and echoic repertoires and they were able to tact visual stimuli as indicated by

Expressive Vocabulary Test (EVT; Williams, 1997), Peabody Picture Vocabulary Test- Fourth Edition (PPVT-4; Dunn & Dunn, 2007), and VB-MAPP (Sundberg, 2008). All experimental sessions were conducted at the experimenter's office. To teach target olfactory tacts, the experimenter used cotton balls saturated in scented oil. The scents were from four categories: citrusy (e.g., Orange), fruity (e.g., Watermelon), stinky (e.g., Nail polish), and yummy (e.g., Chocolate). The experimenter identified three favorite edibles for each participant in preference assessment. These edibles were used as reinforcers during training. The dependent variable was the percentage of trials in which the participant emitted correct tacts of olfactory items, categories, novel categories (i.e., generalization), and category matching. The response was recorded correct if it was emitted within 5 s of presenting the scent and the verbal instruction (e.g., What is it?).

In addition to the aforementioned preference assessment, the experiment was preceded by parent interviews and pretest. The parental interview involved asking the parents about the skills of their children, compliance, verbal operants (e.g., intraverbals), food allergies, preferences, and tacting nonvisual items. The pretest was conducted to determine if participants could tact the target scents prior to the experiment. During pretest, the experimenter presented each target scent and asked the participant "What is it?" to probe tacts of target items. To probe the category tacts, the experimenter asked the participant "How does it smell?". During these probes, the scented cotton ball was placed approximately 1.5 to 2 centimeters from the child's nose. Baseline sessions were conducted to ensure that participants did not learn the target tacts of items or categories prior to experiment. Baseline sessions were similar to pretest. Correct or incorrect response were not reinforced or corrected during baseline sessions. Training sessions were similar to baseline except the vocal prompts that were immediately presented after the question.

Echoing the response was followed by praise, token, and a secondary target (e.g., Watermelon smells fruity). The echoic prompt was repeated when no response was emitted within 5 seconds. After two sessions, the echoic prompts were delayed from 0-s to 5-s. During 5-s prompt delay, tokens were awarded for independent responses only. The control condition involved probing non-target items. Procedures of control condition were similar to baseline. The experimenter also probed category tacts. These probes were similar to baseline in which the experimenter presented a target scent and asked, "How does it smell?". Correct and incorrect responses were not reinforced or corrected. Subsequently, category matching was probed in which one scent was presented to the participant at a time. After presenting the scent (e.g., Lemon), the participant was asked to select another scent that falls under the same category (e.g., Orange). Maintenance of item and category tacts was probed two and four weeks following the termination of training. Maintenance sessions were similar to baseline. Ten parents and instructors were asked to observe training and complete treatment acceptability rating form (TARF-R; Reimers & Wacker, 1988) in order to obtain social validity ratings about the interventional package. Interobserver agreement (IOA) and procedural integrity were also measured in 33 and 100% of experimental sessions, respectively. The mean percentage of IOA ranged from 94 to 97% across the three participants, whereas the procedural integrity ranged from 98 to 100% across the three participants

The findings of the experiment were as follows: First, all participants demonstrated acquisition of tacts of olfactory items (e.g., lemon) following training. Second, all participants demonstrated category tacts (e.g., fruity) following training. Third, generality of category tacts was evidenced across the three participants. Fourth, emergence of category marching was demonstrated across the three participants. Fifth, all three participants maintained their performance at mastery level for item and category tacts and generality target at 2- and 4-week follow-up probes. The authors suggested that echoing the secondary targets contributed to acquisition of related responses. They also suggested that covert tacting facilitated acquisition of intraverbal responses. For example, emitting the intraverbal response “fruity” following the question “How does it smell?” was preceded by silently tacting the item (e.g., cherry). The study encompasses some potential limitations. First, training items (i.e., 8) and generalization items (i.e., 2) were not equal. Second, the study was not conducted in a natural setting. Third, the olfactory stimuli used throughout the experiment were not natural. Fourth, the impact of MET on the efficiency of training is unknown as researchers did not compare efficiency of training with and without multiple exemplars. Fifth, the experimenter used the verbal (e.g., what is it?) along with nonverbal (e.g., scents) stimuli throughout the experiment. Accordingly, the source of control for the target responses is unknown. In other words, it is unknown if tacts of items and categories were solely or multiply controlled by verbal and nonverbal stimuli.

Using a concurrent multiple-baseline across three subjects design, Schmick et al. (2018) examined the effect of a training package consists of video-based scenario, prompts, and multiple exemplar training (for one participant) on tacting private events of others (e.g., happy, sad) for three adolescents with ASD. The three participants ranged in age from 13 to 17 years. Prior to experiment, the three participants were assessed using PEAK-Transformation pre-assessment (PEAK-T-PA). The pre-assessment results indicated that all three participants possessed the three types of relations of the coordination relation frame. These types were arbitrary, non-arbitrary, and cultural. The authors mentioned that all three participants had developed verbal repertoires without further details. The experiment took place at an empty classroom in absence of non-participants. To teach tacts of private events, the experimenters who were trained graduate students used six novel video-based scenarios. These videos represented four private events: angry, excited, happy, and scared. The experimenters used preferred items as reinforcers (i.e., edibles, iPad™). The dependent variable was the percentage of correct responses the participants emitted within each trial block which consisted of 8 trials.

During baseline, the experimenters tested four types of relations. The first relation was AB. This relation consists of watching a short video (e.g., A relation) and telling what's happening in the video (i.e., B relation). For example, the participant viewed a video of a person crying at a wedding (i.e., A relation) and was asked to tell the experimenter what was happening in the video (i.e., B relation). The second relation was BC in which the participant was told what is happening (i.e., B relation) without viewing the video (e.g., if a person is crying at a wedding), then was asked to tact the feeling of that person (i.e., C relation). The third relation was AC in which the participant was asked to tact the feeling of the person who appeared in the video crying or engaged in any other private event. The fourth relation was YZ. The YZ relation represented transformation of stimulus function. For example, the experimenter told the participant that she felt angry and she was screaming. The participant was asked to tell where the experimenter was (e.g., football game) when she felt angry and she was screaming. During baseline probe, neither reinforcement for correct responses nor error correction for incorrect ones were presented. The preferred items (e.g., edibles, iPad™) were only delivered upon completion of the trial block. Relational frame training was similar to baseline except the delivery of praise for correct responses and prompts for incorrect ones. It is important to note that relational training was limited to AB and BC relations. Each participant had to master AB relations first before receiving training on BC relations. The AC and YZ relations were probed with training relations (i.e., AB, BC) as in baseline in between AB and BC training. These relations were probed again after BC training. A maintenance probe that was identical to baseline was conducted two weeks after the last training trial for the three participants. Because one of the participants could not reach the mastery level (i.e., 80% of correct responding in three consecutive 8-trial blocks) for all relations after AB and BC training, a multiple exemplar training (MET) was needed for that participant. Prior to MET, the experimenters probed the novel items they planned to use in MET following procedures identical to baseline to confirm the novelty of these items. The novel items used in MET were two videos represented two novel private events: Excited and scared. The participant was noncompliant throughout the experiment. Accordingly, the experimenters changed the magnitude of reinforcement. The percentage of IOA was measured in 65% of all experimental trials, whereas the percentage of treatment fidelity was measured in 80% of all experimental trials. The average IOA for the three participants was 100%, whereas the average procedural fidelity was 100%.

The following were the findings of the experiment: First, two participants were able to meet the mastery criterion for the four relations after relational frame training for AB and BC relations. They were also able to remain at mastery level for the four relations two weeks after the last training trial. Second, the remaining participant was able to meet the mastery criterion for the four relations after receiving MET. The study encompasses some potential limitations. First, the results of this experiment have limited generality to learners with ASD who have limited verbal repertoires as all three participants in this experiment had developed verbal abilities. Second, the target relations were not assessed in real-life contexts. Third, the effect of MET on acquisition of the four relations was not assessed for all participants. Fourth, the experimenters did not examine the impact of changing the magnitude of reinforcement during MET on performance.

Welsh et al. (2019) used a multiple-baseline-across-subjects design to examine the effect of a training package consisting of MET, error correction, and reinforcement on tacting what others are sensing in natural environment for three children with ASD ranged in age from four to eight years old. Prior to the experiment, the three participants had been receiving home-based EIBI for 15 to 30 hours per week. At the outset of study, the three participants performed at level three on VB-MAPP (Sundberg, 2008). They we are able to produce full sentences, tact the target stimuli (e.g., TV, book), respond to questions that included pronouns (e.g., what can I see?) and names of familiar persons (e.g., what can (person's name) see?), and tact stimuli they sensed when asked (e.g., what do you taste?). All experimental sessions took place at different places of participants' homes (e.g., kitchen, backyard). The materials that the experimenters used were a wide range of stimuli such as foods, toys, household items, sounds, and clothes. The dependent variable was the percentage of tacting correctly what others were sensing when the participant was asked "What could (person's name) see/hear/feel/smell/taste?". The response was recorded correct if it was emitted within 5 of presenting the question.

During baseline probe, the experimenter asked the participant to tact what the target person (e.g., what can (person's name) hear?) or the experimenter (e.g., what can I feel?) was sensing. Neither reinforcement nor error correction was provided for correct or incorrect responses. The stimuli used in baseline and training were not similar. Similarly, people involved in baseline and training were not the same. Procedures followed during training were similar to baseline with except the social praise and preferred items delivered for correct responses and error correction for incorrect ones. The experimenter introduced two senses (i.e., see and taste) to the first session. Meeting the mastery criterion of 80% correct responding was required to introduce an additional sense (i.e., feel) to the next session. The same criterion was required to introduce the fourth (i.e., hear) and fifth (i.e., smell) senses. Upon achieving the mastery criterion for the five senses, the experimenters initiated the novel person probe. It is important to note that praise and preferred items were delivered on a continuous schedule of reinforcement (CRF) during training and novel person probe. However, the reinforcement was thinned into variable ratio schedule (i.e., VR-3) when participants met the mastery criterion at novel person probe. Post-training probe was similar to baseline. The same people and stimuli involved in baseline were introduced to post-training probe. The experimenters measured the percentage of IOA on 84 to 88% of all experimental sessions for the three participants. The average IOA ranged from 98.9 to 100% for the three participants.

The findings of the experiment were as follows: First, all three participants were able to increase the percentage of correct tacting of what others were sensing across the five senses after receiving the training package. Second, the three participants demonstrated generalization across novel stimuli used at post-training probe. Third, generalization to non-training people was also observed across the three participants at post-training probe. Fourth, all three participants met the mastery criterion at novel person probe. Fifth, they all maintained mastery of target tacts when reinforcement was thinned into VR-3 schedule. The study encompasses two potential limitations. First, absence of treatment integrity data. Second, lack of control in teaching tacts of what others were hearing. In other words, it is possible that participants were simply tacting what they were hearing when they asked, “What can (I/person’s name) hear?” as the participant and the target person were hearing the same sound.

Systematic Review II: Strand II: Multiple Response Exemplar Training (MRET)

Olaff et al. (2017) used a nonconcurrent multiple-probe-across-subjects design to examine the efficacy of multiple response exemplar training (MRET) on acquisition of full repertoire of naming which consists of speaker and listener responses for three preschoolers with autism. The participants ranged in age from 5 to 6 years. Two participants had been receiving EIBI prior to the experiment. At the outset of the study, all three participants demonstrated mastery of matching-to-sample (MTS) tasks, echoic repertoire, compliance (e.g., following instructions), 15-20 pure tacts, and 15-20 impure tacts. All experimental session took place at participants' kindergartens. To teach the target skills, the experimenters used five sets of pictures for each participant. Each set consisted of five pictures. Tangibles (e.g., toys) were given to participants during breaks. Multiple responses exemplar training (MRET) is a variation of MET in which the instructor presents multiple responses classes during training. For example, the instructor presents a visual stimulus and asks the learner to tact it, then the instructor places the visual stimulus among an array of pictures and tacts it vocally to the learner in order to obtain a listener response (e.g., pointing). Naming, the main dependent variable in this experiment, consisted of four skills. The first skill was pure tact which is evoked solely by the visual stimulus (i.e., picture). The second skill was impure tact which is evoked by verbal (e.g., What is this?) and nonverbal (i.e., picture) stimuli. The third skill was the listener component of naming which involved pointing to the stimulus tacted by the experimenter. The fourth skill was echoing tacts emitted by adults during MTS tasks. However, echoing was not a target skill because it was a prerequisite for participating in the experiment.

To assess the novelty of target stimuli, the experimenters tested each participant's ability to identify the pictures used in the experiment as a speaker and listener. Naming was probed for all participants during baseline. Baseline probes were preceded by pretraining which involved teaching echoics during MTS tasks. During MTS tasks, the experimenter placed five pictures (i.e., comparisons) on the table, presented one picture as a stimulus, then tacted the verbal stimulus. The participant was required to match the stimulus to the comparison and echoed the tact the experimenter emitted. Probes of novel speaker responses included pure and impure tacts. Pure tacts were probed by presenting a picture and waiting the student for 6 s to emit a tact. Impure tacts were probed by presenting a picture and asking the student “What is this?”. Listener responses were probed by placing four pictures on the table and asking the student to point to one of them. In MRET, the experimenters rotated the four response classes (i.e., MTS with echoics, pure tacting, impure tacting, pointing to responses). Namely, the participant was asked to match the first visual stimulus; then he was taught to emit a pure tact evoked solely by the second stimulus. Subsequently, the participant was taught to emit an impure tact which is evoked by the third verbal stimulus and the question “What is this?”. Thereafter, the experimenter asked the participant to point to the fourth stimulus which was placed in an array of four pictures, whereas the fifth stimulus was tacted and presented to the participant in order to match it to a sample. It is important to note that each stimulus in the picture set was trained among the four response classes. The training was delivered in a discrete trial format. The experimenters used tokens and social rewards (e.g., praise, smile) as reinforcers during training. Emission of incorrect response or failure to respond within 6 s of presenting the stimulus resulted in repeating the trial and providing prompts (i.e., verbal, gestural) that were faded systematically. The experimenters measured the percentage of IOA in 47% of all sessions and treatment integrity in five sessions that were selected randomly. The mean percentage of IOA was 98% for all participants, whereas the percentage of treatment integrity ranged from 93 to 100% for the three participants.

The results of the experiment were as follows: First, one participant only developed full naming repertoires at post-training probes of naming for two picture sets. However, one of the participants developed full naming repertoire for one picture set, whereas the third participant could not acquire the full naming repertoire. Second, all three participants acquired the listener component of naming. The authors suggested that the modest performance of the third participant was due to frequent noncompliance behaviors (e.g., crying) and lack of instructional history similar to the other two participants who had been receiving EIBI prior to the experiment. The study encompasses two possible limitations. First, the source of control over responding in MTS tasks is undetermined. In other words, it is unknown if responding during MTS tasks was under the control of verbal stimuli, the vocal tacts emitted by the experimenters, or both. Second, it was not possible to isolate the effects of MRET from the effect of post-training naming probes on responding due to the design used in the experiment. However, the authors suggested that MRET contributed to behavior change as responding during post-training probes were higher than pretraining probes.

Systematic Review II: Strand III: Sequential and Concurrent Multiple Exemplar Training

The other two variations of MET are serial MET (S-MET) and concurrent MET (C-MET). Serial MET involves presenting one exemplar of the target stimulus at a time, whereas the other exemplars are probed after training to test for generality of responding. Concurrent MET involves presenting multiple exemplars of each target stimulus simultaneously during training, whereas the non-training exemplars are used to test for generality of responding. Schnell et al. (2018) used an adapted alternating treatments design to investigate the effects and efficiency of three treatments: a) Serial-MET (S-MET), b) Concurrent-MET (C-MET), and c) Instructional feedback (IF) for three children with ASD ranged in age from 4 to 8 years old. Prior to the experiment, all three participants had been receiving 30 hours of behavior analytic therapy. At the outset of the study, all three participants had mand, tact, echoic, intraverbal, and listener repertoires as measured by VB-MAPP (Sundberg, 2008). All experimental sessions took place at a classroom in absence of nonparticipating students. The dependent variables were the percentage of correct independent and prompted tacts and session duration in each of the following conditions: C-MET, S-MET, IF, and control. To teach target tacts and probe generalization and control ones, the experimenters used 5 sets of pictures for each student. Each set consisted of three targets with three exemplars for each target. Targets were determined in a pretest.

During baseline sessions, the experimenter held up the picture, asked "What is it?" and waited 5 s for the participant to emit a tact. Neither correct nor incorrect responses were followed by feedback. During S-MET condition, the experimenter held up one exemplar of each stimulus and asked the participant "What is it?". The question was immediately followed by an echoic prompt (e.g., Ruler). The immediate vocal prompts were systematically faded into delayed ones (i.e., 5-s prompt delay). Correct responses were followed by praise and tokens. Incorrect responses were followed by error correction in which the trial was repeated. Three exemplars of each target were used to assess generality of responding. The same procedures were followed during C-MET. However, the difference between C-MET and S-MET was in the number of exemplars presented during training and those used to test for generalization. That is, three exemplars of each target were presented during training and one exemplar of each target was used to test for generalization. The instructional feedback condition (IF) involved presenting three targets in each trial: a) One secondary target presented with the antecedent part of the trial, b) One target presented as primary target, and c) A third target was used as an additional secondary target introduced to the consequence part of the trial. For example, the experimenter presented a picture of a secondary target (e.g., wok) and said, "this is a wok". Thereafter, the experimenter presented the picture of the primary target and asked, “What is it?”. Lastly, the experimenter either reinforced the correct response or corrected the incorrect then presented an additional secondary target and tacted it vocally (e.g., This is ginger). Control session was similar to baseline. Control condition aimed to control for confounds such as history and maturation. The experimenter measured the percentage of IOA and treatment fidelity in 33% of all sessions for the three participants. The mean IOA and treatment fidelity for the three participants ranged from 90 to 96% and 99 to 100%, respectively.

The findings of the experiment were as follows: First, all three arrangements (i.e., C-MET, S-MET, IF) were effective in increasing the percentage of correct training and generalization tacts for the three participants. The effects of these arrangements were replicated for one participant. Second, no change was observed in control condition throughout the experiment. Third, S-MET was the most time-efficient treatment for two participants. Fourth, instructional feedback was the most time-efficient for the third participant. The authors made some suggestions to interpret the variability in responding. For instance, they suggested that S-MET was more efficient was more efficient than C-MET because the former is easier than the latter. That is, S-MET was easier because the participant was required to discriminate between three visual stimuli in the training session. On other hand, C-MET was more difficult because the participant had to discriminate between 9 visual stimuli (i.e., three exemplars for each of the three targets) in one session. The authors, however, recommend further replication of their experiment as C-MET was found more efficient than S-MET in previous studies (e.g., Wunderlich et al., 2014). Additionally, previous research (e.g., Reichow & Wolery, 2011) indicated that IF is the most time-efficient strategy. However, IF was the least time-efficient for two participants in this experiment and the most efficient for one participant only. The study encompasses some potential limitations such as absence of maintenance probes and social validity data.

Systematic Review II: Discussion and Summary of Results

This section discusses the outcomes of different MET arrangements used to teach tacts to learners with ASD. The outcomes are discussed in terms of acquisition, generalization, and maintenance.

Outcomes of MET Arrangements

Four arrangements were identified: 1) Multiple Exemplar Training (MET), 2) Multiple Response Exemplar Training (MRET), and 3) Serial MET, and 4) Concurrent MET.

Outcomes of Acquisition. The five reviewed studies included a total of 15 participants ranging in age from 4 to 17 years old. However, the participants who received MET were 13 as this arrangement was not given to two participants in the experiment of Schmick et al. (2018). Those 13 participants were ranging in age from 4 to 13 years at the outset of experiments. Overall, the four arrangements resulted in increased tacts among the participants. Acquisition of tacts, however, varied across participants. This is possibly due to different factors such as preexisting verbal repertoires, previous learning histories, compliance during instruction, and cognitive performance. It is important to note that some participants had robust tacts (e.g., Dass et al., 2018) prior to experiments. In addition, the majority of participants (n= 11, 73.3%) had been receiving behavior analytic services prior to intervention. The verbal repertoires of participants and their previous learning histories possibly facilitated the acquisition of tacts. Hence, it is unclear if the reviewed arrangements are also effective in teaching tacts and/or naming to children with ASD who have extremely limited tact repertoires and those who are not familiar with contingency-based teaching procedures. None of the reviewed experiments involved natural behavior change agents such as parents, siblings, and peers in implementation. Therefore, it is unclear if these MET arrangements are also successful when implemented by natural agents. It is important to note that 4 of the 5 research teams measured impure tacts only, although this operant is frequently evoked by nonverbal stimuli in the natural environment. In addition, the experimenters in 4 of the 5 reviewed studies provided both tangible (e.g., token, preferred item) and social (e.g., praise, smile) reinforcers upon emitting correct tacts. The experimenters in the remaining study (i.e., Schmick et al., 2018) used social reinforcers only after each correct tact, but they delivered a preferred item upon completing each trial block. Accordingly, it is unclear if the participants in these 5 studies could emit the same percentage of correct tacts if social reinforcers were solely delivered.

Outcomes of Generalization. In terms of generalization, all five research teams measured generality of tacts across novel stimuli and/or people. All participants who received generality probes demonstrated tacts evoked by novel stimuli. In one study (Olaff et al., 2017), however, one participant did not tact untaught stimuli. The authors explained the modest performance of this participant by lack of instructional history and noncompliance during training. Olaff et al.'s (2017) study is the only experiment in which response generalization was assessed. Therefore, it is unclear if participants in the other four studies could emit untaught responses varying in both topography and function. It is important to note that no natural stimuli used to evoke target and generalization tacts in most experiments. For example, Dass et al. (2018) used scented oil rather than natural scents to evoke olfactory tacts. Hence, the evidence is insufficient to support the efficacy of the reviewed MET arrangements in facilitating acquisition and generalization across natural stimuli.

Outcomes of Maintenance. Generalization across time (i.e., maintenance) was measured in two experiments only. The participants in these two studies remained at the mastery level at 2- (i.e., Schmick et al., 2018) and 4-week (i.e., Dass et al., 2018) follow-up probes. Maintenance is an important facet of generality in behavior change (Baer, Wolf, & Risley, 1968; Stokes & Baer, 1977). Therefore, further studies are needed to determine the role that MET plays in facilitating maintenance of acquired tacts following the withdrawal of training. Obviously, MET has played a role in facilitating acquisition and generalization of target tacts among participants who received this intervention. For example, one participant in Schmick et al.'s (2018) experiment could meet the mastery criterion only when MET was introduced. The role of MET, however, is still not very clear, as all research teams used MET arrangements as a part of treatment package consisting of different components (e.g., echoic prompts, progressive time delay). Conducting component analysis (i.e., dropout, add-in) in future studies will possibly help with clarifying the role that MET arrangements play in facilitating acquisition and generalization of tacts among children with ASD.

Systematic Review II: Conclusion and Future Directions

The present systematic review found that MET arrangements were generally successful in teaching a generalized tact repertoire among 13 students with ASD ranging in age from 4 to13 years old. However, the reviewed studies encompass some limitations. Future research may extend the findings of the reviewed studies by a) examining the efficacy of the reviewed MET arrangements in increasing tacts among children with extremely limited tact repertoires and those with no previous contingency-based learning histories (e.g., EIBI, VB), b) involving natural behavior change agents such as parents, siblings, and peers in implementation of these arrangements, c) paying more attention to pure tacts as they occur frequently in the natural environment, d) examining the efficacy of these arrangements using social reinforcers only as they are more natural than tangible and activity reinforcers, e) studying both stimulus and response generalization, f) using natural rather stimuli to evoke tacts, and g) examining generalization across (i.e., maintenance).

Using Stimulus Pairing Observation Procedure to Teach Tacts and Naming: Systematic Review III

Systematic Review III: Overview

Horne and Lowe's (1996) naming theory imply that naming is a bidirectional relation between the speaker and listener responses. In other words, acquiring the speaker response (i.e., tact) results in emergence of listener response, and vice versa. For example, when a parent points to the stars in sky and says, 'star,' their child will acquire the name 'star' as a speaker and listener without explicit teaching. In other words, if the parent points again to the star and says, 'What is this?' the child will say, 'star' (i.e., speaker response). Furthermore, if the mother asks her child to find 'star,' they will point to it (i.e., listener response). Conversely, if the mother points to a labeled object, her child will acquire the name as a speaker (i.e., pure or impure tact) and as a listener. The incidental exposure to the item or event and its label will help the child acquire further names in future simply through observing others tacting and without direct teaching capability. Thus, naming is identified as a cusp (Gilic & Greer, 2011).

Respondent-type responding (Leader et al., 1996), more recently known as Stimulus Pairing Observation Procedure (SPOP; Smyth et al., 2006), is a procedure based on the notion that merely pairing stimuli results in emergence of untaught responses. For example, presenting the toy train with its sound. This association helps the child makes the sound of train when the toy train is presented again. What distinguishes this procedure is the straightforwardness and the ease of use (Rosales et al., 2012). Unlike traditional contingency-based procedures which require a response from the learner and a consequence from the teacher contingent on the learner's response, SPOP requires only the instructor to pair the stimuli and the learner to attend to these stimuli. Using SPOP to teach names of items or events mimics natural interactions between caregivers and children (Rosales et al., 2012). That is, caregivers frequently tact items or events in the environment without necessarily eliciting a response from their children (Hart & Risley, 1995). SPOP has been used successfully to teach tacts in English and listener behavior to typically developing Spanish-speaking preschoolers (Rosales, 2012).

Using SPOP to teach tacts to children with ASD was also examined. This review aims to synthesize the literature of using SPOP to teach tact only and/or naming to young children with ASD. Specifically, it aims to answer these two questions: 1) does using SPOP result in acquisition of the speaker component of naming among young children with ASD? and 2) did learners who received SPOP generalize and maintain the tacts they acquired?

Systematic Review III: Search Process

The search process consisted of three rounds. In Round One, a four-step process (see Figure 4) was followed to locate and review studies in which stimulus pairing observation procedure (SPOP) was used to teach tacts or naming to children with ASD. The first step is identification. This step included conducting a combined electronic search using the following keywords: *"stimulus pairing"* and "*autism*" or "*ASD*" or "*autism spectrum disorder*" or "*asperger's*" or "*asperger's syndrome*" or "*autistic disorder*" or "*aspergers*". The combined databases were: Academic Search Premier, Education Full Text, ERIC, and PsychINFO. The following filters were applied in the combined search: English and scholarly (peer-reviewed) journals. After removing duplicates, this search resulted in 42 articles. The second step was *screening*. During this step, the records were screened to verify their relevance to the topic of the research by reading the title and abstract of each record. This step resulted in excluding 8 records. The third step was eligibility in which 34 records were screened in full to determine the eligibility. Records were considered eligible if they met the following inclusion criteria: 1) published in English, 2) experimental research, 3) included participants with ASD, 4) examined the effect of SPOP on acquisition of tacts or naming, and 5) participants raged from zero to 59 months. This process resulted in one record. Therefore, the age criterion was expanded to 18 years. This resulted in 4 additional records. The last step was reviewing and summarizing these 5 records in one matrix. The matrix involved the following information about each record: A) purpose and/or research questions, B) characteristics of participants, C) implementer, D) experimental design, E) experimental settings, F) materials, G) dependent variables, H) type of tact (i.e., pure, impure), I) independent variable, J) treatment procedures, K) type of consequence (i.e., reinforcement), L) findings, M) generalization, N) maintenance, O) social validity, and P) limitations.

Two more rounds (see Figures 5 & 6) were needed to identify studies in which auditory-auditory stimulus pairing have been examined. The criteria of age and diagnosis (i.e., ASD) were removed in order to synthesize studies in which auditory-auditory stimulus pairing was used to teach auditory tacts regardless of age and diagnosis of learners. Round Two resulted in no records, whereas Round Three resulted in three. The studies were reviewed and summarized in the same matrix of Round One.

Figure 4

Round One: Four-Step Search Process

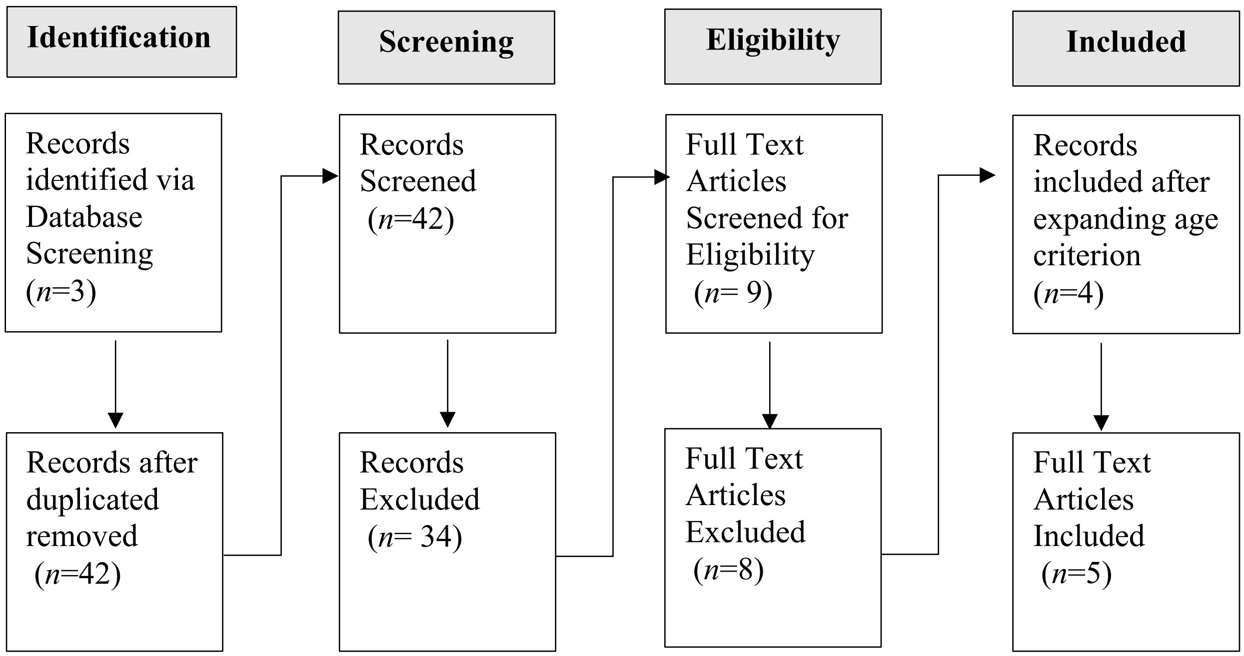


Figure 5

Round Two: Two-Step Search Process

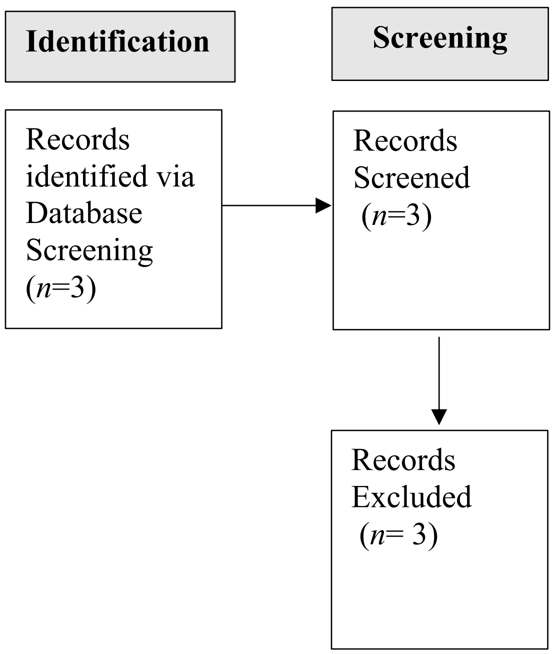
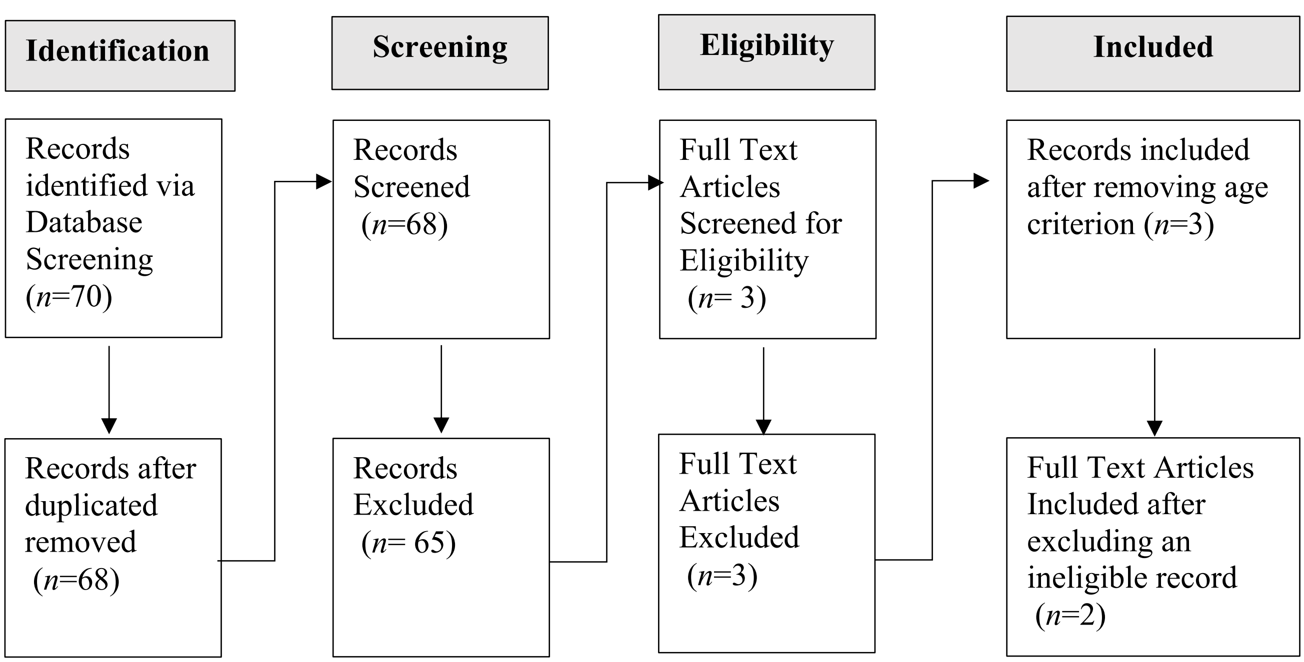


Figure 6

Round Three: Four-Step Search Process



Systematic Review III: Results

The studies identified in the first and third rounds were categorized into two themes: 1) Auditory-visual stimulus pairing, and 2) Auditory-auditory stimulus pairing.

Systematic Review III: ***Strand I: Auditory-Visual Stimulus Pairing***

Byrne et al. (2014) examined the effect of a combination of stimulus pairing observation procedure (SPOP) and multiple exemplar instruction (MEI) on acquisition of tacts and listener responses in three seven-year-old children with autism, using a concurrent multiple probe design across participants. The three participants already had tact, mand, and listener repertoires that are parallel to those of children fall in the developmental stage of 1-48 months, as measured by VB-MAPP (Sundberg, 2008). Tact repertoires of the participants were mainly composed of tacts for classroom objects. The experiment was conducted in the classroom that the participants attended. The experimenters created three unique sets of pictures for each participant. The dependent variables that were percentages of correct tacts and listener responses during pretest and posttest probes.

Tacts were probed prior to SPOP intervention. During these probes, the experimenter held each picture and asked the participant "What is it?", then waited 5 s for the participant to respond. Listener responses were also probed by presenting an array of three pictures and asking the participant to point to a particular one. Correct responses were not reinforced, and incorrect responses were not prompted or corrected during the probes. However, the experimenters delivered one token every 30 seconds to reinforce proper attending during the probes. SPOP sessions involved pairing verbal (i.e., tact) and nonverbal (i.e., picture) stimuli by stating the name of the item while holding the picture for 2 s. No response was required from the child during SPOP sessions. Similar to pretest probe, the participants received tokens every 30 s for proper attending. After SPOP instruction, posttests were conducted. Posttest procedures were similar to pretest. However, participants were required to meet specific mastery criteria for tacts and listener responses during posttest probes. Failure to meet these criteria resulted in receiving MEI sessions in which students were exposed to two 3-picture sets of novel items using the aforementioned SPOP procedures until mastery. Failure to meet the mastery criteria for tacts and listener responses after MEI instruction resulted in remedial SPOP sessions in which the original stimuli sessions were used.

The posttest data show that single exposure to SPOP was not enough for tacts to emerge. After the multiple exposures to SPOP combined with MEI, all three participants demonstrated emergence of tacts and listener behaviors, and they met the mastery criteria for the novel items. However, remedial SPOP was required for the three participants because no one could meet the mastery criteria with the original items after receiving SPOP instruction combined with MEI. It is worthy of note that tacts and listener responses with the original sets of pictures increased for the three participants after the remedial SPOP, but only participant could meet the mastery criteria. The study encompasses some potential limitations. First, it is unknown if MEI is still necessary or not. In other words, it is possible tacts and listener responses could emerge if SPOP instruction (without MEI) was repeated. Second, the role of echoic behavior in facilitating emergence of tacts in unknown. That is, it is possible that the participants were silently echoing the names of items that the experimenter was stating during SPOP instruction. Third, it is possible that the lower and variable scores that one participant obtained during posttest probes were influenced by the challenging behaviors. The authors suggest that these behaviors resulted from the extinction that occurred because SPOP instruction includes no reinforcement of correct responses.

Solares & Fryling (2019) replicated the study of Byrne et al. (2014) using a multiple baseline design across participants. The participants were three children with autism who received behavioral intervention at their homes. Two participants had age-appropriate expressive and receptive language abilities as measured by PLS-5 (Zimmerman, Steiner, & Pond, 2011). However, the age equivalence for auditory comprehension and expressive language for the remaining participant were, as measured by the same test, 3 years 6 months and 3 years 7 months, respectively. The study took place at home settings, while the stimuli that were used to teach the target responses were three unique 3-picture sets. Each set was assigned to one participant. The dependent variables involved percentages of correct tacts and listener responses on pretests and posttests.

The data of IOA ranged from 89% to 100%, whereas data for treatment integrity were also in the same range. To probe tacts, the experimenter held the picture card and asked the participant, "What is it?". Tact responses were recorded correct if they included the correct label and emitted within 5 s of the question. Correct responses were not followed by any form of reinforcement. The participants were praised for proper attending only. During SPOP instruction, the experimenter held up each picture and stated the name of the item. No response was required from the participants. Posttest probes were conducted after SPOP instruction. These probes were identical to pretests. The experimenters planned to deliver further SPOP instruction if the participants could not demonstrate mastery of performance criteria for tact and listener responses during posttests. They also planned to introduce MEI if the participants could not achieve the mastery criteria after receiving further SPOP instruction. However, neither further SPOP instruction nor MEI were needed as the three participants demonstrated mastery of the criteria following the initial training. One week after the final posttest probe, maintenance probes were conducted for the three participants. These probes were similar to pretests and posttests.

Unlike the study of Byrne et al. (2014), posttest data show that the three participants were able to demonstrate emergence of tacts and listener responses following single SPOP session. The participants also maintained high levels of the acquired tacts and listener responses one week following the last posttest session. Solares & Fryling (2019) believed that the inconsistency of results between the two studies was due to differences in the characteristics of the participants. That is, two participants in the study of Solares & Fryling (2019) had age-appropriate language skills and no one demonstrated challenging behaviors during throughout the study. However, this assumption requires further investigation. Lack of data on maintenance of the acquired tacts and listener responses for longer than a week is a possible limitation.

Omori & Yamamoto (2013a) used multiple-probe-across-behaviors design to examine the effects of sequential stimulus pairing of visual and auditory stimuli on the percentage of correct responding in picture naming, word reading, and letter reading tests for 6 participants with different disabilities. The participants ranged in age from 4 to 10 years. Three of them had William Syndrome, two had intellectual disability, and one had autism. The participant with autism was a 10-year-old male. The PPVT-IV (Dunn & Dunn, 2007) age equivalence of this participant was 6 years; 7 months. The experiment took place at a university-based research lab. The experimenters used Microsoft PowerPoint presentation to present the stimuli during preassessment, baseline, training, post-training probes, and follow-ups. The visual stimuli were Hiragana words, letters, pictures, and a blackout presented in between trials. The auditory stimuli were the spoken words and letters. The dependent variable was the percentage of correct responses the participants obtained at picture naming, word reading, and letter reading tests.

At the outset of experiment, the experimenters conducted a preassessment to identify 3 target stimulus sets for each participant. Each stimulus consisted of 4 three-letter Hiragana words, the letters of these words, and their corresponded pictures. During baseline, the participants received three tests: a) Picture naming, b) Word reading, and c) Letter reading. During picture naming test, each participant was asked to name the pictures presented on the computer screen. During word reading, participants were required to read aloud a total of twelve Hiragana words displayed on the computer screen. These words corresponded the pictures displayed on the screen during picture naming test. During letter reading test, the participants were asked to read aloud one letter at a time displayed on the screen. The letters presented on that test were the letters of the words displayed during word reading test. During sequential stimulus pairing, the participants were exposed to one stimulus set at a time. During training, each letter was presented for 2-s either at the top (the first letter), the middle (the second letter), or the bottom (the third letter) of the screen. Simultaneously, the participants were listening to the spoken letters. Thereafter, the full word was displayed on the screen for 2 s along with its auditory stimulus (i.e., the spoken word). The picture corresponded to the same word was then presented for 2 s before the blackout was displayed for 1 s. Each of the four words in the stimulus set was presented 3 times for a total of 12 trials. After training, the participants received the same three tests (i.e., picture naming, word reading, letter reading) conducted during baseline probe. Successful reading of the four words in the stimulus set was required to introduce the subsequent set. Two follow-up probes were conducted one- and two-weeks following training. The procedures of follow-up were similar to baseline. The experimenters also measured the percentage of IOA for all six participants during picture naming, word reading, and letter reading tests. The percentage was 100% for all participants across the three phases: Baseline, post-training, and follow-up probes. The interrater reliability of vocal responses was also measured using Kappa (Cohen, 1968). The value of Kappa was 1.0 which indicated perfect agreement among the observers.

The findings of the experiment were as follows: First, the mean percentage of correct responses in picture naming test increased after sequential stimulus pairing. It is important to note that it was not possible to determine if the participant with autism demonstrated a significant increase in the percentage of correct responses on picture naming test because the authors reported the mean of two groups: With and without William Syndrome. That is, the individual score of each participant on picture naming test was not reported. Second, word reading improved for all participants. Lack of generalization and social validity are two potential limitations of this experiment.

Similar to Omori and Yamamoto (2013a), Omori and Yamamoto (2013b) examined the effect of sequential stimulus pairing training on acquisition of stimulus relations between written words, sounds, and corresponding pictures for six learners with ASD and attention deficit hyperactivity disorder (ADHD), using a multiple-probe-across-behaviors design. Three participants had ASD, whereas the remaining participants had ADHD. The participants with ASD ranged in age from 11 to 14 years, whereas their PPVT-IV (Dunn & Dunn, 2007) age equivalence scores for those participants ranged from 5;10 to 10;04 years. The experiment took place at a university-based research lab. The experimenters used Microsoft PowerPoint to present he target visual (i.e., written words, pictures) and auditory stimuli (i.e., spoken words) during preassessment, baseline, training, and follow-up probes. The dependent variable was the percentage of correct responses that participants obtained on picture naming test, the Kanji reading test, and two MTS tests; Kanji-Picture and Picture-Kanji.

A preassessment test was conducted to identify target Kanji characters and their corresponding pictures. The characters were presented on a computer screen. Each participant was asked to read a total of 28 characters and name their corresponding pictures. This test resulted in identifying 9 characters and corresponding pictures. It is important to note that the participants could not read the target characters, but they were able to tact the corresponding pictures. During baseline, all participants received four tests: a) picture naming test, b) the Kanji reading test, c) Kanji-Picture MTS test, and d) Picture-Kanji MTS test. Picture naming test involved tacting pictures displayed on the screen. The Kanji reading test involved reading aloud the Kanji characters displayed on the screen. Kanji-Picture MTS test involved matching Kanji character to the corresponding picture displayed in a set of three pictures. Picture-Kanji MTS test involved matching a picture to the corresponding Kanji character displayed in a set of three characters. During stimulus pairing training, each target Kanji letter was displayed on the screen for 2-s along with the spoken word (i.e., visual-auditory stimulus pairing). The picture corresponding to the Kanji letter was then displayed for 2-s without an auditory stimulus. Thereafter, a blackout appeared for 1-s before the next sequence was initiated. The participants were not required to make any response during training. They were asked to observe the stimuli (i.e., paired, unpaired) displayed on the screen. Following training, the participants received the same tests conducted in baseline. One- and two-week after training, follow-up probes were conducted using the same tests conducted in baseline and post-training. The experimenters measured the percentage of IOA during baseline, post-training, and follow-up probes during the aforementioned tests. The percentage of IOA was 100%. The experimenters also used Kappa (Cohen, 1968) to measure interrater reliability of vocal responses. The value of Kappa was 1.0 which indicates a perfect reliability.

The findings of the experiment were as follows. First, no change in picture naming was observed as all participants were able to name pictures corresponding to target Kanji characters at the outset of the study. In other words, the percentage of correct responses on picture naming test remained 100% across all experimental phases. Second, all participants acquired the stimulus equivalence relations between Kanji characters and corresponding sounds and pictures as evidence by the increased percentage of correct responses they obtained on Kanji reading and MTS tests. Third, all participants maintained the high levels of correct responses on Kanji reading and MTS tests on 1- and 2-week follow-up probes that followed training. The study encompasses three possible limitations. First, lack of social validity data. Second, it is unknown if participants generalized the reading abilities across novel stimuli and contexts as no generalization probes were conducted. Third, the effect of sequential stimulus pairing on tacting pictures in this experiment is unknown as participants were able to name the pictures corresponding to target Kanji characters at the outset of the study.

Vallinger-Brown & Rosales (2014) used a nonconcurrent multiple-baseline-across-participants design to compare the effects of listener training (LT) and stimulus pairing (SP) on emergence of novel untrained intraverbals for three children with autism. The participants ranged in age from 4 to 7 years. At the outset of the study, all three participants had established tact and mand repertoires as measured by VB-MAPP (Sundberg, 2008). In addition, they all had been receiving DTT for at least one year at the outset of the experiment. The study took place at a classroom. The target stimuli used throughout the experiment were displayed on an iPad™ through PowerPoint presentation. The dependent variable was the number of intraverbal responses the participants emitted during pretest, posttest, direct training, and follow-up probes.

The experimenters conducted pretraining for all participants in which they learned how to perform the actions required during LT training (e.g., pressing on icons). They also learned how to follow the instructions of LT training by asking them to point to pictures displayed on iPad™. The pictures used during pretraining were other than those used during the experiment. Pretraining was followed by tact training in which one target picture at a time was displayed on iPad™. The picture was presented along with the experimenter's question "What is it?". Correct responses were followed by praise, whereas incorrect responses were followed by systematically faded echoic prompts. Pretest phase consisted of asking the participants questions such as "What keeps food cold?" without using any visual stimulus in order to obtain an intraverbal response. No feedback was given for correct and incorrect responses. Following pretest, the participants received LT and SP. During LT, the participants were exposed to a display of 6 pictures on iPad™. They were asked to touch the sound icon on the screen. The sound icon released a verbal instruction telling the participant to touch one of the 6 pictures. The target picture was identified by its feature or function. Correct responses were followed by praise, whereas incorrect responses were followed by gestural prompt and repeating the trial. During SP, one picture at a time was displayed on iPad™ screen. Participants touched on the sound icon to hear the auditory stimulus which described the picture displayed on the screen. Participants were not required to emit any overt response during this condition. Posttest similar to pretest was conducted following SP and LT. However, no posttest conducted after LT for one participant. Direct intraverbal training was required for two participants as they could not meet mastery criterion on posttest. During this training, the experimenter followed the same procedures of pretest except the consequences that followed correct (i.e., praise, token) and incorrect responses (i.e., time-delayed echoic prompt, repeating the trial) responses. Direct intraverbal training continued until mastery criterion was met for all participants. Generalization probe was also conducted for two participants to assess the generality of acquired responses to novel teachers who were not involved in the preceding conditions. Procedures followed during generalization probe were similar to pretest and posttest. Follow-up probes were conducted 2-4 weeks following posttests for one participant only. The procedures of follow-up were similar to pretest and posttest. Last, the experimenters measured the percentage of IOA for the three participants in 46 to 58% of all experimental sessions. They also measured the percentage of treatment integrity in 32 to 33% of all sessions for all three participants. The mean percentage of IOA ranged from 96.5 to 98.8%, whereas the mean treatment integrity ranged from 99.6 to 100%.

The following were the findings of the experiment: First, all participants acquired the tacts of target stimuli prior to LT and SP. Second, one participant met the mastery criterion of emerged intraverbals without direct training, whereas direct training was required for the remaining two participants. It is important to note that LT and SP were both successful in increasing emerged intraverbal responses for all participants, but it was only one participant who met the mastery criterion of emerged intraverbal responses after LP and SP training. The authors suggested that the variance in meeting mastery criteria was due to the echoic responses the participant with the highest level of responding emitted during training. That is, the participant who met the mastery criterion of intraverbal responses after LT and SP training was echoing the vocal instructions and descriptions of target visual stimuli. The authors suggested that echoing the auditory stimuli has possibly facilitated acquisition of emerged intraverbal responses. However, this claim requires further investigation. Third, the same participant also maintained mastery of the emerged intraverbals at 2- and 4-week follow-up probes and with novel teachers. Fourth, the other participant who received generalization probe demonstrated maintenance of mastery with novel teachers. The study encompasses three possible limitations. First, lack of posttest data after LT for one participant. Second, the intertrial time between SP trials varied due to technical issues. Third, multiword questions were used to evoke intraverbal responses. Therefore, the experimenters were unsure which word exerted control over the response.

Systematic Review III: *Strand II: Auditory-Auditory Stimulus Pairing*

Carnerero & Pérez-González (2015) used a repeated probe design to examine the effects of pairing auditory stimuli on emergence of tacts, intraverbals, and selections for typically developing adults. The experiment took place at a room located in a school building. Three auditory stimuli were used in the experiment: a) Sounds of 8 musical instruments, b) Names of instruments, and c) Names of countries corresponding to those instruments. The dependent variable was the number of correct responses emitted on pre- and post-training probes. The responses were tacts, intraverbals, and selections. The tact was recorded correct when the participant accurately emitted the instrument's name or county corresponding to the sound presented. The selection was recorded correct if the participant selected the circle corresponding to instrument's name or country the experimenter verbalized. Last, the intraverbal response was recorded correct if the participant emitted the instrument's name or country with accurate pronunciation in response to question the experimenter asked. The twelve participants were assigned to three conditions: A control condition and two experimental conditions. Each experimental condition consisted of two parts. In Part 1 of Condition 1, the participants received pairing of four musical instruments with their names. In Part 2 of Condition 1, the remaining four instruments were paired with names of the corresponding countries. A reverse order of Parts 1 and 2 was followed in Condition 2.

The experiment consisted of 7 phases. In Phase 1, the experimenter conducted three pretraining probes to test: a) country tacts, b) instrument tacts, and c) intraverbals. Phases 2 and 5 consisted of two steps. In Step 1, the participants listened to the instrument's name or country paired with instrument's sound. In Step 2, the experimenter probed tacts of instrument or country. In Phases 3 and 6, the participants were asked to press on four circles displayed on the corners of screen. Each circle produced a unique instrument sound. The experimenter said the name of instrument or country, then asked the participant to select the circle corresponding to instrument's name or country spoken by the experimenter. Procedures of Phase 4 and 7 were similar to those of Phase 1. The mean percentage of IOA and treatment fidelity were 98.9 and 100%, respectively.

The findings of the experiment were as follows: First, tacts of musical instruments and their countries emerged in all participants who received auditory-auditory stimulus pairing. Second, most participants demonstrated emergence of selections following auditory-auditory stimulus pairing. Third, intraverbals emerged in Condition 1 after exposure to paired auditory stimuli were more than those emerged in Condition 2. This finding suggests that the order of stimulus pairing has possibly played a role in emergence of intraverbal. The study encompasses two potential limitations. First, the small number of participants assigned to each condition (i.e., 4 participants) is possibly insufficient to make conclusions about the role that order of stimulus pairing played in emergence of intraverbals. Second, the probes in phase 7 were not repeated. The authors suggested that repeating these probes would have probably increased emergence of intraverbals.

Carnerero et al. (2019) systematically replicated the previous study with 11 typically developing adults using a repeated probe design. The only difference between the two studies is the order of tact and selection probes. That is, tacts were probed before selection in the original study (Carnerero & Pérez-González, 2015) while a reverse order was followed in the replicated study. The findings of this systematic replication were as follows: First, most participants demonstrated emergence of tacts of instruments and corresponding countries. Second, all participants demonstrated emergence of selections. Third, more intraverbals emerged in Condition 1 than Condition 2. As in the original study, the authors of the replicated study suggested that pairing sounds with names of musical instruments before pairing them with corresponding countries has possibly played a role in facilitating emergence of intraverbals. The authors compared the overall mean of intraverbal responses in the replicated study was larger than the original experiment. Depending on this finding, the authors suggested that probing selections before tacts has possibly contributed to this increase in the overall mean of intraverbals. The study encompasses two potential limitations. First, the small number of participants in each condition. Second, all participants were adults with complex verbal abilities. Accordingly, it is unknown if the findings of this experiment apply to learners who are younger and those with limited verbal repertoires.

Systematic Review III: Discussion and Summary of Results

Depending on the research questions for this review, this section discusses the reviewed studies in terms of acquisition of the speaker component of naming after SPOP and generalization and maintenance of tacts after SPOP.

Acquisition of the Speaker Component of Naming After SPOP

Overall, the efficacy of SPOP in increasing tacts among learners with ASD is clear in some, but not all studies. That is, two studies found that single (Solares & Fryling, 2019) or repeated (Byrne et al., 2014) exposures to SPOP were enough for tact responses to master new tacts. The remaining three studies were inconclusive in terms of tact emergence among learners with ASD.

Due to the small number of studies in which SPOP was used to teach tacts to learners with ASD, the factors that increase the success of SPOP in teaching tacts is unclear. Rosales et al. (2012) suggest that joint attention and covert echoics play an important role in the efficacy of SPOP. Absence of problem behaviors and higher language abilities as Solares and Fryling (2019) suggested may also play a role in the efficacy of SPOP.

Auditory-auditory stimulus pairing was found effective in increasing tacts among most participants who received this procedure in the experiments of Carnerero & Pérez-González (2015) and Carnerero et al. (2019). However, it is unknown if the results of these two experiments generalize to learners with autism. Therefore, research can extend the findings of these two experiments by examining the impact of auditory-auditory stimulus pairing on increasing tacts and/or Naming relations among learners with autism.

Generalization and Maintenance of Tacts Following SPOP

Overall, there is no clear evidence in the reviewed studies that learners who receive SPOP can generalize tacts across novel settings, stimuli, and time (i.e., maintenance). The limited evidence of generalization refers to for the following reasons: 1) generalization across novel settings and stimuli was not assessed in any study, 2) measuring generalization among verbal operants other than tacts in one study (Vallinger-Brown & Rosales, 2014), 3) maintenance was assessed in three studies only, and 4) the outcomes of maintenance are inconclusive due to the previously mentioned reasons. Due to the limited evidence of generality, further research is needed to support the efficacy of SPOP in establishing tact repertoires that are generalized across settings, stimuli, and time.

Systematic Review III: Conclusion and Future Directions

Overall, SPOP has the potential to increase tacts and other relations (e.g., intraverbals, listener responses). However, the factors that increase the efficacy of this procedure is unclear. Furthermore, it is unclear if tacts learned through SPOP are generalized across people, settings, and time due to limited evidence. Research should continue to determine the factors that increase the efficacy of SPOP, examine the effect of auditory-auditory stimulus pairing on acquisition of tacts and/or naming among children with autism, and examine the generality of tacts after termination of SPOP across stimuli, settings, and time.

Training Parents of Children with ASD Via Telehealth to Implement Communication Interventions: Systematic Review IV

Systematic Review IV: Overview

As mentioned in Chapter 1, previous studies indicated that both children with ASD and parents benefit from parental involvement in intervention. Previous studies found that parents can successfully teach verbal operants such as mands (Loughrey et al., 2014) and promote interaction styles with their children (McConachie & Diggle, 2007). In addition, parents involved in intervention reported improved depression (McConachie & Diggle, 2007) and other psychological symptoms such as anxiety and insomnia (Tonge et al., 2006).

The gap between children with ASD who need interventions and availability of interventionists is related to the increased prevalence of this disorder over the past two decades (Ingersoll et al., 2016; 2017). Unfortunately, many families are placed on waitlists due to increased demand and shortage in interventionists (Simacek et al., 2017). Placing families and children on waitlists results in developing stress and concerns such as uncertainty and loosing time in their children’s development (Keating et al., 1998). In addition, accessing services becomes more difficult when families live in rural communities (Mello et al., 2016). Luckily, recent advances in technology have offered cost-effective option to provide services to children with ASD and their families known as telehealth. Telehealth enables interventionists to provide services to parents and children with ASD who live in rural and underserved areas. Research shows that coaching parents through videoconferencing technology was helpful in improving their verbal responsiveness to their children's communicative acts (McDuffie et al., 2013), increasing children's functional verbalizations (Vismara et al., 2013), and other outcomes.

Because of the abovementioned importance of coaching and involving parents in intervention and the benefits of telehealth as a cost-effective modality, this review aims to synthesize the existing literature about training parents of children with ASD via telehealth to implement communication interventions. Specifically, it aims to answer the following questions: 1) What methods were used to train parents on implementation? 2) Who coached the parents? 3) What is the efficacy of remote parent training on acquisition of communicative behaviors among children with ASD? 4) What are the outcomes of generalization and maintenance? and 5) Is the social validation of target behaviors, interventions, and outcomes supported?

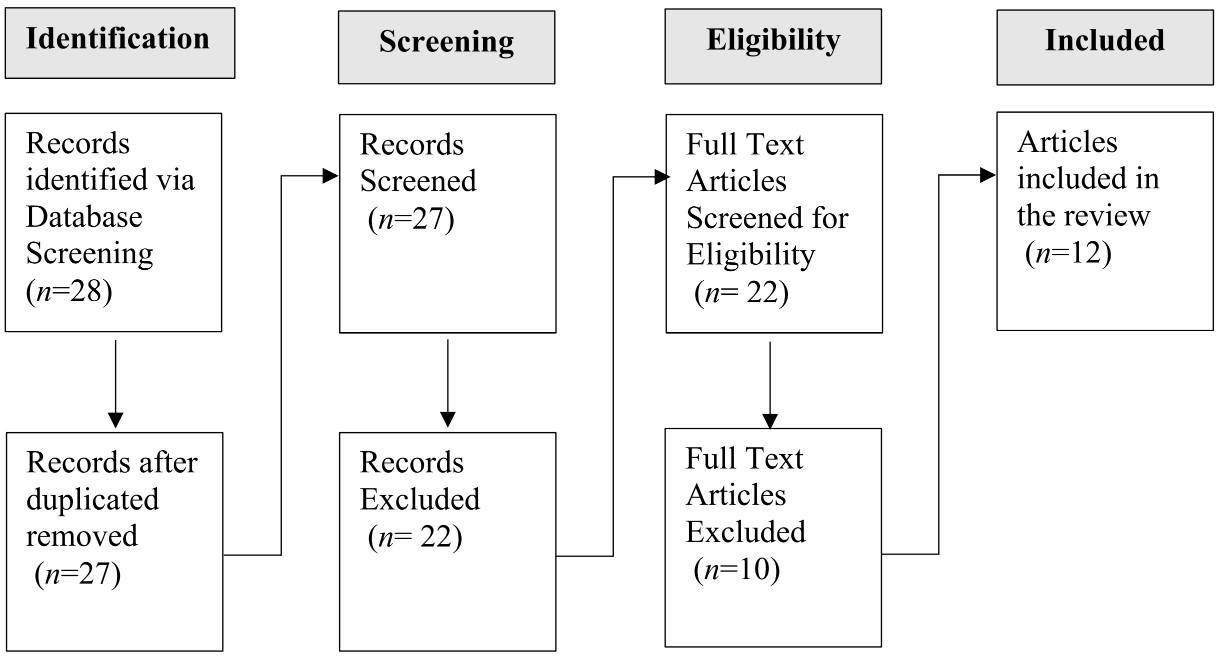
Systematic Review IV: Search Process

A four-step process (see Figure 7) was followed to locate and review studies that examined the efficacy of training parents of children with ASD via telehealth to implement interventions. The first step is *identification*. This step included conducting a combined electronic search using the following keywords: *autism* or *ASD* or *autism spectrum disorder* or *asperger's* or *asperger's syndrome* or *autistic disorder* or *aspergers* AND *parent training* or *parent education* or *parent coaching* or *parent-implemented* or *parent-mediated* AND *speech* or *language* or *communication* or *verbal* AND *telehealth* or *telemedicine* or *telemonitoring* or *telepractice* or *telenursing* or *telecare* or *virtual.* The databases were: Academic Search Premier, Education Full Text, ERIC, and PsychINFO. The following filters were applied in the combined search: English and scholarly (peer-reviewed) journals. After removing duplicates, this search resulted in 27 articles. The second step was *screening*. During this step, the records were screened to verify their relevance to the topic of the research by reading the title and abstract of each record. This step resulted in excluding five records.

The third step was *eligibility* in which 22 records were screened in full to determine eligibility. Records were considered eligible if they met the following inclusion criteria: 1) published in English, 2) experimental research, 3) included participants with ASD, 4) examined the efficacy of parent training to implement training via telehealth, and 5) participants ranged from zero to 18 years. Excluded records included literature reviews and studies that were limited to population with disabilities other than ASD and aspects not related to speech, language, communication and verbal behavior such as problem behaviors. This process resulted in 12 records. The last step was reviewing and summarizing these 12 records in one matrix. The matrix included the following information about each record: a) purpose and/or research questions, b) characteristics of participants, c) coaches, d) experimental design, e) experimental settings, f) materials, g) dependent variables, h) independent variable, i) treatment procedures, j) findings, k) generalization, l) maintenance, m) social validity, and n) limitations.

Figure 7

Four-Step Search Process



Systematic Review IV: Results

The studies identified in this review were categorized into themes: 1) Single-modality, and 2) Multi-modality studies.

Systematic Review IV: Strand I: Single-Modality Studies

Lindgren et al. (2020) examined the effects of parent-mediated package composed of functional analysis (FA) and functional communication training (FCT) on reduction in problem behaviors and increase in manding for 38 young children with ASD. The researchers used a hybrid research design consists of single subject research design and randomized controlled trial (RCT). The children ranged in age from 21 to 84 months. Participants ranged in intelligence from severe intellectual disability to above average IQ. They received intervention by their parents in their homes. Parents received training on implementing FA and FCT and supervision weekly via teleconferencing. The study outcomes included frequency of problem behaviors, increase in mands, and number of tasks completed. The researchers also assessed maintenance of treatment outcomes at six months following completion of intervention.

Children with a confirmed diagnosis of ASD were allocated to two group: immediate FCT (*n*= 21) and delayed FCT/control (*n*= 17). Children in immediate FCT group received intervention for 12 weeks, whereas participants in control group received treatments other than FCT such as speech therapy, occupational therapy, medications, and dietary restrictions. FA+FCT, however, was provided to children in control group following completion of RCT. Parents were asked to complete a 7-point Likert scale survey to rate acceptability of intervention

Researchers found that children who received parent-mediated FA+FCT demonstrated significant reduction in percentage of intervals with problem behavior, a significant increase in percentage of opportunities to mand, and a significant increase in percentage of tasks completed during sessions. Treatment outcomes were maintained for six months following completion of intervention. A small increase in problem behaviors, however, was noticed. In addition, parents rated favorably for the treatment. On the other hand, no significant improvement in problem behavior was observed among children in control group. Interestingly, FA+FCT was helpful for children across all IQ ranges. The study, however, has several potential limitations. First, the modest sample size. Second, parents were not blinded as they were aware of group assignment. Third, inclusion of participants and severity of problem behaviors were determined based on parents' and clinicians' identification rather than global measures or rating scales. Fourth, 6-month follow-up probes were not taken for all participants. Fifth, FA+FCT was not compared with psychoactive medication. Researchers, however, noticed that FA+FCT was effective for approximately all children regardless of their use of medications.

Rooks-Ellis et al. (2020) examined the effects of parent-Early Start Denver Model (P-ESDM) delivered via telehealth on fidelity of parent implementation and changes in ASD symptomatology among 10 toddlers with ASD using multiple-baseline-across-participants design. ESDM is a relationship-based and behavior-analytic intervention model for young children with ASD. The mean age of participants was 29.3 months. The study took place at children's homes who lived in rural areas in the Northeast. The dependent variables were parent and interventionist fidelity and pretest to posttest change in ASD symptomatology as measured by *Autism Impact Measure* (AIM; Kanne et al., 2014).

During baseline, the investigator asked parents to interact with their children as they usually would during daily routines. No coaching was provided to parents during baseline. Baseline sessions were videorecorded for later analysis and parents were provided with copies of manuals related to P-ESDM. Parents were also trained on using Bluetooth earbuds and videoconferencing technology.

During each 90-min intervention session, parents were coached by the interventionist who was a certified P-ESDM provider and experienced in early intervention. During coaching sessions, the parent was listening to the interventionist's instructions via Bluetooth earbuds while implementing the target strategies (e.g., capturing the child's attention). Parents were encouraged to embed the strategies into the daily routine, to demonstrate the previously taught strategies to measure fidelity, and to complete social validity questionnaire. Two weeks following the last intervention session, one maintenance session for each dyad (i.e., parent and child) was conducted in which parents were interacting with their children during play and other activities.

Parents were observed by the interventionist, but no coaching was provided. To measure generalization, each parent was asked to submit a video in which they implemented the previously taught strategies without coaching. Interobserver agreement (IOA) was measured across all conditions by two certified P-ESDM providers. The percentage of IOA for interventionist fidelity and parent fidelity was 94% and 95%, respectively. To assess social validity of telehealth and coaching procedures, parents were asked to complete a questionnaire.

The investigators found that fidelity of parent implementation increased after receiving training via telehealth. They also observed statistically significant change in AIM scores, which suggests improvement in ASD symptomatology. Social validity assessment indicated that parents were satisfied with the procedures and outcomes. The study encompasses five potential limitations. First, there is no clear functional relationship between coaching and fidelity of parent implementation due to increasing and decreasing trends during baseline and lack of immediacy in behavior change following the intervention. Second, the unstable internet connection was a challenge for two parents during intervention. Third, raters who measured the fidelity of implementation were trained on P-ESDM. Thus, the measurement was not blind. Fourth, confounding variables such as age and gender were not controlled when change in ASD symptomatology was assessed using AIM. Fifth, the external validity of outcomes is limited as participants were not well-diversified.

Simacek et al. (2017) investigated the effects of parent-implemented functional analysis and functional communication training via telehealth on early communication skills for three young children with developmental disabilities. The investigators used multielement design for functional analysis and a combination of ABAB and multiple-probe-across-contexts design. It is important to note that ABAB design was embedded only into the top panel of the multiple-probe design. The participants were two girls with ASD and one girl with Rett Syndrome ranging in age from 3.5 to 4 years. All the participants had limited and inconsistent usage of babbling and/or word approximations. Additionally, they all had previous exposure to AAC aids, but no one used them consistently. All training sessions took place at children's homes. Training was conducted by parents who were coached remotely via telehealth. Materials used in the experiment included computers, webcams, headsets, 2D PECS cards (for two participants), a microswitch (for one participant), and reinforcers. Two types of communicative behaviors were identified for each participant: idiosyncratic responses (e.g., reaching, leading) and AAC requests (e.g., pressing microswitch, touching PECS card). The aim of training was to replace the idiosyncratic responses with AAC requests because the latter are more recognizable and possibly less effortful than the former through differential reinforcement of alternative behavior. The dependent variables included the frequency of target behaviors for two participants and percentage of intervals with target behaviors for one participant.

Prior to intervention, a functional assessment interview was conducted to learn from parents about the challenging and idiosyncratic behaviors and their contexts. Additionally, parents were interviewed using the interview form of the Vineland Adaptive Behavior Scales (VABS; Sparrow et al., 2005) to learn about the functional, communicative, and motor skills of child participants. Structured Descriptive Assessment (SDA) was also conducted to observe and document idiosyncratic and challenging responses without asking parents to do any programmed consequence. One child participant did not demonstrate any challenging behavior during SDA. Therefore, functional analysis was not required for that participant. Functional analysis, however, was required for the other two child participants because they demonstrated challenging behaviors during SDA. The purpose of functional analysis was to determine the function of the problem behaviors and to help with identifying alternative responses (i.e., AAC requests) that serve the same function of the problem behavior. During baseline, child participants had access to reinforcers contingent on occurrence of idiosyncratic behaviors (e.g., leading). During training, parents were coached to withhold access to reinforcers when idiosyncratic responses occurred. Access to reinforcers was contingent on demonstrating AAC requests of word approximations. Parents were asked to complete a modified version of Treatment Acceptability Rating Form-Revised (TARF-R; Reimers & Wacker 1988; Reimers et al., 1991) to assess acceptability of treatment and improvement in communication and/or challenging behaviors. Fidelity of implementation was measured in one fifth of baseline and intervention sessions. The average of fidelity for all three participants ranged from 93 to 96%. Trial-by-trial interobserver agreement (IOA) was also measured in at least one quarter of sessions for idiosyncratic and AAC responses across the three participants. The average of IOA for all three participants ranged from 89 to 97%.

The investigators found that two participants acquired multiple target AAC responses and one participant acquired single AAC response. Acquisition of those responses occurred across the three contexts (e.g., snack time, parental attention). Additionally, they found that idiosyncratic responses decreased for all three participants. In terms of acceptability, parents rated treatment and improvement in challenging and/or communicative behaviors as “highly acceptable”. The study included four potential limitations. First, two participants had access to communication intervention outside the study. Access to outside intervention could have influenced outcomes. The observed outcomes, however, indicated that access to outside intervention had no significant influence as the data obtained through multiple-probe and ABAB designs suggested. Second, AAC training is possibly more difficult for children with severe motor impairments. Hence, generality of study results is limited. Third, two parents in each family were involved in training. Thus, training would be more difficult for single-parent families. Fourth, no maintenance probe was taken.

Tsami et al. (2019) examined the effect of functional analysis and functional communication training implemented by parents of 12 children with ASD from around the world who were coached via telehealth on independent mands and problem behaviors. The researchers used multielement design for functional analysis, whereas functional communication training was introduced to participants in a staggered fashion. The study included 12 children with ASD from Costa Rica, Greece, Mexico, Russia, Saudi Arabia, Turkey, and Ukraine ranging in age from 3 to 13 years. Mothers were involved in implementation across all participants. One father and one sibling, however, were involved in generalization for two participants. Families implemented the intervention at their homes. Two families, however, implemented the intervention at therapy centers. Materials used in the experiment involved computers, telehealth software, smartphones/iPads, and Debut software to score and analyze the videotaped sessions. Dependent variables included percentage of trials in which independent mands were emitted and percentage of intervals with problems behaviors (8 participants) or responses per minute (4 participants).

Therapists trained interpreters who were competent in families' languages and cultures on purpose and procedures of functional analysis and functional communication training. Therapists also met with the families in presence of interpreters to identify problem behaviors, to establish operational definitions, and to identify the conditions in which those behaviors tend to occur. Therapists met again with families to explain the purpose, conditions, and roles of parents during functional analysis. Conditions of functional analysis were individualized for each participant. For example, tangible condition was not conducted for two participants because their families reported that they did not demonstrate problem behaviors when access to reinforcers was withheld. Functional analysis was conducted by parents who were coached by therapists. Interpreters were translating therapists' instructions to parents. Based on functional analysis results, independent mands were identified for each participant. For example, the independent mand "Don't touch me" was identified and taught during functional communication training to one participant who appeared to demonstrate problem behaviors the most when touched by others. Similar to functional analysis, functional communication training was conducted by parents who were coached by therapists via telehealth with translation from the interpreters. During training, access to reinforcement (e.g., attention, escape, tangible) was given when the child demonstrated the independent mand. Access to the reinforcement, however, was withheld when problem behaviors occurred. Social validity was assessed by asking families to complete translated, modified version of Treatment Acceptability Rating Form (Reimers & Wacker, 1988). Specifically, they assessed the acceptability of functional analysis and functional communication training procedures and the acceptability of telehealth as a service modality. Procedural integrity was measured for all families during functional analysis and functional communication training. Average of procedural integrity for all families ranged from 84 to 100%.

Researchers found that parent-implemented intervention was very effective in teaching independent mands and reducing problem behaviors for all participants. They also found that parents were generally positive toward the procedures and telehealth as a service delivery model. Researchers believe that presence of interpreters facilitated the success of procedures by eliminating the cultural and linguistic barriers between therapists and families. The study, however, encompasses potential limitations. First, the sample was not necessarily representative of all families of children with ASD as most parents were holders of degrees higher than high school diploma. Second, they did not collect information about the socioeconomic status of children. Third, they did not count the number of prompts they provided to families during implementation. Fourth, they did not assess implementation when parents were not coached by therapists via telehealth. Fifth, none of the participants demonstrated serious problem behaviors (e.g., physical harm). Accordingly, the procedures examined in this study may not generalize to learners who demonstrate such behaviors.

Systematic Review IV: Strand II: Multi-Modality Studies

Flippin & Clapham (2021) examined the effects of a combination of remote and in-person coaching on parents' communicative responsiveness and child's use of spontaneous single words using multiple-baseline-across-behaviors design. The participants were a 5 year, 6-month-old boy with ASD and his 40-year-old father. The researchers measured one dependent variable and a collateral effect. The dependent variable was the proportion of parents' application of three strategies (i.e., commenting, directing, responsive object play), whereas the collateral effect was frequency of child-initiated single words.

During baseline sessions, the father and the child were interacting with each other without receiving instruction or feedback from the experimenters. Remote parent coaching (i.e., telehealth) consisted of creating buy-in, describing the target strategies and the rationale, providing examples on strategies, and planning to implement the strategies. During remote coaching sessions, the father received feedback on their use of each strategy. Each strategy was introduced when the preceding one was mastered by the father. In-person coaching was implemented in an indoor swimming pool (i.e., aquatics sessions). Each session lasted 40 minutes and was divided into two halves. The first 20 minutes were dedicated to answering father's questions, discussing feedback, and problem-solving. The second half was dedicated to observing unstructured interactions between the father and the child during swimming. The experimenters took follow-up and maintenance data. Follow-up data were collected immediately following intervention to monitor implementation of strategies, whereas maintenance probe was taken 8 weeks following intervention. In addition to the aforementioned dependent variable and collateral effect, the experimenters measured IOA and social validity. Social validity was assessed using a 7-point Likert scale to measure the father's satisfaction with coaching package and its effectiveness.

Interobserver agreement was measured in 31% of sessions. The average IOA was 93.1%. In terms of social validity, the father was highly satisfied with the package and its effectiveness. In terms of dependent variable (i.e., father's implementation of the three target strategies), the father increased his use of two strategies only (i.e., follow-in comments and directive comments) and maintained it for 8 weeks. Father's use of the third strategy (i.e., responsive object play), however, increased on the first coaching session only then demonstrated a decreasing trend. In terms of the collateral effect, the child's use of spontaneous single words increased slightly. The study has three potential limitations. First, the study included one child and one father only. Second, the child lived in a two-parent household. Accordingly, the results of this study have limited generalizability as one third of children with ASD in United States live in single-parent households. Third, parents of children with ASD represent all socioeconomic classes and professional backgrounds. Consequently, the results may not generalize to all children with ASD as participant's parents were from middle class and held professional degrees.

Gevarter et al. (2021) used a nonconcurrent multiple probe design to examine the effectiveness of brief coaching for Latinx parents and early childhood specialists on their communication turns with children with ASD and children's independent communicative responses. The participants were three children with an official diagnosis of ASD (*n*= 1) or of high risk of the same disorder (*n*= 2), three Latinx parents, and three developmental specialists. The children ranged in age from 21 to 33 months. All sessions were conducted at parents' homes, whereas materials used throughout the study included video models, visual supports, and items that parents usually use during daily activities (e.g., toys, drinks, foods). The primary dependent variables included the number of completed communication turns between parents and children and the number of children's independent responses. The researchers also measured the strategies used by parents and those addressed by provides.

Researchers asked parents during baseline probes to interact with their children as they usually would during play activities. During training, the researchers showed parents and the developmental specialist baseline videos to provide rationale for addressed strategies. Thereafter, they viewed training videos. The training videos showed the researcher interacting with a nonparticipant with ASD. The videos served as models to parents and specialists. The researchers also played coaching videos. In coaching videos, the researcher was coaching the parent of the same child who appeared in training video on using strategies such as helping the mother to prompt the child. In addition to videos, parents and specialists used visual supports. Those supports outlined the addressed strategies. The training was initially conducted in-person. However, the training was switched to remote for two triads due to restrictions in response to COVID-19 pandemic. During remote training, the researchers used screen sharing feature in Zoom to demonstrate videos and other materials. Following training, parents and specialists were asked to conduct 10-min sessions to implement the target strategies. The researcher was available in two sessions to provide further coaching. Coaching was entirely faded by the fourth session. Following post-training probe sessions, each parent conduced three sessions in absence of specialists to demonstrate their ability to implement the target strategies without coaching. The researchers measured the fidelity of implementation. The fidelity was 100% for all triads and in all sessions. Additionally, they assessed social validity through an online survey completed by parents and specialists. The survey consisted of open-ended questions that addressed achievements, challenges, and suggestions for enhancement.

In addition to graphing primary dependent variables, researchers calculated Nonoverlap of All Pairs (NAP) to report effect size. NAP scores for the three triads indicated large effect size. Visual analysis, however, indicated differences in trend, level, and variability. All three triads demonstrated variability in number of communicative turns between children and parents. The communicative turns, however, were above baseline. All triads continued to increase turns when coaching was absent. Similarly, the number of children's independent communicative responses were higher than baseline. Interestingly, the outcomes for the triad which received in-situ training was the highest. It is not possible, however, to determine the role that in-situ training played in enhancing the outcomes for that triad. The responses of parents and specialists to social validity survey were generally positive. Despite the positive outcomes, the study encompasses the following limitations. First, using a nonconcurrent rather than a concurrent multiple probe design. Second, the fluctuations in responding. Third, absence of long-term maintenance probe. Fourth, using the sign MORE. The researchers assume that using a general sign such as MORE might facilitate overgeneralization. In other words, children might use the sign MORE to request anything even if they request it for the first time rather than using it to ask for an additional quantity of something. Fifth, the small number of Latinx families who participated in the study.

Sixth, exclusion of Latinx families who are non-proficient in English due to lack of Spanish proficiency among researchers and specialists.

In a pilot RCT study, Ingersoll et al. (2016) compared the effects of therapist-assisted and self-directed parent-mediated intervention on a series of parent- and child-related outcomes. Parent-related outcomes included fidelity of implementation, scores of *Parent Sense of Competence Scale* (PSOC; Gibaud-Wallston & Wandersmann, 1978), and scores of *Family Impact Questionnaire* (FIQ; Donenberg & Baker, 1993). Child-related outcomes included language targets (e.g., word approximations, single words), scores of *MacArthur-Bates Communicative Development Inventory* (MCDI; Fenson et al., 2007), and scores of *Vineland Adaptive Behavior Scales, Second Edition* (VABS-II; Sparrow et al., 2005). A total of 28 families of children with ASD ranging in age from 19 to 73 months participated in the study. Thirteen families were randomly allocated to self-directed group, whereas the other fifteen families were allocated to therapist-assisted group.

Parents in self-directed group were asked to sign in to ImPACT Online website, complete one 75-min lesson a week, and to implement what they learned with their children between lessons. No support was given to parents allocated to this group. Parents in therapist-assisted group were asked to sign into ImPACT Online website and to complete the same weekly lessons assigned to families in self-directed group. In addition, parents in therapist-assisted group received two weekly coaching sessions via video-conferencing technology. Coaches were master's level therapists. Coaches measured fidelity of parent implementation. Average fidelity was 99.6%. Additionally, 10% of coaching sessions were randomly selected to measure inter-rater reliability by independent raters. The inter-rater reliability was 97.8%. The researchers measured language targets by counting them and converting the count to rate per minute. The aforementioned tests and scales (i.e., PSOC, FIQ, MCDI, VABS-II) were administered prior to and after treatment.

Researchers found that parents in both groups enhanced fidelity which suggests that self-directed program is adequate in increasing interventional skills of families. Higher gains in use of intervention and positive perception of their children, however, were observed in therapist-assisted group. The researchers noticed that completion of program was higher in therapist-assisted group as no one discontinued intervention, whereas four parents in self-directed group discontinued intervention. The researchers also found that parental self-efficacy and stress enhanced for parents in both groups. Language targets also enhanced for children in both groups. The increase of language targets, however, was marginally higher in therapist-assisted group. Interestingly, scores on socialization subdomain of VABS-II enhanced for children in therapist-assisted group only. The study includes the following limitations. First, the small sample size. Second, absence of control group. Thus, maturation or placebo effects were not ruled out. These effects, however, were minimized as no improvement observed in the two subdomains of VABS-II that are not related to skills addressed by the program (i.e., Motor Skills and Daily Living). Third, percentages of families from minority groups in the two experimental groups were largely different. That is, families from minority groups in self-directed and therapist-assisted groups were 8% and 36%, respectively. This large difference could have contributed to the observed outcomes.

Pierson et al. (2021) examined the effects of telehealth on parent implementation of modified dialogic reading (DR) procedures and the effects of these procedures on language skills of four children with developmental disabilities. The investigators used multiple-probe-across-subjects design. The children ranged in age from 5 years to 7 years 3 months. All child participants were diagnosed with ASD except one boy with Down syndrome. Assessment, coaching, and training sessions were carried out by the primary investigator who was a doctoral student and a licensed speech-language pathologist. All sessions took place at children's' homes. Materials used throughout the study included 20 commercially available storybooks, technology (e.g., computer, videoconferencing), reinforcers, questions, picture answer choices, and book reading calendars. The dependent variables included parent implementation of DR procedures and number of questions the child participants answered correctly.

During baseline, parents were asked to read the storybooks to their children and to read the assigned questions. No prompts were given to children during baseline. Parents were both trained and coached. Parent training included the mnemonic PEER and CROWD. PEER stands for *prompt, evaluate, expand,* and *repeat*, whereas CROWD stands for *completion*, *recall*, *open-ended*, *wh-questions*, and *distancing*.

Training was delivered in synchronous (e.g., verbal instructions, role-play, feedback) and asynchronous (i.e., cheat sheet) formats. Coaching was delivered in a synchronous format. Coaching was delivered in 60-min weekly sessions. The interventionist viewed the video recording of the preceding session and gave verbal and visual (e.g., graphs) feedback to parents during coaching sessions. During intervention, parents were asked to read the storybooks, ask questions, and complete the remaining steps of mnemonic PEER. The investigator collected generalization data during the three experimental conditions: baseline, intervention, and maintenance. During generalization, parents were asked to follow the same procedures of intervention and read storybooks other than those used in the experiment. One week following the last intervention session, maintenance sessions were conducted for three participants. No coaching was provided during the week of maintenance probes. The investigators asked three raters to measure point-by-point IOA for nearly 30% of all data points. Raters were retrained because IOA fell below 80%. Training fidelity was measured for sessions in which the investigator trained parents. Training fidelity ranged from 75% to 100%. In addition, procedural integrity was measured for all coaching sessions in which the investigator provided parents with feedback. Procedural integrity ranged from 89% to 100%.

The investigators could not determine a functional relationship between remote training/coaching and parent implementation of modified DR procedures due to the variability in responding. In addition, only a small change in questions that children answered correctly was noted. In terms of social validity, parents were generally positive about the goals, outcomes, and procedures. However, they reported some challenges with their children's behavior and procedures. The study encompasses six potential limitations. First, providing prompts to one participant by the investigator during the first reading session in presence of the parent. This could have influenced data collected for parent implementation. Second, absence of fidelity data for parent during baseline. Third, parent and child preferences were not considered when selecting the storybooks. Fourth, no masked raters involved in measuring IOA. Fifth, one of the parents had a coaching history with the investigator, which could have influenced implementation and generalizability. Sixth, the investigators did not measure the *evaluate* component of the modified DR procedure.

In a pilot study, Baharav & Reiser (2010) compared two models of intervention: a traditional model in which children received two 50-min speech-language therapy sessions a week and a hybrid model in which children received one traditional 50-min session in the clinic followed by one 50-min parent-implemented session conducted at home and supervised/coached by the clinician via telehealth. The investigators used a single subject time-series (A-B) design to compare the effects of the previously mentioned models on raw scores on *Vineland Adaptive Behavior Scales, Second Edition* (VABS-II; Sparrow et al., 2005), raw scores on MacArthur Communicative Development Inventories (MCDI; Fenson et al., 1993), number and frequency of initiations and responses made by children, number of opportunities the clinician and parents offered for children to interact, and time spent in reciprocal interactions. Participants were two children with ASD aged 4 years 6 months and 5 years 2 months, their parents, and a clinician. Each parent was provided with a laptop, a webcam, a videoconferencing software, and a Bluetooth headset. Materials used in intervention (e.g., books, toys) were not described.

The experiment consisted of two 6-week periods: period A and period B. Period A was the traditional model, whereas period B was the hybrid model. In both models, parents were present in the clinic and encouraged to use strategies that address communicative and social skills such as joint attention, gestures, and initiations. During telehealth sessions, parents were observed and coached by the clinician on implementing the intervention via videoconferencing. Parents were also offered with a platform to meet with the clinician, ask questions, and exchange information. Data were collected at three points of time: 1) at the midpoint of period A, 2) during the baseline for period B, and 3) at the end of period B. Sessions were videorecorded to measure the dependent variables. Measurement was conducted by two observers and their interrater agreement was 81%. Additionally, the investigators assessed the social validity by asking parents to complete a questionnaire that addressed their experience with telehealth and as interventionists.

The investigators found that one participant maintained the social and communicative gains obtained in the traditional model when intervention switched to the hybrid model, whereas the other participant continued to increase those gains when intervention switched from the traditional to the hybrid model. In addition, number of opportunities parents offered for their children to interact increased when intervention was delivered in a hybrid model. Social validity ratings indicated that parents were positive regarding the technology used in the hybrid model and its benefits. However, parents did not agree on the observed benefits of home-based sessions compared to the clinic-based sessions. This difference was reflected in their sense of self-efficacy as one parent reported that they did not feel qualified to provide intervention to their child. It is important to note that this experiment served as a pilot study for a large-scale project. Therefore, the results of this study must be interpreted with caution.

Ura et al. (2021) examined the effect of parent coaching program delivered via telehealth on social communication and other collateral effects (e.g., stereotypy) for children with ASD using one group pretest-posttest design. A total of 92 families attended coaching sessions. Children ranged in age from 2 to 18 years. Due to missing data and exceeding the age criterion (18 years), data of four children were excluded from the statistical analysis. Parent coaches were doctoral-level graduate assistants enrolled in special education and school psychology programs, seeking certification in applied behavior analysis, and supervised by one of the investigators. Materials and technologies used in remote coaching were not described. The dependent variable was the scores that parents scored on Autism Spectrum Rating Scales (ASRS; Goldstein & Naglieri, 2010). ASRS was used to measure changes in behavior of children with ASD from their parent perspective.

Parents were asked to watch a blended (synchronous and asynchronous) 3-h webinar. The webinar provided parents with information and opportunities to practice strategies that address communication needs of children with ASD such as prompting and modeling. Following the webinar, parents were asked to complete ASRS. Parent coaching was delivered remotely over 12 weekly sessions. It is important to note that many parents who attended at least three coaching sessions were no more than 40. Based on information gathered from families and their priorities, coaches developed intervention goals with parents on the first coaching session. In the second session, coaches gave parents a structured plan and reviewed the strategies they learned in the webinar. In the following sessions, parents received feedback from coaches on their use of social communication strategies. The feedback was given based on parent-child sessions videotaped few days before each coaching session. Thereafter, parents practiced the strategies with the coaches through roleplaying. ASRS was completed again after the last coaching session.

Results indicated that social communication scores on ASRS improved significantly after attending the coaching program. In addition, the investigators found that even skills and ASD symptoms that were not addressed directly in the coaching program (e.g., stereotypy) improved significantly. However, the investigators could not confirm if those changes resulted from the coaching program due to absence of control group. In addition, those changes were measured based on parent scoring rather than direct observation and measurement of behavior. The study includes further limitations such as the high retention rate and the low survey response rate.

Vismara et al. (2013) examined the effect of Parent-Implemented Early Start Denver Model (P-ESDM; Rogers et al., 2012) facilitated via telehealth and consisted of live coaching and a website on parent satisfaction, parent intervention skills, parent engagement style, parent website usage, and behaviors of eight children with ASD ranging in age from 22 to 45 months. The researchers used multiple-baseline-across-dyads design to examine the effects of the telehealth program. Each dyad consisted of at least one parent and one child with ASD. Parents implemented the intervention at their homes. Materials used throughout the experiment included desktop computers/laptops, webcam, a website, toys, and materials that parents usually use in their daily interactions with children. Coaches were one of the authors and a therapist qualified to deliver ESDM. Dependent variables measured throughout the experiment included parent scores on satisfaction survey, parent scores on fidelity tool, parent engagement style as measured by Maternal Behavior Rating Scale (MBRS; Mahoney et al., 1986), parent website usage as measured by time spent on each page of the website, and child behaviors. Child behaviors included functional verbalizations and nonverbal joint attention initiations. Child behaviors were measured directly from videotaped sessions and indirectly by parents who completed MacArthur Communicative Development Inventories (MCDI; Fenson et al., 2007).

During baseline, parents were asked to interact with their children as they typically would. No instruction or coaching was given during baseline. During intervention, parents implemented ESDM via telehealth across 1.5 h sessions for 12 weeks followed by three monthly follow-up sessions. This model consists of 10 topics such as increasing child's attention, building imitation skills, and promoting speech development. Therapists began interventions sessions with discussing the events related to implementing the preceding topic with the parent. The discussion was followed by 10-min interaction between the child and the parent who was watched and coached by the therapist via webcam. This 10-min interaction was followed by discussion and feedback from the therapist. Parents were also able to login into the website to watch their own session. In addition, they were encouraged to sign into the website and access the materials (e.g., modules, calendar) and to contact the therapist. After intervention, parents were asked to interact with their children for three follow-up sessions without coaching to assess maintenance of intervention skills. Those sessions were conducted over three months and each session lasted 1.5 h.

Pilot data indicated that most parents learned how to use ESDM with their children in seven weeks and maintained that for three months following intervention. Additionally, the investigators found a strong correlation between intervention usage and parent engagement style (e.g., responsiveness, affect). They also found a significant correlation between children's verbalizations and their parents' usage of intervention strategies and their engagement styles. In addition, they found a significant correlation between the children's verbalizations as informed by their parents on CDI, parents' interventional skills, and engagement style. In terms of social validity, parents indicated that they improved their understanding and confidence of meeting their children's needs and exchanging information with other care providers. The study encompasses at least five limitations. First, small sample size. Second, sample homogeneity. That is, most parents were from the same age group, socioeconomic class, and ethnic group. Third, no standardized measures were used when measuring the target behaviors. Fourth, measuring parents' usage of website was not necessarily accurate. That is, the investigators measured the time spent in an opened tab. An opened tab, however, was not necessarily active. Fifth, it is unknown how parents who do not have access to technologies used in the experiment would have responded to telehealth program.

In a randomized controlled trial (RCT), Vismara et al. (2018) compared the efficacy of P-ESDM with treatment-as-usual early intervention program in increasing fidelity, website usage, program satisfaction, and children's social communication behaviors among 24 families of young learners with ASD. Child participant were 17 boys, 4 girls, 20 non-Hispanic, 4 Hispanic, and ranged in age from 18 to 48 months. Parent participants were 19 females, 5 males, 2 high-school graduates, 5 attended some college, 9 college graduates, and 9 graduate degree holders. Participants were randomized to two groups: P-ESDM (*n*= 14) and treatment-as-usual early intervention program (*n*= 10). Coaches were two investigators and one therapist. All coaches were certified in ESDM. All sessions took place at participant's homes. Coaches, however, interacted with parents remotely via telehealth. Materials used in the experiment included computers/laptops/tablets, videoconferencing software, and webcams. Dependent variables included the scores on P-ESDM fidelity tool, program website usage as measured by the time spent viewing the webpages, program satisfaction as measured by scores on 20-item questionnaire, and children's social communication behaviors (i.e., functional verbalizations, imitative functional play actions, independent nonverbal joint attention behavior) as measured by rate per minute. Measurement of dependent variables occurred at three points: 1) baseline, 2) after 12 weeks of intervention, and 3) at 12-week follow-up.

During baseline, parents interacted with their children as they typically would. Parents assigned to P-ESDM treatment group received telehealth coaching, implemented the intervention, and accessed the website as in Vismara et al. (2013). Parents in control group (i.e., treatment as usual) received monthly rather than weekly coaching sessions via telehealth and they accessed the website. However, telehealth coaching for parents in control group did not include the content of P-ESDM. Instead, coaching was focused on the programs in which their children were enrolled during the experiment.

The investigators found no difference between the two groups during baseline. During intervention, parents in P-ESDM showed higher fidelity. At 12-week follow-up, parents in P-ESDM showed higher fidelity while no change was observed in control group. Interestingly, two parents in control group met fidelity. Investigators suggested that this possibly happened because of the commonality between skills addressed in early intervention programs and P-ESDM. Investigators found no correlation between website usage and fidelity. This suggests that obtaining interventional skills requires active participation in treatment rather than accessing information as a sole source of learning. Treatment effect was not determined for children's social communication skills. In terms of program satisfaction, parents in P-ESDM group were more satisfied, encouraged, and confident from coaching sessions and website than controls as measured by their scores on the questionnaire. In addition, they observed more progress in their children's skills than controls. The study includes four limitations. First, while all children were officially diagnosed with ASD, their diagnoses were not necessarily accurate. Second, no standardized measures were used in measuring children's behaviors. Third, group differences were not controlled. As a result, children in control group varied greatly in the amount of early intervention services they received during the experiment. Fourth, fidelity was not met by all parents in P-ESDM group.

Systematic Review IV: Discussion and Summary of Results

Methods of Parent Training

Obviously, there are multiple methods to deliver services to children with ASD and their families via telehealth. The reviewed studies addressed either single or multiple modalities. Single-modality studies addressed real-time coaching only (Lindgren et al., 2020; Rooks-Ellis et al., 2020; Simacek et al., 2017; Tsami et al., 2019). Multiple-modality studies addressed multicomponent telehealth packages or compared two modalities with each other (e.g., remote vs in-person coaching). Multicomponent telehealth packages included a combination of remote and in-person coaching (Flippin & Clapham, 2021), viewing videotaped therapy sessions and visual supports (i.e., outlines) followed by brief real-time coaching (Gevarter et al., 2021), synchronous (e.g., verbal instructions, role-play, feedback) and asynchronous (i.e., cheat sheet) training followed by synchronous coaching in which feedback on implementation was given to parents based on pre-recorded videos (Pierson et al., 2021), real-time coaching followed by viewing website modules (Vismara et al., 2013; 2018), and viewing blended (synchronous and asynchronous) webinar followed by coaching sessions in which feedback on implementation was given to parents based on pre-recorded videos (Ura et al., 2021). Comparative studies included comparing therapist-assisted and self-directed intervention (Ingersoll et al., 2016) and clinician-delivered with hybrid (clinician- and parent-delivered) intervention (Baharav & Reiser, 2010). It is important to note that component analysis was not conducted in any study in which multicomponent telehealth packages were used. Component analysis could have helped with determining the components of telehealth package that are necessary to increase parent fidelity of implementation.

Parent Coaches

Parents who participated in the reviewed studies were coached/trained by people varying in their training, licensure, experience, and qualifications. Parents in some studies were coached directly by the researcher (Flippin & Clapham, 2021; Gevarter et al., 2021; Pierson et al., 2021; Vismara et al., 2012; 2018). Two of those research teams (i.e., Vismara et al., 2012; 2018) involved therapists who were certified to deliver the intervention (i.e., ESDM). Parents in the other studies were coached by behavioral consultants (Lindgren et al., 2020), master's-level therapists (Ingersoll et al., 2016; Tsami et al., 2019), doctoral-level therapist (Tsami et al., 2019), speech-language pathologist (Baharav & Reiser, 2010), a certified P-ESDM provider (Rooks-Ellis et al., 2020), and a doctoral student seeking certification in applied behavior analysis (Ura et al., 2021). Simacek et al. (2017) mentioned that parents were coached by therapists without describing their qualifications and/or licensure. Apparently, all those coaches were generally able to coach parents successfully regardless of their experience, licensure, and degree. While coaches varied in their qualifications, all of them were experienced in their fields (e.g., behavior analysis, speech-language therapy). Accordingly, the extent to which entry-level therapists can coach parents efficiently is unknown. In addition, the best strategy to coach coaches is unknown. Research on comparing coaching strategies is needed.

Efficacy of Remote Parent Training on Acquisition of Communicative Behaviors Among Children with ASD

All single-modality studies indicated that interventions mediated by parents trained via real-time coaching alone were effective in increasing mands (Lindgren et al., 2020; Tsami et al., 2019), improving ASD symptomatology (Rooks-Ellis et al., 2020), increasing usage of AAC devices to request access to reinforcers (Simacek et al., 2017), and reducing idiosyncratic responses such as leading (Simacek et al., 2017).

Most, but not all, studies on multicomponent telehealth packages indicated that parent-mediated interventions were effective in increasing spontaneous single words (Flippin & Clapham, 2021), rates of children's independent communication responses (Gevarter et al., 2021), functional verbalizations (Vismara et al., 2013), and social communication skills (Ura et al., 2021). Two research teams (Pierson et al., 2021; Vismara et al., 2018), however, could not determine the effects of parent-mediated intervention on children's communicative responses. It is important to note that some research teams such as Ura et al. (2021) used parent-reported scales instead of direct measurement of children's communication responses. As mentioned earlier, no research team conducted a component analysis to determine which component of the telehealth coaching package was the most or the least needed to coach parents effectively. For instance, Gevarter et al. (2021) could have conducted the coaching without visual supports then introduced them at a later point of time to determine if they were necessary to increase parent fidelity of implementation.

The comparative study of Ingersoll et al. (2016) indicated that children's language gains were marginally higher among children who received therapist-assisted intervention than those who received self-directed intervention. This finding suggests that parents were able to improve their children's language without receiving direct coaching and supervision from clinicians. In addition, it is unknown which component of self-directed intervention was most helpful in enabling parents to implement the intervention effectively. It is possible that some components (e.g., homework) were more helpful than others (e.g., self-check). The other comparative study (Baharav & Reiser, 2010) indicated that the hybrid model in which clinician-delivered sessions were followed by parent-mediated sessions had an additive effect to the traditional model (i.e., clinician-delivered only). This additive effect, however, was not observed in the other participant. The results of this study must be interpreted with caution due to the small sample size (*n*= 2).

Outcomes of Generalization and Maintenance

Generality of behavior change was assessed in one third (*n*= 4) of studies. Authors of those studies assessed generality across novel stimuli (Pierson et al., 2021), non-training family members (Tsami et al., 2019), and when coaches were not present (Gevarter et al., 2021). Rooks-Ellis et al. (2020) assessed generalization of parent fidelity rather than children's behavior. Generalization outcomes in those studies were generally positive except Pierson et al. (2021) as intervention data were highly variable and overlapped with baseline.

Generality of change in children's behavior across time (i.e., maintenance) was assessed in less than the half (*n*= 5) of the reviewed studies. Rooks-Ellis et al. (2020) assessed maintenance of parent fidelity rather than children's behavior. Maintenance probes were taken one week (i.e., Pierson et al., 2021) to six months (i.e., Lindgren et al., 2020) following intervention. With the exception of Pierson et al. (2021), outcomes of maintenance in the reviewed studies were generally positive.

Due to limited generalization and maintenance data, the extent to which most children were able to generalize and maintain behavior change after receiving parent-mediated intervention is unknown. It would be helpful if researchers compare parent-delivered with clinician-delivered intervention in terms of generalization and maintenance. It is possible that generalization and maintenance outcomes differ when intervention is delivered by different providers. For example, DeVeney et al. (2017) suggested that parent-delivered intervention for late talkers has the potential to yield better outcomes than clinician-delivered intervention. This assumption was based on results of 8 studies with a total of 175 children. Therefore, additional data from children with ASD and their families are needed.

Social Validity

Social validity from parents' perspective was assessed in the majority of reviewed studies (*n*= 10, 83.3%). Pierson et al. (2021) is the only study in which the three facets of social validation: a) acceptability of treatment package, b) social significance of target behaviors, and c) importance of intervention outcomes (Wolf, 1978) were assessed. The other nine studies included social validation of treatments and/or dependent variables. However, all those ten studies included social validation of coaching via telehealth except Lindgren et al. (2020). All those studies reported overall parent acceptability of dependent variables, treatment, outcomes, and/or coaching via telehealth. Some parents reported technical difficulties during telehealth coaching sessions (e.g., Baharav et al., 2010) and challenges with implementing intervention and managing their children's problem behaviors (e.g., Pierson et al., 2021). While obtaining parents' perspectives about treatment packages and coaching is important, it is equally important to assess acceptability from the perspective of intervention recipients (i.e., the children). None of the reviewed studies, however, included validation of intervention from children's perspective. It would be more helpful to compare acceptability of treatment from children's perspectives when delivered by their parents and other caregivers (e.g., therapists).

Systematic Review IV: Conclusion and Future Directions

This systematic review found that different methods were successful in coaching parents on implementing communication interventions for their children with ASD. In addition, this review found that most parent-implemented interventions were effective in increasing children's communication skills such as mands, spontaneous verbalizations, and AAC requests. However, the reviewed literature encompasses some limitations. It is important to address the following limitations in future research: 1) examining parent fidelity of implementation when coached by entry-level therapists, 2) determining the most and/or least necessary component of multicomponent parent coaching package, 3) comparing generality and maintenance of behavior change when intervention is delivered by different implementers (e.g., parents versus interventionists), and 4) involving children in social validity evaluations and comparing their acceptability of intervention when delivered by different implementers (e.g., parents versus interventionists).

Chapter Three: Method

Experimental Design

In the present study, a multiple-probe design across stimulus sets (Horner & Baer, 1978) was used to examine the efficacy of the intervention package which consists of SPOP and MET. This design was selected because it does not require withdrawal of a possibly effective intervention (Gast & Ledford, 2014), it does not require continuous measurement of the dependent variable prior to intervention (Gast & Ledford, 2014), and because it allows the researcher to see the replication of effect across tiers.

The participant received at least three preintervention probes and one generalization probe prior to introducing the intervention to each stimulus set. Preintervention and generalization probes started for all three stimulus sets at the same time. Intervention, however, was introduced to each stimulus set in a staggered fashion. During preintervention probes, the stimulus sets “home sounds” and “transportations” had no trend while the remaining set (i.e., musical instruments) showed little variation. As “home sounds” and “transportations” showed the most stable pattern of responding, intervention (i.e., SPOP+MET) was randomly introduced to one of those tiers (i.e., home). Random assignment of intervention occurred by drawing one of two slips of paper. When the participant started demonstrating increase in the number of correct auditory tacts in “home sounds”, the intervention was introduced to the next stimulus set with the most stable baseline (i.e., transportations). The intervention was introduced to “musical instruments” when an increase in the number of correct auditory tacts was observed in “transportations”. Intervention was followed by five postintervention probes for each stimulus set. Intervention was repeated (i.e., remedial intervention) for each stimulus set because the mastery criterion was not met. The mastery criterion was responding at 8 out of 9 trials across three consecutive postintervention probes. Remedial intervention was followed by another five postintervention probes. Also, one generalization probe was taken for each stimulus set after those five probes. One week after generalization probe, a follow-up probe was taken for each stimulus set.

Participants

The Child

One kindergartener with ASD participated in the study. To recruit the participant, the study flyer was shared with families of children who meet the following criteria: 1) the age ranges from 36 to 84 months, 2) a formal diagnosis of ASD, 3) a repertoire of a minimum 20 visual tacts (e.g., pictures, objects) as measured by a recent formal assessment (e.g., VB-MAPP, ABLLS-R). In absence of formal assessment, the parent was asked to estimate the tact repertoire of the potential participant, 4) absence of previous training on auditory tacts, 5) absence of frequent problem behaviors that interfere with one-to-one training such as lengthy temper tantrums, property destruction, and aggression, and 6) the ability to sit and orient toward the adult (e.g., teacher, caregiver) for a minimum of 3 minutes as confirmed by parent and/or therapists. Recruitment of participant occurred after obtaining IRB approvals (see Appendices A & B). Written parent permission and informed parent consent were obtained from the participant's parent. Additionally, verbal assent was obtained from the child before initiating research activities.

The participant was a 6 year 2 months old, white female, with ASD. She attended an inclusive kindergarten classroom. The participant received special education support for 15 min a day. In addition, she received four speech therapy sessions a week for a total of 190 minutes. According to the most recent speech and language assessment, the participant obtained composite scores ranging from 92 to 97 on *Test of Language Development-Fourth Edition: Primary* (TOLD-P:4; Hammill & Newcomer, 2008) which considered average. In terms of speech, the participant obtained a word articulation standard score of 76 and a sentence articulation standard score of 75 on *Arizona Articulation Proficiency Scale-Fourth Edition* (Arizona-4; Fudala & Stegall, 2017). Those scores suggested that the participant had moderate articulation impairment due to errors in the following sounds: /sh/ and /ch/. Additionally, the participant demonstrated age-appropriate speech errors in /r/, /r/-blends, /l/-blends, and /th/. Due to absence of formal assessment of auditory tacts, the mother was asked to estimate the repertoire of auditory tacts. According to the mother, the participant could label familiar sounds (e.g., animals) but inconsistently. English is the only language the participant used at home and school.

The Parent

The mother of the participant also participated in the present study. Her role in the study involved 1) attending the training provided by the researcher prior to the experiment, 2) implementing the proposed intervention package, 3) conducting desensitizing session, screening, preintervention, postintervention, generalization, and follow-up probes, and 4) completing social validity questionnaire. The participant's mother was recruited because she met the following inclusion criteria: 1) having the willingness and time to carry out the aforementioned responsibilities, and 2) absence of previous experience in delivering SPOP and/or auditory tact instruction.

Setting

All experimental conditions were conducted at the participant's place of living. Desensitizing, screening, preintervention, intervention, postintervention, generalization, and follow-up probes were conducted in the same room. Homes are not distraction-free settings.

Therefore, the participant's parent was asked to minimize distractors during training and probes. For example, the parent restricted access of participants' sibling to the room during intervention and probe sessions.

Materials

Materials for Intervention and Probes

The participant's mother was given a list of environmental sounds (see Appendix C). The mother was asked to select at least nine sounds from three different categories (e.g., animals, musical instruments) she thinks are important for her child to learn their labels. Additionally, she was asked not to choose previously learned sounds and those present in the tact repertoire of the participant. Depending on the mother's selections, audio files were downloaded from different websites. Most audio files were downloaded from BBC Sound Effects (http://sound-effect.bbcrewind.co.uk) and YouTube. Further audio files, however, were downloaded because some sounds were found familiar to the child during screening. The parent used laptop to present the audio files. Each target sound had six exemplars: three for intervention and three for generalization probes. The exemplars numbered one to three were used in preintervention, intervention, postintervention, and follow-up probes, whereas exemplars numbered four to six were used to probe generalization prior to and after intervention. All audio files used in the current experiment had the same length (i.e., 5 seconds). Table 1 presents auditory tacts addressed in the current study.

Table 1

Target Sounds and Their Assignment to Stimulus Sets

Home Sounds	Transportations	Musical Instruments
Washing Machine	Backing up	Piano
Lawn Mower	Helicopter	Flute
Doorbell	Siren	Harmonica

Reinforcers

The parent was asked to complete a survey (see Appendix D) to identify the three most preferred items to use during the experiment. These items were selected from different categories (e.g., foods, toys) due to the variability of preference throughout the day. For example, food does not serve as a strong reinforcer when the child is full. The participant's parent mainly used praise and tangibles such as books and toys as reinforcers after each probe.

Materials for Parent and Independent Rater Training

The researcher used Zoom app to deliver synchronous training to the parent and the independent rater on implementation and data collection, respectively. The training was supplemented with PowerPoint slides.

Videoconferencing

In addition to the laptop that the parent used to play sound files during the experiment, she used iPad for videoconferencing during parent training and all other research-related activities (e.g., intervention, probes).

Measurement

Response Measurement and Interobserver Agreement (IOA)

The dependent variable in the present experiment was the number of auditory tacts the participants emitted correctly during preintervention, postintervention, generalization, and follow-up probes. The researcher and the independent rater independently identified each response as either correct or incorrect. A doctoral student in special education who was a Board-Certified Behavior Analyst (BCBA) and worked with learners with ASD, participated in the study as an independent rater. The response was recorded correct (see Appendix E) if it corresponded to the presented sound (e.g., saying *siren* when siren is presented) and emitted after the parent asked the question, "What is this?" and within 5 seconds after the audio file stops. An incorrect auditory tact means that the emitted tact does not match the sound file (e.g., saying *train* when washing machine sound is presented), when the response is unintelligible, or when no response is given within 5 s after the parent asks, "What is this?" and the audio file stops. Additionally, relevant responses such as saying "airplane" when hearing "helicopter" or saying "firetruck" when hearing "siren" were considered incorrect because they do not necessarily match the stimuli. For example, sirens used in the experiment were sounds of different emergency vehicles (e.g., fire truck, ambulance). Therefore, using a word in an excessively general manner such as saying "fire truck" upon hearing any siren is an error known as *overextension* (Rescorla, 1980). The same rule was applied to all three stimulus sets.

The researcher measured the participant's responses on 100% of sessions, whereas the independent rater measured the responses on at least 33% of sessions in each phase. The IOA was calculated by counting the number of agreements then dividing that number by the total number of trials in the session (see Appendix F). The resulting number was multiplied by 100 to obtain the percentage of IOA for the session. The mean of response measurement IOA for all stimulus sets prior to and after intervention was 100%, except postintervention probes of "home sounds" and "musical instruments" in which the means were 88.9% (range, 77.8-100%) and 94.4% (range, 88.9-100%), respectively. Table 2 shows the number and percentage of sessions each observer attended for each stimulus set and the mean and range of IOA.

Table 2

Summary of Response Measurement IOA Data

Stimulus Set	Observer	Preintervention[a]			Postintervention[b]		
		Sessions		IOA	Sessions		IOA
		n	%	*M (%)*	*n*	%	*M (%)*
Home Sounds	Researcher	3	100	100	12	100	88.9
	Independent Rater	2	66.7		4	33.3	
Transportations	Researcher	4	100	100	12	100	100
	Independent Rater	2	50		4	33.3	
Musical Instruments	Researcher	5	100	100	12	100	94.4
	Independent Rater	3	60		4	33.3	

Note. *n= Number of sessions, M= Mean*

[a] Includes generalization probe taken prior to intervention

[b] Includes generalization and follow-up sessions.

Treatment Integrity and Interobserver Agreement (IOA)

The researcher measured treatment integrity on 100% of sessions across all phases, whereas the independent rater measured treatment integrity on at least 33.3% of randomly selected sessions in each phase. The researcher created two checklists. The checklists included the steps the parent had to follow during probes (see Appendix G) and intervention (see Appendix H). At the end of each observation, each observer counted the number of steps the parent implemented as described in the checklist. The number of correctly implemented steps was divided by the total number of steps in the checklist. The resulting number was multiplied by 100 to obtain the percentage of treatment integrity for that particular session. Similar to response measurement IOA, trial-by-trial IOA for treatment integrity was measured (see Appendix I). The mean of IOA across all stimulus sets and phases was 100%. Number of intervention sessions each observer attended, mean of treatment integrity for each observer, and IOA data were summarized in Table 3.

Table 3

Summary of Treatment Integrity IOA Data

Stimulus Set	Observer	Preintervention				Intervention[a]				Postintervention[b]			
		Sessions		TI	IOA	Sessions		TI	IOA	Sessions		TI	IOA
		n	%	*M (%)*	*M (%)*	*n*	%	*M (%)*	*M (%)*	*n*	%	*M (%)*	*M (%)*
Home Sounds													
	Researcher	3	100	100	100	2	100	100	100	12	100	98.3 (range, 80 to 100)	100
	Independent Rater	2	66.7	100		2	100	100		4	33.3	100	
Transportations													
	Researcher	4	100	100	100	2	100	100	100	12	100	100	100
	Independent Rater	2	50	100		1	50	100		4	33.3	100	
Musical Instruments													
	Researcher	5	100	100	100	2	100	100	100	12	100	100	100
	Independent Rater	3	60	100		1	50	100		4	33.3	100	

Note. *n= Number of sessions, M= Mean, TI= Treatment Integrity*

[a] Includes initial and remedial intervention.

[b] Includes generalization and follow-up sessions.

Procedure

This section describes the general procedure of the present study which consists of parent training, independent rater training, sensitizing sessions, screening, preintervention, generalization, SPOP+MET, postintervention, and follow-up.

Parent Training

The researcher trained the parent on the procedures she conducted throughout the experiment. Training was conducted remotely using Zoom. Parent training consisted of two modules: probing and intervention (see Appendix J). The researcher presented the two modules in one session. The researcher began each module with verbal explanation of the procedure. The verbal explanation was accompanied by texts and pictures displayed on PowerPoint slides. The pictures were animated to provide virtual demonstration of probes and intervention. At the end of training, the researcher answered the parent's questions and emailed PowerPoint slides to the parent to review the procedures before experimental procedures initiated.

Independent Rater Training

The researcher met the independent rater via Zoom for training on data collection. Training consisted of two modules: response measurement and treatment integrity (see Appendix J). The two modules were presented in one session. As in parent training, the researcher started each module with verbal explanation of each procedure. The verbal explanation was supplemented with texts and animated pictures to provide the independent rater with virtual demonstration of probe and intervention sessions. The training also included definitions of correct and incorrect responses. In addition, the researcher emailed the PowerPoint slides to the independent rater to review the procedures before the experimental sessions initiated.

Sensitizing Session

Reactivity to direct observation threatens internal and external validity (Harris & Lahey, 1982). It was predicted that the participant would alter her performance when observed by the researcher and the independent rater through videoconferencing. To decrease reactivity, one sensitizing sessions was conducted prior to screening. During sensitizing session, the researcher watched the participant doing activities not related to the study (e.g., eating, talking to mother).

Screening

Auditory tacts unknown to the participant were used in the intervention. To identify unknown auditory tacts, the parent conducted screening to assess the novelty of each sound she chose earlier. Prior to screening, the parent made sure the child was staying still and paying attention by making eye contact with the parent or by looking at the device the parent held. When the participant was not paying attention, the parent asked her to pay attention (e.g., listen, we will hear fun sounds). When the child was paying attention, the parent asked, "what is this?" and immediately played the audio file. The parent did not deliver any consequence contingent on the child's response (e.g., praise, error correction). The researcher viewed the screening session through Zoom to determine sounds unknown to the child. Sounds tacted correctly by the child were replaced by other sounds the parent chose and tested for novelty following the procedure mentioned above. Screening continued until nine target sounds (see Table 1) were identified.

Preintervention Probes

As in screening, the parent made sure that the child was paying attention prior to preintervention probe. During this probe, the parent conducted the same procedures of screening. Each probe consisted of single 9-trial block. The block consisted of three target sounds (e.g., flute, harmonica, piano) and each target had three exemplars for a total of 9 audio files. Audio files were presented in a randomized order. The researcher varied the order of audio files prior to each probe to avoid unwanted stimulus control. After each probe, the parent praised the child for attending and delivered a highly preferred item (e.g., toy). Each tier (i.e., home, transportations, musical instruments) received at least three preintervention probes.

Generalization Probes

Generalization probes were conducted prior to and after the intervention. The preintervention generalization probe was similar to the one described in the previous section. The only difference between the two probes is the audio files. Hence, the parent played novel (i.e., non-training) exemplars of the sounds used in the intervention, preintervention, and postintervention probes. Generalization probes were taken at the same room in which intervention was conducted. The parent took two generalization probes for each tier: one before intervention and one after intervention. Generalization probes that followed intervention were taken for each tier after the five probes that were taken after remedial intervention.

Intervention

During SPOP+MET intervention sessions, the parent sat with the child at the table. The parent conducted intervention at the same place in which preintervention probes were taken. The researcher watched all intervention sessions via Zoom to measure treatment integrity, whereas the independent rater observed 50-100% of intervention sessions. As in preintervention, the parent made sure that the child was paying attention. When the child was paying attention, the parent vocally tacted the object that makes the sound and immediately played the corresponding audio file. Similar to preintervention probes, the parent did not reinforce or correct any response the child made during the procedure. Unlike probes, the parent did not ask the participant any question about the sounds she presented. The same audio files used in the preintervention were presented during SPOP+MET. Each SPOP+MET session consisted of two 9-trial blocks. Thus, each audio file was played twice. Sounds were introduced in a randomized order to avoid unwanted stimulus control. At the end of intervention, the parent praised the child for proper attending and allowed access to a highly preferred item or activity. The same procedure was followed during the remedial intervention.

Postintervention Probes

Following SPOP+MET intervention session, the parent used the same procedures and audio files of preintervention probe. Each intervention session was followed by at least five postintervention probes with no more than two probes a day for the same stimulus set. Because the participant did not meet the mastery criterion for any stimulus set (i.e., 8 out 9 correct tacts for three consecutive probes), SPOP+MET intervention was repeated (i.e., remedial intervention). A generalization probe was taken for each tier after the fifth postintervention probe following the remedial intervention.

Follow-up Probes

To evaluate maintenance of mastered and novel sounds, the parent took a follow-up probe one week following the postintervention generalization probe for each tier. The parent followed the same procedures of pre- and postintervention probes during follow-up. Follow-up probes included the same audio files presented during intervention. The parent took follow-up probes in the same room in which all previous probes were taken.

Social Validity

The researcher asked the parent to complete a survey (see Appendix K) to evaluate the social significance of the dependent variable, the procedures, and the results. The questionnaire was composed of 11 five-point Likert scale items covering the three aspects of social validity in applied behavior analysis identified by Wolf (1978): 1) the dependent variable, 2) behavior change procedure, and 3) results of intervention. Additionally, the parent asked the child after each intervention session to point to a happy face if she liked the activity or the sad face if she did not like it.

Chapter Four: Results

Data Analysis

Research Question One

Will the parent-mediated SPOP+MET intervention increase the number of correct tacts of auditory stimuli in a child with autism?

Home Sounds

Prior to intervention, number of correct auditory tacts for each preintervention probe was 0 (see Figure 8). After intervention, the participant displayed an immediate increase in number of correct tacts for a mean of 2 (range, 1 to 3). It is possible that number of correct tacts on the second postintervention probe was higher than the first one due to increased attention. That is, the participant on the first probe looked frequently at herself on Zoom screen when her mother was presenting the sounds. Therefore, the participant's mother was asked to cover the screen with a sheet of paper to avoid reactivity on subsequent probes.

Interestingly, postintervention data showed an increasing trend followed by a decreasing trend. Those two trends occurred due to the increase in number of correct tacts for "washing machine" and "lawn mower" which was followed by a decline in those two tacts.

The only home sound the participant labeled correctly on each of her five postintervention probes was "washing machine" (see Figure 9). It is important to note that she correctly labeled all three exemplars of "washing machine" in one postintervention probe only. In the other four postintervention probes, the participant correctly labeled either one or two exemplars of "washing machine". Additionally, the participant correctly labeled two exemplars of "lawn mower" on one postintervention probe only. The participant, however, did not label any exemplar of "lawn mower" on the other four postintervention probes. No correct labeling of “doorbell” occurred at probe after initial intervention (see Table 5). The participant said, “ding dong” after each presentation of “doorbell”.

To determine the effect size for this stimulus set, the percentage of nonoverlapping data points (PND; Scruggs et al., 1987) was calculated. The PND for this stimulus set was 100%. This value suggests that intervention was very effective (Scruggs & Mastropieri, 1998). This effect size, however, was overestimated as not all target tacts were acquired after the initial intervention (i.e., doorbell). To obtain more accurate effect size, the PND was calculated independently for each target tact. The PND for “washing machine” was 100% (i.e., very effective), 20% for “lawn mower” (i.e., ineffective), and 0% for “doorbell” (i.e., ineffective).

After remedial intervention, number of correct tacts in this stimulus set ranged from 2 to 5 for a mean of 4.2. Surprisingly, “washing machine” decreased from a mean of 1.6 (range, 1 to 3) after initial intervention to a mean of 0.4 (range, 0 to 1) after remedial intervention. The tact “lawn mower” increased from a mean of 0.4 (range, 0 to 2) after initial intervention to a mean of 1.6 (range, 1 to 2) after remedial intervention, while “doorbell” increased from a mean of 0 after initial intervention to a mean of 2.2 (range, 0 to 3) after remedial intervention.

Effect size for the entire stimulus set and for each target was determined after remedial intervention using PND. The PND for the stimulus set was 100%, whereas the PND for “washing machine” was 40% (i.e., ineffective), 100% for “lawn mower” (i.e., very effective), and 80% for “doorbell” (i.e., effective).

Figure 8

Number of Correct Tacts Across the Stimulus Sets

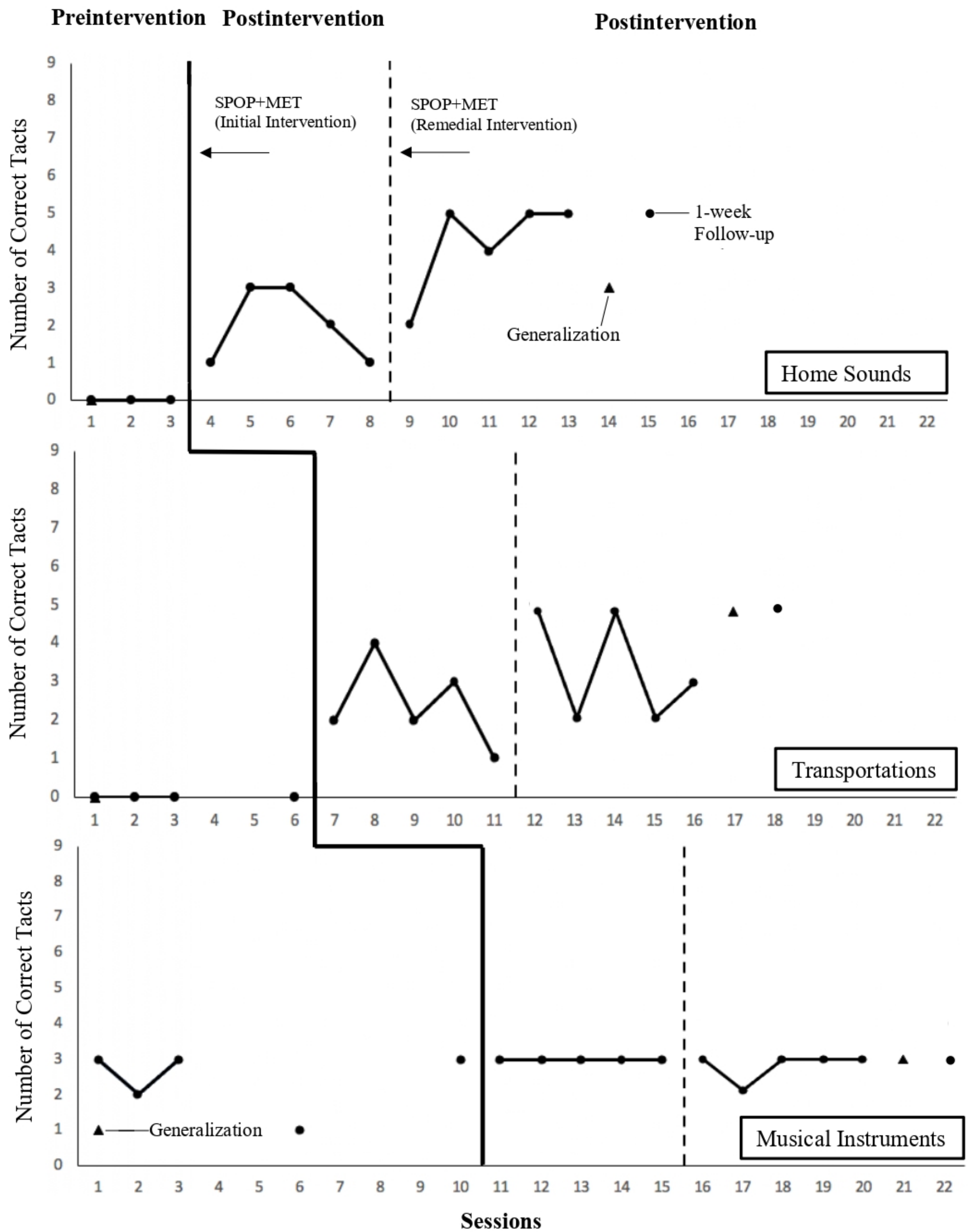


Figure 9

Number of Correct Tacts for Each Target Stimulus

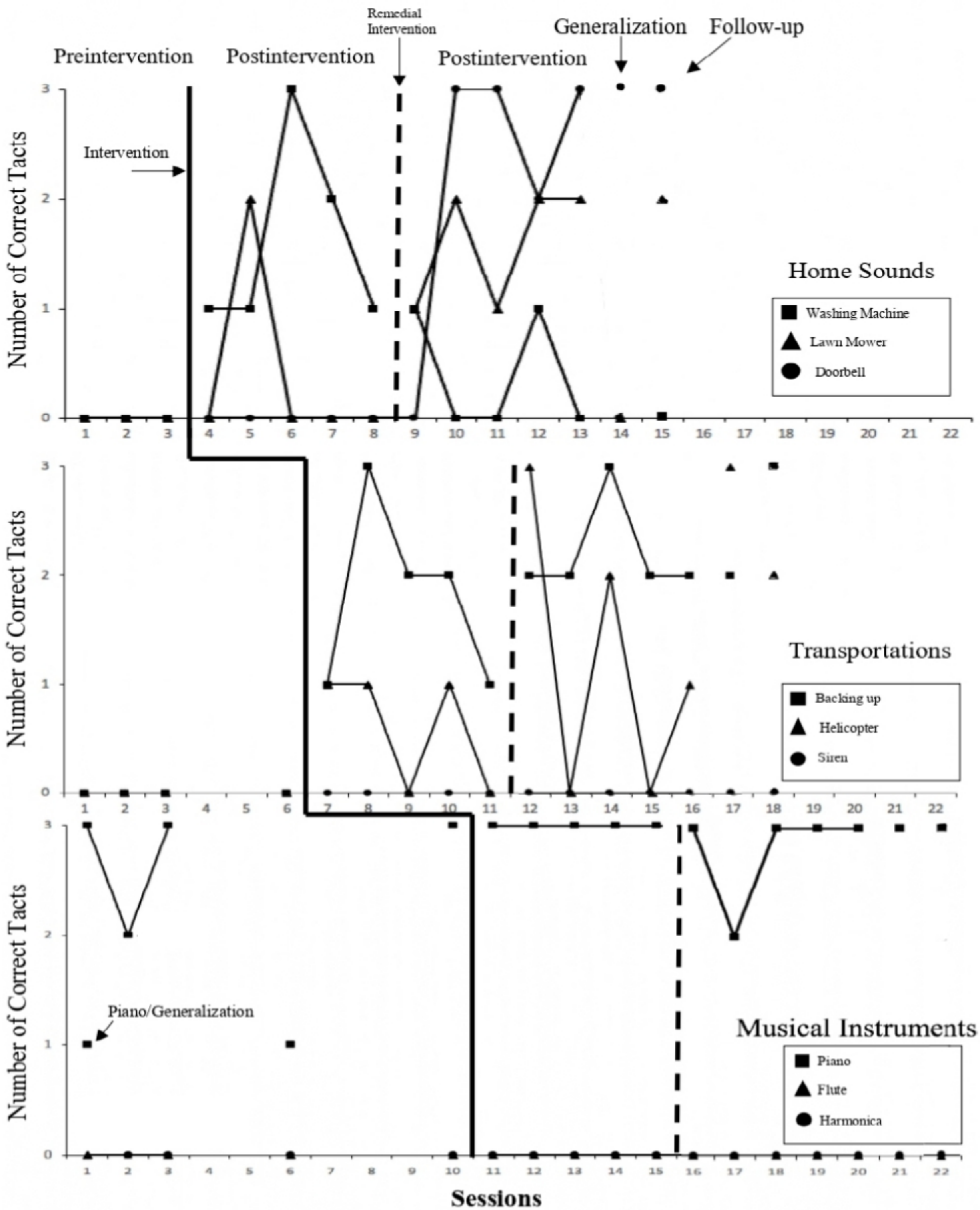


Table 4

Number of Correct Tacts for Each Target Stimulus Across Conditions

		Gen Pre	Pre-intervention					Post-intervention					Post-remedial intervention					Gen Post	F
Home	Washing Machine	0	0	0	0	_	_	1	1	3	2	1	1	0	0	1	0	0	0
	Lawn Mower	0	0	0	0	_	_	0	2	0	0	0	1	2	1	2	2	0	2
	Doorbell	0	0	0	0	_	_	0	0	0	0	0	0	3	3	2	3	3	3
Transports	Backing up	0	0	0	0	0	_	1	3	2	2	1	2	2	3	2	2	2	3
	Helicopter	0	0	0	0	0	_	1	1	0	1	0	3	0	2	0	1	3	2
	Siren	0	0	0	0	0	_	0	0	0	0	0	0	0	0	0	0	0	0
Musical Instruments	Piano	1	3	2	3	1	3	3	3	3	3	3	3	2	3	3	3	3	3
	Harmonica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Flute	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note. Gen= Generalization Pre= Preintervention, Post= Postintervention, F= Follow-up

Transportations

The participant made no correct tacts in this stimulus set during the four preintervention sessions. Following intervention, the participant showed an immediate increase in number of correct tacts for a mean of 2.4 (range, 1 to 4). The only two sounds the participant was able to tact correctly during postintervention probes were “backing up” and “helicopter” (see Figure 9). The participant, however, did not tact all exemplars of “backing up” and “helicopter”. The participant labeled all three exemplars of “backing up” correctly in one postintervention probe only. On the other four probes, the participant labeled either one or two exemplars of “backing up”. The participant correctly labeled one exemplar of “helicopter” in three postintervention probes. No correct tacts of “helicopter” were emitted on the remaining two probes. It is important to note that the participant did not label the same exemplar on each probe. For example, she labeled the exemplar "helicopter 1" correctly on some, but not all probes.

As the graph shows (see Figure 8), postintervention data in this stimulus set showed a slowly decreasing trend. This is primarily due to the gradual reduction in number of correct tacts for "backing up" after the second postintervention probe.

The participant did not tact "siren" correctly at any postintervention probe. The participant emitted related, but incorrect, responses to "siren" such as "beeping sound" and "fire truck".

Effect size for this tier was determined using the PND. The effect size for "transportations" was 100% (i.e., very effective). Similar to "home sounds", the effect size was overestimated because number of correct tacts for one target (i.e., siren) remained 0 after intervention. Therefore, the PND was calculated independently for each target tact. The PND for "backing up" was 100% (i.e., very effective), 60% (i.e., questionable) for "helicopter", and 0% (i.e., ineffective) for "siren".

Number of correct tacts increased further after remedial training for a mean of 3.4 (range, 2 to 5). While the overall mean of this stimulus set increased after remedial intervention, the tact "siren" remained 0. The mean of "backing up" increased (*M*= 2.2, range 2 to 3), while the mean of "helicopter" increased from 0.6 (range, 0 to 1) after initial intervention to 1.2 (range, 0 to 3) after remedial intervention. The PND for the entire stimulus set remained 100% (i.e., very effective) after remedial intervention. The effect size was possibly overestimated as one target tact (i.e., siren) was not acquired. Hence, the PND for each target tact was calculated. The following were the PND scores for each target tact following remedial intervention: 100% (i.e., very effective) for “backing up”, 60% (i.e., questionable) for “helicopter”, and 0% (i.e., ineffective) for “siren”.

Musical Instruments

During the five preintervention sessions, number of correct tacts ranged from 1 to 3 for a mean of 2.4. The only sound the participant was able to tact correctly and independently during her five preintervention sessions was “piano” although she could not label any exemplar of it during screening which was conducted the day before the first preintervention probe. It is important to note that number of correct tacts of “piano” ranged from 1 to 3, indicating that “piano” was not well-established in the participant’s tact repertoire prior to intervention.

While the mean of correct tacts increased after intervention from 2.4 to 3, the participant did not acquire any new tact. Specifically, the only sound the participant labeled correctly following intervention was “piano”. The intervention, however, stabilized the response “piano” (see Figure 9) as it ranged from 1 to 3 prior to intervention and remained 3 across the five postintervention probes.

As all postintervention data points overlapped with preintervention, the PND for this stimulus set was 0% (i.e., ineffective). Similarly, the PND for each target (i.e., piano, harmonica, flute) was 0% (i.e., ineffective).

Following remedial intervention, the participant did not tact any sound other than “piano”. Number of correct tacts ranged from 2 to 3 for a mean of 2.8. The PND for the stimulus set and for each stimulus remained 0% (i.e., ineffective).

Table 5

Responses Emitted by the Participant Across All Phases

Preintervention Probes (Home Sounds)									
Stimulus	Lawn Mower 2	Washing Machine 1	Lawn Mower 3	Doorbell 2	Washing Machine 2	Doorbell 3	Washing Machine 3	Doorbell 1	Lawn Mower 1
Response	Dumpster	Truck	UR	Ding Dong	Truck	Ding Dong	Truck	Ding Dong	Truck
Stimulus	Lawn Mower 2	Doorbell 2	Washing Machine 3	Lawn Mower 1	Lawn Mower 3	Washing Machine 2	Doorbell 1	Doorbell 3	Washing Machine 1
Response	Truck	Ding Dong	Truck	Truck Air	Smoke	NR	Ding Dong	Ding Dong	Water
Stimulus	Doorbell 1	Doorbell 3	Lawn Mower 2	Doorbell 2	Lawn Mower 1	Washing Machine 3	Washing Machine 1	Washing Machine 2	Lawn Mower 3
Response	Ding Dong	Ding Dong	UR	Ding Dong	NR	NR	Train	Truck	I don't know
Preintervention/Generalization Probe (Home Sounds)									
Stimulus	Lawn Mower 5	Washing Machine 6	Doorbell 6	Washing Machine 5	Lawn Mower 6	Lawn Mower 4	Doorbell 4	Doorbell 5	Washing Machine 4
Response	Truck	Truck	Ding Dong	Airplane	Truck	Motorcycle	Ding Dong	Ding Dong	Truck
Post-Initial Intervention Probes (Home Sounds)									
Stimulus	Lawn Mower 3	Lawn Mower 2	Washing Machine 1	Doorbell 1	Washing Machine 3	Washing Machine 2	Doorbell 2	Doorbell 3	Lawn Mower 1
Response	Drying Machine	Drying Machine	Drying Machine	Ding Dong	Washing Machine	NR	Ding Dong	Ding Dong	Truck
Stimulus	Lawn Mower 1	Doorbell 3	Washing Machine 1	Lawn Mower 3	Doorbell 1	Lawn Mower 2	Washing Machine 2	Doorbell 2	Washing Machine 3
Response	Lawn Mower	Ding Dong	Washing Machine	NR	Ding Dong	Lawn Mower	Air	Ding Dong	Air
Stimulus	Washing Machine 2	Washing Machine 1	Doorbell 1	Lawn Mower 3	Lawn Mower 2	Doorbell 3	Doorbell 2	Washing Machine 3	Lawn Mower 1
Response	Washing Machine	Washing Machine	Ding Dong	I don't know	UR	Ding Dong	Ding Dong	Washing Machine	I don't know
Stimulus	Washing Machine 1	Lawn Mower 1	Doorbell 2	Doorbell 1	Washing Machine 2	Doorbell 3	Washing Machine 3	Lawn Mower 3	Lawn Mower 2
Response	Washing Machine	Backing up	Ding Dong	Ding Dong	Washing Machine	Ding Dong	UR	UR	Backing up
Stimulus	Washing Machine 3	Doorbell 2	Doorbell 3	Lawn Mower 3	Washing Machine 1	Doorbell 1	Washing Machine 2	Lawn Mower 2	Lawn Mower 1
Response	Backing up	Ding Dong	Ding Dong	NR	Washing Machine	Ding Dong	Backing up	NR	I don't know

Post-Remedial Intervention Probes (Home Sounds)									
Stimulus	Lawn Mower 2	Lawn Mower 3	Doorbell 2	Doorbell 1	Lawn Mower 1	Washing Machine 3	Washing Machine 1	Doorbell 3	Washing Machine 2
Response	I don't know	I don't know	Ding Dong	Ding Dong	Lawn Mower	Washing Machine	NR	Ding Dong	I don't know
Stimulus	Doorbell 1	Washing Machine 2	Lawn Mower 1	Doorbell 3	Washing Machine 1	Lawn Mower 3	Washing Machine 3	Lawn Mower 2	Doorbell 2
Response	Doorbell	Smoke	I don't know	Doorbell	I don't know	Lawn Mower	I don't know	Lawn Mower	Doorbell
Stimulus	Lawn Mower 2	Lawn Mower 1	Washing Machine 2	Washing Machine 3	Doorbell 2	Lawn Mower 3	Doorbell 3	Doorbell 1	Washing Machine 1
Response	I don't know	I don't know	I don't know	I don't know	Doorbell	Mow Lawner	Doorbell	Doorbell	I don't know
Stimulus	Washing Machine 1	Washing Machine 2	Doorbell 2	Doorbell 3	Lawn Mower 2	Lawn Mower 1	Washing Machine 3	Doorbell 1	Lawn Mower 3
Response	I don't know	I don't know	I don't know	Doorbell	Lawn Mower	NR	Washing Machine	Doorbell	Lawn Mower
Stimulus	Doorbell 3	Lawn Mower 2	Washing Machine 3	Doorbell 1	Washing Machine 2	Doorbell 2	Lawn Mower 1	Washing Machine 1	Lawn Mower 3
Response	Doorbell	Mow Lawner	NR	Doorbell	NR	Doorbell	I don't know	Helicopter	Mow Lawner
Postintervention/ Generalization Probe (Home Sounds)									
Stimulus	Doorbell 5	Washing Machine 6	Lawn Mower 5	Lawn Mower 6	Washing Machine 5	Doorbell 6	Washing Machine 4	Doorbell 4	Lawn Mower 4
Response	Doorbell	NR	NR	Domino	Rocket Ship	Doorbell	Domino	Doorbell	UR
Follow-up Probe (Home Sounds)									
Stimulus	Lawn Mower 1	Lawn Mower 3	Doorbell 2	Doorbell 1	Doorbell 3	Washing Machine 1	Washing Machine 2	Lawn Mower 2	Washing Machine 3
Response	Lawn Mower	Lawn Mower	Doorbell	Doorbell	Doorbell	Helicopter	Mow Lawner	Vacuum	Helicopter
Preintervention Probes (Transportations)									
Stimulus	Siren 1	Backing up 3	Helicopter 2	Siren 3	Helicopter 3	Siren 2	Helicopter 1	Backing up 1	Backing up 2
Response	Fire Truck	Dumpster	Dumpster	NR	NR	Train	NR	Beep Beep	Beep Beep
Stimulus	Backing up 1	Siren 3	Backing up 2	Backing up 3	Helicopter 1	Siren 2	Siren 1	Helicopter 3	Helicopter 2
Response	Beep	I don't know	Beep sound	Beep	Vehicle	Honking	Fire Truck	Air	Truck
Stimulus	Siren 2	Siren 3	Helicopter 3	Backing up 3	Backing up 1	Helicopter 2	Siren 1	Helicopter 1	Backing up 2
Response	NR	NR	Air	NR	NR	Air	Fire Truck	Airplane	NR

Stimulus	Helicopter 3	Backing up 1	Helicopter 2	Helicopter 1	Siren 3	Siren 2	Backing up 3	Siren 1	Backing up 2
Response	NR	NR	I don't know	Lawn Mower	NR	NR	Beeping Sound	NR	Beeping Sound

Preintervention/Generalization Probe (Transportations)

Stimulus	Siren 6	Backing up 5	Siren 4	Helicopter 4	Siren 5	Helicopter 5	Backing up 4	Helicopter 6	Backing up 6
Response	Fire Truck	NR	NR	NR	NR	Air	Beep	Airplane	Beep Beep

Post-Initial Intervention Probes (Transportations)

Stimulus	Siren 1	Backing up 1	Siren 2	Helicopter 1	Helicopter 3	Siren 3	Backing up 3	Helicopter 2	Backing up 2
Response	Fire Truck	Backing up	Backing up	Van	I don't know	Beep Beep Sound	I don't know	Helicopter	I don't know
Stimulus	Helicopter 1	Backing up 2	Siren 3	Siren 1	Helicopter 2	Siren 2	Backing up 3	Backing up 1	Helicopter 3
Response	Backing up	Backing up	Backing up	Truck	Helicopter	UR	Backing up	Backing up	Air
Stimulus	Backing up 2	Backing up 1	Helicopter 3	Siren 3	Siren 2	Backing up 3	Helicopter 2	Helicopter 1	Siren 1
Response	NR	Backing up	UR	I don't know	Honking	Backing up	I don't know	UR	Fire Truck
Stimulus	Siren 2	Backing up 1	Siren 1	Helicopter 3	Helicopter 2	Backing up 3	Siren 3	Helicopter 1	Backing up 2
Response	NR	Backing up	I don't know	I don't know	I don't know	I don't know	Fire Truck	Helicopter	Backing up
Stimulus	Siren 1	Backing up 1	Siren 2	Helicopter 2	Helicopter 3	Siren 3	Backing up 2	Backing up 3	Helicopter 1
Response	I don't know	Backing up	Backing up	Smoke	I don't know	NR	NR	I don't know	I don't know

Post-Remedial Intervention Probes (Transportations)

Stimulus	Backing up 3	Helicopter 1	Siren 2	Helicopter 3	Backing up 2	Siren 3	Siren 1	Backing up 1	Helicopter 2
Response	Backing up	Helicopter	NR	Helicopter	Backing up	I don't know	Fire Truck	NR	Helicopter
Stimulus	Siren 3	Siren 2	Helicopter 3	Backing up 1	Siren 1	Helicopter 1	Backing up 2	Backing up 3	Helicopter 2
Response	I don't know	NR	NR	Backing up	NR	NR	NR	Backing up	NR
Stimulus	Siren 1	Backing up 1	Helicopter 2	Siren 2	Backing up 3	Siren 3	Backing up 2	Helicopter 1	Helicopter 3
Response	NR	Backing up	Helicopter	NR	Backing up	NR	Backing up	NR	Helicopter

Stimulus	Siren 3	Backing up 2	Siren 2	Backing up 3	Helicopter 2	Backing up 1	Siren 1	Helicopter 1	Helicopter 3
Response	NR	Backing up	NR	Backing up	NR	NR	NR	NR	NR
Stimulus	Backing up 2	Siren 3	Backing up 3	Siren 2	Backing up 1	Helicopter 2	Siren 1	Helicopter 3	Helicopter 1
Response	Backing up	NR	Backing up	NR	NR	NR	NR	NR	Helicopter
Postintervention/Generalization Probe (Transportations)									
Stimulus	Backing up 4	Siren 6	Backing up 5	Siren 5	Backing up 6	Helicopter 5	Siren 4	Helicopter 4	Helicopter 6
Response	I don't know	Fire Truck	Backing up	UR	Backing up	Helicopter	I don't know	Helicopter	Helicopter
Follow-up Probe (Transportations)									
Stimulus	Siren 2	Backing up 2	Helicopter 3	Siren 1	Backing up 3	Helicopter 2	Backing up 1	Helicopter 1	Siren 3
Response	NR	Backing up	I don't know	I don't know	Backing up	Helicopter	Backing up	Helicopter	NR
Preintervention Probes (Musical Instruments)									
Stimulus	Piano 3	Harmonica 1	Flute 2	Harmonica 3	Flute 1	Flute 3	Piano 1	Piano 2	Harmonica 2
Response	Piano	Instrument	Music	Music	Owl	Music	Piano	Real Piano	Piano
Stimulus	Flute 1	Flute 3	Piano 2	Flute 2	Harmonica 3	Harmonica 2	Harmonica 1	Piano 1	Piano 3
Response	Whistling	Whistling	Piano	NR	UR	Song	Music	Piano	Song
Stimulus	Flute 2	Harmonica 2	Flute 1	Piano 3	Harmonia 1	Harmonica 3	Flute 3	Piano 1	Piano 2
Response	Song	NR	Song	Piano	UR	I don't know	I don't know	Piano	Piano
Stimulus	Flute 3	Piano 1	Harmonica 2	Piano 3	Piano 2	Flute 2	Harmonica 1	Flute 1	Harmonica 3
Response	UR	Music	Song	Song	Piano	UR	UR	Song	Song
Stimulus	Piano 2	Flute 1	Flute 2	Flute 3	Piano 1	Piano 3	Harmonica 1	Harmonica 3	Harmonica 2
Response	Piano	I don't know	Music	I don't know	Piano	Piano	UR	Music	Music
Preintervention/Generalization Probe (Musical Instruments)									
Stimulus	Flute 5	Flute 6	Harmonica 5	Harmonica 4	Piano 5	Flute 4	Piano 6	Harmonica 6	Piano 4
Response	UR	Music	Music	Music	UR	Music	NR	Music	Piano

Post-Initial Intervention Probes (Musical Instruments)									
Stimulus	Piano 3	Harmonica 1	Flute 1	Piano 2	Harmonica 3	Flute 2	Flute 3	Piano 1	Harmonica 2
Response	Piano	I don't know	I don't know	Piano	I don't know	Piano	I don't know	Piano	I don't know
Stimulus	Harmonica 2	Piano 2	Harmonica 1	Flute 2	Harmonica 3	Piano 1	Piano 3	Flute 3	Flute 1
Response	I don't know	Piano	UR	UR	Song	Piano	Piano	Instrument	Instrument
Stimulus	Harmonica 3	Piano 2	Flute 3	Flute 1	Piano 1	Harmonica 1	Harmonica 2	Flute 2	Piano 3
Response	NR	Piano	I don't know	Music	Piano	I don't know	Music	I don't know	Piano
Stimulus	Piano 2	Harmonica 1	Piano 1	Flute 1	Piano 3	Flute 2	Harmonica 3	Flute 3	Harmonica 2
Response	Piano	I don't know	Piano	I don't know	Piano	I don't know	I don't know	NR	NR
Stimulus	Piano 3	Piano 2	Harmonia 3	Flute 3	Flute 2	Harmonica 1	Harmonica 2	Flute 1	Piano 1
Response	Piano	Piano	I don't know	Music	NR	NR	Music	UR	Piano
Post-Remedial Intervention Probes (Musical Instruments)									
Stimulus	Harmonica 1	Piano 2	Piano 3	Flute 2	Harmonica 3	Harmonica 2	Piano 1	Flute 1	Flute 3
Response	NR	Piano	Piano	NR	NR	NR	Piano	NR	I don't know
Stimulus	Piano 2	Harmonica 1	Flute 2	Piano 3	Harmonica 3	Piano 1	Harmonica 2	Flute 3	Flute 1
Response	NR	NR	NR	Piano	NR	Piano	NR	NR	NR
Stimulus	Flute 2	Piano 2	Piano 3	Harmonica 3	Piano 1	Harmonica 1	Flute 3	Flute 1	Harmonica 2
Response	NR	Piano	Piano	NR	Piano	NR	NR	NR	NR
Stimulus	Harmonica 3	Harmonica 1	Flute 3	Flute 2	Piano 2	Piano 3	Piano 1	Harmonica 2	Flute 1
Response	I don't know	NR	Music	Music	Piano	Piano	Piano	Music	I don't know
Stimulus	Flute 2	Piano 2	Piano 3	Harmonica 3	Piano 1	Harmonica 1	Flute 3	Flute 1	Harmonica 2
Response	I don't know	Piano	Piano	I don't know	Piano	I don't know	I don't know	I don't know	I don't know

Postintervention/Generalization (Musical Instruments)									
Stimulus	Flute 6	Piano 4	Harmonica 5	Flute 4	Harmonica 6	Piano 5	Flute 6	Piano 6	Harmonica 4
Response	I don't know	Piano	Desert Song	I don't know	Desert Music	Piano	Ninja Music	Piano	Lion King Music
Follow-up Probe (Musical Instruments)									
Stimulus	Piano 2	Piano 3	Harmonica 2	Flute 2	Piano 1	Harmonica 1	Flute 3	Harmonica 3	Flute 1
Response	Piano	Piano	I don't know	UR	Piano	NR	I don't know	I don't know	I don't know

Note. UR= Unintelligible Response, NR= No Response

Research Question Two

Will the participant tact different exemplars of original stimuli?

Prior to intervention, the participant did not tact any untrained stimulus in "home sounds" (see Table 4). On postintervention generalization probe, the participant tacted all three untrained exemplars of "doorbell". The participant did not tact any untrained exemplar of "washing machine" and "lawn mower".

In "transportations", the participant did not tact any untrained stimulus prior to intervention. On her postintervention generalization probe, she tacted two untrained exemplars of "backing up" and all three untrained exemplars of "helicopter" correctly.

In "musical instruments", the participant tacted one generalization exemplar of "piano" during preintervention. After remedial intervention, she tacted all three untrained exemplars of "piano". The participant did not tact any untrained exemplar of "harmonica" and "flute" prior to and after intervention. Interestingly, she emitted new responses when "harmonica" and "flute" were presented during the postintervention generalization probe (see Table 5) such as "desert music”, “Ninja music”, and “Lion King music”. However, those responses were incorrect because they did not match the definition of correct response.

Research Question Three

Will the participant maintain the tacts she will acquire one week following the last postintervention probe?

Number of correct tacts in “home sounds” was 5 at 1-week follow-up probe. This included two exemplars of “lawn mower”, and all three exemplars of “doorbell”. The participant did not tact correctly any exemplar of “washing machine”.

At 1-week follow-up probe, number of correct tacts in “transportations” set was 5. This included three exemplars of “backing up” and two exemplars of “helicopter”. The tact “siren” remained zero.

In “musical instruments, the participant tacted all three exemplars of “piano” at 1-week follow-up probe. The tacts “flute” and “harmonica” remained zero.

Research Question Four

Will the participant and her parent support the social validity of SPOP intervention?

For the child, postintervention social validity assessments were conducted six times. She pointed to happy face on all those assessments, indicating that she was satisfied with the intervention.

Results of social validity survey (see Table 6) showed that the parent rated six items (54.5%) positively. Specifically, the parent supported the importance of teaching tacts of environmental sounds to her child, the ease of training protocol, cost- and time-efficiency of procedures, the significance of results, and her child’s enjoyment of the intervention. The parent, however, disagreed that intervention and probe procedures were easy. Also, the parent may not implement the intervention with her child in future. Anecdotally, the parent reported that switching between audio files was difficult. In terms of the importance of sounds used in the experiment and recommending the intervention to parents and educators of children with autism, the parent's responses were neutral.

Table 6

Results of Social Validity Parent Survey

1= Strongly Disagree 2= Disagree 3= Neutral 4= Agree 5= Strongly Agree	
1. Target Behaviors	
Teaching my child to tact environmental sounds (e.g., animals, vehicles) is socially important	4
The sounds used in intervention are important to learn.	3
2. Procedures	
The training protocol is easy to read.	5
Procedures of preintervention, postintervention, generalization, and follow-up are easy to implement.	2
Procedures of SPOP+MET are easy to implement.	2
SPOP+MET intervention is not costly.	5
SPOP+MET intervention is not time-consuming.	4
I will implement this intervention package with the child in future.	2
I recommend this intervention package to parents and educators of children with autism.	3
3. Results	
The increase in sounds the child learned to tact is socially significant.	4
The child appeared to enjoy the intervention	4

Chapter Five: Discussion

The aim of this study was to examine the efficacy of an intervention package consisted of MET and SPOP on acquisition of the auditory tacts for preschool-aged children with ASD. Specifically, it aimed to examine a) the impact of this package on the number of correct tacts of auditory stimuli, b) the effectiveness of teaching multiple exemplars of auditory stimuli in establishing a repertoire of auditory tacts that are generalized across novel stimuli, c) the maintenance of auditory tacts for one week following the last postintervention probe, and d) the social significance of the intervention package from the perspective of the participant and her parent.

The participant was a six-year-old child with ASD with average language profile and moderate speech impairment. The participant met the following inclusion criteria: 1) the age ranges from 36 to 84 months, 2) a formal diagnosis of ASD, 3) a repertoire of a minimum 20 visual tacts (e.g., pictures, objects), 4) absence of previous training on auditory tacts, 5) absence of frequent problem behaviors that interfere with one-to-one training such as lengthy temper tantrums, property destruction, and aggression, and 6) the ability to sit and orient toward the adult (e.g., teacher, caregiver) for a minimum of 3 minutes as confirmed by parent and/or therapists. The intervention was implemented by the participant's mother. The investigator trained the participant's mother on conducting the intervention and probes remotely via Zoom. Additionally, the investigator trained the independent rater on response measurement and treatment integrity via Zoom. The independent rater was a doctoral student in special education who was a BCBA and worked with learners with ASD.

This chapter discusses the results of this study in relation to the following research questions: Will the parent-mediated SPOP+MET intervention increase the number of correct tacts of auditory stimuli in a child with autism? Will the participant tact different exemplars of original stimuli? Will the participant maintain the tacts she will acquire one week following the last postintervention probe? Will the participant and her parent support the social validity of SPOP intervention? In addition, this chapter discusses implications, and recommendations for future research.

Acquisition of Auditory Tacts

Despite the modest effect of the intervention, the present experiment lends some support for using SPOP+MET in teaching auditory tacts to children with ASD. In the light of results, the functional relation between the intervention and the increase among some tacts existed. The following interpretations discuss the possible factors that facilitated or impeded acquisition of target tacts in the present study:

The first interpretation is using stimuli of varying familiarity. It is important for practitioners to select stimuli that children are exposed to and hear people talk about frequently (Sundberg & Partington, 1998). Thus, when the child tacts familiar stimuli in their natural environment, chances of reinforcement and maintenance will increase (Bak et al., 2021). For example, it is presumable that "backing up" was the highest among transportations because the participant heard it more frequently in her natural environment than "helicopter" and "siren".

The second interpretation is selection of target words. For example, the participant frequently said, "fire truck" for "siren" and "airplane" for "helicopter". Hence, using more familiar labels such as "fire truck" and "airplane" could have improved the outcomes of intervention.

The third interpretation is the possible role of covert echoing in facilitating acquisition of some tacts. It is possible that the participant acquired some tacts because she was echoing them silently during intervention. This assumption was also raised by other researchers (Byrne et al., 2014). For example, the participant possibly said, "washing machine" silently after her mother emitted this response during intervention. This assumption is based on the suggestion of Horne and Lowe (1996) that echoic repertoire accelerates naming among typically developing toddlers. The assumption is also based on empirical evidence that overt echoics facilitate acquisition of tacts among children with ASD (Bloh, 2008; Kodak & Clements, 2009). However, it was impossible to prove the occurrence of covert echoing due to inaccessibility of such behavior. It is important to note that further research is needed to support the notion that echoics (i.e., overt and covert) facilitate acquisition of tacts. For instance, Byrne et al. (2014) measured overt echoic responses among the three participants with ASD to investigate the possible role of echoics in facilitating acquisition of tacts. Unexpectedly, they found that the only participant who met the mastery criteria of tact and listener responding, emitted the least echoic responses during SPOP sessions and probes. This finding, though, may not generalize to all learners with ASD. In addition, they could not determine the role of covert echoing due to inaccessibility.

The fourth interpretation is duration and volume of sounds. While all audio files were equal in duration (i.e., 5 s), longer audio files were possibly required to recognize some sounds. Additionally, volume of sounds used in the experiment was not controlled. Hence, it is plausible that some sounds were louder than others. The sounds were presented from the same laptop throughout the experiment. Nevertheless, it is unknown if the volume of sounds remained within a predetermined limit as in the experiment of Hanney et al. (2019). In their experiment, Hanney et al. used a decibel meter to ensure that volume did not exceed 65 decibels. Considering duration, volume, and quality of sounds in auditory tact programs for children with ASD is imperative as they experience longer latencies than typically developing children and impaired rapid auditory processing (Demopoulos et al., 2015).

The fifth interpretation is the isolated presentation of auditory stimuli. All sounds used in the present experiment were presented without visual stimuli. In the study of Hanney et al. (2019), the investigators compared acquisition of auditory tacts when sounds presented alone and when combined with visual stimuli. They found that presenting the combined presentation of stimuli (e.g., a toy with its sound) was more effective and required fewer sessions to meet mastery criterion than isolated auditory stimuli (e.g., a sound without a toy). In the light of the findings of Hanney et al. (2019), presenting the sounds with their visual stimuli could have helped the participant in the present experiment with acquisition of more auditory tacts. However, isolated auditory stimuli were presented in the present study because they are not always combined with visuals in the natural environment.

The sixth interpretation is similarity of some stimuli. Some stimuli were relatively similar even though they were not in the same category (e.g., lawn mower, helicopter). For example, the participant said, “lawn mower” for “helicopter” and “helicopter” for “washing machine” in some postintervention probes. The similarity between those stimuli has possibly caused the interference of responses. Thus, using less similar sounds could have facilitated acquisition of auditory tacts.

The seventh interpretation is number of times in which each stimulus was presented and labeled during intervention. Each intervention session consisted of two 9-trial blocks for a total of 18 trials. Thus, each stimulus was presented and labeled twice. Some sounds, especially unfamiliar ones, possibly required additional pairing of tacts and auditory stimuli. Data obtained in the present study support this explanation. That is, some target tacts (e.g., lawn mower) increased after the additional exposure and pairing the participant received during remedial intervention. Repeating SPOP was also successful in increasing tacts in another study (i.e., Byrne et al., 2014). The number of trial blocks in each intervention session possibly plays a role in increasing tacts. Previous studies on SPOP (i.e., Byrne et al., 2014; Solares & Fryling, 2019) included five 9-trial blocks for a total of 45 trials. However, it was not possible to conduct the same number of trials in the present experiment due to the difference in stimuli. Byrne et al (2014) and Solares and Fryling (2019) used visual stimuli (i.e., picture cards), while stimuli used in the current experiment were auditory (i.e., audio files). Thus, presenting 45 audio files in one session could have annoyed the participant as some stimuli were noises (e.g., lawn mower, helicopter).

The eighth interpretation is probing a relatively large number of various stimuli in one session. While the intervention was introduced to each tier in a staggered fashion, most sessions included probing all intervention stimuli with short breaks (i.e., about 1 minute) in between the probes. Consequently, presenting 27 or more stimuli on the same session has possibly impeded acquisition of some sounds. In practice, therapists are advised not to present too many tacts at the same time, so learners do not mix up the responses (Sundberg & Partington, 1998). Instead, therapists are advised to teach a small number of tacts at a time and introduce additional stimuli gradually. However, the experimental design used in the present study necessitates a concurrent probing of all three stimulus sets.

The ninth interpretation is the potential role of uncontrolled (i.e., confounding) variables in facilitating acquisition of at least one target tact. For instance, the participant did not tact any exemplar of “doorbell” during her five postintervention probes and the first postintervention probe after the remedial intervention. On the second postintervention probe after the remedial intervention, however, the participant labeled all three exemplars of “doorbell”. The mother reported that the participant and her brother rang the doorbell several times the day before the probe. It is possible that her brother said, “doorbell” and that facilitated acquisition of this tact. However, it was not possible to verify this assumption because it is unknown if the participant’s brother said, “doorbell” and how many times he said it.

Generalization and Maintenance

Considering the generalization data for all target tacts, it is apparent that generalization was successful in four tacts only. Interestingly, the participant recognized the novelty of the exemplars used in the generalization probes of “transportations” and “musical instruments” as she made statements like “new one, I guess”. There are some possible interpretations for the variation in the generalizability of the target stimuli. First, the exposure to the target stimulus in the natural environment. It is possible that the participant heard more exemplars of some sounds (e.g., doorbell) at her natural environment and at a higher frequency than other sounds (e.g., lawn mower). Consequently, the other two stimuli in the same set (i.e., washing machine, lawn mower) possibly required more exposures to the multiple exemplars during intervention. The main concept that MET relies on is teaching sufficient exemplars (Stokes & Baer, 1977). Thus, it is conceivable that teaching three exemplars of each target tact was insufficient for some tacts to generalize.

Second, the frequency of exposures and number of exemplars alone may not fully explain lack of generalization among some target tacts. There are other interpretations such as lack of diversity among the exemplars. Plausibly, some stimulus sets used in the present study were either greatly or minimally diverse. A limited range of diversity among exemplars may not help the learner identify a wider range of exemplars when presented during generalization probe.

Similarly, Stokes and Baer (1977) warned that excessive diversity of exemplars can be counterproductive. Therefore, they called for a combination between the sufficiency and diversity of exemplars. One example on insufficient diversity from the present study is “washing machine”. Washing machines make different noises at different speeds. It is possible that the exemplars used in intervention represented a limited range of noises, whereas exemplars presented at generalization probe represented a greater range. Thus, the participant could not identify those exemplars.

Third, an instructional technology that could have improved generalization outcomes for some tacts is general case programming (Horner & Albin, 1988). Using this technology, the interventionist selects the exemplars carefully and presents them sequentially in individual sessions. It was not possible, however, to use this strategy in the present experiment due to the experimental design and nature of intervention. That is, general case programing is a structured process that requires an explicit instructional technology, unlike SPOP.

Data indicated that five out of nine target tacts were maintained at 1-week follow-up probes. The following explanations discuss the possible reasons for variability in maintenance:

First, lack of reinforcement. According to Skinner (1957), children learn tacts when they receive generalized reinforcement (e.g., praise, acknowledgement) contingent upon the responses they make. No reinforcement was given for any response the participant made during probes to avoid unwanted stimulus control. She received, however, praise and access to a preferred object (e.g., book, toy) after each probe. Those reinforcers were provided for proper sitting and behavior during the probe and they were not contingent upon the tacts she emitted. Although some tacts were acquired despite absence of reinforcement, it is conceivable to assume that “washing machine” was not maintained because the learner did not receive reinforcement during probes. It is important to note that the participant maintained some tacts because she possibly received reinforcement outside the experiment. For example, it is possible that the participant tacted a helicopter flew over the school and received acknowledgement from others (e.g., Yes! That's a helicopter!).

Second, intensity of intervention. The participant received intervention twice for each stimulus set. It is plausible that distributed rather than massed trials were required to promote maintenance outcomes. Distributed trials refer to distributing the number of intervention trials over several sessions instead of conducting the same number of trials in a few sessions. Based on previous studies on distributed trials, Warren et al. (2007) predicted that distributed trials are more efficient than massed trials in terms of learning, generalization, and maintenance.

Third, the intervention was conducted at a natural setting (e.g., home) and mediated by a natural implementer (i.e., the parent). However, intervention and probe sessions were conducted in a tabletop format which is not a naturally occurring context. Delivering the intervention in a naturalistic activity (e.g., play-based) could have improved maintenance because such a format increases the likelihood of emitting the target tacts in a similar context after ending the intervention (Bak et al., 2021). This claim is supported by empirical evidence. For instance, Duenas et al. (2019) taught tacts to three preschoolers with ASD in a play-based format. All three children showed rapid acquisition of tacts. Maintenance data were taken for two participants. The two participants displayed maintenance of tacts over two weeks following the withdrawal of intervention.

Fourth, using naturally occurring cues. Using stimuli similar to those occurring in the natural environment is one method to promote maintenance (Pinkelman & Barton, 2012). Therefore, it is possible that the participant maintained most sounds she acquired because they were similar to naturally occurring ones. On the other hand, the participant possibly did not maintain the tact "washing machine" because of lack of resemblance between some exemplars used in the experiment (e.g., old-fashioned washing machines) and those exist in the natural environment.

Social Significance of Dependent Variables, Procedures, and Results

Social validity assessments indicated that the child was satisfied with SPOP+MET intervention. There are several possible reasons for satisfaction such as sounds used in the procedure, the quickness of procedure, implementing the intervention at home, and not asking the child to respond during intervention. To determine the possible reasons of satisfaction, more robust social validation methods such as in-depth interviews are required. However, it was not possible to use such methods in the present study due to age and language abilities of the participant. It is important to note that only six social validity assessments were conducted. Accordingly, it is unknown if satisfaction would have remained high if further intervention sessions were conducted.

With regard to the parent, social validity survey indicated that she was satisfied with the training protocol, cost- and time-efficiency of procedures, and outcomes. The parent also agreed that her child enjoyed the intervention, but she rated negatively for the ease of intervention and probe procedures. Consequently, the parent indicated that she will not use it with her child in future. The reason of dissatisfaction with the procedure was the difficulty she experienced in switching between audio files as per an anecdotal report. The parent, however, reported anecdotally that she would recommend the intervention to parents and educators if the procedure was more user-friendly. She suggested clicking one button at a time on PowerPoint slides instead finding the audio files on a folder. The parent also recommended conducting more intervention sessions and taking fewer probes. Last, she recommended correcting the errors the learner makes during probes.

Presumably, the child and parent would have been less satisfied if another intervention was used as some one-to-one interventions are time-consuming and effortful such as discrete trial teaching (DTT; Zaragoza Scherman, 2015). Also, the online format of the present study has possibly enhanced the overall satisfaction as it reduced family's wait time and travel needed for traditional (i.e., face-to-face) therapy sessions. It is important to note that only one child and one parent participated in the study. Hence, results of social validity obtained in the present study do not necessarily generalize to other children, parents, and behavior change agents such as teachers and therapists.

Implications

Implications for Research

First, the present study adds to the emerging research on using SPOP to teach tacts to children with ASD. However, comparative studies are needed to examine the difference in efficacy between SPOP and other interventions in teaching tacts. For instance, researchers may introduce SPOP and another intervention (e.g., DTT) alternately using alternating treatment design (Barlow & Hayes, 1979) to compare their efficacies.

Second, further research is needed to explore the factors that facilitate acquisition of tacts when SPOP is used. It was mentioned earlier that theoretical (Horne & Lowe, 1996) and empirical (e.g., Bloh, 2008) literature suggested that echoing helps with acquisition of tacts. Echoing, however, is not the only component of naming as per the theory of Horne and Lowe (1996). Listener (i.e., receptive) responses is one component of naming capability as well. Barbera and Kubina (2005) examined two transfer procedures to teach tacts of visual stimuli to a child with ASD. The first procedure was receptive to echoic to tact and the second procedure was echoic to tact. The researchers could not compare those two procedures because they were introduced simultaneously. Though, they recommended the first procedure (i.e., receptive to echoic to tact) to facilitate vocal tacting for children who do not respond consistently to prompts to verbalize. This transfer procedure was presumably less needed in the present study as the participant was responding consistently to the prompt (i.e., what's this?). However, teaching receptive identification of sounds prior to intervention could have facilitated acquisition of target tacts in the present experiment. Two previous studies (i.e., Carnerero & Pérez-González, 2015; Carnerero et al., 2019) probed receptive identification of sounds after delivering SPOP to typically developing adults and they found that receptive selections emerged, but they did not teach the receptive selection of sounds prior to SPOP. Thus, the potentially facilitative role of listener responding in acquiring tacts through SPOP remains unknown.

Third, verbal operants are reinforced typically by reinforcement mediated by others (Skinner, 1957). However, the findings of the present and previous studies (e.g., Solares & Fryling, 2019; Byrne et al., 2014) indicated that SPOP can increase tacts, even though the participants did not receive reinforcement from the implementer during or after intervention. Adding reinforcement to probes that follow SPOP, however, may presumably promote the outcomes of intervention. To examine the additive effect of reinforcement to SPOP, researchers may consider add-in component analysis in which SPOP is introduced without reinforcement followed by another phase in which reinforcement is delivered during postintervention probes.

Fourth, researchers may consider delivering more intervention sessions and taking fewer probes when studying the effects of SPOP on tacts. That is, unlike the current experiment in which five probes were taken before the remedial intervention, researchers may take no more than two probes and introduce the remedial intervention if needed.

Fifth, it seems that SPOP can be embedded easily into classroom as it is quick, cost-efficient, does not require any response from the learner, and does not require prompting and feedback from the educator. For instance, an early childhood educator may incorporate SPOP incidentally into natural classroom activities such as circle time, stories, and play. However, this recommendation cannot be made to educators as SPOP was used in the present and previous studies (e.g., Solares & Fryling, 2019; Byrne et al., 2014) in a structured format only. Therefore, further research is needed to examine the efficacy of SPOP in less structured and unplanned activities.

Implications for Practice

The results of this study have the following implications for professionals (e.g., teachers, therapists) who plan and implement verbal behavior programs to children with ASD:

First, professionals may conduct an echoic assessment before they begin teaching tacts to ensure target responses are in the echoic repertoire of the student. For example, the participant in the present study said, “more lawner” frequently for “lawn mower”. Thus, shortening the word to “mower” or replacing it with an easy-to-articulate noun (e.g., grass cutter) could have improved outcomes for this tact. Additionally, consulting a speech language pathologist may help with selecting target words that suit the phonological repertoire of the learner. This is particularly important for children with articulation and phonological disorders.

Second, naming is a behavioral cusp because it enables the incidental learning of novel names through observing the tacts emitted by others (Gilic & Greer, 2011). In addition, research suggests that naming is a capability that helps children learn faster in school by attending to teacher demonstrations of target responses prior to delivering direct instruction (Greer et al., 2011). Therefore, addressing this vital capacity among learners with ASD at an early age will presumably promote their future academic performance and school readiness. This may include assessing this behavioral cusp at an early age and providing intervention for those who lack naming skills.

Third, professionals may select the exemplars carefully when programming for generalization to obtain the optimum outcomes. Horner & Albin (1988) suggested that the greatest generalization can be achieved in teaching when: a) a full range of stimulus variation is used, b) when negative stimuli that are very different from the original ones are used, and c) when teachers use negative stimuli that are very similar to original ones. For example, to consider a full range of stimulus variation to teach the tact "washing machine", the professional may gather the full range of noises the washing machines make at different speeds. In addition, the professional needs negative examples that are very different from the original one such as the sound of car horn. Also, the professional needs the negative stimuli that are hard to reject because of the similarity between them and the original stimuli such as the sound of dishwasher. However, professionals may not use an excessively diverse range of exemplars because this can be counterproductive (Stokes & Baer, 1977). Instead, professionals may balance between the sufficiency and diversity of exemplars.

Limitations and Directions for Future Research

The present study encompasses seven limitations. The first limitation is the sample size and age of the participant. The present study was limited to one kindergartener with ASD who was verbal. Therefore, future researchers might replicate it with a larger number of young children, children with ASD who are nonverbal or minimally verbal, a different age group, and/or learners with other disabilities.

The second limitation is shortness of follow-up probes (i.e., 1-week). Future researchers might take longer probes (e.g., weeks, months). This is particularly important for learners with ASD as they have difficulties with maintaining the skills they learn for an extended period (Gunning et al., 2019; Neely et al., 2016).

The third limitation is limiting the intervention to one setting (i.e., home) and one behavior change agent (i.e., the parent). While involving parents of children with ASD in intervention is important, the results of the present experiment do not necessarily generalize to other settings and behavior change agents. A literature review of eight studies (i.e., DeVeney et al., 2017) suggested that implementing intervention by parents produced better outcomes for children who were late talkers than clinician-mediated intervention. Consequently, future research may evaluate the effect of therapist-mediated SPOP+MET on auditory tacts in educational and clinical settings. In addition to therapists, researchers may evaluate the effects of the same intervention when mediated by peers.

The fourth limitation is the focus on one type of stimuli (i.e., auditory). Thus far, research on SPOP has focused on visual and/or auditory stimuli. It is important to examine the effects of SPOP when different types of stimuli are used for two reasons. First, children with ASD and other learners constantly receive five different types of sensory inputs: visual, auditory, gustatory, olfactory, and tactile. Second, tact by definition is evoked by objects, events, or their properties (Skinner, 1957). Hence, tact is not limited to a particular form of stimulus.

The fifth limitation is limiting the definition of correct response to responses that matched the target label (e.g., saying “siren” when hearing the siren). As mentioned earlier, the participant made relevant responses that considered incorrect because they did not match the target label such as saying, “fire truck” and “desert music” when hearing the siren and harmonica, respectively. Number of correct tacts could have increased if those responses were considered correct. Hence, future researchers may consider more flexible definitions of correct responses.

The sixth limitation was conducting no more than two intervention sessions for each stimulus set. As the data indicated, further increase in number of correct tacts was observed after the remedial intervention. Thus, researchers may take fewer probes and conduct more intervention sessions in order to improve the outcomes. Additionally, researchers may increase the number of trials in which each exemplar is presented in one session. As mentioned earlier, introducing a large number of noises in one session might be annoying. Therefore, future researchers are encouraged to give a short break after each 9-trial block.

The seventh limitation was not providing any form of feedback (e.g., reinforcement, error correction) during probes to avoid unwanted stimulus control. Therefore, researchers may examine the additive effect of reinforcement and error correction by conducting add-in component analysis as described earlier.

In addition to the aforementioned directions, future researchers may consider a convenient way for presenting the audio files during SPOP+MET intervention such as embedding the audio files into PowerPoint slides and clicking on one button at a time as the participant’s parent suggested. Researchers may also examine the efficacy of the same intervention without involving an implementer. That is, a child is asked to click on each slide on their own and listen to each file without an implementer.

Conclusion

Previous research showed that SPOP is an effective intervention to teach tacts of visual stimuli to children with ASD. The present study lends a preliminary support for using SPOP+MET to teach a generalized repertoire of auditory rather than visual tacts to children with ASD. While previous research revealed SPOP is effective in teaching tacts of auditory stimuli to typically developing adults (i.e., Carnerero & Pérez-González, 2015; Carnerero et al., 2019), the present study showed that this intervention had a modest effect for a child with ASD. In respect of social validity, the participant was satisfied after all intervention sessions. While the participant's parent was satisfied with the results, she was not satisfied with the procedures due to the difficulty she experienced with switching between audio files. It is important to note that acquisition, generalization, and maintenance of tacts were observed in some, but not all, target tacts. In addition, the study was limited to one participant. So, the findings may not generalize to other learners with ASD.

Appendix A

IRB Approval

UNLV

DATE: December 23, 2021 **TO:** Joshua Baker

Social/Behavioral - Expedited Review Approval Notice

FROM: Social/Behavioral
PROTOCOL TITLE: UNLV-2021-207 A Parent-mediated Package to Teach Auditory Tacts to Preschoolers with ASD

SUBMISSION TYPE: Initial

ACTION: Approved
APPROVAL DATE: December 23, 2021
NEXT REPORT DUE: December 31, 2999
REVIEW TYPE: 7. Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

Children's Finding 46.404
Waiver of Documentation of Assent under 45 CFR 46.117, 46.408

Thank you for submission of materials for this proposal. The Social/Behavioral IRB has approved your study. This approval is based on an appropriate risk/benefit ratio and a study design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission. Only copies of the most recently submitted and approved/acknowledged Informed Consent materials may be used when obtaining consent.

This study has been determined to be minimal risk.

PLEASE NOTE:
Should there be any change to the study, it will be necessary to submit a **Modification** for review. No changes may be made to the existing study until modifications have been approved/acknowledged.

All unanticipated problems involving risk to subjects or others, and/or serious and unexpected adverse events must be reported promptly to this office. All FDA and sponsor reporting requirements must also be followed where applicable.

Any non-compliance issues or complaints regarding this protocol must be reported promptly to this office.

All approvals from appropriate UNLV offices regarding this research must be obtained prior to initiation of this study (e.g., IBC, COI, Export Control, OSP, Radiation Safety, Clinical Trials Office, etc.).

If you have questions, please contact the Office of Research Integrity - Human Subjects at IRB@unlv.edu or call 702-895-2794. Please include your study title and study ID in all correspondence.

Office of Research Integrity - Human Subjects
4505 Maryland Parkway . Box 451047 . Las Vegas, Nevada 89154-1047 (702) 895-2794 . FAX: (702) 895-0805 .
IRB@unlv.edu

Appendix B

IRB Modification to Approved Research

UNLV

Social/Behavioral - Expedited Review
Modification Approved

DATE: April 4, 2022

TO: Joshua Baker
FROM: Social/Behavioral

PROTOCOL TITLE: UNLV-2021-207 A Parent-Mediated Intervention to Teach a Generalized Repertoire of Auditory Tacts to a Child with Autism
SUBMISSION TYPE: Modification

ACTION: Approved
APPROVAL DATE: April 4, 2022
REVIEW TYPE: EXPEDITED REVIEW

Thank you for submission of materials for this proposal. The Social/Behavioral IRB has approved your study. This approval is based on an appropriate risk/benefit ratio and a study design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission. Only copies of the most recently submitted and approved/acknowledged Informed Consent materials may be used when obtaining consent.

Modifications reviewed for this action include:

Revised study procedures to change the implementer of intervention from therapists to parents
Added parents as research participants
Revised inclusion criteria to expand target age group
Changed study title
Changed location of intervention from clinic to home
Revised recruitment materials and consent forms
Changed independent rater

PLEASE NOTE:
Should there be any change to the study, it will be necessary to submit a Modification for review. No changes may be made to the existing study until modifications have been approved/acknowledged.

All unanticipated problems involving risk to subjects or others, and/or serious and unexpected adverse events must be reported promptly to this office. All FDA and sponsor reporting requirements must also be followed where applicable.

Any non-compliance issues or complaints regarding this protocol must be reported promptly to this office.

All approvals from appropriate UNLV offices regarding this research must be obtained prior to initiation of this study (e.g., IBC, COI, Export Control, OSP, Radiation Safety, Clinical Trials Office, etc.).

If you have questions, please contact the Office of Research Integrity - Human Subjects at IRB@unlv.edu or call 702-895-2794. Please include your study title and study ID in all correspondence.

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Appendix C

List of Target Sounds

Child ____________________________________Parent _______________________________

Please circle at least three sounds (from each category) you think are important for the child to learn their names. (Example: 3 animals, 3 Home sounds, 3 musical instruments).

Animals	**Home Sounds**	**Transportations**	**Musical Instruments**	**Actions**
Cat Dog Cow Horse Sheep Bird Chicken Duck	Doorbell Smoke Detector/Fire Alarm Blender Baby's cry Breaking/Crushing Vacuum Cleaner Telephone Lawn Mower Washing Machine Dishwasher Hairdryer	Car Motorcycle Airplane Truck Train Siren Dump Truck Backing Up Helicopter	Piano Drum Guitar Violin Harmonica Xylophone Flute	Bouncing a basketball Skateboarding Swimming Climbing stairs Jumping Stomping on leaves Running

Appendix D

Preference Assessment

Child ___________________________________ Parent ______________________________

Please list your child's preferences and place (✓) under the number the best describes the child's interest in the item/activity

	Least Preferred		Somewhat		Most Preferred
	1	2	3	4	5
Edibles					
1.					
2.					
4.					
4.					
5.					
Games/Toys					
1.					
2.					
3.					
4.					
5.					
Activities/Actions (e.g., songs, tickles, praise)					
1.					
2.					
3.					
4.					
5.					

Appendix E

Trial-by-Trial Response Measurement Sheet

Child____________________________________ Trainer ______________________________

Definitions of behaviors being measured: Tacting the sounds played by answering the question "What is it?" correctly within 5 s without prompt.

Correct Response (C): The tact matches the sound played (e.g., saying "car" when hearing the car's horn **and** the response is made within 5 s of the question "What is it?")

Incorrect Response (I): The tact does not match the sound played (e.g., saying "bird" when hearing the car's horn **or** no response made within 5 s of the question "What is it?")

Gen/Pre: Generalization/Pretest Gen/Post: Generalization/Posttest F: Follow-up

Date / / Condition (Check One): Pretest ☐ Posttest ☐ Gen/Pre ☐ Gen/Post ☐ F ☐								
Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9

Date / / Condition (Check One): Pretest ☐ Posttest ☐ Gen/Pre ☐ Gen/Post ☐ F ☐								
Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9

Date / / Condition (Check One): Pretest ☐ Posttest ☐ Gen/Pre ☐ Gen/Post ☐ F ☐								
Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9

Date / / Condition (Check One): Pretest ☐ Posttest ☐ Gen/Pre ☐ Gen/Post ☐ F ☐								
Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9

Date / / Condition (Check One): Pretest ☐ Posttest ☐ Gen/Pre ☐ Gen/Post ☐ F ☐								
Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9

Date / / Condition (Check One): Pretest ☐ Posttest ☐ Gen/Pre ☐ Gen/Post ☐ F ☐								
Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9

Date / / Condition (Check One): Pretest ☐ Posttest ☐ Gen/Pre ☐ Gen/Post ☐ F ☐								
Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9

Date / / Condition (Check One): Pretest ☐ Posttest ☐ Gen/Pre ☐ Gen/Post ☐ F ☐								
Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9

Appendix F

Trial-by-Trial Interobserver Agreement (IOA) Sheet

Participant__________________ Observer 1_________________ Observer 2 _______________

Date / /	Condition (Check One): Pretest ☐ Posttest ☐ Gen/Pre ☐ Gen/Post ☐ F ☐								
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9
Observer 1									
Observer 2									
Percentage of IOA									

Date / /	Condition (Check One): Pretest ☐ Posttest ☐ Gen/Pre ☐ Gen/Post ☐ F ☐								
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9
Observer 1									
Observer 2									
Percentage of IOA									

Date / /	Condition (Check One): Pretest ☐ Posttest ☐ Gen/Pre ☐ Gen/Post ☐ F ☐								
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9
Observer 1									
Observer 2									
Percentage of IOA									

Date / /	Condition (Check One): Pretest ☐ Posttest ☐ Gen/Pre ☐ Gen/Post ☐ F ☐								
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9
Observer 1									
Observer 2									
Percentage of IOA									

Date / /	Condition (Check One): Pretest ☐ Posttest ☐ Gen/Pre ☐ Gen/Post ☐ F ☐								
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9
Observer 1									
Observer 2									
Percentage of IOA									

Date / /	Condition (Check One): Pretest ☐ Posttest ☐ Gen/Pre ☐ Gen/Post ☐ F ☐								
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9
Observer 1									
Observer 2									
Percentage of IOA									

Date / /	Condition (Check One): Pretest ☐ Posttest ☐ Gen/Pre ☐ Gen/Post ☐ F ☐								
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9
Observer 1									
Observer 2									
Percentage of IOA									

Date / /	Condition (Check One): Pretest ☐ Posttest ☐ Gen/Pre ☐ Gen/Post ☐ F ☐								
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9
Observer 1									
Observer 2									
Percentage of IOA									

Appendix G

Treatment Integrity Checklist

(Screening/Preintervention/Generalization/Postintervention/Follow-up)

Observer ___________________ Date___________________Session # __________________
Target Child ________________ Implementer_______________________________________

Implementer Behavior	Yes	No	N/A
The parent makes sure that the child is paying attention by making eye contact with the implementer or looking at the device (e.g., iPad™, iPhone™) they hold			
If the child is not paying attention, the parent asks the child to pay attention (e.g., listen, we will hear fun sounds).			
If the child is paying attention, the parent asks, "what is this?" and plays the sound file immediately.			
The parent provides no consequences contingent on the child's response (e.g., praise, error correction).			
After the session, the parent will praise the child for attending and will deliver a highly preferred item.			

Number of applicable steps: ______

Number of applicable steps implemented as planned: ________

Percentage of applicable steps implemented as planned: ______%

Appendix H

Treatment Integrity Checklist (SPOP+MET)

Observer ____________________ Date____________________Session # ___________________
Target Child _________________ Implementer____

Implementer Behavior	Yes	No	N/A
The parent sits with the child at the table or on the floor across from each other.			
The parent conducts training at the same place of preintervention probe.			
As in preintervention, the parent makes sure that the child is paying attention.			
If the child is paying attention, the parent vocally tacts the object or animal that makes the sound and will immediately play the corresponding audio file.			
The parent does not reinforce or correct any response the child makes during the procedure.			
When the audio file stops, the parent labels the next object/animal and plays the corresponding audio file immediately.			
At the end of training, the parent praises the child for proper attending and delivers a highly preferred item.			

Number of applicable steps: ______

Number of applicable steps implemented as planned: ________

Percentage of applicable steps implemented as planned: ______%

Appendix I

Treatment Integrity Interobserver Agreement (IOA) Form

Participant ___________________ Observer 1___________________Observer 2____________

Date / / Condition (Check One): Pretest ☐ Posttest ☐ Gen/Pre ☐ Gen/Post ☐ F ☐								
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Percentage of IOA
Observer 1								
Observer 2								

Date / / Condition (Check One): Pretest ☐ Posttest ☐ Gen/Pre ☐ Gen/Post ☐ F ☐								
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Percentage of IOA
Observer 1								
Observer 2								

Date / / Condition (Check One): Pretest ☐ Posttest ☐ Gen/Pre ☐ Gen/Post ☐ F ☐								
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Percentage of IOA
Observer 1								
Observer 2								

Date / / Condition (Check One): Pretest ☐ Posttest ☐ Gen/Pre ☐ Gen/Post ☐ F ☐								
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Percentage of IOA
Observer 1								
Observer 2								

Date / / Condition (Check One): Pretest ☐ Posttest ☐ Gen/Pre ☐ Gen/Post ☐ F ☐								
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Percentage of IOA
Observer 1								
Observer 2								

Date / / Condition (Check One): Pretest ☐ Posttest ☐ Gen/Pre ☐ Gen/Post ☐ F ☐								
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Percentage of IOA
Observer 1								
Observer 2								

Date / / Condition (Check One): Pretest ☐ Posttest ☐ Gen/Pre ☐ Gen/Post ☐ F ☐								
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Percentage of IOA
Observer 1								
Observer 2								

Date / / Condition (Check One): Pretest ☐ Posttest ☐ Gen/Pre ☐ Gen/Post ☐ F ☐								
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Percentage of IOA
Observer 1								
Observer 2								

Date / / Condition (Check One): Pretest ☐ Posttest ☐ Gen/Pre ☐ Gen/Post ☐ F ☐								
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Percentage of IOA
Observer 1								
Observer 2								

Date / / Condition (Check One): Pretest ☐ Posttest ☐ Gen/Pre ☐ Gen/Post ☐ F ☐								
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Percentage of IOA
Observer 1								
Observer 2								

Appendix J

Summary of Parent and Independent Training Module

Parent Training

Module 1: Intervention

- How is a session started?
- What should you do during the session?
- What should you do if your child refuses to respond or listen?
- What to do after the session?

Module 2: Probing

- What is a probe?
- How is a probe taken?
- What should you do if your child refuses to respond or listen?
- What should I do after a probe is taken?

Independent Rater Training

Module 1: Response Measurement

- Definition of correct response
- Definition of incorrect response

Module 2: Treatment Integrity

- Steps of implementation in each experimental condition

Appendix K

Social Validity Survey

Parent's name_____________________________________ Date______________________

Question	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)
1. Target Behaviors					
Teaching my child to tact environmental sounds (e.g., animals, vehicles) is socially important					
The sounds used in intervention are important to learn					
2. Procedures					
The training protocol is easy to read.					
Procedures of preintervention, postintervention, generalization, and follow-up are easy to implement.					
Procedures of SPOP+MET are easy to implement					
SPOP+MET intervention is not costly.					
SPOP+MET intervention is not time-consuming.					
I will implement this intervention package with the child in future.					
I recommend this intervention package to parents and educators of children with autism.					
3. Results					
The increase in sounds my child learned to tact is socially significant.					
My child appeared to enjoy the intervention					

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Curriculum Vitae

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Education

2018- 2022 (expected)	**Ph.D. Special Education** University of Nevada, Las Vegas
2016-2017	**M.Ed. Curriculum and Instruction** Arizona State University
2006-2009	**B.Sc. Speech and Hearing Sciences** The University of Jordan

Professional Experience

August 2018 - Present	**Graduate Assistant** University of Nevada, Las Vegas Department of Early Childhood, Multilingual, and Special Education Las Vegas, Nevada
April 2019- March 2020	**Intern** University of Nevada, Las Vegas Lynn Bennett Early Childhood Education Center UNLV/CSUN Preschool
September 2014 - June 2018	**Speech Therapy Specialist** Hamad Medical Corporation Department of Psychiatry Child and Adolescent Mental Health Service Doha, Qatar
December 2011 - August 2013	**Speech Therapist** Applied Behavior Center (ABC) Kuwait City, Kuwait

October 2009 - November 2011 — **Speech Therapist**
Dubai Autism Center
Dubai, United Arab Emirates

Licensure

2021- Present — **Board Certified Behavior Analyst®**
Board Analyst Certification Board

2013- Present — **Speech Therapist License**
Ministry of Health
Amman, Jordan
Licensure # 12002/71

Teaching Experience

Courses taught at University of Nevada Las Vegas:

Course #	Level	Course Name	Co-teaching/ Independent	Format	Semester/ Year	# of Students
ESP 740	Graduate	Speech and Hearing Therapy for Classroom Teachers	Co-teaching with Dr. Cori More	In-Person	Spring 2019	25
			Independent	In-Person & Online	Spring 2020	29
			Independent	Online/ Synchronous	Spring 2021	30
EDSP 453	Undergraduate	Behavior Management Techniques for Students with Disabilities.	Independent	In-Person	Fall 2019	21
				Online/ Synchronous	Fall 2020	28
				In-Person	Fall 2021	12

				Online/ Synchronous	Fall 2021	20
EDSP 411	Undergraduate	Students with Disabilities in General Education Settings.	Independent	Online/ Asynchronous Online/ Asynchronous	Fall 2019 Fall 2020	30 30
EDSP 432	Undergraduate	Serving Individuals with Disabilities and Their Families	Independent	Online	Spring/2020	30

Courses

Online Teaching Essentials. 4-week course (Aug-Sep 2020). University of Nevada, Las Vegas.

Publications

Aal Ismail, H. (In Progress). *Anti-bullying interventions for students with ASD: A systematic review.*

Aal Ismail, H. (In Progress). Preparing students with autism for pandemics: A literature review.

Aal Ismail, H. (In Progress). Teaching Mands for Information.

Aal Ismail, H., More, C., Baker, J., & Huff, S. (2021). Increasing augmentative and alternative communication into stay-play-talk program in preschool. *Teaching Exceptional Children*, https://doi.org/10.1177/00400599211058748

Aal Ismail, H., Weglarz-Ward, J., & Sarisahin, S. (2021). *Increasing social initiations in elementary-age children with autism: A literature review.* Manuscript submitted for publication.

Rodgers, W. J., Weiss, M. P., & Ismail, H. A. (2021). Defining specially designed instruction: A systematic literature review. *Learning Disabilities Research and Practice*, *36*(2), 96–109. https://doi.org/10.1111/ldrp.12247

Conference Presentations

Aal Ismail, H. (2015, November). *Challenges facing speech-language pathologists in Arab world.* Seminar presented at American Speech-Language-Hearing Association Convention, Denver, CO.

Aal Ismail, H. (2019, November). *A treatment package to teach generalized social initiations to children with autism.* Kaleidoscope session presented at TED's 42nd Annual Conference, New Orleans, LA.

Matute-Chavarria, M., Dennis, J., Choi, E., & Aal Ismail, H. (2019, November). *Motivation to succeed: Factors influencing international and CLD domestic doctoral students' persistence.* Conversation session conducted at TED's 42nd Annual Conference, New Orleans, LA.

More, C., Aal Ismail, H., & Tredwell, C. (2019, November). *When needs collide: Unmasking mutually beneficial collaborative opportunities.* Single paper presented at TED's 42nd Annual Conference, New Orleans, LA.

Aal Ismail, H., More, C., & Huff, S. (2021, March). *Using Stay-Play-Talk with preschoolers who use aided AAC*. Poster session presented at CEC 2021 Convention and Expo.

Aal Ismail, H. (2021, March). *Teaching nonvisual tacts to children with autism and relevant disabilities.* Teacher Slam session presented at CEC 2021 Convention and Expo.

Aal Ismail, H. (2021, March). *Teaching mand for information in natural environments*. Teacher Slam session presented at CEC 2021 Convention and Expo.

Aal Ismail, H. (2021, March). *Preparing students with autism for pandemics: A literature review.* Data Blitz session presented at CEC 2021 Convention and Expo.

Aal Ismail, H. (2021, March). *Anti-bullying interventions for students with ASD: A systematic review.* Data Blitz session presented at CEC 2021 Convention and Expo.

Membership in Professional Organizations

2021- Present

Council for Learning Disabilities (CLD)
Student Membership
Membership # 61024980

2019 - Present

Council for Exceptional Children (CEC)
Nevada CEC Chapter
Division on Autism and Developmental Disabilities (DADD)
Membership # 1225142

2013- Present	**National Student Speech-Language-Hearing Association (NSSLHA)** Membership # 14075910