Establishment of the Imitation Developmental Cusp via a Synchronous Mirror Protocol and the Role of Imitation as a Foundational Verbal Cusp

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Abstract

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Across two experiments I sought to determine the relation between the Imitation developmental cusp and the emulative echoic cusp in preschoolers classified with a learning disability. In Experiment I, the participants were 36 preschoolers selected via a convenience sample, where the goal was to test for relations between the preverbal developmental cusp and foundational learning capability of Imitation, the preverbal and emulative verbal developmental cusps in the participant's repertoire, and the reinforcement value of age-appropriate toys and activities. Results showed significant correlations between Imitation and conditioned reinforcement for observing adult faces and voices, parroting, echoics, and listener literacy, as well as significant relations between Imitation and conditioned reinforcement for playing with toys, puzzles, coloring materials, and Play-Doh. Findings show that Imitation is either a prerequisite or a corequisite to emulative verbal developmental cusps. Experiment II had two goals. The first was to determine whether educationally classified preschoolers with a disability can emit various imitative responses when the researcher presents instruction through a smart device using the mirror training protocol. The second was to determine whether the echoic behavior and observing responses of the participants would change as a result of undergoing the synchronous mirror training protocol. Results show a functional relation between the acquisition of the verbal foundational Imitation cusp and increases in emission of various imitative responses and emulative echoic responses, across both in-person and virtual conditions.

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Dedication

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Introduction

If I tell you to "Do This," while modeling an action using my extremities or through object use, the reader may ask themselves "Do what?" Are you expected to observe my actions through the manner in which I move my arms or the object, and then perform the same behavior? Or are you expected to observe my actions and figure out a way in which you come to the same end goal using different means? If you answered yes to the first option, then you are *imitating* my behavior by emitting the same response with point-to-point correspondence. If you answered yes to the second option, then you are *emulating* by finding the most efficient way to match the end goal. Research shows that children imitate first, rather than emulate, following a demonstration (Carpenter et al., 2005; Hopper et al., 2008). Thus, being able to observe others and then imitate is a foundational skill in the trajectory of human development (Du & Greer, 2014; Philp, 2016)

Typically developing children have been noted to imitate simple motor movements such as: tongue protrusion, eye opening, and simple finger movements as early as 32 hours (Melzoff & Moore, 1983; 1989), at two/three-weeks old (Meltzoff & Moore, 1977; 1997), and at 11 months old (Poulson & Kymissis, 1998). However, children diagnosed with *autism spectrum disorder* (ASD) either fail to immediately imitate or imitate at all the behaviors of others that they observed (Rogers et al., 2003; Rogers & Pennington, 1991; Vivanti et al., 2014; Williams et al., 2004). The U. S. Centers for Disease Control and the American Academy of Pediatrics characterize ASD as a pervasive neurodevelopmental disability that affects children's social behaviors and communication skills, where they often emit restrictive, repetitive patterns of behavior towards singular activities with no respective function (e.g., stereotypy) ("Autism Spectrum Disorder," 2020; "Prevalence of Autism Spectrum Disorder," 2020).

Early childhood research shows that children with ASD have deficits in their imitation skills, object play, and joint attention skills (Baron-Cohen et al., 1992; Charman et al., 2003; Ingersoll & Schreibman, 2006; Mussey & Klinger, 2020; Pecukonis et al., 2019; Poon et al., 2012; Ritvo & Provence, 1953). Their deficits include difficulty in communicating and language development, where research points to an association between language development in children with ASD and their imitation repertoire (Bates et al., 1988; Miniscalco et al., 2014; Smith & Bryson, 1994; Stone et al., 1997). Overall, a weak imitative repertoire can negatively affect a child's developmental trajectory (Rogers et al., 2003; Rogers & Pennington, 1991; Williams et al., 2001). I will systematically review the imitation, Generalized Imitation, and emulation literature. Similarities and differences will be noted, as well as the implications of these repertoires in a child's developmental trajectory.

Chapter: 1 Review of the Literature

Imitation

What is Imitation?

The *Oxford Dictionary of English* defines *imitation* as “the action of using someone or something as a model” (Imitation, n.d.). From this definition we can only infer that either a person or an object can be a model. Although this definition is satisfactory for the general public, it does not answer the questions in regard to whether there are any other important defining factors that differentiate imitation from copying, how imitation is established, when imitation is established, and whether different imitation topographies have different implications.

Thorndike (1898) wrote that “if one can from an act witnessed learn to do the act, he in some way makes use of the sequence seen, transfers the process to himself; in the common sense of the world, he imitates” (p. 54). Thorndike’s (1898) definition—albeit older—points out two important distinctions: (1) that one must *observe* another perform a sequence, before he can perform the same sequence himself, and (2) that one can learn from imitation. Therefore, the imitator must not only orient in the direction of the model, but also follow the movements of the model, in order to successfully imitate and ultimately learn. Thorndike (1898) argued that imitation is “common in human life [as it is made] apparent in ontogeny;” therefore, positing that imitation is learned through our learning history and not through the development of the species (p. 54). He argues that children can acquire skills through observing their parents and imitating their behaviors. Thorndike’s rationale serves as the logical basis for Bandura and Huston’s (1961) theory of observational learning, where children model the behaviors of others who they observed.

Differences between Observational Learning and Imitation

It is important to note the key differences between imitation and observational learning, as the two terms are often used interchangeably when discussing the notion of “learning from observation.”

Observational Learning. The theory of observational learning states that vicarious learning (Bandura & Huston, 1961) is the “active imitation [made] by a child of attitudes and patterns of behavior that [were] never directly taught” (p. 311). Therefore, children can imitate, or learn from, observing the behavior(s) of others. This notion is not entirely accurate when using Catania’s (2007) definition of observational learning. Catania (2007) provides important stipulations as to what constitutes observational learning. First, many “different skills come together for observational learning to work [and] it’s likely that there’s also a very large verbal component” (Catania, 2007, p. 228). This stipulation posits the importance of children having the appropriate prerequisite skills and verbal behavior repertoires in place, in order to learn from observing others. Specifically, Catania (1995; 2007) references self-talk, say-do correspondence, and generalized imitation. The verbal behavior developmental theory (VBDT) identifies each of these skills as verbal developmental cusps, where in a child’s developmental trajectory generalized imitation is established as a preverbal foundational learning capability (Du & Greer, 2014; Greer, 2020; Greer et al., 2017; Greer & Ross, 2008; Greer & Speckman, 2009). The verbal developmental cusps and capabilities will be discussed extensively in a later section.

Greer et al. (2017), Greer and Ross (2008), and Greer and Speckman (2009) all agree that for one to be verbal (e.g., social), they must acquire various verbal developmental cusps and learning capabilities. Once the relevant stimulus control associated with a given cusp/capability is acquired, one can move along the developmental trajectory of verbal behavior. Thus, when self-talk is acquired as a verbal developmental cusp, children can emit both overt (e.g., observable) and covert (e.g, unobservable) conversational units (Greer et al., 2017; Greer & Ross, 2008; Greer & Speckman, 2009). The establishment of say-do correspondence allows for a child to listen to their own speaker behavior and do what was just said, which is the beginning of the joining of the separate listener and speaker repertoires (Greer et al., 2017; Greer & Ross, 2008; Greer & Speckman, 2009). Finally, the establishment of Generalized Imitation allows for a child to both learn through a correction procedure that requires a model demonstration and gaining the correspondence between seeing and doing as a conditioned reinforcer (Gladstone & Cooley, 1975; Greer et al., 2017; Greer & Ross, 2008; Greer & Speckman, 2009). Therefore, when returning to Catania's (2007) original stipulation about observational learning encompassing a large verbal component, he is correct and his notion is supported by the VBDT camp. For a child to learn through observation, they must have the foundational verbal milestones established (Greer, 2020; Greer et al., 2017; Greer & Ross, 2008; Greer & Speckman, 2009).

Catania's (2007) final stipulation is that observational learning must include "subtle discriminations of another organism's actions and their outcomes and some history with respect to the effects of related actions on the part of the observer" (p. 228). Simply, the observer can learn from the contingencies that are established and contacted by the model. This is supported by observational learning research from Greer et al. (2006), Singer-Dudek, et al. (2008), and Lanter and Singer-Dudek (2020), where observational learning is truly established when the observer can learn from the corrections provided to the peer confederate who functions as the model.

Imitation. Behavior analysis focuses the study of imitation in relation to the principles of behavior and the motivation behind it (Baer et al., 1967; Baer & Sherman, 1964). Baer et al. (1967) define imitation as a class of behaviors that are similar to and temporally follow the behaviors of another organism, in a topographically controlled dimension. However, Catania (2007) goes one step further to state that imitation is a “duplication of the behavior modeled by another organism” (p. 228). Thus, imitative responses are directly produced due to an existing imitative repertoire, where those responses can be shaped following an instructional history of reinforcement for imitating. It is important to note that there is a difference between an imitative repertoire and a Generalized Imitative repertoire, which will be distinguished in later sections (Du & Greer, 2014; Greer & Ross, 2008; Holth, 2003; Moreno, 2012; Philp, 2016).

Development of Imitation in Infants

When stating that the study of Generalized Imitation in infants has yielded generally positive results (Meltzoff & Moore, 1977; 1983; 1989; 1997; Poulson & Kysmiss, 1988), a distinction needs to be made. Originally, when Baer and Sherman (1964) used the term “generalized imitation” in their seminal work, the behaviors taught to their target participants were behaviors that children can normally imitate or are requested to imitate regularly. For example, pressing a bar lever, pointing to one’s head, and moving one’s mouth. Therefore, if using Catania’s (2007) stringent definition of Generalized Imitation, we re-state the original sentence to “the study of *imitation* in infants has yielded generally positive results.”

The questions that arise are two-fold: (1) can infants imitate only oral-motor actions and simple finger movements and (2) are infants able to imitate certain responses at different points in their development? Jones (2007) studied the development of various imitative classes in 162 infants, whose ages ranged from 6 months to 20 months. The imitation classes that the infants were required to imitate were gross motor, simple finger movements, oral motor, and vocalizations (*emulation*). Jones (2007) had the parents perform the target imitative and emulative responses directly in front of their infant, where the researchers sat on the side. The results of the study showed that at eight to 12-months infants were able to imitate tap table and emulate "ahh," and between 10 to 12-months infants imitated clap hands and bye-bye (sans sound). At the 16 to 18-month age range infants imitated hand on head and tongue protrusions, and around 24 months finger movements and "eh-eh" were imitated and emulated, respectively. The results from Jones's (2007) study confirm that imitation, or an imitative repertoire, develops within the first two years of a child's life and that more gestures are observed towards the end of the first year, specifically around 12 months.

Poulson and Kymissis' (1988) experiment found that three 11-month-old infants acquired imitative responses across 45 different response topographies for motor-actions with toys. They argued that since only vocal praise was provided during correct responding in the intervention, vocal praise then functioned as a reinforcer for the infants. This strengthens two notions: (1) that these infants acquired an imitative repertoire and (2) that the reinforcer for Generalized Imitation should be the correspondence between the behavior of the model and the imitation of the observer with no vocal praise. Nevertheless, the results of Poulson and Kymissis' (1988) study are consistent with the results of Jones (2007), where gross motor imitation is observed more towards the end of a child's first year. If gross motor imitation develops towards the 12-month mark, then when do the other imitative responses or classes begin to emerge? The typical development of duplicative responses from infancy to 36 months can be found in Table 1. We utilized the developmental milestones made available by the Academy of Pediatrics (Hagan et al., 2017; Harstad & Albers-Prock; Scharf et al., 2016), in order to establish the sequential emergence of duplicative responses.

Table 1
Typical Development of Duplicative Responses from Infancy to 36 Months

Age in Months	Duplicative Responses: Gross Motor Imitation	Finger Imitation	Actions with Objects	Copying Marks	Vocal Behavior/ Emulation
0-3	-inconsistent motor imitation[4]	-open-close hands[3]	-toy to mouth[2, 3, 4]		-cooing[2] -vowel sounds[3, 4]
3-6	-reaches with one hand[4]		-shakes rattle[2] -pass toy from one hand to another[3]		-"ah-goo"[2] -babble with consonants[2, 4]
6-9	-bounces in-seat[2] -arms up/out[3]	-palmar grasp[2, 4]	-bangs spoon[2]		-mama/dada[2, 3, 4]
9-12	-tap table[1] -clap hands[1] -shake head[4] -imitates gestures & facial expressions[4]	-bye-bye[1,2] -radial-digital grasp[2, 3] -pointing[2, 4]	-rattles spoon in cup[2] -stir spoon[2] -put object in[4] -take object out[4]	-hold crayon[2] -scribbling[2, 4]	-"ahh"[1] -vocalizations to song[2] -vocalizes sounds & words[4] -first words[4]
12-15	-stand up[2]	-fine pincer grasp[2,3, 4]	-dump object[2,3] -drink from cup[2]	-back and forth scribble[2, 3]	-gestures with vocalizations[2]
15-18	-hands on head[1] -sit down[2, 3]		-turn pages in book[2, 3] -put puzzle piece in[2]		-jargon with real word[2, 4]
18-21	-squat[2, 3] -walk downstairs[2]		-throw ball[2, 3]	-vertical stroke[2]	-environmental sounds (e.g., animal sounds)[2]
21-24	-walk upstairs[2, 3] -climb up[3]	-sequential finger movements[1]	-kicks ball[2, 4] -close lid[2] -stack objects[3]	-vertical lines[2, 3, 4] -circular scribble[2, 4]	-"eh-eh"[1] -two-word combinations[2, 3, 4]
24-30	-jump[2, 3, 4] -walk on toes[2, 4]	-digital pronate grasp[3]	-turn paper pages[2, 3] -open door[2, 3]	-circles[2, 3, 4] -horizontal line[2, 3]	-names 10-15 pictures[2] -echolia & jargon gone[2]
30-36	-wash hands[2] -pedal tricycle[2, 3, 4]		-adult activities (e.g., talking on phone)[2]	-cross[2] -square[2, 4]	-three-word sentances[2, 3, 4]

Note. Synthesized from Hagan, et al. (2017), Harstad and Albers-Prock (2011), and Jones (2007). 1= Jones (2007); 2= Scharf, et al. (2016); 3= Hagan, et al. (2017); 4= Harstad & Albers-Prock (2011).

Thus far we established that the development of various imitative classes, or duplicative responding, occurs at particular points in a child's chronological age. After the 12-month mark, the imitative responses become more complex, requiring the child to continuously observe their caregivers who function as models in order to imitate them accurately. Even the development of vocal behavior requires the observation of the caregiver's mouth so that infants can imitate their oral-facial movements. However, the shift begins to occur where the child begins to produce their own vocalizations in an attempt to match those of their caregivers (Greer & Ross, 2008; Greer & Speckman, 2009). Through trial-and-error, the child will emit vocalizations until they have point-to-point correspondence between what they heard and what was said.

Interestingly, Pelaez et al. (2011) conducted a group experiment where 35 three- to eight-month-old infants' vocalizations were either directly reinforced with their mother's high-pitched voice (i.e., motherese), directly reinforced by the mother imitating their vocalization (e.g., topography and duration), or the mother non-contingently reinforcing the infant's vocalizations. The results showed that the infant's vocalizations had increased across both the contingent motherese and contingent imitation conditions, where both conditions yielded fairly equal results (Pelaez et al., 2011). The mothers imitating (*emulating*) each vocal response made by their infant, resulted in a rise of spontaneous vocalizations. This finding supports the establishment of the correspondence between hearing and saying, or the echoic, during infancy (Greer & Ross, 2008). Every spontaneous vocalization by an infant was met with their mother imitating (*emulating)* them, to where the reinforcement for the infant's vocalizations shifted from automatic reinforcement (e.g., for themselves) to the correspondence between hearing their own voice and their mothering saying the same back to them (Gladstone & Cooley, 1975; Sundberg, 2001; Sundberg et al., 1996). One can argue that the infants began to establish point-to-point vocal correspondence as a conditioned reinforcer and began establishing the higher-level reinforcer associated with emulative responding, where the function is the reinforcer.

Imitation in Individuals Diagnosed with ASD

The literature on the demonstration of the imitation repertoire in individuals—children, adolescents, and adults—diagnosed with ASD is mixed. There are experiments that found that individuals diagnosed with ASD can imitate completely or most of an observed action, with similar accuracy when compared to their typically developing peers (Hobson & Hobson, 2008; Hobson & Lee, 1999; Mussey & Klinger, 2020) and then other research states that individuals diagnosed with ASD have limited or severe deficits in their imitation skills (Charman et al., 2003; Ingersoll & Schreibman, 2006; Rogers et al., 2003; Rogers & Pennington, 1991; Vivanti et al., 2014; Williams et al., 2004).

Edwards (2014) conducted a meta-analysis as a means of parsing out the data and to determine whether individuals diagnosed with ASD have overall impairments in their imitation skills when compared to individuals not diagnosed with ASD (i.e., developmentally delayed and typically developing). A total of 53 studies were analyzed which supported the notion that individuals diagnosed with ASD do have overall deficits in their imitation skills when compared to individuals without an ASD diagnosis. An interesting finding was that the "average individual diagnosed with ASD performs between the 18th and 21st percentile on imitation tasks" (Edwards, 2014, p. 375). These deficits were not restricted to one type or one class of imitative responses, in fact the results found that individuals with ASD have deficits across oral-facial imitation, gross motor imitation, and object imitation tasks, thus, establishing that the imitative repertoire in the average individual diagnosed with ASD is limited and results in a cascading effect in their ability to learn (Edwards, 2014).

Neuroscientific Account

Several studies have found an association between the firing of a neural circuit found in both primate and human brains and imitation (Gallese, et al., 1996; Gallese, et al., 2012; Iacoboni & Dapretto, 2006; Rizzolatti & Craighero, 2004). Researchers call this neural circuit the mirror neuron system (MNS) and state that these mirror neurons are responsible for the observing, processing, and performance of imitative responses (Iacoboni, et al., 1999). The MNS is found in the "supplementary motor area [which is] mainly dedicated to movement initiation and sequencing, and the medial temporal lobe [that is] principally involved in memory tasks" (Gallese, et al., 2012, p. 16). In studies using typically developing adults, fMRI scans showed that the MNS was activated when the participants were asked to perform an imitative task immediately following the presentation (Iacobani, et al., 1999) and when the participants were asked to perform the imitative task after a delay in presentation (Buccino, et al., 2004). Buccino, et al. (2004) argued that adults rely on the MNS as a neural mechanism to acquire visual input, process the information, and then reproduce a motor plan so that they can imitate what was just observed. This suggests that an intact MNS is important to facilitate imitation and learning by extension.

Interestingly, when looking at studies with people with ASD and MNS, there is little homogeneity. Some studies report that people with ASD have MNS deficits known as the "broken mirror" theory which results in difficulty with imitation (Dapretto et al., 2006; Oberman et al., 2005; Williams et al., 2001), whereas others report no significant differences in the MNS of people with ASD when compared to the MNS of typically developing adults (Avikainen et al., 1999; Bastiaansen et al., 2011; Hamilton et al.. 2007; Oberman et al., 2008; Raymaekers et al., 2009). There are questions that arise as to whether the MNS is an accurate mechanism or if it is the correct neurological mechanism that is related to the observe-produce correspondence, or imitation. Furthermore, limited research has been conducted on other neurological factors such as dopamine, endorphin, or serotonin levels accounting for differences in imitation skills across individuals.

The Socio-Cognitive Approach

Piaget's theory (1951, 1962) on how children learn language provides support to the idea that imitation is learned, not phylogenetic. His six-stage trajectory states that intelligence is established through sensory-motor development, where motor, facial, and vocal imitations develop throughout all six stages. Piaget (1962) finds that children can and do learn important socio-communicative behaviors through imitation; however, he finds imitation to be in line with Bandura and Huston's (1961) theory of observation learning, where children model the behavior(s) of others. Interestingly, Piaget (1962) argued that infant imitations are not a true imitation, but rather a reflexive response, because they are unable to understand the equivalence between their own behavior and the behavior of others.

Infants can imitate facial and simple motor movements very early in their infancy; thus, by extension they can learn from imitation. Cognitive psychology takes this notion further and argues that children can acquire important socio-communicative behaviors through imitation—including play skills and language (Meltzoff, 2006; Meltzoff, 2007). In particular, Meltzoff (2006) contends that imitation is a "cognitive act [where there are] two representations: in one case to match one's own acts to the other (imitative correction), and in the other case to detect being matched oneself (recognition of being imitated)" (p. 38). Furthermore, that imitation has a bi-directional effect of "mapping the actions of other people onto actions of their own body" (Meltzoff, 2007). I argue that Meltzoff's (2006) definition of imitation follows the logic of Greer

(2020), where if a child can imitate novel or previously unreinforced responses then they have the operant of imitation in their repertoire (Meltzoff's correction). I also argue that once a child acquires see-do correspondence as a reinforcer it results in the acquisition of a class of operants and not just a single imitative operant, or imitative repertoire (Meltzoff's recognition). Meltzoff's (2006) definition utilizes mentalistic notions in particular an individual being able to "detect being matched [to] oneself." If his definition were to utilize behavioral terms and definitions, then it can be suggested that the acquisition of a class of operants follows the definition of a higher order operant (Du & Greer, 2014; Greer, 2020; Greer et al., 2017; Greer & Speckman, 2009; Pohl et al., 2018).

The link between an Imitative Repertoire and Language Development

A longitudinal study conducted by Stone et al. (1997) yielded results which supported the association/link between motor imitation and the development of expressive language across 26 two-year-old children diagnosed with autism. The experimenters reported that the participants' imitations-with-objects repertoire was concurrently associated with their play skills (Stone et al., 1997). Furthermore, Stone and Yoder (2001) investigated whether there was an association between child variables (e.g., play level, joint attention, and motor imitation ability) and environmental variables (e.g., socioeconomic status, number of speech therapy hours between the ages of two and three) on the language development of 35 children who received an ASD diagnosis at the age of two. The results showed that the only two predictors of language development at the age of four were: motor imitation skills and the number of speech therapy hours received (Stone & Yoder, 2001), thus, providing scientific evidence for the relation between an imitative repertoire and language development.

Poon et al. (2012) investigated this relation further. The researchers collected home videos from 29 families of children diagnosed with ASD to measure the rates of change in targeted socio-communicative behaviors (e.g., joint attention, imitation skills, and object play) at early infancy (e.g., nine-12 months) and later infancy (e.g., 15-18 months), to determine the extent to which these three socio-communicative behaviors during infancy predict the language development of those 29 children whose current ages ranged from three to seven years old (Poon et al., 2012). Their results supported the relation between the three socio-communicative behaviors and later language development, specifically that by the nine to 12-month age range these targeted behaviors play a fundamental role in accurately predicting language and communication outcomes for children diagnosed with ASD (Poon et al., 2012).

Miniscalco et al. (2014) conducted a longitudinal study on 34 children diagnosed with ASD, where the participant's mothers completed two inventories of the MacArthur Communicative Developmental Inventory for Words and Gestures (with a focus on pre-linguistic skills, actions and gestures, and core language skills) and the MacArthur Communicative Developmental Inventory for Words and Sentences (with a focus on expressive core language and pragmatics) at the onset of the study and 13 months later. Their results added to the literature that imitating adult actions is a predictor of pragmatic language development in children diagnosed with ASD and that core language was not a predictor (Miniscalco et al., 2014), These finding pose the question: why is imitation a learning mechanism that, if in a child's repertoire, can allow them to learn language?

The Behavior Analytic Account

From Skinner's (1953) perspective, he also agreed that imitation and imitative behaviors "do not arise because of any inherent reflex mechanism" (p. 119). Therefore, imitation is neither a reflex nor a by-product of respondent conditioning. However, Skinner (1953) stated that imitation develops "in the history of the individual as the result of discriminative reinforcements showing [the] same three-term contingency" (p. 119-120). Thus, he argued that imitation arises from an operant conditioning procedure, where imitative behaviors were reinforced by the verbal behavior community and have a history of reinforcement. Whether it was imitating choreographed dance movements, artwork, or the behaviors of an actor, the individual contacted reinforcement for not only correctly imitating the model, but also contacted reinforcement in the correspondence between themselves and their model (Gladstone & Cooley, 1975; Greer, 2020; Greer et al., 2017; Skinner, 1953). Gladstone and Cooley (1975) confirmed the notion through a series of three experiments that, due to an instructional history of conditioned reinforcement for imitation a well-established generalized imitative repertoire is acquired; thus, the correspondence between the model and imitator becomes the reinforcer of the imitator's behavior(s).

Generalized Imitation

What is Generalized Imitation?

Generalized Imitation is defined as the "correspondences between behavior of model and observer in novel instances and is a class of responses that may be differentially reinforced" (Catania, 2007, p. 228). The use of the term "generalized" was novel in the 1960s and the field of behavior analysis has taken the term "generalization," and for lack of a better term "ran" with it. This caused for the term "generalized" to become idiosyncratic with applied behavior analysis when describing any behavior that occurs outside of the learning environment. The key notion that Baer and Sherman (1964) underscored was that imitative behaviors must not be reinforced in order to determine the establishment of Generalized Imitation; therefore, no extrinsic reinforcement should be delivered (Gewirtz & Stingle, 1968). Since there is no extrinsic reinforcement what maintains the behavior? Gewirtz and Stingle (1968) and Gewirtz (1971) argue that since the imitative behavior is reinforced on an intermittent schedule of reinforcement, then that schedule functions to maintain the Generalized Imitation repertoire, or through an operant conditioning procedure. However, later research by Du and Greer (2014) found that a conditioned reinforcement relation that follows Pavlovian procedures, where reinforcing every correct response and providing a correction procedure for incorrect responses maintained imitative responding. This procedure differs greatly from the operant conditioning procedures, where schedules of reinforcement are utilized as a means of inducing or maintaining a behavior (Gewirtz, 1971; Gewirtz & Stingle, 1968).

Nevertheless, Holth (2003) examined the term of “generalization” and how it became widespread within the field when Baer and Sherman (1964) first introduced it. Initially, “generalized imitation” was defined as the emission of novel instances of imitative behaviors. However, Holth (2003) redefines Generalized Imitation as both the formal similarity between the behaviors of the model and imitator, where the “behavior of the imitator must itself enter into the controlling relation” (p. 156) and that the relevance of such “similarity or any other point-to-point correspondence can be inferred only to the extent that novel cases yield the same pattern” (p. 157). We will refer to Generalized Imitation as the imitation developmental cusp or Imitation herein. The only other mention of Generalized Imitation will be to describe the assessment used to determine its presence or absence.

The Imitation Developmental Cusp in Infants. When we consider the definition set out by Catania (2007) and the major limitation of the aforementioned studies not utilizing novel imitative behaviors, Horne and Erjavec (2007) tried to induce the imitation developmental cusp in 11 to 19-month-old infants, one to two-year-old infants (Erjavec et al., 2009), and two- and three-year-olds (Erjavec & Horne, 2008). Horne and Erjavec (2007) created a list of imitative responses that infants and children are not typically requested to do, such as: right hand crossing to their left shoulder, left hand on top of their right hand, both hands touching the same ears, etc. Unfortunately, across all of their studies, Horne and Erjavec (2007), Erjavec and Horne (2008), and Erjavec et al. (2009) failed to induce Imitation as a developmental cusp and learning capability in infants. Their results pose the question: why were they unsuccessful in replicating the results of Meltzoff and Moore (1977, 1983, 1989, 1997) and Poulson and Kymissis (1988)? Possible answers include that the individual learning histories of the participants may not have been controlled for, that possibly only certain responses can be observed and produced at that early developmental stage, and that the antecedents used were not consistent across experimental conditions.

Imitation as a Higher Order Operant

The VBDT community (Greer & Ross, 2008; Greer & Speckman, 2009) take the notion of Imitation further and make a distinction. Researchers propose that once an individual gains both an *imitative repertoire*—where they are able to imitate novel behaviors using motor movement, facial manipulation, and object use—and the reinforcement in the form of the *correspondence between seeing and doing*—often referred to as "see-do" correspondence—then that individual has an Imitation repertoire, or the imitation developmental cusp (Du & Greer, 2014; Greer, 2020; Greer & Ross, 2008; Greer et al., 2017). Imitation now covers a more encompassing definition of a response class. It aligns with the definition set out by Catania (2007) of a *higher order operant*, or a class of behaviors that "include within it other classes that can themselves function as operants" (p. 392). Examples of behavior classes that fall under the higher order operant of Imitation are motor movements, facial movements, object use, copying marks, and finger movements to name a few. Du and Greer (2014) showed how imitation can be conditioned through Pavlovian conditioning procedures and that the acquired see-do correspondence is a conditioned reinforcer.

Imitation leads to Speaker Behavior

Earlier, the association between having an imitative repertoire and future speaker behavior was presented across multiple studies (Miniscalco et al., 2014; Partington & Sundberg, 1998; Poon et al., 2012; Poulson & Kymissis, 1988; Stone et al., 1997; Stone & Yoder, 2001). An imitative repertoire, but more specifically the developmental cusp and learning capability of Imitation, is the essential prerequisite to acquiring speaker behavior. Greer and Speckman (2009) theorize that the correspondence between seeing and doing—an observation and production relation—is crucial in the establishment of speaker behavior.

Particularly, the *echoic* operant—the fundamental speaker operant—can be "induced as a result of special arrangements for joining see-do and hear-say as a higher order copying class (Greer and Speckman, 2009, p. 455). Specifically, the correspondence between observing and production responses become "more frequently reinforced by social reinforcement [through which] learning from social contact becomes more prevalent" (Greer et al., 2017, p. 681). A shift in reinforcement occurs from prosthetic reinforcement in the form of primary reinforcers to generalized and natural reinforcers; therefore, the motivating condition of accessing social reinforcement for accurate observing and production responses is established as a conditioned reinforcer (Greer, 2020; Greer, 2002; Greer & Du, 2015). However, the echoic is an example of an *emulative response*, because the "speaker matches the auditory stimulus produced by another person, and not the unobservable musculature components used to produce speech" (Greer &

Ross, 2008, p. 291). Musculature movements and the movement of vocal cords cannot be imitated because they cannot be seen.

Studies conducted by Ross and Greer (2003) and Tsiouri and Greer (2003, 2007) utilized a rapid motor imitation antecedent intervention, in order to increase the probability of a child emitting an echoic response, for children who had the imitation developmental cusp in their repertoire. Their results showed a functional relation between the use of the rapid motor imitation antecedent intervention and the emission of independent imitative responses, independent mands, and independent tacts—where independent mands and independent tacts are regarded as emulative responses. Tsiouri and Greer (2003) posit that both vocal and motor imitation are part of a broader functional response class that "involves the learning of the rule 'do as the model does,' which implies that the acquisition of generalized imitation can be seen as a subclass of instructional control" (p. 203). Therefore, as a result of an existing imitative repertoire speaker behavior comes under the control of the observation-production higher order copying class (Greer & Speckman, 2009). These results add to the literature and support the notion that imitative responses are generally acquired first and followed by emulative responding (Philp, 2016).

A Preverbal Developmental Cusp and Foundational Capability

Preverbal Developmental Cusp.

Across all of VBDT research Imitation is considered both a *preverbal foundational cusp* and a *verbal learning capability* (Du & Greer, 2014; Greer et al., 2017; Greer & Ross, 2008; Greer & Speckman, 2009). VBDT researchers define Imitation as a *preverbal foundational cusp* because it functions as the building block for an overarching duplicative class akin to correspondence (Michael, 1982). It is not deemed a verbal developmental cusp but is one of the major steppingstones required for one to become fully verbal (Greer, 2020).

A *behavior developmental cusp* is defined as a subtle change within an individual in which they come under a new stimulus control as a function of being paired with reinforcement and therefore, allows them to contact environmental contingencies that they could not before the onset of said cusp (Rosales-Ruiz & Baer, 1997). Greer and Speckman (2009) build off of Rosales-Ruiz and Baer's (1997) original scholarship by extending the implications of *verbal developmental cusps* to the development of verbal behavior and language in children. Most importantly, once a child acquires certain verbal developmental cusps, they no longer require direct contingencies to learn. Acquisition of verbal developmental cusps allows a child to move along the sequence of verbal behavior development and the newly acquired conditioned reinforcers lead to new stimulus control (Greer & Du, 2015).

The VBDT (Greer and Ross, 2008; Greer and Speckman, 2009) is an extension of Skinner's work, *Verbal Behavior* (1957). In his original work, Skinner (1957) focused solely on the role of the speaker, with little attention being given to the role of the listener. Through research Greer and Ross (2008) and Greer and Speckman (2009) expanded the role of the listener, where the joining of the listener repertoires with the speaker repertoires both covertly and overtly, allow for one to become fully verbal (Greer et al., 2017). Findings from their lab indicate that there are many verbal developmental cusps and various levels of verbal behavior functioning. For example, children who do not orient to/observe adult faces, adult voices, two-dimensional stimuli (e.g., pictures, print), three-dimensional stimuli (e.g., objects, toys), do not follow vocal directions without prompts, little or no independent speaker behavior, and do not demonstrate the presence of Imitation fall under the pre-listener/pre-speaker level of development (Greer & Ross, 2008; Greer & Speckman, 2009). These children are pre-verbal, because they lack the necessary reinforcement for observing and orienting to various stimuli in their environment. VBDT researchers (Greer & Ross, 2008) have complied and outlined not only what the specific verbal developmental cusps are, but also how to determine if a student is missing one, what intensive intervention (often called a protocol) to run to induce the missing cusp, and what changes will be observed in the child once the verbal developmental cusp is established.

Verbal Learning Capability.

A *verbal learning capability* is defined as a higher-order operant, whose presence allows an individual to learn in way that was not available to them before the acquisition of said learning capability (Greer & Ross, 2008; Greer & Speckman, 2009). Specifically, if a child is missing a verbal learning capability, then they cannot learn from observing others and most likely cannot learn from indirect contact with various environmental contingencies. Once a verbal learning capability is acquired, not only will the child's rate of learning accelerate, but also, they will be able to contact higher order operants.

According to VBDT, there are four verbal learning capabilities that we know of: Imitation, Incidental BiDirectional Naming (Inc-BiN), Observational Learning, and conditioned reinforcement through observation (Greer, 2020; Greer et al., 2017; Greer & Ross, 2008; Greer & Singer-Dudek, 2008; Greer & Speckman, 2009). Once a child acquires Imitation, they are then able to learn from simply modeling a correction procedure with little to no physical prompting (Du & Greer, 2014). Children can learn from observing their teacher and when they emit the correct imitative response, that correspondence is the reinforcer (Du and Greer, 2014; Greer, 2020). The establishment of BiN allows a child to acquire language incidentally without the need for direct instruction on various nouns, adjectives, and modifiers (Greer et al., 2017). No longer do teachers have to sit a child down and teach various words to a child individually. With BiN in their verbal behavior repertoire, a child can now acquire language as both a listener through selection-based responding (e.g., selecting the requested/target item from an array of three items) and as a speaker through production responses. Finally, the acquisition of Observational Learning as a verbal learning capability allows a child to learn from observing one's peers receive a correction, or learn from contacting remote environmental contingencies. This final verbal learning capability is crucial to induce because it is indicative of how typically children learn in a general education setting. In a general education setting a child will observe their teacher ask their peer what three plus three is. If the peer incorrectly responds five, the teacher will then provide the correction of stating that the answer is six. Now if Observational Learning is present in the child's repertoire, they will correctly answer six if asked by their teacher what three plus three is, due to being able to learn from observing corrections.

Therefore, the evidence presented suggests that the induction of missing verbal learning capabilities is important in changing the manner in which a student contacts the environmental learning contingencies, which are related to a student's educational outcomes.

Emulation

Emulation vs. Imitation

When Wood (1989) first used the term *emulation,* he defined it as a response where a different or novel method is used to meet the same end-state as the original action. Tomasello's (1990, 1996) research with apes evolved the definition of emulation, or affordance learning, to include the observation of a demonstrated behavior by another where the goal (e.g., the effect on the environment) will be reproduced by whatever means necessary. Byrne (2002) questioned the validity of Tomasello's (1990; 1996) research, specifically whether the apers were actually emitting emulative responses. Byrne (2002) argued if Tomasello (1990; 1996) was confirming the null hypothesis of if the apes do not emit an imitative response, then by default they emitted an emulative response. This resulted in Byrne (2002) expanding the definition of emulation to include three distinct instances of its occurrence. The three distinct instances are: "(1) [when] learning [about the] physical properties of objects, (2) [when] learning [about] the relationships among objects, and (3) [when] understanding cause-and-effect relationships and changes of state of objects" (p. 20).

The definitions of emulation herein present a problem in how to measure whether a behavioral response is emulation versus imitation. To mediate this problem Hamilton (2008) added the function of the behavioral response in question to the definition. Hamilton (2008) defined emulation as a goal-oriented representation that is explicit and controlled, where its function is practical (e.g., to gain food, use tools). She distinguished imitation as the mimicry of kinematic features that are implicit and automatic, where its function is social behavior (e.g., to create a handshake, facial actions to express emotions; Hamilton, 2008). With the definition of emulation encompassing the function—or Tomasello's (1990, 1996) notion of the behavior having an effect on the environment—researchers can now create situations where the behavior can be isolated and the reinforcement for emitting emulative responses can be determined.

Behavior Analytic Perspective. From a behavior analytic perspective, emulation varies from imitation. We will use Philp's (2016) definition herein as our definition of emulation. Philp's (2016) definition of emulation is that of a behavior being emitted resulting in the same goal that was produced by the model; however, there is no point-to-point correspondence with the manner in which the behavior was originally modeled. As a result of the behavior having no point-to-point correspondence with the model, or no formal similarity, the production of the goal/outcome shifts to being the reinforcer for emitting the behavior. Why do people emit emulative responses? It is due to the reinforcement shifting from the see-do correspondence between the model and the imitator to the function of the behavior itself, or its effect on the environment (Clement, 2019; Greer, 2020; Philp, 2016). Differences between Imitation and emulation are described in Table 2.

Table 2
Differences between Generalized Imitation and Emulation

	Imitation	Emulation
What is the reinforcer?	See-do correspondence, emitting the same behavior as the imitator	The function, where the end-goal is the reinforcer
How does one observe this difference?	Teacher will model the toy bunny hopping from Point A to Point B. Student will make the bunny hop from Point A to Point B. Student emitted the same behavior as the teacher, with point-to-point correspondence.	Teacher will model the toy bunny hopping from Point A to Point B. Student will make the bunny slide from Point A to Point B. Student did not emit the same behavior as the teacher; however, they reached the same end-goal.

Emulation in Children: Typically Developing and Children Diagnosed with ASD

Hobson and Lee (1999) studied imitation and emulation in children diagnosed with ASD and children with developmental delays, following a model demonstration. The participants were matched based on chronological age and verbal mental age. Specifically, Hobson and Lee (1999) looked at style—the manner in which the participants completed the task "harshly" or "gently"—and at goal-directed actions—whether the participants were able to reach the same end goal as the model. The results of Hobson and Lee (1999) show that the children diagnosed with ASD were less likely to imitate the style in which the task was modeled. When comparing these results to the developmentally delayed children, they did imitate the researcher's style. Therefore, the children with developmental delays *imitated* the model because there was point-to-point correspondence, or a formal similarity. Interestingly, the children diagnosed with ASD did produce the end-goal as the model, thus emulating (Hobson & Lee, 1999). The results suggest that children diagnosed with ASD are emulators versus imitators.

Hobson and Hobson (2008) aimed to replicate their earlier (Hobson & Lee, 1999) findings, by matching 16 children diagnosed with autism with 16 typically developing children and investigating their responses to imitating style and goal-directed actions. Their results supported their earlier findings (Hobson & Lee, 1999) where the participants diagnosed with ASD were able to imitate the goal-directed actions (*emulate)* but were unable to imitate the style with which the action was modeled even when style was insignificant in reaching the end-goal (Hobson & Hobson, 2008). The typically developing participants were able to imitate both the style and meet the end-goal. However, using the definition set out by Philp (2016), we argue that the typically developing children imitated their models due to the point-to-point correspondence with style and did not use other means to reach the end-goal. Hobson and Hobson (2008) theorized that the differences in imitation and emulation may be attributed to an underlying mechanism where imitating actions is an implicit process that results in the automatic copying of the style with which the behavior is modeled; whereas, for emulation the process is explicit that results in "conscious" matching of the outcome. It is unclear whether Hobson and Hobson (2008) are referring to a neurological mechanism similar to MNS being responsible for the emission of imitative and emulative responses or if they are inferring another covert mechanism beneath the skin.

Mussey and Klinger (2020) investigated the findings of Hobson and Lee (1999) and Hobson and Hobson (2008) further. Their participant pool consisted of 25 children with a diagnosis of ASD, who were matched across two groups of typically developing children. The first group consisted of 29 children who were matched based on chronological age and the second group of 28 typically developing children was matched based on their receptive language scores from the Mullen Scales of Early Learning. The participants were given a choice-imitation task to determine whether they will imitate the manner (hopping the block versus sliding the block), the path (the block moving up versus the block moving down), and/or the goal (the block ending up on the bowl or the block ending up in the bowl) of the experimenter's demonstration (Mussey & Klinger, 2020). The results of the study showed that the children diagnosed with ASD were able to imitate the path of the model and the goal (*emulate*) with the similar accuracy when compared to their peers matched on chronological age and receptive language skills. Conversely, the children diagnosed with ASD were less likely to accurately imitate the manner the experimenter modeled the action. Therefore, the results of Mussey and Klinger (2020) support the findings of Hobson and Lee (1999) and Hobson and Hobson (2008) where children diagnosed with ASD are more likely to emulate rather than imitate, with specific difficulty in imitating the manner in which the action was demonstrated.

The literature and the aforementioned studies support the notion that children diagnosed with ASD emulate and typically developing children imitate (Hobson & Hobson, 2008; Hobson & Lee, 1999; Mussey & Klinger, 2020). Interestingly, an unpublished dissertation (Philp, 2016) had found the exact opposite. She conducted two experiments to test the presence of imitation and emulation using immediate and delayed testing conditions in 50 preschool children, where half had a medical ASD diagnosis. In the immediate testing condition, Philp (2016) assessed whether the participant imitated versus emulated 5 s after the model demonstration and if the participant imitated versus emulated in the delayed condition, which occurred one week later. Across both experiments, Philp (2016) found that in the immediate testing condition both the typically developing preschoolers and the preschoolers diagnosed with ASD imitated the model demonstration—they emitted point-to-point correspondence. However, in the delayed testing condition (one week later), the preschoolers diagnosed with ASD continued to imitate whereas the typically developing preschoolers emulated—they used different means in order to reach the same end goal (Philp, 2016). Philp (2016) hypothesized that for the typically developing participants the source of reinforcement shifted between the immediate and delayed testing conditions, where the effect on the environment (i.e., the function) was the newly acquired reinforcer. She suggested that this shift in the source of reinforcement allowed the typically developing preschoolers to learn that "their behavior is instrumental to producing changes within the environment" (Philp, 2016, p. 88).

Neuroscientific Account

Hamilton (2008) tested the functionality of the MNS on emulation tasks across two groups, one group of 25 children diagnosed with ASD and one control group of 31 typically developing children who were matched based on mental and verbal age. The results of the study showed that the participants with ASD emitted the same level of responding as their typically developing peers in emulative tasks. Hamilton (2008) concluded that the results of this study do not support the notion of a "broken mirror" theory in children with ASD and that a different neural circuit mechanism may need to be explored.

Emulative Verbal Developmental Cusps

Philp's (2016) data suggests that an imitative repertoire is a necessary prerequisite to establishing the higher order operant of emulation, and emulative responding. Since her typically developing preschoolers shifted from the point-to-point responding after observing a model demonstration to meeting the end-goal, or the effect the demonstrated behavior had on the environment, their verbal developmental trajectory expanded to include function as newly conditioned reinforcer (Greer & Du, 2015; Greer & Ross, 2008). This is one instance of the initially separate observing and producing repertoires joining together as the see-do correspondence (i.e., Imitation) and expanding to come under the control of the duplicative class of responding (Du & Greer, 2014; Greer & Du, 2015; Greer & Speckman, 2009).

Clement (2019) did a similar experiment to that of Philp (2016) and argued her findings showed that the verbal learning capability of Imitation is a corequisite of an emulative repertoire. Her results indicated that children diagnosed with ASD were more likely to imitate versus emulate. Clement (2019) also investigated whether three of the many verbal developmental cusps and learning capabilities identified in VBDT are correlated with correct emulative responding. The three targeted verbal developmental cusps were capacity for sameness and listener literacy, and the learning capability was Imitation. Only listener literacy was significantly correlated with emulative responding, prompting the question why? Clement (2019) argues that this correlation may be due to the fact that fluency in responding to the auditory stimuli is a measure of whether one is under the correct stimulus control—is the person following the direction as they hear it or looking for any non-vocal verbal cues that will prompt the correct response?

The question then becomes what the other emulative cusps are where the function is the reinforcer? I argue that conditioned reinforcement for acoustical properties (*parroting*), point-to-point vocal correspondence (*echoics*), correspondence between production and delivery of reinforcer (*independent mands*), correspondence between production and social reinforcement (*independent tacts*) are all emulative verbal developmental cusps (Greer & Du, 2015; Greer, et al., 2017; Greer & Ross, 2008; Greer & Speckman, 2009). Across each of these verbal developmental cusps, the final product or the effect on the environment is the target reinforcer. It is through the establishment of the various correspondences (i.e., for parroting it is hear-say, echoics is point-to-point vocal, independent mands is say-receive reinforcer, and for independent tacts it is say-receive social reinforcement) that the observing and production responses come together as duplicative responses and allow one to move along the verbal trajectory as scripted out by VBDT (Greer & Ross, 2008; Greer & Speckman, 2009; Michael, 1982). Not all observation-production correspondences are a result of emulative responding and the reinforcer shifting to the function/outcome of the behavior. For example, the correspondence between hearing and doing (e.g., Listener Literacy) is not an emulative cusp because the behavior is coming under the control of vocal verbal stimuli (Greer & Ross, 2008; Greer & Speckman, 2009). See Table 3 for a list of correspondences, the associated verbal developmental cusp/capability, and the acquired reinforcer for each stimulus control.

Table 3
Correspondences with the Associated Verbal Developmental Cusps and Acquired Reinforcer for each Stimulus Control

Observing-Production Correspondence	Associated Verbal Behavior Cusp/Capability	Stimulus Control/Reinforcer Acquired
Say-hear	Parroting	Point-to-point vocal responses are under the control of automatic reinforcement
Hear-say	Echoics	Point-to-point vocal phonemic discrimination
Hear-do	Listener Literacy	Behavior comes under the control of discriminating auditory stimuli
See-do	Imitation	Point-to-point correspondence between the behavior of the model and the imitator
See-say	-Independent Mands -Independent Tacts	-Correspondence between seeing a stimulus, requesting it, and receiving the item -Correspondence between observing a stimulus, labeling it, and receiving social attention
Read-do	Reading Governs Responding	Correspondence between the print stimuli and the behavior emitted

Note: Synthesized from Greer, et al. (2017), Greer and Ross (2008), Greer and Speckman (2009)

Educational Significance of Duplicative Responding

The VBDT camp posits that the formation of an imitative repertoire, the establishment of Imitation as a foundational learning capability, and an emulative repertoire all encompass the overarching class of duplicative responding (Greer, 2020; Greer & Du, 2014; Greer & Ross, 2008; Greer & Speckman, 2009). It is important for educators and clinicians to focus on aiding their students and clients in the acquisition of these separate but intertwining repertoires. In their book *Social Learning and Imitation* (1945)*,* Miller and Dollard wrote about the significance of duplicative responding in education and on the ability to learn:

> Imitation can hasten the process of learning by forcing the subject to respond correctly to the proper cue more quickly than he otherwise would. In this way, a preliminary phase of imitation or copying is often useful in teaching a subject to respond independently to the proper environmental cues. In fact, one of the chief functions of copying as it is commonly used in the schoolroom is to get the subject to the stage where he can make the socially appropriate response independently and in the absence of a model. This use of the mechanism of imitation is of enough practical importance to deserve special attention. A more thorough understanding of the details of the process may suggest when imitation should be expected to be of great aid, of little aid, or a positive hindrance to independent learning. (p. 169)

VBDT theorists agree that the acquisition of duplicative responding allows a child to learn more quickly and through the use of models, as these are the methods of pedagogy utilized in general education classrooms (Greer & Ross, 2008; Greer & Speckman, 2009, Michael, 1982). Even activities as simple as playing with toys, puzzles, or blocks require that parents or teachers model *how* to functionally play with those items. Caregivers may not be aware that through imitation, they are serving as models to young children (Moreno, 2012). Given the deficit children diagnosed with ASD exhibit in appropriate play skills, it is through modeling procedures that they are taught to how to play with toys, puzzles, and blocks both appropriately and functionally (Greer, 2002).

Rationale for Experiment I

Based on the findings mentioned above, research needs to be conducted to determine whether any of the VBDT preverbal developmental cusps are statistically correlated with one another and with the verbal learning capability of Imitation. Identifying a relation between Imitation as a verbal learning capability and the other emulative verbal developmental cusps may suggest prerequisite or corequisite cusps, which will allow teachers to tailor their instruction. Research also needs to be conducted on identifying whether there is a relation between the reinforcement value of age-appropriate items and demonstrating Imitation as a foundational learning capability.

I will use a statistical analysis to answer the following questions:

1. Is there a relation between demonstrating Imitation as a foundational learning capability and the other preverbal developmental cusps (i.e., conditioned reinforcement for observing three-dimensional stimuli, conditioned reinforcement for observing two-dimensional stimuli, conditioned reinforcement for observing adult faces, conditioned reinforcement for observing adult voices, listener literacy)?
2. Is there a relation between demonstrating Imitation as a foundational learning capability and the emulative verbal developmental cusps (i.e., parroting, echoics, independent mands, and independent tacts)?
3. Is there a relation between the reinforcement value of age-appropriate items and demonstrating Imitation as a foundational learning capability?

Chapter 2: An Analysis of the Imitation Developmental Cusp, Emulative Cusps, and the Reinforcement value of Age-Appropriate Items

Purpose

The purpose of this study was to determine the possible relations between the foundational learning capability of Imitation, the verbal development cusps in the participants' repertoire, and the reinforcement value of age-appropriate items that are traditionally used to condition as reinforcers.

Method

Participants. We selected 36 preschoolers (86.1% male) with a mean age of 4.6 years (*SD* = 0.5889 years) via a convenience sampling procedure across six classrooms in a publicly funded private school located outside a metropolitan area. Participants are discussed in further detail in Table 4. The school utilized the Comprehensive Application of Behavior Analysis to School (CABAS®) model of education (www.cabasschools.org), which focuses on creating individualized programming for each student, applying a research-driven and evidence-based curriculum, and expanding children's verbal developmental milestones (Greer, 2002; Singer-Dudek et al., 2010).

Table 4
Demographic Characteristics of Participants at the Onset of Experiment 1

Measure	Mean (SD)	n(%)
Age (years)	4.6228 (.5889)	36 (100%)
Sex		
Male		31 (86.1%)
Female		5 (13.9%)
Year in Preschool	1.64 (.639)	
First Year		16 (44.4%)
Second Year		17 (47.2%)
Third Year		3 (8.3%)
IEP	1 (.00)	36 (100%)
Race/ethnicity		
Asian		3 (8.3%)
Black		7 (19.4%)
Hispanic/Latinx		10 (27.8%)
White		11 (30.6%)
Other		5 (13.9%)
English as a second Language		13 (36.1%)

Note. All demographic information was gathered from the student's Individualized Education Plan's and the school's data base.

Measures and materials. Measures collected during probe sessions will be discussed below and include: conditioned reinforcement for observing three-dimensional stimuli, conditioned reinforcement for observing two-dimensional stimuli, conditioned reinforcement for observing adult faces, conditioned reinforcement for observing adult voices, parroting, generalized imitation, listener literacy, echoics, independent mands, independent tacts, transfer of motivating operations, conditioned reinforcement for toys, conditioned reinforcement for books, conditioned reinforcement for puzzles, conditioned reinforcement for blocks, conditioned reinforcement for coloring, and conditioned reinforcement for Play-Doh®.

Procedures.

Conditioned reinforcement for observing three-dimensional stimuli. To measure conditioned reinforcement for observing three-dimensional stimuli, we collected the participant's observing responses to a variety of antecedents as set by the "Observing Responses" domain in the *Early Learner Curriculum and Achievement Record (ELCAR): A CABAS® Developmental Inventory* (Greer, et al., 2019). See Table 5 for a complete list of observing response measures and antecedents provided.

For all the Observing Response probes the probe sessions were conducted during non-instructional time, such as: singular free play, group play, lunch time, reading time, and daily transitions. These probe sessions created naturalistic opportunities versus contrived, in order to determine the degree of strength the varying stimuli evoke across each participant.

A correct response to a target antecedent was defined as the participant visually orienting to and/or visually tracking the stimuli within 5 s. An incorrect response was defined as the participant not visually orienting to and/or tracking the stimuli within 5 s. Each participant had seven opportunities per probe session to respond and three observing response probes were conducted in total. The total number of opportunities to respond to observing three-dimensional stimuli was 21, across three probe sessions. The percent of correct responses was calculated by dividing the total number of correct responses across three probes by the total number of opportunities across three probes. Across each Observing Response probe, the number of correct responses was converted to a percentage.

Table 5

List of Observing Response Measures for Experiment 1

Observing Response	Antecedents	Response Definition
CR+ for Observing Three-Dimensional Stimuli	-Action with object (light up toy, toy with sound) -Teacher presents stationary object -Teacher presents moving object -Teacher presents stationary reinforcer -Teacher presents moving reinforcer -Reinforcer removed -Non-reinforcer removed	Visually orienting towards and/or visually tracking the stimuli
CR+ for Observing Two Dimensional Stimuli	-Teacher presents pictures -Teacher presents letters/number on flashcards -Teacher presents pictures on stationary device (no videos) -Teacher presents letters and numbers on stationary device (no videos)	Visually orienting towards and/or visually tracking the stimuli
CR+ for Observing Adult Faces	-Teacher moves within 2' -Teacher moves within 2" at eye-level -Teacher makes facial expressions without sound -Teacher enters/leaves the room quietly	Turning, looking up, and looking in the direction of the person. Eye contact is not required.
CR+ for Observing Adult Voices	-Teacher enters the room speaking -Teacher makes non-speech vocal sounds -Teacher sings songs for a 5 min session -Teacher tells story without pictures for 5 min session -Teacher calls name and greets student OR gives directions -Teacher calls student's name -Teacher greets student (no name) -Teacher gives an approval (no name) -Peer gives direction	Turning, looking up, and looking in the direction of the person. Eye contact is not required.
Echoics	-Teacher will say a word (e.g., lemon), to test for vocal approximations -Teacher will say a word (e.g., lemon) for point-to-point correspondence	Child repeats words or sound said that match either the prosody or phonemes of the presented vocalization

Note. CR+ = Conditioned Reinforcement

Conditioned reinforcement for observing two-dimensional stimuli. To measure conditioned reinforcement for observing two-dimensional stimuli, we collected the participant's observing responses to the antecedents set out by the "Observing Responses" domain in the *ELCAR* (Greer, et al., 2019). See Table 5 for a complete list of observing response measures and antecedents provided.

As stated earlier, probe sessions were conducted during non-instructional time to create naturalistic opportunities in order to determine the degree of strength the varying stimuli evoke across each participant.

A correct response to a target antecedent was defined as the participant visually orienting to and/or visually tracking the pictures, flashcards, and letters/numbers within 5 s. An incorrect response was defined as the participant not visually orienting to and/or tracking the stimuli within 5 s. Each participant had four opportunities per probe session to respond and three observing response probes were conducted in total. The total number of opportunities to respond to observing two-dimensional stimuli was 12, across three probe sessions. The percent of correct responses was calculated by dividing the total number of correct responses across three probes by 12.

Conditioned reinforcement for observing adult faces. To measure conditioned reinforcement for observing adult faces, we collected the participant's observing responses to the antecedents set out in the "Observing Responses" domain in the *ELCAR* (Greer, et al., 2019). See Table 5 for a complete list of observing response measures and antecedents provided.

As stated earlier, probe sessions were conducted during non-instructional time to create naturalistic opportunities in order to determine the degree of strength the varying stimuli evoke across each participant.

A correct response to a target antecedent was defined as the participant turning, looking up, and looking in the direction of the researcher's face within 5 s. An incorrect response was defined as the participant not turning, looking up, and not looking in the direction of the researcher's face within 5 s. Each participant had four opportunities per probe session to respond and three observing response probes were conducted in total. The total number of opportunities to respond to observing an adult's face was 12, across three probe sessions. The percent of correct responses was calculated by dividing the total number of correct responses across three probes by 12.

Conditioned reinforcement for observing adult voices. To measure conditioned reinforcement for observing adult voices, we collected the participant's observing responses to the antecedents set out by the "Observing Responses" domain in the *ELCAR (*Greer, et al., 2019). See Table 5 for a complete list of observing response measures and antecedents provided.

As stated earlier, probe sessions were conducted during non-instructional time to create naturalistic opportunities in order to determine the degree of strength the varying stimuli evoke across each participant.

A correct response to a target antecedent was defined as the participant turning, looking up, and looking in the direction of the researcher within 5 s. The participants were not required to look at the researcher's face during these probes. An incorrect response was defined as the participant not turning, looking up, and not looking in the direction of the researcher within 5 s. Each participant had nine opportunities per probe session to respond and three observing response probes were conducted in total. The total number of opportunities to respond to observing an adults' voices was 21, across three probe sessions. The percent of correct responses was calculated by dividing the total number of correct responses across three probes by 21.

Parroting/Vocalizations. To measure conditioned reinforcement for acoustical properties or vocalizations, we collected data on the number of sounds the participant made during the probe sessions.

Three probe sessions were conducted during non-instructional time in the play area across both singular free play and group play, where each probe lasted for 10 mins. A fourth probe session was conducted during a 20 min instructional session. Once all four probe sessions were completed the researcher conducted one 20 trial session, where responses were not consequated (no reinforcement was delivered for emitting a sound and a correction was not provided for not emitting a sound).

A correct response was defined as the participant emitting a sound after the researcher's presentation of a sound (e.g., la la), a word (e.g., car), or phrase (e.g., twinkle little star) within 5 s. The participant's responses did not have to have point-to-point correspondence with the researcher's. An incorrect response was defined as the participant not emitting a sound after the researcher's presentation of a sound (e.g., la la), a word (e.g., car), or phrase (e.g., twinkle little star) within 5 s. Mastery criterion was set at 80% or higher accurate responding within one session.

Imitation. The Imitation probes were composed of 26 target actions, that have been utilized as the standard from Du and Greer (2014) also known as the Generalized Imitation probe list. See Table 6 for complete list of imitative actions presented during pre- and post-experimental probes.

A correct response was defined as the researcher providing the vocal antecedent of "Do this," while simultaneously modeling a motor response (e.g., right hand to right shoulder), and the participant imitating the response by tapping their right shoulder with their right hand within

5 s. An incorrect response was defined as the researcher providing the vocal antecedent of "Do this," while simultaneously modeling a motor response (e.g., right hand to right shoulder), and the participant either emitting another motor response or not responding at all within 5 s.

The participants had only one opportunity to respond to each imitative response, where mastery criterion was set at 80% or higher accurate responding across two consecutive sessions or 100% accurate responding in one session. Responses between zero and 45 were collected as one. Responses between 46 and 74 were collected as two. Responses between 75 and 100 were collected as three.

Table 6
List of Generalized Imitative Actions for Experiment 1

Number	Target Response	Response Definition
1	Right hand cross to shoulder	Right hand tapping left shoulder
2	Right hand to same shoulder	Right hand tapping right shoulder
3	Left hand cross shoulder	Left hand tapping right shoulder
4	Left hand same shoulder	Left hand tapping left shoulder
5	Both hands same shoulders	Right hand tapping right shoulder & left hand tapping left shoulder
6	Both hands cross shoulders	Right hand tapping left shoulder & left hand tapping right shoulder
7	Right hand cross to elbow	Right hand tapping left elbow
8	Left hand cross to elbow	Left hand tapping right elbow
9	Right hand cross to wrist	Right hand tapping left wrist
10	Left hand cross to wrist	Left hand tapping right wrist
11	Palms up bowl	Half folding palms together in front
12	Arms crossed in front	Two arms cross in front of body
13	Right hand cross to knee	Right hand tapping left knee
14	Right hand same knee	Right hand tapping right knee
15	Left hand cross to knee	Left hand tapping right knee
16	Left hand same knee	Left hand tapping left knee
17	Right hand cross to ankle	Right hand tapping left ankle
18	Right hand same ankle	Right hand tapping right ankle
19	Left hand cross to ankle	Left hand tapping right ankle
20	Left hand same ankle	Left hand tapping left ankle
21	Right hand cross to ear	Right hand tapping left ear
22	Right hand same ear	Right hand tapping right ear
23	Left hand cross to ear	Left hand tapping right ear
24	Left hand same ear	Left hand tapping left ear
25	Both hands same ear	Right hand tapping right ear & left hand tapping left ear
26	Both hands cross ears	Right hand tapping left ear & left hand tapping right ear

Listener literacy. To measure conditioned reinforcement for auditory discrimination, or listener literacy, we utilized the list of 20 vocal directions with visual distractors from Choi (2012). See Table 7 for the complete list of vocal directions with the accompanying visual distractor.

A correct response was defined as the researcher providing a vocal antecedent such as "Touch your nose," while simultaneously presenting the visual distractor (e.g., researcher touches their own mouth), and the participant following the vocal direction within 5 s. An incorrect response was defined as the researcher providing a vocal direction such as "Touch your nose," while simultaneously presenting the visual distractor (e.g., researcher touches their own mouth), and the participant either emitting the response corresponding with the visual distractor, another unrelated response, or not responding at all within 5 s.

The participants had only one opportunity to respond to vocal direction, where mastery criterion was set at 90% or higher accurate responding in one session.

Table 7
List of Vocal Directions and Visual Distractors Used in Experiment 1

Vocal Direction	Visual Distractor
Touch nose	Touch mouth
Touch ear	Touch eyes
Clap hands	Stand up
Blow kiss	Roll arms
Roll arms	Touch nose
Touch eyes	Touch ear
Touch mouth	Clap hands
Stand up	Blow kiss
Stomp feet	Touch head
Tap lap	Touch belly
Touch arm	Touch feet
Tap table	Touch knees
Touch head	Tap table
Touch belly	Touch arm
Touch feet	Tap lap
Touch knee	Stomp feet
Wave hands	Touch elbow
Raise arms	Touch shoulder
Touch elbow	Raise arms
Touch shoulder	Wave hands

Echoics. To measure phonemic discrimination as a listener or echoics, we collected the participants' observing responses to a variety of antecedents as set by the "Observing Responses" domain in the *Early Learner Curriculum and Achievement Record (ELCAR): A*

CABAS® Developmental Inventory (Greer, et al., 2019). See Table 4 for a complete list of observing response measures and antecedents provided.

Probe sessions were conducted during non-instructional time, such as: singular free play, group play, lunch time, reading time, and daily transitions. These probe sessions created naturalistic opportunities versus contrived, in order to determine the determine the degree of strength the varying stimuli evoke across each participant.

A correct response to a target antecedent was defined as the participant emitting a vocalization that matched either the prosody or phonemes of the presented vocalization within 5 s. An incorrect response was defined as the participant emitting a vocalization that did not match either the prosody or phonemes of the presented vocalization within 5 s. Each participant had two opportunities per probe session to respond and three observing response probes were conducted in total. The total number of opportunities to respond to echoics (i.e., hear-say correspondence) was six, across three probe sessions. The percent of correct responses was calculated by dividing the total number of correct responses across three probes by the total number of opportunities across three probes.

Independent Mands. To measure the correspondence between production and delivery of reinforcer, or independent mands, we collected data on the participants' responses to a variety of mand forms as set out in the "Speaker" domain in the *Early Learner Curriculum and Achievement Record (ELCAR): A CABAS® Developmental Inventory* (Greer, et al., 2019). See Table 8 for a complete list of mand forms assessed.

Classroom observations were conducted across five consecutive school days, in order to create naturalistic opportunities versus contrived for each mand form. A mand form was considered mastered if the participant emitted three mands under that natural contingency across five consecutive school days.

Independent mands were considered in the participant's repertoire if they mastered four mand forms out of the 11 assessed.

Table 8

List of Mand Forms Assessed in Experiment 1

Mand Forms
Intraverbals
Coordinated eye contact when emitting a mand
Food and drink
Objects (e.g., toys, materials to complete task)
Vestibular, proprioceptive, or tactile stimuli (e.g., swing, tickles, hug, bounce)
Activities (e.g., play, go to gym, climb, jump, take a walk)
Help or assistance
Terminate or remove from environment (e.g., stop, break, out)
Social interaction
Shared experience
"Turn" or "opportunity"

Independent Tacts. To measure the correspondence between production and social reinforcement, or independent tacts, we collected data on the participants' responses to a variety of tact forms as set out in the "Speaker" domain in the *Early Learner Curriculum and Achievement Record (ELCAR): A CABAS® Developmental Inventory* (Greer, et al., 2019). See Table 9 for a complete list of tact forms assessed.

Classroom observations were conducted across five consecutive school days, in order to create naturalistic opportunities versus contrived for each tact form. A tact form was considered mastered if the participant emitted three tacts under that natural contingency across five consecutive school days.

Independent tacts were considered in the participant's repertoire if they mastered four mand forms out of the 11 assessed.

Table 9
List of Tact Forms Assessed in Experiment 1

Tact Forms
Intraverbals
Stimuli (e.g., pictures, objects)
Private events, physical or emotional (e.g., "I feel sick," "I'm hungry")
Likes and dislikes (e.g., "I like chocolate," "I don't like carrots")
Tacts as exclamations (e.g., "Wow!" "Oh my goodness!")
Oddities, absurdities, or something is missing (e.g., "The cat has no tail!" "The clock is missing!")
Introductions (e.g., "This is my friend, Maddie.")
Own or other's possessions (e.g., "That is my coat," "That is Ms. Kate's cup")
Responds with "yes" or "no" in a tact function (e.g., "Is this blue?" "Is this a boat?"

Conditioned reinforcement for toys. To measure conditioned reinforcement for toys, we collected data on the participants' responses during a 5 min 5 s whole-interval recording session.

Probe sessions were conducted during non-instructional time in the free-play setting. Across all probe sessions, the participants had access other play items. For these probes we left between three to four puzzles, blocks and books inside the free-play setting. As well as a coloring book with four markers and a canister of Play-Doh® with three shape inserts. Across all probe session, the participants were presented with more target items. Between five and eight cause-and-effect toys were left inside the free-play setting. A correct response was defined as the participant manipulating the toys, taking them apart, pressing buttons, or putting cars down the ramp during the entire 5 s interval. An incorrect response was defined as the participant not visually orienting to the toy, emitting interfering stereotypical behaviors with the toys, or not responding at all during the entire 5 s interval. The number of opportunities was the same across each probe session and across each age-appropriate item. Each participant had 60 opportunities per probe session to play with the toys and three probe sessions were conducted in total. The percent of correct responses was calculated by dividing the total number of correct responses to the 5 s whole-interval recording for each probe by the total number of intervals in a single probe session.

Across each age-appropriate item, it was considered a conditioned reinforcer if the participant emitted 90% or higher accurate responding across three consecutive sessions. If the participant emitted zero correct responses during any probe session, probes were terminated, and toys were not considered to function as a conditioned reinforcer.

Conditioned reinforcement for books. To measure conditioned reinforcement for books, we collected data on the participant's responses during a 5 min 5 s whole-interval recording session.

Probe sessions were conducted during non-instructional time in the free-play setting. As stated earlier, the participants had access other play items during the probe sessions. For these probes we left puzzles, blocks, coloring materials, Play-Doh®, and cause-and-effect toys inside the free-play setting. A correct response was defined as the participant looking at the books, turning the pages, pressing buttons on the sides, or reaching to get a new book during the entire 5 s interval. An incorrect response was defined as the participant not visually orienting to the books, emitting interfering stereotypical behaviors with the books, or not responding at all during the entire 5 s interval. Total number of correct responses per probe session were converted to a percentage.

The same criterion of 90% or higher accurate responding across three consecutive sessions was utilized. If the participant emitted zero correct responses during any probe session, probes were terminated, and books were not considered to function as a conditioned reinforcer.

Conditioned reinforcement for puzzles. To measure conditioned reinforcement for puzzles, we collected data on the participant's responses during a 5 min 5 s whole-interval recording session.

Probe sessions were conducted during non-instructional time in the free-play setting. As stated earlier, the participants had access other play items during the probe sessions. For these probes we left books, blocks, coloring materials, Play-Doh®, and cause-and-effect toys inside the free-play setting. A correct response was defined as the participant manipulating the puzzles, taking the pieces out, putting the pieces back in, or requesting help in completing the puzzle during the entire 5 s interval. An incorrect response was defined as the participant not visually orienting to the puzzles, emitting interfering stereotypical behaviors with the puzzles, or not responding at all during the entire 5 s interval. Total number of correct responses per probe session were converted to a percentage.

Criterion of 90% or higher accurate responding across three consecutive sessions was utilized to consider puzzles functioning as conditioned reinforcers. The emission of zero correct responses during any probe session resulted in the probes being terminated and considering puzzles to not function as a conditioned reinforcer.

Conditioned reinforcement for blocks. To measure conditioned reinforcement for blocks, we collected data on the participant's responses during a 5 min 5 s whole-interval recording session.

Probe sessions were conducted during non-instructional time in the free-play setting. The participants had access to the following play items during the probe sessions: books, puzzles, coloring materials, Play-Doh®, and cause-and-effect toys. A correct response was defined as the participant manipulating the blocks, building a tower, taking the tower apart, trying to keep the structure from falling over, or picking up blocks that fell to the floor during the entire 5 s interval. An incorrect response was defined as the participant not visually orienting to the blocks, emitting interfering stereotypical behaviors with the blocks, or not responding at all during the entire 5 s interval. Total number of correct responses per probe session were converted to a percentage.

Criterion was set at 90% or higher accurate responding across three consecutive sessions. Probes were terminated if the participant emitted zero correct responses during any probe session and blocks were not considered to function as a conditioned reinforcer.

Conditioned reinforcement for coloring. To measure conditioned reinforcement for coloring, we collected data on the participant's responses during a 5 min 5 s whole-interval recording session.

Probe sessions were conducted during non-instructional time at the table. The participants had access other play items during the probe sessions. For these probes we left books, blocks, puzzles, Play-Doh®, and cause-and-effect toys on top of the table. A correct response was defined as the participant looking at the coloring sheet while holding the coloring utensil and drawing, scribbling, or making marks on the page during the entire 5 s interval. An incorrect response was defined as the participant not visually orienting to the coloring sheet, emitting interfering stereotypical behaviors with the materials, or not responding at all during the entire 5 s interval. Total number of correct responses per probe session were converted to a percentage.

Coloring was considered a conditioned reinforcer is the participant emitted 90% or higher accurate responding across three consecutive sessions. If the participant emitted zero correct responses during any probe session, probes were terminated, and coloring was not considered to function as a conditioned reinforcer.

Conditioned reinforcement for Play-Doh®. To measure conditioned reinforcement for Play-Doh®, we collected data on the participant's responses during a 5 min 5 s whole-interval recording session.

Probe sessions were conducted during non-instructional time at the table. The participants also had access to books, blocks, puzzles, coloring materials, and cause-and-effect toys. A correct response was defined as the participant looking directing at it while squishing it between hands and/or on the table, using the toys provided to manipulate, or rolling it into a ball or shape during the entire 5 s interval. An incorrect response was defined as the participant not visually orienting to the Play-Doh®, emitting interfering stereotypical behaviors with the materials, or not responding at all during the entire 5 s interval. Each participant had 60 opportunities per probe session to play with the toys and three probe sessions were conducted in total. Total number of correct responses per probe session were converted to a percentage.

The same criterion of 90% or higher accurate responding across three consecutive sessions was utilized. If the participant emitted zero correct responses during any probe session, probes were terminated, and Play-Doh® was not considered to function as a conditioned reinforcer.

Interobserver Agreement. Interobserver agreement (IOA) was recorded simultaneously by having a second independent observer record data on whether the participant emitted a correct response or not. IOA was reported for 100% of the Observing Response probe sessions that measured conditioned reinforcement for observing three-dimensional stimuli, conditioned reinforcement for two-dimensional stimuli, conditioned reinforcement for observing adult faces, conditioned reinforcement for observing adult voices, and echoics. For the Observing Response probes IOA was 100%. IOA was reported for 100% of the parroting, Generalized Imitation, and listener literacy probe sessions, where IOA was 100%.

IOA was reported for 64% of the independent mand, independent tact, conditioned reinforcement for toys, conditioned reinforcement for books, conditioned reinforcement for puzzles, conditioned reinforcement for blocks, conditioned reinforcement for coloring, and conditioned reinforcement for Play-Doh probe sessions, where mean IOA was 93.67%, ranging from 80% to 100%.

Results

The results of Experiment I will be discussed in terms of the research questions asked in the beginning of the paper.

Is there a relation between demonstrating Imitation as a foundational learning capability and the other preverbal developmental cusps (i.e., conditioned reinforcement for observing three-dimensional stimuli, conditioned reinforcement for observing two-dimensional stimuli, conditioned reinforcement for observing adult faces, conditioned reinforcement for observing adult voices, listener literacy)?

Table 10 shows the correlations between demonstrating Imitation as a foundational learning capability and the preverbal developmental cusps. There was no significant correlation between demonstrating Imitation as a foundational learning capability and having conditioned reinforcement for three-dimensional stimuli, r_s (34) = .165, p < .05. There was no significant correlation between demonstrating Imitation as a foundational learning capability and having conditioned reinforcement for two-dimensional stimuli, r_s (34) = .279, p < .05. There was a significant positive correlation between demonstrating Imitation as a foundational learning capability and having conditioned reinforcement for observing adult faces, r_s (34) = .413, p = .05. There was a significant positive correlation between demonstrating Imitation as a foundational learning capability and having conditioned reinforcement for observing adult voices, r_s (34) = .794, p = .01. There was a significant positive correlation between demonstrating Imitation as a foundational learning capability and having listener literacy as a cusp, r_s (34) = .413, p = .05.

Is there a relation between demonstrating Imitation as a foundational learning capability and the emulative verbal developmental cusps (i.e., parroting, echoics, independent mands, and independent tacts)?

Table 10 shows the correlations between demonstrating Imitation as a foundational learning capability and the emulative verbal developmental cusps. There was a significant positive correlation between demonstrating Imitation as a foundational learning capability and having parroting as an emulative cusp, r_s (34) = .561, p = .01. There was a significant positive correlation between demonstrating Imitation as a foundational learning capability and having echoics as an emulative cusp, r_s (34) = .626, p = .01. There was no significant correlation between demonstrating Imitation as a foundational learning capability and having independent mands as an emulative cusp, r_s (34) = .316, p < .05. There was no significant correlation between demonstrating Imitation as a foundational learning capability and having independent tacts as an emulative cusp, r_s (34) = .316, $p < .05$.

Is there a relation between the reinforcement value of age-appropriate items and demonstrating Imitation as a foundational learning capability?

Table 11 shows the correlations between the reinforcement value of age-appropriate items traditionally used to condition as reinforcers and demonstrating Imitation as a foundational learning capability. There was a significant positive correlation between having conditioned reinforcement for toys and demonstrating Imitation as a foundational learning capability, r_s (34) = .409, $p = .05$. There was no significant correlation between having conditioned reinforcement for books and demonstrating Imitation as a foundational learning capability, r_s (34) = .204, $p < .05$. There was a significant positive correlation between having conditioned reinforcement for puzzles and demonstrating Imitation as a foundational learning capability, r_s (34) = .369, $p = .05$. There was no significant correlation between having conditioned reinforcement for blocks and demonstrating Imitation as a foundational learning capability, r_s (34) = .326, $p < .05$. There was a significant positive correlation between having conditioned reinforcement for coloring and demonstrating Imitation as a foundational learning capability, r_s (34) = .443, $p = .01$. There was a significant positive correlation between having conditioned reinforcement for Play-Doh and demonstrating Imitation as a foundational learning capability, r_s (34) = .426, $p = .01$.

Table 10
Correlations for the Foundational and Emulative Verbal Behavioral Developmental Cusps and Capabilities

	Faces	Voices	Parroting	Imitation	CR+ 2D	CR+ 3D	Listener Literacy	Echoics	Ind Mands	Ind Tacts
Faces	1									
Voices	.794**	1								
Parroting	.278	.257	1							
Imitation	.413*	.453**	.561**	1						
CR+ 2D	.148	.278	.321	.279	1					
CR+ 3D	.377*	.393*	.165	.310	.199	1				
Listener Literacy	.358*	.282	.401*	.413*	.129	.095	1			
Echoics	.169	.226	.757**	.626**	.206	.278	.334*	1		
Ind Mands	.414*	.284	.423*	.316	-.100	.263	.553**	.423*	1	
Ind Tacts	.414*	.284	.423*	.316	-.100	.263	.553**	.423*	1.000**	1

Note. Significance levels * denotes $p < .05$, ** denotes $p < .01$. CR+ 2D= Conditioned reinforcement for observing two-dimensional stimuli; CR+ 3D= Conditioned reinforcement for observing three-dimensional stimuli.

Table 11
Correlations for Imitation and Toys, Books, Puzzles, Blocks, Coloring, and Play-Doh functioning as Conditioned Reinforcers

	Imitation	CR+ Toys	CR+ Books	CR+ Puzzles	CR+ Blocks	CR+ Coloring	CR+ Play-Doh
Imitation	1						
CR+ Toys	.409*	1					
CR+ Books	.204	.605**	1				
CR+ Puzzles	.369*	.806**	.558**	1			
CR+ Blocks	.326	.661**	.558**	.679**	1		
CR+ Coloring	.443**	.674*	.683**	.657**	.657**	1	
CR+ Play-Doh	.426**	.605**	.535**	.558**	.751**	.898**	1

Note. Significance levels * denotes $p < .05$, ** denotes $p < .01$. CR+ = Conditioned Reinforcement.

Discussion

The results of the statistical analyses demonstrate strong relations between demonstrating the foundational learning capability of Imitation and some of the preverbal developmental cusps and some emulative verbal developmental cusps. The results of the analyses also demonstrated a strong positive relation between having various items function as conditioned reinforcers when Imitation is in a participant's repertoire.

Beginning with the preverbal developmental cusps, only two were strongly associated with Imitation: conditioned reinforcement for adult faces and conditioned reinforcement for adult voices. We infer that without being able to observe an adult's face or orient in the direction of an adult's voice, then a child will have great difficulty with imitating any task due to the lack of awareness of the adult in front of them. The child's attention will not be selected out by those visual and auditory stimuli when presenting an imitation task from the model demonstration to the vocal cue of "Do This" (Greer & Ross, 2008; Greer & Speckman, 2009). As a result, the initial correspondences that are established between the voice and the face are not joined. In her meta-analysis, Edwards (2014) found that deficits in imitation for individuals diagnosed with ASD were observed across all oral-facial imitation, gross motor imitation, and object imitation tasks. The results of this analysis support her findings that if adult faces and adult voices do not select out the attention of any individual with ASD, then how are they to learn though modeling?

We posited that Imitation could function as either a prerequisite or a corequisite to the other emulative verbal behavior cusps. The results support that Imitation is strongly associated with the emulative cusps of: parroting/vocalizations and echoics. The results of the analysis also found a strong association between demonstrating Imitation as a foundational verbal capability and listener literacy. Our analyses support and extend the findings of Clement (2019) who found a relation between emulative responses and listener literacy. These findings suggest that by acquiring Imitation as a verbal developmental cusp and capability there is a shift in reinforcement from point-to-point correspondence between the model and the imitator, to the function of the behavior itself, thus, resulting in a new observing-production correspondence, as outlined by Greer & Speckman (2009).

Children diagnosed with ASD also show deficits in their play skills. Our analysis finds that demonstrating Imitation as a foundational learning capability is related to having toys, puzzles, coloring materials, and Play-Doh function as conditioned as reinforcers. It is through modeling and imitation that children are taught to play with various items (Greer, 2002). If a child does not play with puzzles appropriately and prefers to emit stereotypy, then they are first taught the topography (e.g., taking the puzzle pieces out, then putting them back in) before the stimuli are conditioned as reinforcers (Greer 2002; Nuzzolo et al., 2002). That is why Imitation is so important, because there is a shift from hand-over-hand prompting to observing and producing on one's own. Is there emulation when playing with toys, completing a puzzle, using coloring materials, or utilizing Play-Doh? The answer is yes, because there are many ways to play with toys, complete a puzzle, color, or manipulate Play-Doh where the end-goal is functional play. This suggests that Imitation may function as corequisites, where the presence of one may indicate the presence of the other.

Limitations and Suggestions for Future Research. One of the limitations of this analysis was not including participants who were typically developing or had no diagnosis of ASD as a control group. Studies conducted by Hobson and Lee (1999), Hobson and Hobson (2008), Philp (2016), and Mussey and Kilinger (2020) had utilized both typically developing children and children diagnosed with ASD as their participant pool. This allowed the researchers to compare one group to another and infer any group differences. We did not include typically developing children in our analysis, which could have provided the field with interesting findings on the potential relations between Imitation and the higher-level verbal behavioral cusps, and higher-level learning capabilities by extension.

Another limitation was the lack of an emulative responding condition or task, to determine if the participant had the verbal developmental cusp of emulation in their repertoires. Philp (2016) and Clement (2019) provided their participants with a task and collected data on their responses: whether the participants imitated versus emulated. Future research should aim to run a statistical analysis where imitative responding, the presence/absence of Imitation, and emulation as a verbal developmental cusp are all examined to determine if there is a statistically significant result to support the hierarchy in the development of those duplicative responses. The questions future research should aim answer are: (1) which verbal developmental cusps function as prerequisites for the other cusps and (2) if children acquire the reinforcer for one verbal behavior cusp, does it evoke a change or result in the acquisition of other cusps?

Rationale for Experiment II

The results of Experiment I support the notion that the pre-foundational learning capability of Imitation is strongly associated with the emulative verbal developmental cusps of parroting, echoics, and listener literacy, therefore, providing support to the overarching class of duplicative responding.

Originally, the research question for Experiment II was going to be: after undergoing the mirror training protocol what are the observable changes in the participant's imitative responding, echoic behavior, and the observing responses? The goal was to induce Imitation in preschoolers who did not demonstrate the verbal learning capability and assess to what extent are there observable gains in the development of the higher order operant of duplicative responding. Unfortunately, the COVID-19 pandemic caused the abrupt transition to solely virtual instruction and new questions rose as to how educators are to teach educationally vulnerable populations through a computer screen. The research question now became whether the mirror training protocol can even be presented on a virtual platform, by people who are trained in presenting the protocol in person?

Therefore, for Experiment II we pose the following questions: (1) can educationally classified preschoolers with a disability emit various Imitative responses during the mirror training protocol, when the researcher is presenting virtual instruction through a smart device? (Du & Greer, 2014; Moreno, 2012) and (2) are there changes in the echoic behavior and observing responses of the participants as a result of undergoing the synchronous mirror training protocol.

Chapter III: Establishment of Imitative Responses Through a Synchronous Mirror Protocol

In the first experiment, we identified the relation between the foundational learning capability of Imitation and the emulative verbal developmental cusps of parroting, echoics, and listener literacy. This finding suggests that if a participant demonstrates the presence of the Imitation developmental cusp and learning capability, then they are more likely to acquire the higher order operant of duplicative responding (Catania, 1995; Du & Greer, 2014; Greer, 2020; Greer & Ross, 2008; Greer, et al., 2017; Greer & Speckman, 2009; Michael, 1982). Research conducted by the VBDT camp found that the use of a rapid motor imitation antecedent intervention showed a functional relation in increasing the emission of echoics in children who demonstrated Imitation in their repertoires (Ross & Greer, 2003; Tsiouri & Greer, 2003, 2007). Additionally, an imitative repertoire is necessary in bringing speaker behavior under the control of the observation-production higher-order copying class (Catania, 1995; Greer & Speckman, 2009).

Interventions used to Establish Imitation

Thus far it has been established from our findings in the first experiment and in the literature that an imitative repertoire functions as either a prerequisite or co-requisite skill that leads to future speaker behavior (Clement, 2019; Greer & Ross, 2008; Greer & Speckman, 2009; Miniscalco, et a., 2014; Partington & Sundberg, 1998; Poon, et al., 2012; Poulson & Kymissis, 1988; Stone, et al., 1997; Stone and Yoder, 2001). The next question is *how* do we establish an imitative repertoire, or the verbal behavioral learning capability of Imitation?

In-vivo Modeling.

In -vivo modeling is defined as an individual observing a series of target behaviors being emitted directly in front of them (e.g., in a live setting), and then imitating the behavior(s) modeled (Lovass, et al., 1967; Lovaas, et al., 1973). Lovass, et al. (1967) and Lovass, et al. (1973) all utilized discrete trial training when teaching their participants imitative responses and were successful. With the advent of more sophisticated technology, the idea of utilizing videos to teach imitative responses was investigated.

Video Modeling.

Video modeling is defined as an individual observing a recording of another individual emitting a series of target behaviors, where the imitator (e.g., the person who observed the recording), then imitates the behavior(s) modeled (Cardon & Wilcox, 2010; Charlop-Christy, et al., 2000). The behaviors that the model is emitting can be emitted in a natural speed as they occur in the environment or the behaviors can be emitted at a slow/exaggerated pace (Cardon & Wilcox, 2011; Charlop-Christy, et al., 2000). Initially, it was Dowrick (1999) who investigated the effects of video modeling, finding that it was a successful medium in teaching a variety of skills across various disabilities.

Research finds that video modeling is both effective and efficient in establishing *conversational speech* (Baker, 2014; Charlop & Milstein, 1989; Charlop-Christy, et al., 2000), *socio-communicative behaviors* (Gena, Couloura, & Kymissis, 2005; Wilson, 2013), *independent and cooperative play skills* (Boudreau & D'Entremont, 2010; Charlop-Christy, et al., 2000; Jones, Lerman, & Lechago, 2014; Sancho, Sidner, Reeve, & Sidner, 2010), *self-help skills* (Charlop-Christy, et al., 2000; Taber-Doughty, Patton, & Brennan, 2008), and *object imitation* (Cardon & Wilcox, 2011). Interestingly, Charlop-Christy, et al. (2000) found that not only was video modeling more effective when compared to in-vivo instruction in establishing a variety of skills, but also it was effective in generalizing the taught skills across various individuals, settings, and stimuli. Vassare (2017) compared the acquisition of the verbal learning capability of observational learning through a peer-monitoring intervention across both in-vivo and video playback conditions. Across both experiments the participants who received the intervention in-vivo successfully demonstrated observational learning whereas, the participants who received the playback condition did not demonstrate observational learning (Vassare, 2017).

Mirror Training through Learn Units.

Du and Greer (2014) established what may be the first case of establishing the pre-foundational learning capability Imitation through the mirror training protocol. The mirror training protocol is comprised of two levels: (1) the use of a mirror in order for an individual to observe themselves make the same motor movements as the model and (2) the instructional presentation of learn units (Albers & Greer, 1991; Greer & Ross, 2008).

Du and Greer (2014) used learn units when teaching six preschoolers all diagnosed with ASD to imitate actions in front of a mirror, because of the evidence behind the facilitation of instruction using the learn unit (Albers & Greer, 1991; Greer, 2002). By placing the students in front of the mirror—with the individual who was the model sitting behind the student—the student then observed and received "immediate complete visual feedback relative to [their behavior]" (Du & Greer, 2014, p. 171). In particular, the student received both kinesthetic "what the response feels like" and visual "what the response looks like" feedback within the intervention session (Du and Greer, 2014, p. 172). The most impressive result was that the preschoolers acquired Imitation as both a verbal developmental cusp and a foundational learning capability, where they were able to imitate various untaught unilateral and bilateral imitation responses. Not only were these children with ASD able to imitate various motor movements, but they also acquired the observation-production (e.g., see-do correspondence) relation as a newly conditioned reinforcer.

Based on the findings mentioned above, we argue that there is a gap in the literature. In particular, there is little known about the use of live virtual instruction to teach children with ASD to emit various generalized imitative responses. Although Charlop-Christy, et al. (2000) argue that video modeling can establish various skills and can be more effective, the results of Vassare's (2017) experiments question the viability of establishing verbal learning capabilities through video modeling, and by the extension the potential use of live virtual instruction. The question becomes whether live virtual instruction is a viable method of establishing verbal learning capabilities.

The current COVID-19 pandemic caused schools, centers, and laboratories to shut down and transition to virtual learning. The transition was especially difficult for teachers and clinicians of students who are preverbal with limited observing responses and limited to no Imitation repertoire. Therefore, the study aims to determine whether the utilization of the camera on one's smart device to provide synchronous instruction during the mirror training protocol, can teach educationally classified preschoolers with a disability to emit various imitation responses during virtual instruction? The instructional antecedents will be delivered virtually by the researcher, but the adult that is present with the participant will provide the physical correction. The researcher will provide the corrective model simultaneously, but it is the physically present adult who will provide the in-person corrections. The study also aims to determine if Imitation is established as verbal developmental cusp and foundational learning capability via synchronous mirror training, will there be increases in the student's echoic behavior and observing responses?

Purpose

The goals of this study are two-fold. First, the researchers will test whether educationally classified preschoolers with a disability can emit various Imitation responses when the researcher is presenting live instruction through a smart device during the mirror training protocol. Second, the researchers will test whether the echoic behavior and observing responses of the participants change as a result of undergoing the synchronous mirror training protocol.

Method

Participants. The participants of this experiment were four preschool children (one female, three males) all of who functioned on the pre-listener/pre-speaker level of verbal development. Three of the participants had an educational classification of a preschooler with a disability and a single participant had a medical diagnosis of ASD. All the participants are described in further detail in Table 12.

These participants were chosen after conducting assessments for the 26 targeted Generalized Imitative responses (Du & Greer, 2014), simple and complex finger imitations (Moreno, 2012), object imitation, and transcription—which were derived from the Early Learner Curriculum and Achievement Record (ELCAR) (Greer, et al., 2019). Assessments were conducted across both in-person and virtual settings.

Table 12

Description of Participants at the Onset of Experiment 2

Participant	Age	Sex	Vineland III Motor Skill Score	Peabody Developmental Gross Motor Score	Diagnosis/ Classification	Level of VB	Presence of Foundational Cusps						
							IC	CR+ F	CR+ V	CR+ 3D	CR+ 2D	VM 2D/3D	LL
A	3.3	Female	76 (5th Percentile)	70 (2nd Percentile)	Preschooler with a Disability	Pre-Listener/ Pre-Speaker	+	+	+	+	+	-	-
B	4.1	Male	93 (9th Percentile)	68 (1st Percentile)	Preschooler with a Disability	Pre-Listener/ Pre-Speaker	+	+	+	+	+	-	-
C	3.0	Male	Low (Qualitative Description)	N/A	Preschooler with a Disability	Pre-Listener/ Pre-Speaker	+	+	+	+	+	-	-
D	3.1	Male	83 (8th Percentile)	N/A	ASD	Pre-Listener/ Pre-Speaker	+	+	+	+	+	-	-

Note. VB=Verbal behavior; IC=Teacher presence results in instructional control; CR+ F= Conditioned reinforcement for observing adult faces; CR+ V= Conditioned reinforcement for observing adult voices; CR+ 3D= Conditioned reinforcement for observing three-dimensional stimuli; CR+ 2D= Conditioned reinforcement for observing two-dimensional stimuli; VM 2D/3D= Generalized visual matching across two-dimensional and three-dimensional stimuli; LL= Listener Literacy.

Measures and Materials. There were five dependent variables in this study. Data were collected across both in-person and virtual conditions.

Imitation. The Imitation probes were composed of 26 target actions, that have been utilized as the standard from Du and Greer (2014) also known as the Generalized Imitation probe list. See Table 13 for complete list of Generalized Imitative actions presented during pre- and post-experimental probes. We utilized Du and Greer's (2014) four variations of the original list of 26 Generalized Imitative actions to control for sequencing effects and to control for responses to become part of a behavior chain. See Table 14 for the four variations of the original probe list. See Appendix A for pre- and post-intervention data collection form.

A correct response was defined as the researcher providing the vocal antecedent of "Do this," while simultaneously modeling a motor response (e.g., right hand to right shoulder), and the participant imitating the response by tapping their right shoulder with their right hand within 5 s. An incorrect response was defined as the researcher providing the vocal antecedent of "Do this," while simultaneously modeling a motor response (e.g., right hand to right shoulder), and the participant either emitting another motor response or not responding at all within 5 s.

The participants had only one opportunity to respond to each imitative response, where mastery criterion was set at 80% or higher accurate responding in one session.

Table 13

List of Generalized Imitative Actions for Pre- and Post-Experimental Probes for Experiment 2

Number	Target Response	Response Definition
1	Right hand cross to shoulder	Right hand tapping left shoulder
2	Right hand to same shoulder	Right hand tapping right shoulder
3	Left hand cross shoulder	Left hand tapping right shoulder
4	Left hand same shoulder	Left hand tapping left shoulder
5	Both hands same shoulders	Right hand tapping right shoulder & left hand tapping left shoulder
6	Both hands cross shoulders	Right hand tapping left shoulder & left hand tapping right shoulder
7	Right hand cross to elbow	Right hand tapping left elbow
8	Left hand cross to elbow	Left hand tapping right elbow
9	Right hand cross to wrist	Right hand tapping left wrist
10	Left hand cross to wrist	Left hand tapping right wrist
11	Palms up bowl	Half folding palms together in front
12	Arms crossed in front	Two arms cross in front of body
13	Right hand cross to knee	Right hand tapping left knee
14	Right hand same knee	Right hand tapping right knee
15	Left hand cross to knee	Left hand tapping right knee
16	Left hand same knee	Left hand tapping left knee
17	Right hand cross to ankle	Right hand tapping left ankle
18	Right hand same ankle	Right hand tapping right ankle
19	Left hand cross to ankle	Left hand tapping right ankle
20	Left hand same ankle	Left hand tapping left ankle
21	Right hand cross to ear	Right hand tapping left ear
22	Right hand same ear	Right hand tapping right ear
23	Left hand cross to ear	Left hand tapping right ear
24	Left hand same ear	Left hand tapping left ear
25	Both hands same ear	Right hand tapping right ear & left hand tapping left ear
26	Both hands cross ears	Right hand tapping left ear & left hand tapping right ear

Table 14
Four Variations of Generalized Imitative Actions used in Experiment 2

	Probe List 1	Probe List 2	Probe List 3	Probe List 4
1	Right hand cross to shoulder	Right hand cross shoulder	Left hand same shoulder	Right hand cross shoulder
2	Right hand to same shoulder	Left hand same shoulder	Left hand cross to wrist	Left hand cross to shoulder
3	Left hand cross shoulder	Both hands same shoulder	Right hand cross knee	Both hands cross shoulders
4	Left hand same shoulder	Right hand cross elbow	Right hand cross ankle	Right hand cross elbow
5	Both hands same shoulders	Left hand cross wrist	Right hand cross to ear	Righthand cross to wrist
6	Both hands cross shoulders	Palms up bowl	Left hand same ear	Palms up bowl
7	Right hand cross to elbow	Right hand cross left knee	Right hand same shoulder	Right hand cross to knee
8	Left hand cross to elbow	Left hand same knee	Right hand cross to wrist	Left hand cross to knee
9	Right hand cross to wrist	Right hand cross to ankle	Right hand same ankle	Right hand cross to ankle
10	Left hand cross to wrist	Left hand same ankle	Both hands same ears	Left hand cross to ankle
11	Palms up bowl	Right hand cross to ear	Right hand cross to shoulder	Right hand cross to ear
12	Arms crossed in front	Left hand same ear	Both hands same shoulders	Left hand cross to ear
13	Right hand cross to knee	Both hands cross ears	Right hand cross to elbow	Both hands cross ears
14	Right hand same knee	Right hand same shoulder	Palms up bowl	Right hand same shoulder
15	Left hand cross to knee	Left hand cross to shoulder	Left hand same knee	Left hand same shoulder
16	Left hand same knee	Both hands cross shoulders	Left hand same ankle	Both hands same shoulders
17	Right hand cross to ankle	Left hand cross to elbow	Both hands cross ears	Left hand cross to elbow
18	Right hand same ankle	Right hand cross to wrist	Left hand cross to shoulder	Left hand cross to wrist
19	Left hand cross to ankle	Arms crossed in front	Both hands cross shoulders	Arms crossed in front
20	Left hand same ankle	Right hand same knee	Left hand cross to elbow	Right hand same knee
21	Right hand cross to ear	Left hand cross to knee	Arms crossed in front	Left hand same knee
22	Right hand same ear	Right hand same ankle	Right hand same knee	Right hand same ankle
23	Left hand cross to ear	Left hand cross to ankle	Left hand cross to knee	Left hand same ankle
24	Left hand same ear	Right hand same ear	Left hand cross to ankle	Right hand same ear
25	Both hands same ear	Left hand cross to ear	Right hand same ear	Left hand same ear
26	Both hands cross ears	Both hands same ears	Left hand cross to ear	Both hands same ears

Data Collection. In order to gain more information for the participant's imitative responses, the researchers recorded data for the Generalized Imitative responses using the system utilized by Du and Greer (2014). The four categories counted were: mirrored responses as Arabic number 1, non-mirrored responses as Arabic number 2, two-handed responses as Arabic number 3, and not related responses as Arabic number 4 (as seen in Table 15).

A correct mirrored response was defined as the researcher modeling "Right hand cross to knee," where the researcher's right hand tapped her left knee, and the participant taking their left hand and tapping his/her right knee. This correct mirrored response was counted as 1.

A non-mirrored response was defined as the researcher modeling "Right hand cross to knee," where the researcher's right hand tapped her left knee, and the participant taking their right hand and tapping his/her left knee. This non-mirrored response was counted as 2.

There are six imitative responses that required the participant to imitate the researcher by using both of their hands. These responses are numbers five, six, 11, 12, 25, and 26 on the original Probe List. A correct two-handed response was defined as the researcher modeling "Both hands same ears," where the researchers right hand tapped their right ear and their left hand tapped their left ear, and the participant did the same. This correct mirrored two-handed response was counted as 3.

If the participant emitted an incorrect response that had no point-to-point correspondence between the researchers modeled behavior and their own or no response at all, then the researchers counted that response as 4.

Table 15

Response Coding Categories for Experiment 2

Coding Number	Participant's Response
1	Mirrored responses
2	Non-Mirrored responses
3	Bilateral responses
4	Non-related responses

Object Imitations. The object imitations were comprised of 10 object imitative responses as found in the ELCAR (Greer, et al., 2019). See Table 16 for a complete list of object imitative responses. See Appendix B for pre- and post-intervention data collection form.

A correct response was defined as the researcher providing the vocal antecedent of "Do this," while simultaneously modeling an object-use response using the target stimulus (e.g., rolling the toy car back and forth two inches), and the participant imitating the response by rolling the toy car back and forth once within 5 s. An incorrect response was defined as the researcher providing the vocal antecedent of "Do this," while simultaneously modeling an object-use response (e.g., rolling the toy car back and forth two inches), and the participant either extending pushing the car only in one direction, emitting another response, or not responding at all within 5 s.

The participants had only one opportunity to respond to each fine motor response, where mastery criterion was set at 90% or higher accurate responding across two consecutive sessions or 100% accurate responding in one session.

Table 16
List of Object Imitations for Pre- and Post-Experimental Probes for Experiment 2

Number	Target Response
1	Fly Pen
2	Roll Car
3	Feeding Baby
4	Roll Bottle
5	Stir Spoon
6	Stack Blocks
7	Open Book
8	Rock Baby
9	Write a Pen
10	Pop up Toy

Simple and Complex Fine Motor Imitations. The simple and complex finger imitations focused on the participant's ability to imitate fine motor movements across pre- and post-intervention probes. The researchers utilized Moreno's (2012) list of 10 fine motor imitations. See Table 17 for complete list of simple and complex finger imitations. See Appendix B for pre- and post-intervention data collection form.

A correct response was defined as the researcher providing the vocal antecedent of "Do this," while simultaneously modeling a fine motor response (e.g., index finger extension), and the participant imitating the response by extending their index finger out while the other four fingers were enclosed within 5 s. An incorrect response was defined as the researcher providing the vocal antecedent of "Do this," while simultaneously modeling a fine motor response (e.g., index finger extension), and the participant either extending both index and middle fingers out while the other three fingers were enclosed, emitting another response, or not responding at all within 5 s.

The participants had only one opportunity to respond to each fine motor response, where mastery criterion was set at 90% or higher accurate responding across two consecutive sessions or 100% accurate responding in one session.

Table 17

List of Simple and Complex Fine Motor Imitations for Pre- and Post-Experimental Probes for Experiment 2

Number	Simple / Complex	Finger Movement	Response Definition
1	Simple	Palm down/fingers open	Open palm; all fingers extended
2	Simple	Four finger extension	Four fingers up; thumb enclosed
3	Simple	Thumb extension	Thumb extended; four fingers enclosed
4	Simple	Index finger extension	Index finger extended; four fingers enclosed
5	Simple	Pinkie extension	Pinkie extended; four fingers enclosed
6	Complex	Two-finger extension	Index and middle fingers extended; three fingers enclosed
7	Complex	Okay sign	Thumb and index finger touch; three fingers extended
8	Complex	Pinkie and thumb extension	Thumb and pinkie extended; three fingers enclosed
9	Complex	Three-finger extension	Index, middle, and ring fingers extended; pinkie and thumb enclosed
10	Complex	Index and thumb extension	Index and thumb extended; three fingers enclosed (L-shape)

Copying Marks. Copying marks probes targeted untaught handwritten responses across pre- and post-intervention probes. These untaught responses were derived from the ELCAR (Greer, et al., 2019) and from the Sensible Pencil Curriculum (Becht, 1985). See Table 18 for a complete list of copying marks responses.

A correct response was defined as the researcher providing the vocal antecedent of “Do this,” while simultaneously modeling a mark (e.g., drawing a line going down from the first dot to second dot) on the participant’s worksheet, and the participant imitating that response by drawing a line from the first dot to the second dot and staying within ¼ of an inch of the line within 3 s. An incorrect response was defined as the researcher providing the vocal antecedent of "Do this," while simultaneously modeling a mark (e.g., drawing a line going down from the first dot to second dot), and the participant either not staying within ¼ of an inch of the line, emitting another response, or not responding at all within 5 s.

The participants had only one opportunity to respond to each copying mark response, where mastery criterion was set at 90% or higher accurate responding across two consecutive sessions or 100% accurate responding in one session.

Table 18
List of Copying Marks Responses for Pre- and Post-Experimental Probes for Experiment 2

Number	Target Response
1	Line down
2	Line across
3	Lines down and across
4	Circle
5	Square
6	Capital letter "A"
7	Capital letter "B"
8	Capital letter "C"
9	Capital letter "D"
10	Capital letter "E"

Observing Responses. Observing response probes were conducted both in-person and virtually, to determine the level of stimulus control the participants had in regard to a variety of stimuli. See Table 2 for a complete list of observing response probes.

Specifically, when conducting the observing response probes the researchers aim to determine the degree of stimulus control strength the varying stimuli evoke across each participant. For example, to determine if a participant demonstrates conditioned reinforcement for observing adult faces, the participant should orient towards an adult's face when they move within two feet of them, if the adult is within two feet at eye level, if the adult is making facial expressions sans sound, and if the adult leaves/enters the room. If the participant orients and looks in the direction of the adult 75% of the time, then the participant is defined as demonstrating the verbal behavioral developmental cusp of adult faces functioning as a conditioned reinforcer. If the participant does not orient for 75% of the time, then this serves as baseline data and functions as the rationale for inducing the verbal behavioral developmental cusp. One change was made from the original observing response probes. For Experiment II, the researchers are providing four opportunities to emit an echoic response within one probe session, versus the original two opportunities.

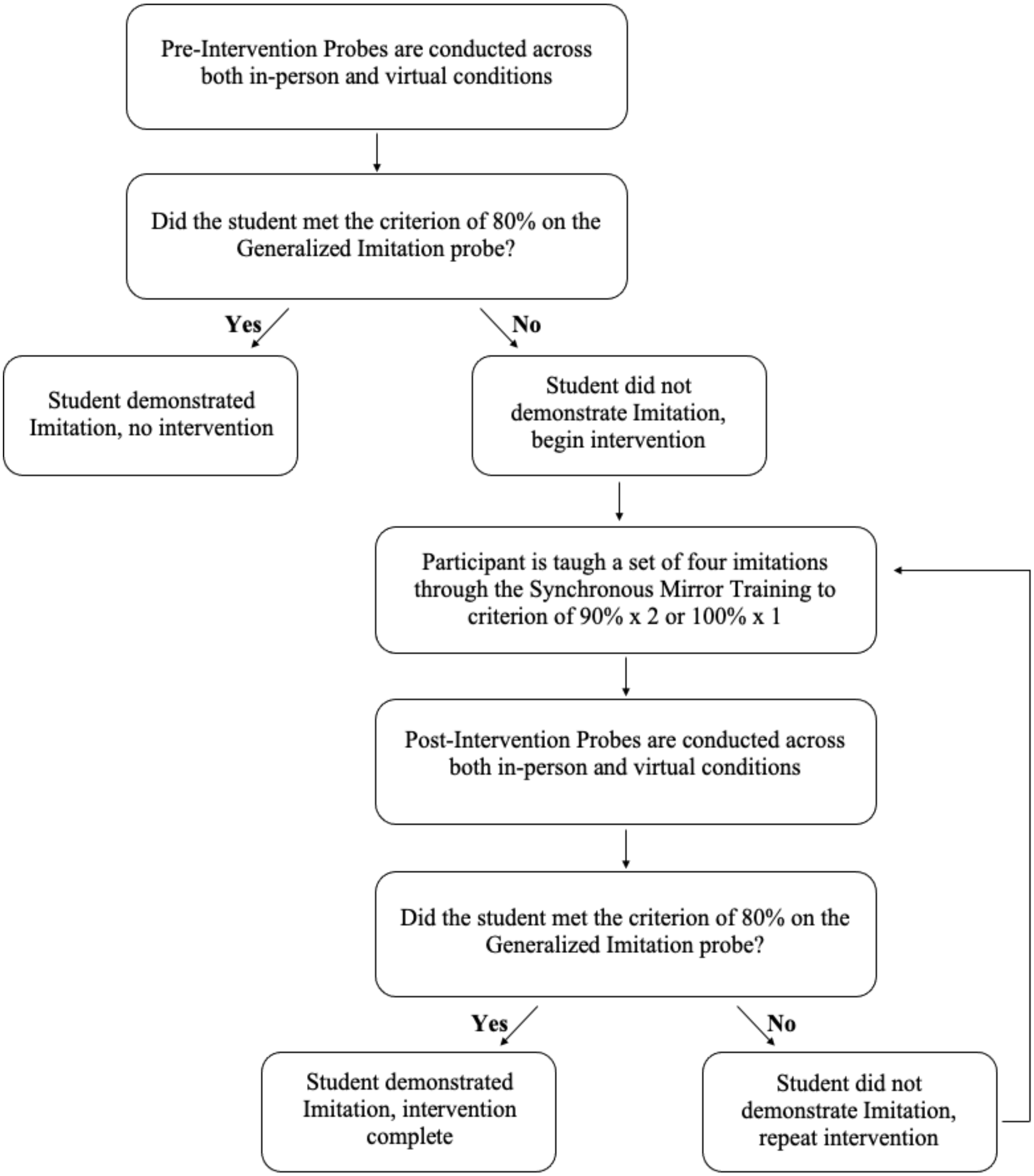
Prompt Frequency. The researchers took frequency data, either as tally marks or the letter "P," to denote the number of vocal and visual re-directives provided to the participants in order to for them to attend to the researcher across all experimental conditions and across both in-person and virtual settings.

Design. We conducted a combined pre- and post-intervention multiple probe design across participants to test the effects of the virtual mirror intervention on the acquisition of Generalized Imitation responses across various imitative topographies.

Procedure.

Pre-intervention probes. Pre-intervention probes were conducted across two settings: in-person and virtually over Zoom. Correct responses were not vocally reinforced and incorrect responses were not corrected. See Tables 2, 10, 13, 14, and 15 for the complete lists of generalized imitative responses used for the pre-experimental probes. See Figure 1 for a flowchart of the experimental sequence.

Figure 1
Experimental Sequence



Face-to-Face In-person. For the in-person pre-experimental probes, the researcher sat the participant directly across from them. The researcher and participant were facing each other while maintaining a distance of three feet. When the participant was attending to the researcher, the researcher then provided the vocal antecedent "Do this," followed by the target imitation. Once the researcher modeled the target imitation, the participant had 5 s to imitate. If the participant imitated correctly, they received a plus (+) on their pre-probe data sheet. If the participant did not imitate correctly or did not respond at all, then a minus (-) was marked on their pre-probe data sheet.

Face-to-Face Virtual. For the virtual pre-experimental probes, the researcher first set up a Zoom link that was to be accessed once the participant was in front of their classroom iPad® with their designated teacher. The researcher and the participant were not in same room during the virtual pre-experimental probes. Once the participant's teacher accessed the Zoom link and the classroom teacher provided vocal confirmation that the participant was attending to the researcher, the researcher provided the vocal antecedent "Do this," followed by the target imitation. Once the researcher modeled the target motor response, the participant had 5 s to imitate. If the participant imitated correctly, they received a plus (+) on their pre-probe data sheet. If the participant did not imitate correctly or did not respond at all, then a minus (-) was marked on their pre-probe data sheet.

Synchronous Mirror Intervention. Before the intervention session began, the researcher first sent each participant's designated teacher a Zoom link that was to be accessed once the participant was sitting in front of the full-length mirror (55 cm x 150 cm). The designated teacher brought the participant to a separate room where the mirror was attached to the wall. The desk was placed parallel to the mirror and behind the participant. The smart device was located on top of the desk. Once the participant was sitting down, the designated teacher clicked on the Zoom link. The participant sat in front of the mirror with the desk behind their left side, in order to see the reflection of the smart device in the mirror. The designated teacher sat off to the participant's right side.

Once the participant was sitting in their chair and looking at the researcher in the mirror, the designated teacher provided vocal confirmation that the participant was attending to the researcher, the researcher then presented the vocal antecedent "Do this," followed by the target imitation. Once the researcher modeled the target motor response, the participant had 5 s to imitate. If the participant imitated correctly, they received a plus (+) on their intervention data sheet and vocal praise was provided by both the researcher and the designated teacher. If the participant did not imitate correctly or did not respond at all, then a minus (-) was marked on their intervention data sheet and the correction procedure began. The first correction required the designated teacher to model the target imitative response in the mirror via smart device and if the participant did not participate in the correction procedure the designated teacher then prompted the correct response. The researcher provided the correction through the mirror simultaneously with the designated teacher. Then the researcher provided the participant with a second independent opportunity to respond. If the participant imitated the researcher correctly, then the researcher provided vocal confirmation "That's doing this" or "That's doing the same" and ended the learn unit. If the participant did not correctly imitate the researcher or did not respond at all, then the designated teacher provided the second in-person correction, and would prompt the correct response while the participant was observing themselves and the researcher perform the correction in the mirror. The researcher then provided the final independent opportunity to respond by presenting the target imitative response one final time. If the participant imitated the researcher correctly, then the researcher provided vocal confirmation “That’s doing this” and ended the learn unit. If the participant did not correctly imitate or respond, then the designated teacher provided the third and final in-person correction of modeling the correct response in the mirror while the participant was observing the designated teacher and the researcher.

The researcher taught each participant a set of four imitative responses to criterion set at 90% accuracy across two consecutive sessions or 100% accuracy in one session. Once a participant reached criterion, post-intervention probes for Generalized Imitation, object imitation, simple fine motor imitation, complex fine motor imitation, and observing responses across both face-to-face in-person and face-to-face virtual conditions were conducted.

Post-intervention probes. Once a participant met criterion on the virtual mirror intervention post-intervention probes were conducted in the same manner as the pre-intervention probes.

Interobserver agreement and Treatment Fidelity. Interobserver agreement (IOA) was recorded simultaneously by having a second independent observer record data on whether the participant emitted a correct response or not, across both in-person and virtual experimental conditions. IOA was reported for 100% of the pre-intervention, intervention, and post-intervention sessions, where IOA was 100%.

Treatment Fidelity was obtained using the Teacher Performance Rate and Accuracy (TPRA) form (Ross, Singer-Dudek, & Greer, 2005). The TPRA allowed for the second independent observer to determine whether every single antecedent was correctly present, record the behavior of the participant (either as a correct or incorrect response), and whether each response was correctly consequated (either reinforcement was provided for a correct response or a correction was provided for an incorrect response) during the intervention sessions (Ross, Singer-Dudek, & Greer, 2005). The second observer counted whether all 20 antecedents, all 20 responses, and all 20 consequences were presented in the manner in which the researcher said they would—as per the information in the Procedure and Data Collection section. Thus, a TPRA consisted of 60 total components and fidelity was measured for 63.46% of intervention experimental sessions, where fidelity was 100%. See Appendix C for TPRA form.

Results

Imitation

Figure 2 shows the number of correct responses to the Generalized Imitation probe list across both in-person and virtual conditions, as well as the participants number of correct responses to the synchronous mirror training protocol. During baseline Participant A emitted a mean of 11.67 correct responses out of 26 to the in-person Generalized Imitation probe, with a range of six to 15. Participant A emitted a mean of 4.33 correct responses out of 26 to the virtual Generalized Imitation probe, with a range of 2 to 6. During the intervention, Participant A emitted a mean of 15 correct responses out of 20 to the synchronous mirror training protocol across three sessions. For her post-intervention probes, Participant A emitted 23 correct responses out of 26 to the in-person Generalized Imitation probe and 25 correct responses out of 26 to the virtual Generalized Imitation probe.

For Participant B during baseline he emitted a mean of 14.67 correct responses out of 26 to the in-person Generalized Imitation probe, with a range of 14 to 15. Participant B emitted a mean of 13.33 correct responses out of 26 to the virtual Generalized Imitation probe, with a range of 12 to 14. During the intervention, Participant B emitted a mean of 17 correct responses out of 20 across three sessions. For his first set of post-intervention probes, Participant B emitted

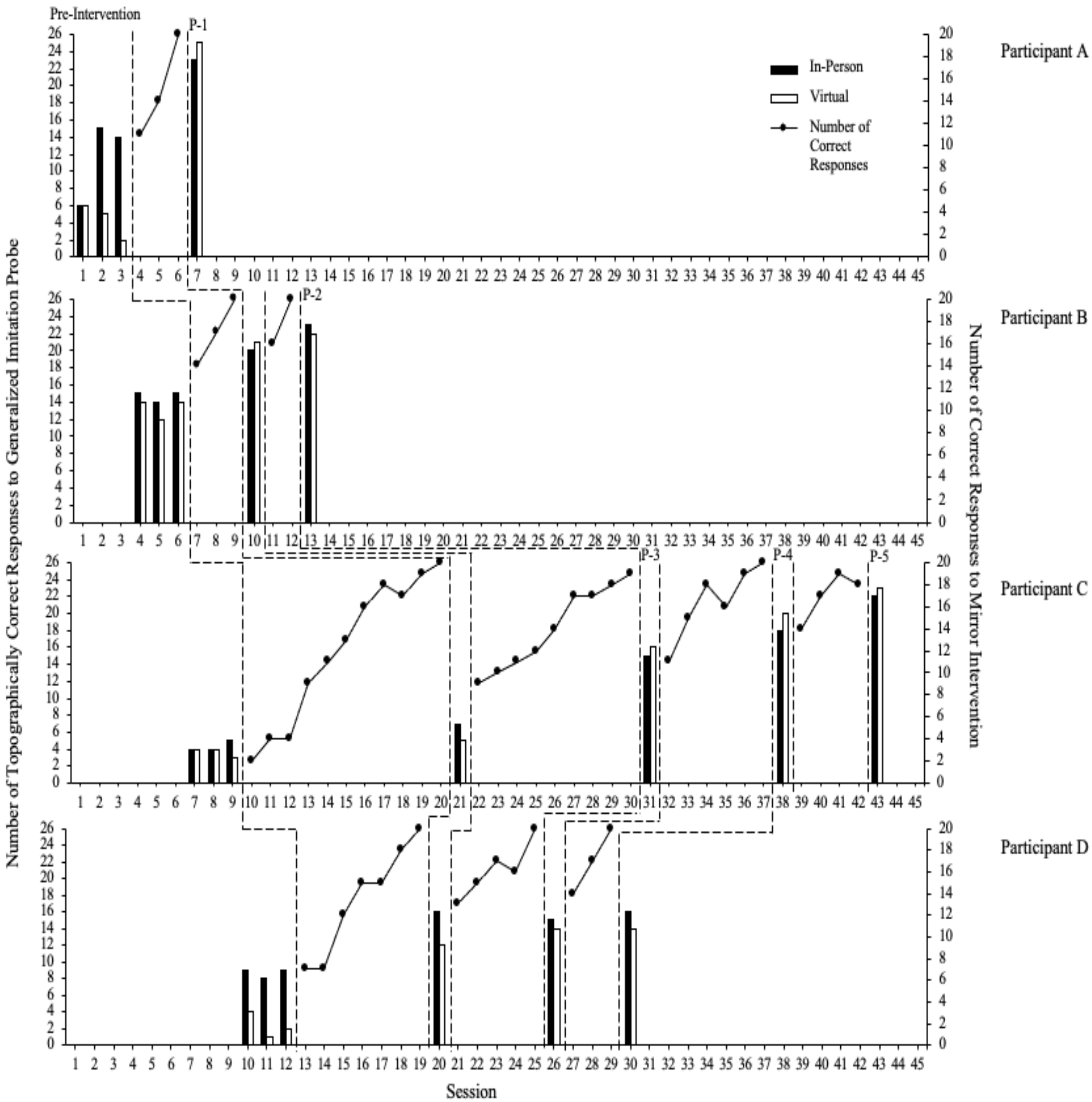
20 correct responses out of 26 to the in-person Generalized Imitation probe and 21 correct responses out of 26 to the virtual Generalized Imitation probe. When Participant B returned to intervention, he emitted a mean of 18 correct responses out of 20 to the synchronous mirror training protocol across 2 sessions. For his second set of post-intervention probes, Participant B emitted 23 correct responses out of 26 to the in-person Generalized Imitation probe and 22 correct responses out of 26 to the virtual Generalized Imitation probe.

During baseline Participant C emitted a mean of 4.33 correct responses out of 26 to the in-person Generalized Imitation probe, with a range of 4 to 5. Participant C emitted a mean of 3.67 correct responses out of 26 to the virtual Generalized Imitation probe, with a range of 3 to 4. During the intervention, Participant C emitted a mean of 12.09 correct responses out of 20 across 11 sessions. For his first set of post-intervention probes, Participant C emitted 7 correct responses out of 26 to the in-person Generalized Imitation probe and 5 correct responses out of 26 on the virtual Generalized Imitation probe. When Participant C returned to intervention, he emitted a mean of 14.11 correct responses out of 20 to the synchronous mirror training protocol across 9 sessions. For his second set of post-intervention probes, Participant C emitted 15 correct responses out of 26 to the in-person Generalized Imitation probe and 16 correct responses out of 26 to the virtual Generalized Imitation probe. Participant C returned to intervention for a third time and emitted a mean of 16.5 correct responses out of 20 to the synchronous mirror training protocol across 6 sessions. For his third set of post-intervention probes, Participant C emitted 18 correct responses out of 26 to the in-person Generalized Imitation probe and 20 correct responses out of 26 to the virtual Generalized Imitation probes. Participant C returned to intervention for a fourth time and emitted a mean of 17 correct responses out of 20 to the synchronous mirror training protocol across four sessions. For his fourth and final set of post-intervention probes, Participant C emitted 22 correct responses out of 26 to the in-person Generalized Imitation probe and 23 correct responses out of 26 to the virtual Generalized Imitation probe.

For Participant D during baseline he emitted a mean of 8.67 correct responses out of 26 to the in-person Generalized Imitation probe, with a range of eight to nine. Participant C emitted a mean of 2.33 correct responses out of 26 to the virtual Generalized Imitation probe, with a range of 1 to 4. During the intervention, Participant D emitted a mean of 13.42 correct responses out of 20 across 7 sessions. For his first set of post-intervention probes, Participant D emitted 16 correct responses out of 26 to the in-person Generalized Imitation probe and 12 correct responses out of 26 to the virtual Generalized Imitation probe. When Participant D returned to intervention, he emitted a mean of 16.2 correct responses out of 20 to the synchronous mirror training protocol across 5 sessions. For his second set of post-intervention probes, Participant D emitted 15 correct responses out of 26 to the in-person Generalized Imitation probe and 14 correct responses out of 26 to the virtual Generalized Imitation probe. Participant D returned to intervention for a third time and final time, where he emitted a mean of 17 correct responses out of 20 to the synchronous mirror training protocol across 3 sessions. For his third and final set of post-intervention probes, Participant D emitted 16 correct responses out of 26 to the in-person Generalized Imitation probe and 14 correct responses out of 26 to the virtual Generalized Imitation probe.

Figure 2

Number of Correct Responses to the In-Person and Virtual Generalized Imitation Probes across both In-Person and Virtual Conditions, and Number of Correct Responses to the Synchronous Mirror Training Protocol



Note: Black bar represents number of topographically correct mirrored responses in the in-person condition. White Bar represents number of topographically correct mirrored responses in the virtual condition. Closed black circles represent the number of correct responses to the synchronous mirror training protocol.

Object Imitation

Figure 3 shows the number of correct responses to the object imitation probes across both in-person and virtual conditions. During baseline, Participant A emitted a mean of 9.67 correct responses out of 10 to the in-person object imitation probe, with a range of 9 to 10. Participant A emitted 9 correct responses out of 10 across all 3 virtual object imitation probes. In her post-intervention probes, Participant A emitted 10 correct responses out of 10 across both the in-person and virtual object imitation probes.

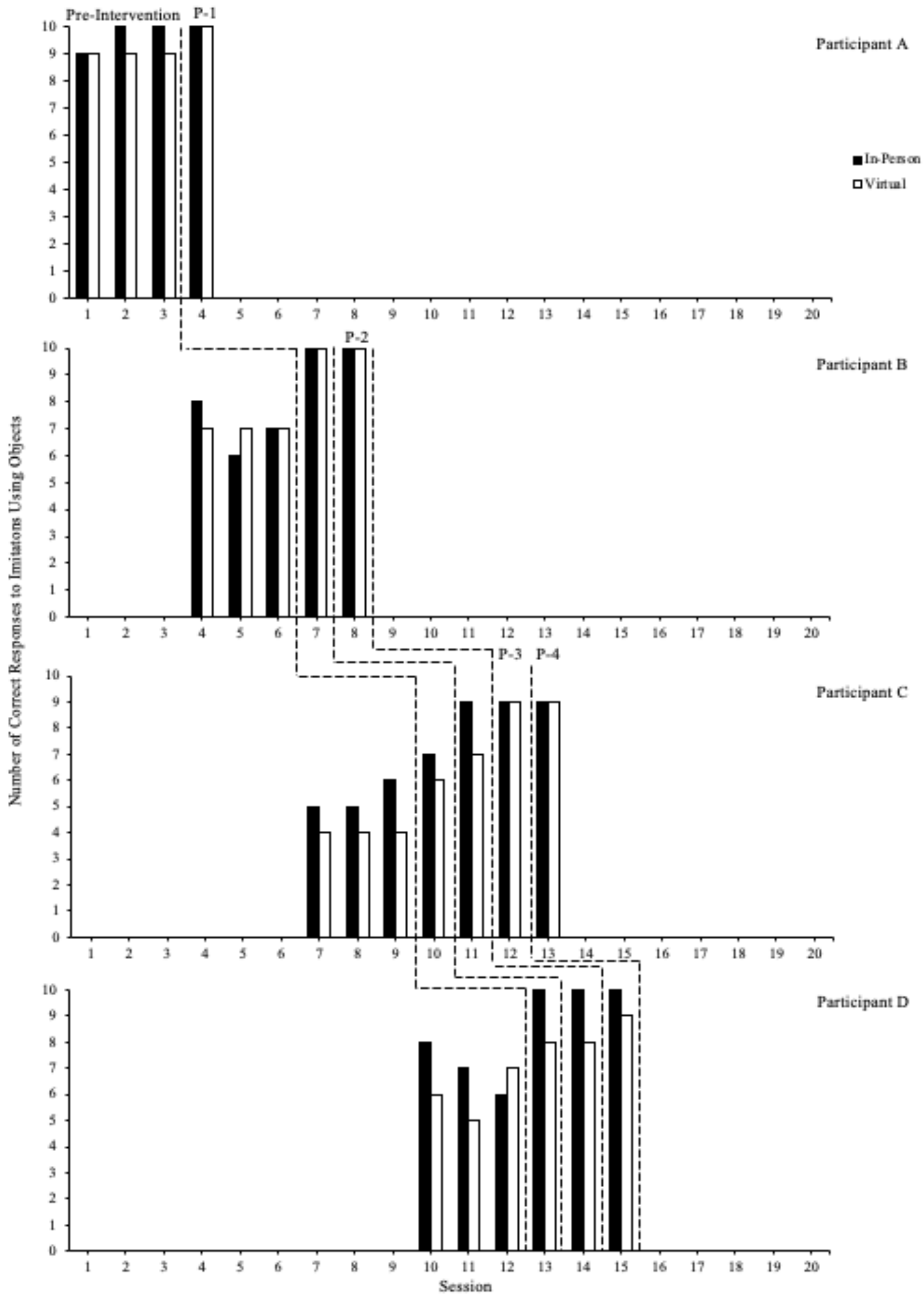
For his baseline, Participant B emitted a mean of 7 correct responses out of 10 to the in-person object imitation probe, with a range of 6 to 8. Participant B emitted 7 correct responses out of 10 across all three virtual object imitation probes. Across both of his 2 post-intervention probes, Participant B emitted 10 out of 10 correct responses to the object imitation probe across both in-person and virtual conditions.

During baseline, Participant C emitted a mean of 5.33 correct responses out of 10 to the in-person object imitation probe, with a range of 5 to 6. For the virtual object imitation probe Participant C emitted 4 correct responses out of 10 across all 3 probes. In his 4 in-person post-intervention object imitation probes, Participant C emitted 7, 9, 9, and 9 correct responses out of 10, respectively. In his 4 virtual post-intervention object imitation probes, Participant C emitted 6, 7, 9, and 9 correct responses out of 10, respectively.

For his baseline, Participant D emitted a mean of 7 correct responses out of 10 to the in-person object imitation probe, with a range of 6 to 8. For the virtual object imitation probe Participant D emitted a mean of 6 correct responses out of 10, with a range of 5 to 7. Across all 3 in-person post-intervention object imitation probes, Participant D emitted 10 correct responses out of 10. In his three virtual post-intervention object imitation probes, Participant D emitted 8, 8, and 9 correct responses out of 10, respectively.

Figure 3

Number of Correct Responses to the Object Imitation Probe across In-Person and Virtual Conditions



Note: Black bar represents number of correct responses during in-person condition. White bar represents number of correct responses during virtual condition. Arrow represents zero correct responses. P-1 represents post-intervention probe one. P-2 represents post-intervention probe two. P-3 represents post-intervention probe three. P-4 represents post-intervention probe four.

Simple Fine Motor Imitations

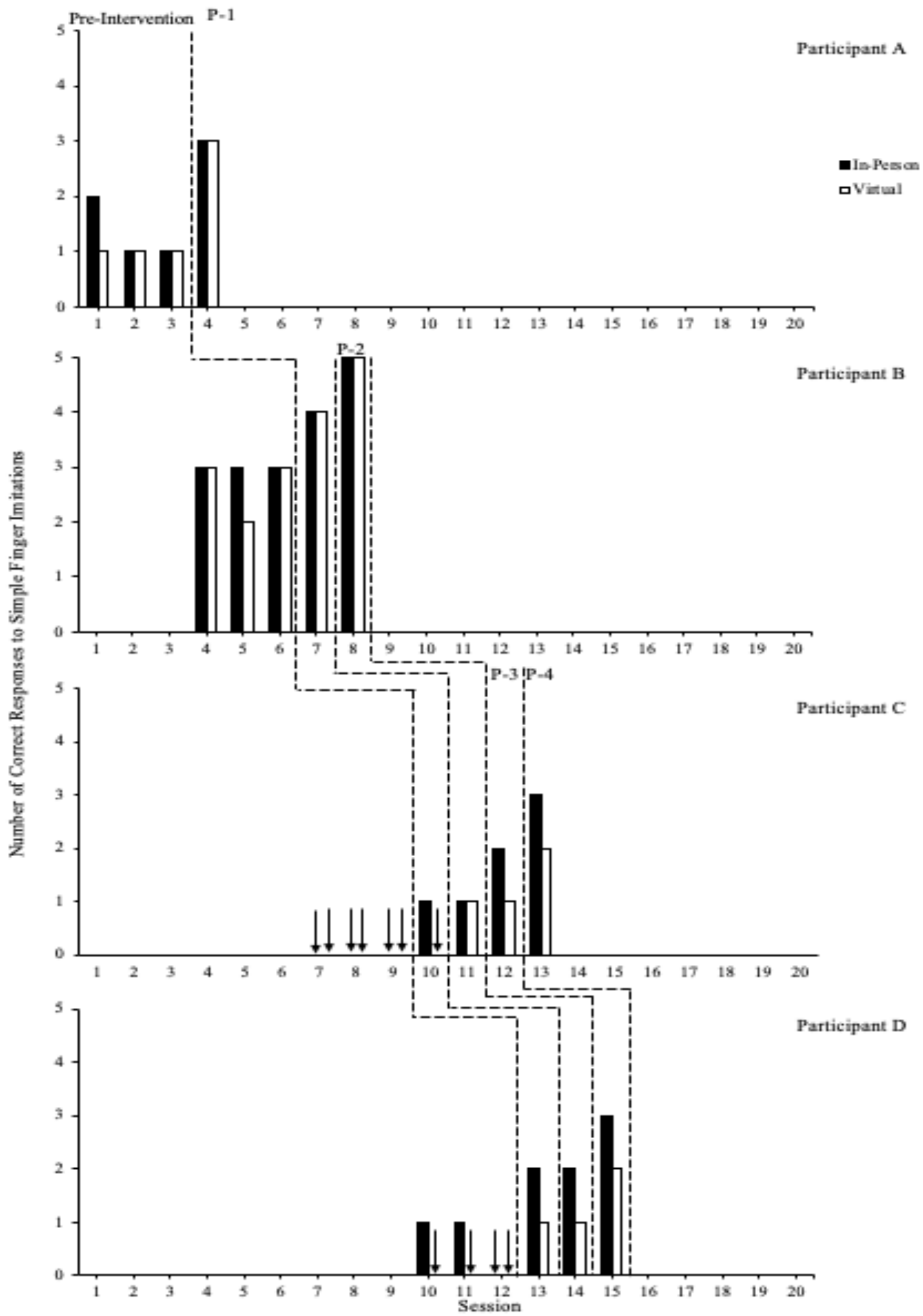
Figure 4 shows the number of correct responses to the simple fine motor imitation probes across both in-person and virtual conditions. During baseline, Participant A emitted a mean of 1.33 correct responses out of 5 to the in-person simple fine motor imitation probe, with a range of 1 to 2. Participant A emitted 1 correct response out of 5 across all 3 virtual simple fine motor imitation probes. In her post-intervention probe, Participant A emitted 3 correct responses out of 5 to the in-person simple fine motor imitation probe and 3 correct responses out of 5 for the virtual simple fine motor imitation probe.

For his baseline, Participant B emitted 3 correct responses out of 5 across all 3 in-person simple fine motor imitation probes. Participant B emitted a mean of 2.67 correct responses out of 5 to the virtual simple fine motor imitation probe, with a range of 2 to 3. In his 2 in-person post-intervention simple fine motor imitation probes, Participant B emitted 4 and 5 correct responses out of 5, respectively. In his 2 virtual post-intervention simple fine motor imitation probes, Participant B emitted 4 and 5 correct responses out of 5, respectively.

During baseline, Participant C emitted a mean of 0 correct responses out of 5 across both in-person and virtual simple fine motor imitation probes. In his 4 in-person post-intervention simple fine motor imitation probes, Participant C emitted 1, 1, 2, and 3 correct responses out of 5, respectively. In his 4 virtual post-intervention simple fine motor imitation probes, Participant C emitted 0, 1, 1, and 2 correct responses out of 5, respectively.

For his baseline, Participant D emitted a mean of 0.67 correct responses out of 5 to the in-person simple fine motor imitation probe, with a range of 0 to 1. For the virtual simple fine motor imitation probe Participant D emitted 0 correct responses out of 5 across all 3 probes. In his 3 in-person post-intervention simple fine motor imitation probes, Participant D emitted 2, 2, and 3 correct responses out of 5, respectively. In his 3 virtual post-intervention simple fine motor imitation probes, Participant D emitted 1, 1, and 2 correct responses out of 5, respectively.

Figure 4
Number of Correct Responses to the Simple Fine Motor Imitation Probe across In-Person and Virtual Conditions



Note: Black bar represents number of correct responses during in-person condition. White bar represents number of correct responses during virtual condition. Arrow represents zero correct responses. P-1 represents post-intervention probe one. P-2 represents post-intervention probe two. P-3 represents post-intervention probe three. P-4 represents post-intervention probe four.

Complex Fine Motor Imitations

Figure 5 shows the number of correct responses to the complex fine motor imitation probes across both in-person and virtual conditions. During baseline, Participant A zero correct responses across all 3 in-person complex fine motor imitation probes. Participant A emitted a mean of 0.67 correct responses out of 3 to the virtual complex fine motor imitation probe, with a range of 0 to 1. In her post-intervention probe, Participant A emitted 3 correct responses out of 5 to the in-person complex fine motor imitation probe and 2 correct responses out of 5 for the virtual complex fine motor imitation probe.

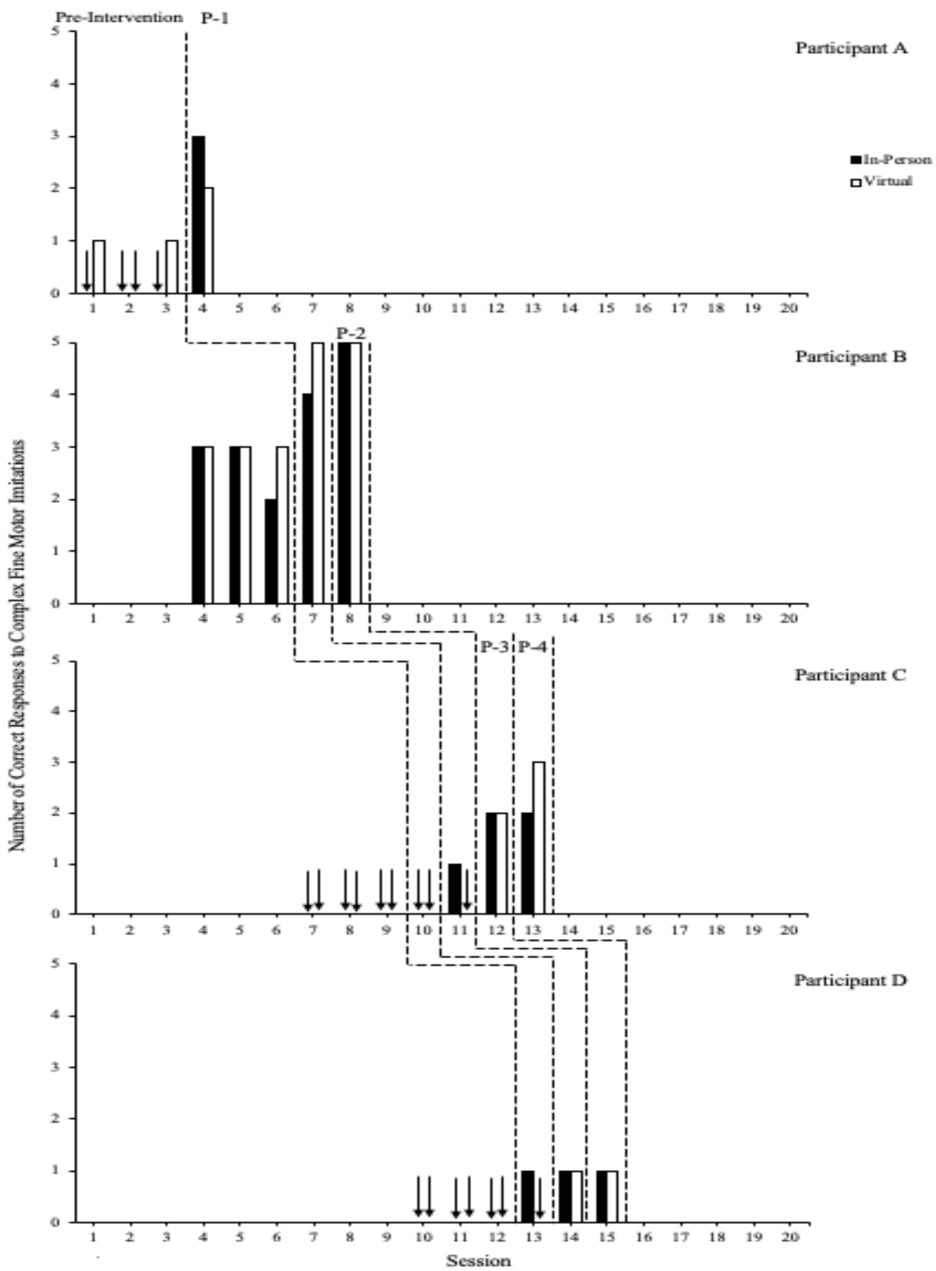
For his baseline, Participant B emitted a mean of 2.67 correct responses out of 5 to the in-person complex fine motor imitation probe, with a range of 2 to 3. Participant B emitted 3 correct responses out of 5 across all 3 virtual complex fine motor imitation probes. In his 2 in-person post-intervention complex fine motor imitation probes, Participant B emitted 4 and 5 correct responses out of 5, respectively. In his 2 virtual post-intervention complex fine motor imitation probes, Participant B emitted 5 correct responses across both probes.

During baseline, Participant C emitted 0 correct responses out of 5 across all 3 in-person complex fine motor imitation probes. Similarly, Participant C emitted 0 correct responses out of 5 during the virtual complex fine motor imitation probe. In his 4 in-person post-intervention complex fine motor imitation probes, Participant C emitted 0, 1, 2, and 2 correct responses out of 5, respectively. In his 4 virtual post-intervention complex fine motor imitation probes, Participant C emitted 0, 0, 2, and 3 correct responses out of 5, respectively.

For his baseline, Participant D emitted 0 correct responses out of five to the in-person and virtual complex fine motor imitation probes. In his 3 in-person post-intervention complex fine motor imitation probes, Participant D emitted only 1 correct response out of 5. In his 3 virtual post-intervention complex fine motor imitation probes, Participant D emitted 0, 1, and 1correct response out of 5, respectively.

Figure 5

Number of Correct Responses to the Complex Fine Motor Imitation Probe across In-Person and Virtual Conditions



Note: Black bar represents number of correct responses during in-person condition. White bar represents number of correct responses during virtual condition. Arrow represents zero correct responses. P-1 represents post-intervention probe one. P-2 represents post-intervention probe two. P-3 represents post-intervention probe three. P-4 represents post-intervention probe four.

Copying Marks

Figure 6 shows the number of correct responses to the copying marks probes across both in-person and virtual conditions. During baseline, Participant A emitted 0 correct responses out of 10 across all 3 in-person copying marks probes. Similarly Participant A emitted 0 correct responses across all 3 virtual copying marks probes. In her post-intervention probe, Participant A emitted 4 correct responses out of 10 during both the in-person and virtual copying marks probes.

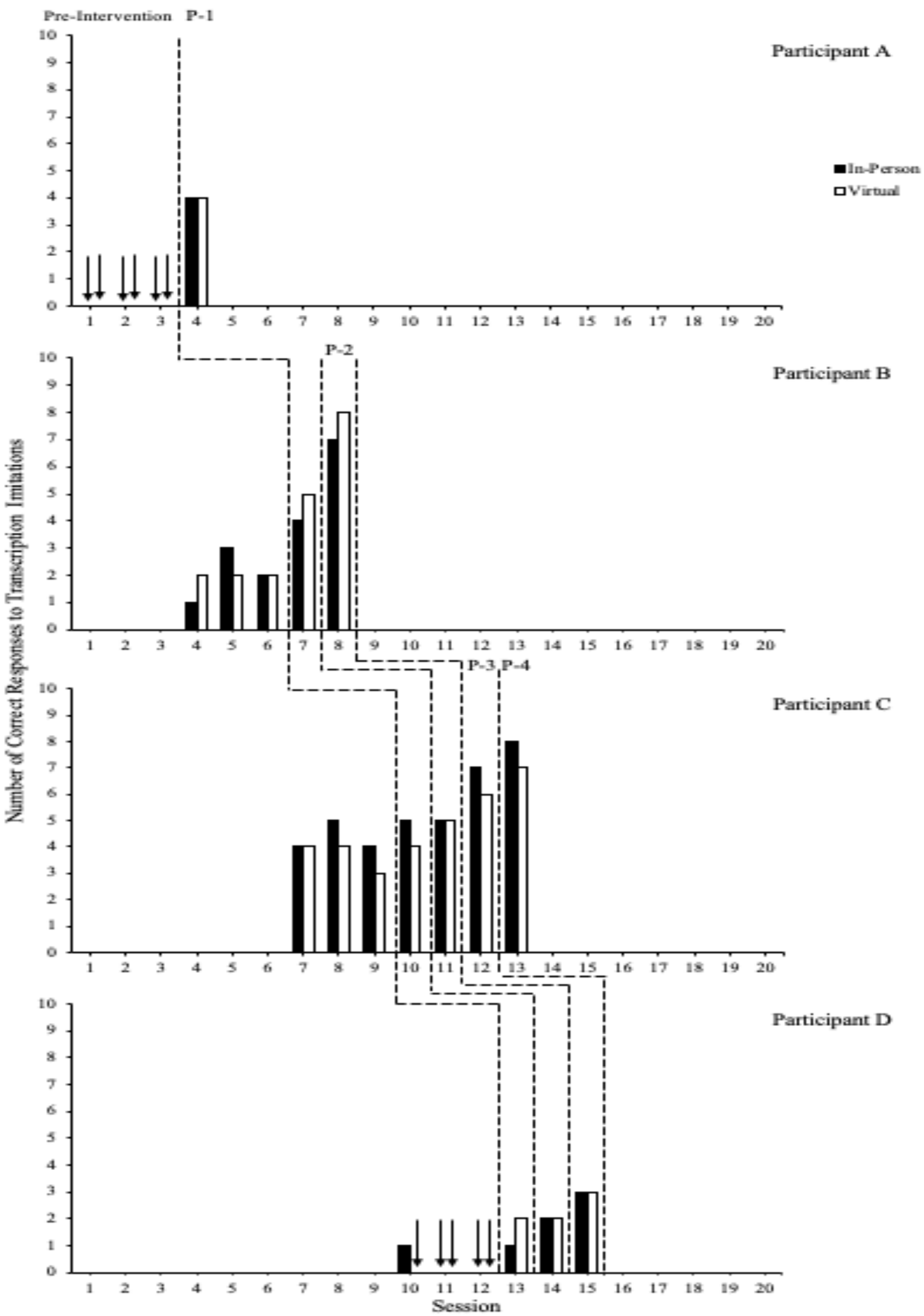
For his baseline, Participant B emitted a mean of 2 correct responses out of 10 to the in-person copying marks probe, with a range of 1 to 2. Participant B emitted 2 correct responses out of 10 across all 3 virtual copying marks probes. In his 2 in-person post-intervention copying marks probes, Participant B emitted 4 and 7 correct responses out of 10, respectively. In his 2 virtual post-intervention copying marks probes, Participant B emitted 5 and 8 correct responses out of 10, respectively.

During baseline, Participant C emitted a mean of 4.33 correct responses out of 10 to the in-person copying marks probe, with a range of 4 to 5. For the virtual copying marks probe Participant C emitted a mean of 3.67 correct responses out of 10, with a range of 3 to 4. In his 4 in-person post-intervention copying marks probes, Participant C emitted 5, 5, 7, and 8 correct responses out of 10, respectively. In his 4 virtual post-intervention copying marks probes, Participant C emitted 4, 5, 6, and 6 correct responses out of 10, respectively.

For his baseline, Participant D emitted a mean of 0.33 correct responses out of 10 to the in-person copying marks probe, with a range of 0 to 1. For the virtual copying marks probe Participant D emitted 0 correct responses across all 3 copying marks probes. In his 3 in-person post-intervention copying marks probes, Participant D emitted 1, 2, and 3 correct responses out of 10, respectively. In his 3 virtual post-intervention copying marks probes, Participant D emitted 2, 2, and 3 correct responses out of 10, respectively.

Figure 6

Number of Correct Responses to the Copying Marks Imitation Probe across In-Person and Virtual Conditions



Note: Black bar represents number of correct responses during in-person condition. White bar represents number of correct responses during virtual condition. Arrow represents zero correct responses. P-1 represents post-intervention probe one. P-2 represents post-intervention probe two. P-3 represents post-intervention probe three. P-4 represents post-intervention probe four.

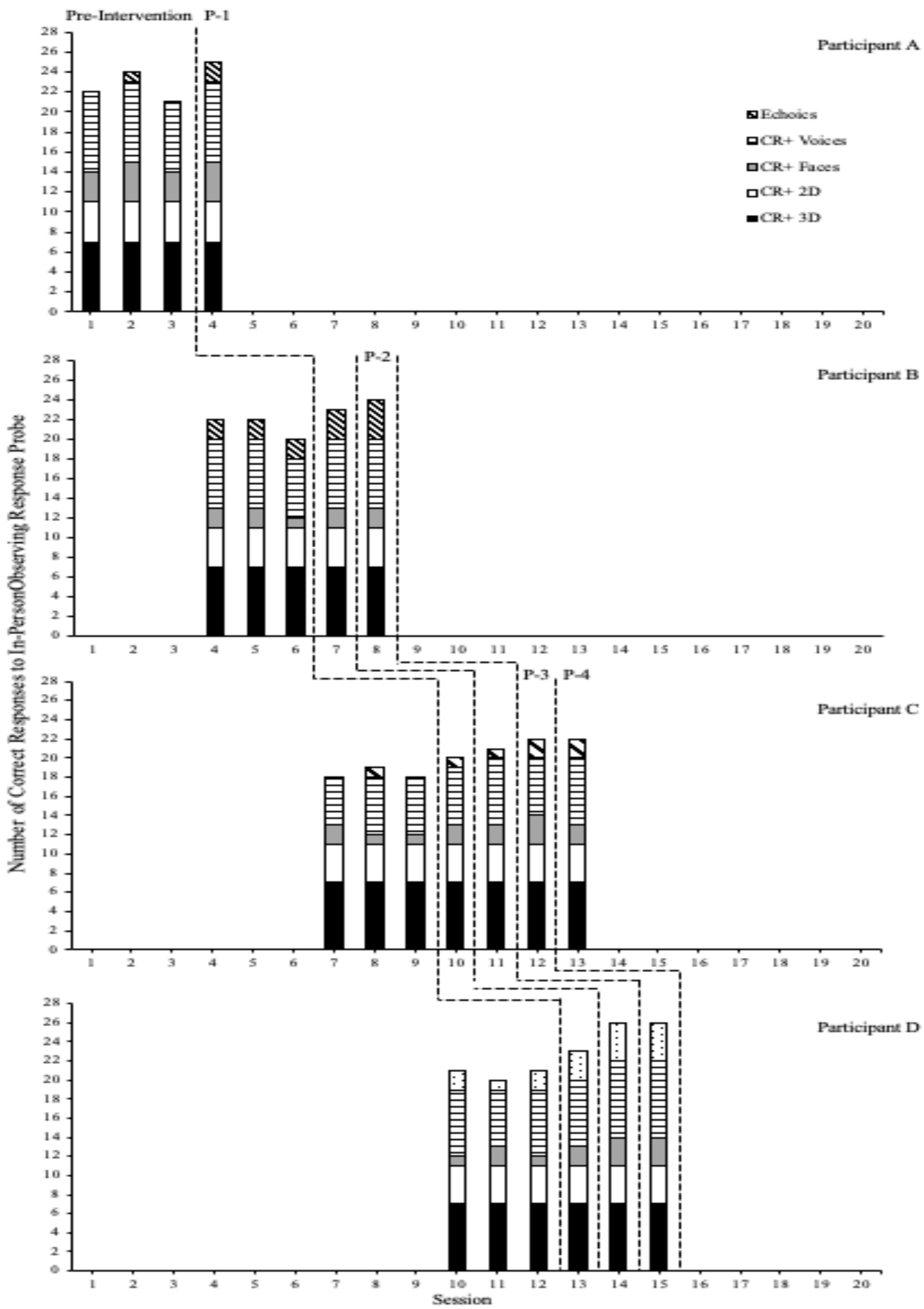
In-Person Observing Responses

Figure 7 shows the number of correct responses to the in-person observing response probes. During baseline, Participant A emitted a mean of 22.33 correct responses out of 28 to the in-person observing response probes, with a range of 21 to 24. In her post-intervention probe, Participant A emitted 25 correct responses out of 28 to the in-person observing response probe. For her baseline, Participant B emitted a mean of 21.33 correct responses out of 28 to the in-person observing response probe, with a range of 20 to 22. In his 2 in-person post-intervention observing response probes, Participant B emitted 23 and 24 correct responses out of 28, respectively.

During baseline, Participant C emitted a mean of 18.33 correct responses out of 28 to the in-person observing response probe, with a range of 18 to 19. In his 4 in-person post-intervention observing response probes, Participant C emitted 20, 21, 22, and 22 correct responses out of 28, respectively. For his baseline, Participant D emitted a mean of 21.33 correct responses out of 28 to the in-person observing response probe, with a range of 21 to 22. In his 3 in-person post-intervention observing response probes, Participant D emitted 23, 26, and 26 correct responses out of 28, respectively.

Figure 7

Number of Correct Responses to the In-Person Observing Response Probe



Note: CR+ represents conditioned reinforcement. Black bar represents number of correct responses to CR+ for three-dimensional stimuli. White bar represents number of correct responses to CR+ for two-dimensional stimuli. Gray bar represents number of correct responses to CR+ for observing adult faces. Horizontal line bar represents number of correct responses to CR+ for observing adult voices. Diagonal bar represents number of correct responses to echoics.

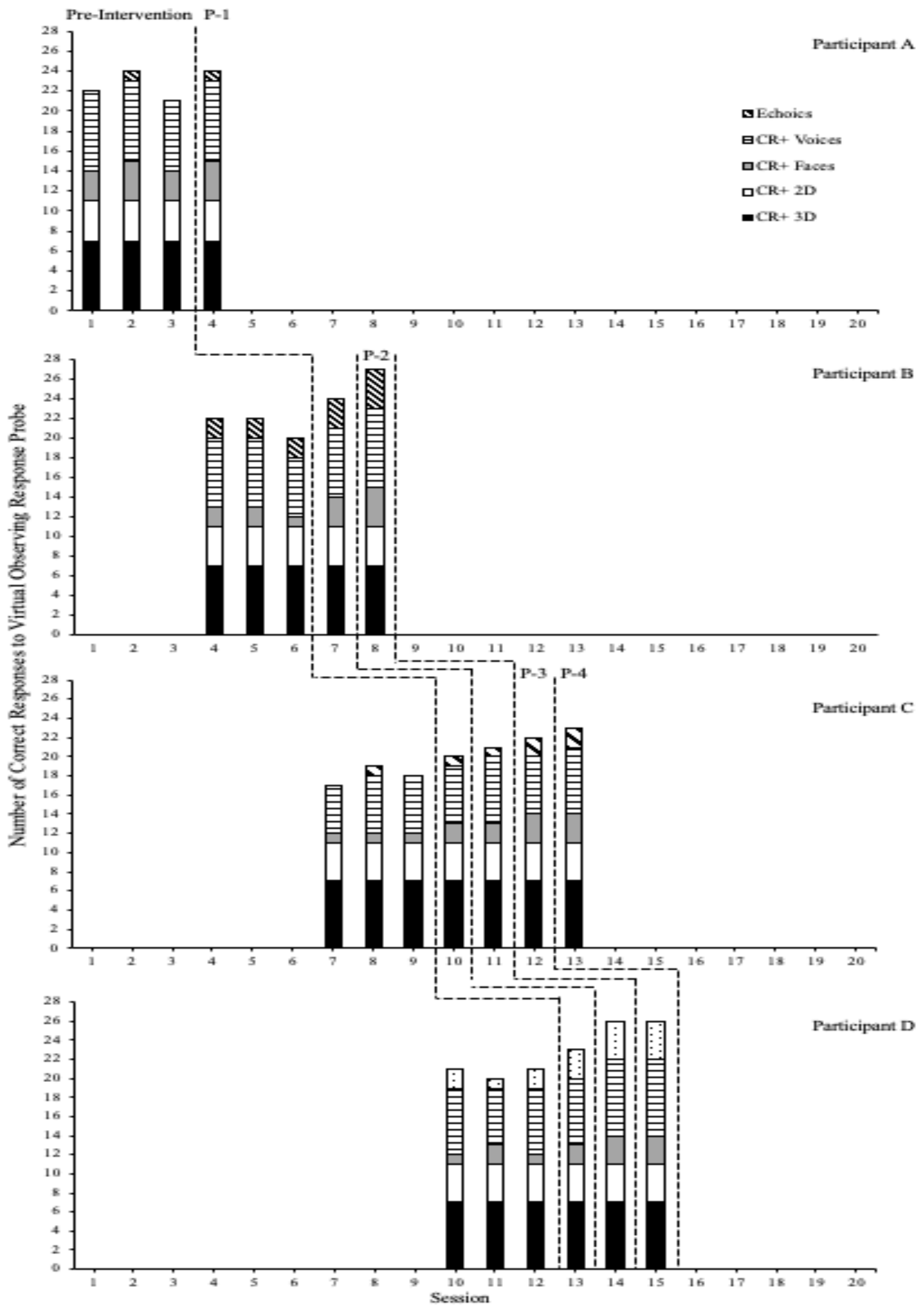
Virtual Observing Responses

Figure 8 shows the number of correct responses to the virtual observing response probes. During baseline, Participant A emitted a mean of 22.33 correct responses out of 28 to the virtual observing response probes, with a range of 21 to 24. In her post-intervention probe, Participant A emitted 24 correct responses out of 28 to the virtual observing response probe. For his baseline, Participant B emitted a mean of 21.33 correct responses out of 28 to the virtual observing response probe, with a range of 20 to 22. In his 2 virtual post-intervention observing response probes, Participant B emitted 23 and 24 correct responses out of 28, respectively.

During baseline, Participant C emitted a mean of 18.33 correct responses out of 28 to the virtual observing response probe, with a range of 18 to 19. In his 4 virtual post-intervention observing response probes, Participant C emitted 20, 21, 22, and 23 correct responses out of 28, respectively. For his baseline, Participant D emitted a mean of 20.67 correct responses out of 28 to the virtual observing response probe, with a range of 20 to 21. In his 3 virtual post-intervention observing response probes, Participant D emitted 23, 26, and 26 correct responses out of 28, respectively.

Figure 8

Number of Correct Responses to the Virtual Observing Response Probe



Note: CR+ represents conditioned reinforcement. Black bar represents number of correct responses to CR+ for three-dimensional stimuli. White bar represents number of correct responses to CR+ for two-dimensional stimuli. Gray bar represents number of correct responses to CR+ for observing adult faces. Horizontal line bar represents number of correct responses to CR+ for observing adult voices. Diagonal bar represents number of correct responses to echoics.

Prompt Frequency

Figure 9 shows the number of prompts delivered to each participant during the Generalized Imitation across both in-person and virtual conditions. During baseline Participant A required a mean of 29.67 prompts delivered during the in-person Generalized Imitation probe, with a range of 27 to 32. Participant A required a mean of 44.67 prompts delivered during the virtual Generalized Imitation probe, with a range of 35 to 59. For her post-intervention probes, Participant A required 23 prompts to be delivered during the in-person Generalized Imitation probe and 12 prompts during the virtual Generalized Imitation probe.

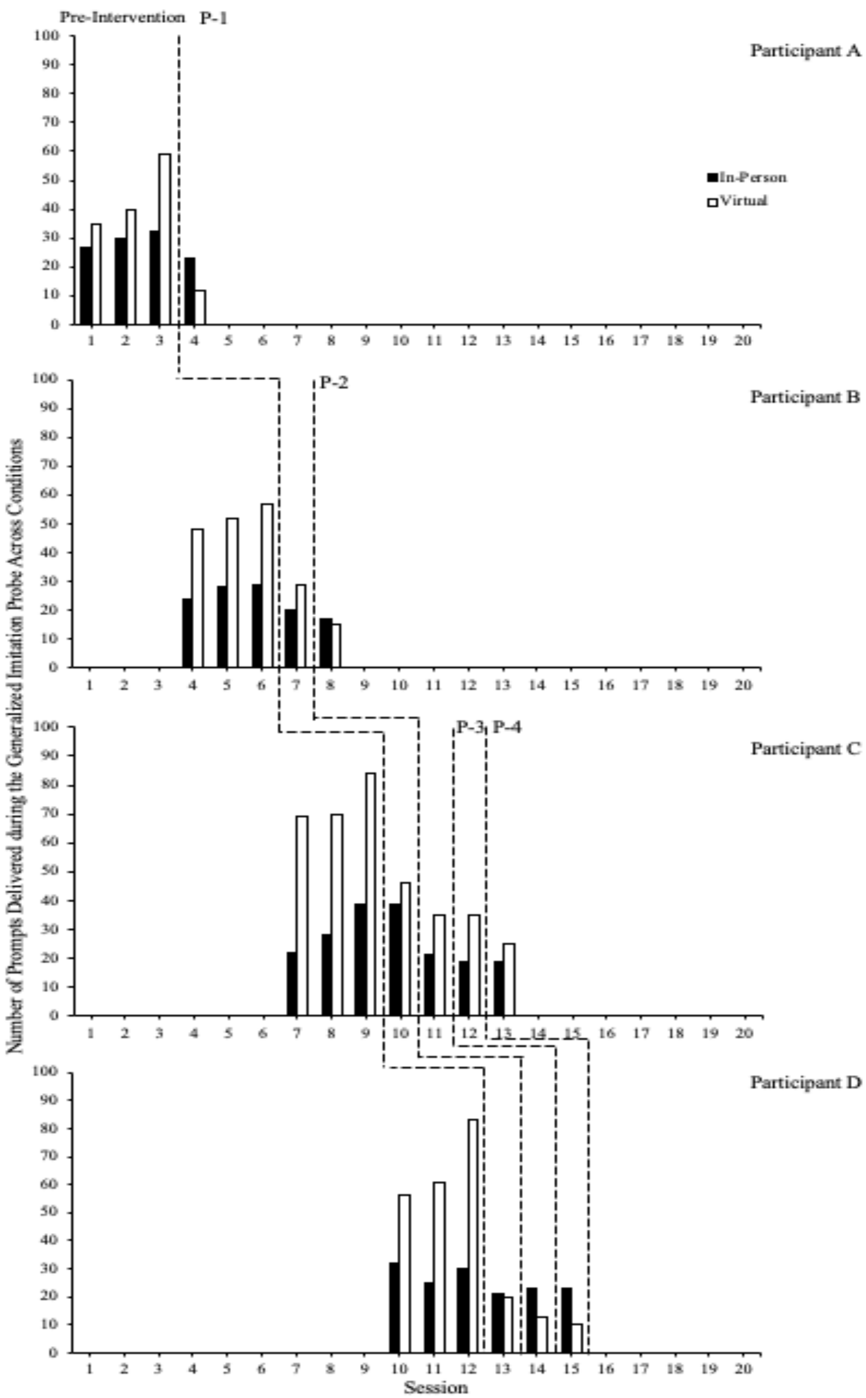
For Participant B during baseline he required a mean of 27 prompts delivered during the in-person Generalized Imitation probe, with a range of 24 to 29. Participant B required a mean of 52.33 prompts delivered during the virtual Generalized Imitation probe, with a range of 48 to 57. For his first set of post-intervention probes, Participant B required 20 prompts to be delivered during the in-person Generalized Imitation probe and 29 prompts during the virtual Generalized Imitation probe. For his second set of post-intervention probes, Participant B required 17 prompts to be delivered during the in-person Generalized Imitation probe and 15 prompts during the virtual Generalized Imitation probe.

During baseline Participant C required a mean of 29.67 prompts delivered during the in-person Generalized Imitation probe, with a range of 22 to 39. Participant C required a mean of 74.33 prompts delivered during the virtual Generalized Imitation probe, with a range of 69 to 84. For his first set of post-intervention probes, Participant C required 39 prompts to be delivered during the in-person Generalized Imitation probe and 46 prompts during the virtual Generalized Imitation probe. In his second set of post-intervention probes, Participant C required 21 prompts to be delivered during the in-person Generalized Imitation probe and 35 prompts during the virtual Generalized Imitation probe. For his third set of post-intervention probes, Participant C required 19 prompts to be delivered during the in-person Generalized Imitation probe and 35 prompts during the virtual Generalized Imitation probes. For his fourth and final set of post-intervention probes, Participant C required 19 prompts to be delivered during the in-person Generalized Imitation probe and 25 prompts during the virtual Generalized Imitation probe.

For Participant D during baseline he required a mean of 29 prompts to be delivered during the in-person Generalized Imitation probe, with a range of 25 to 32. Participant C required a mean of 66.67 prompts delivered during the virtual Generalized Imitation probe, with a range of 56 to 83. For his first set of post-intervention probes, Participant D required 21 prompts to be delivered during the in-person Generalized Imitation probe and 20 prompts during the virtual Generalized Imitation probe. For his second set of post-intervention probes, Participant D required 23 prompts to be delivered during the in-person Generalized Imitation probe and 13prompts during the virtual Generalized Imitation probe. For his third and final set of post-intervention probes, Participant D required 23 prompts to be delivered during the in-person Generalized Imitation probe and 10 prompts during the virtual Generalized Imitation probe.

Figure 9

Number of Prompts Delivered to each Participant during the Generalized Imitation Probe across In-Person and Virtual Conditions



Note: Black bar represents number of correct responses during in-person condition. White bar represents number of correct responses during virtual condition.

In-Person Generalized Imitation Probe Results based on Response Type

Figure 10 shows the number of correct responses based on response type to the Generalized Imitation probes during the in-person conditions. During baseline, Participant A emitted a mean of 3 mirrored responses, with a range of 2 to 4. For the non-mirrored responses, Participant A emitted a mean of 9 non-mirrored responses, with a range of 3 to 8. Then she emitted a mean of 4 two-hand mirrored responses, with a range of 1 to 4. In her post-intervention probe, Participant A emitted 3 mirrored, 14 non-mirrored, and 6 two-hand mirrored responses during the in-person Generalized Imitation probe.

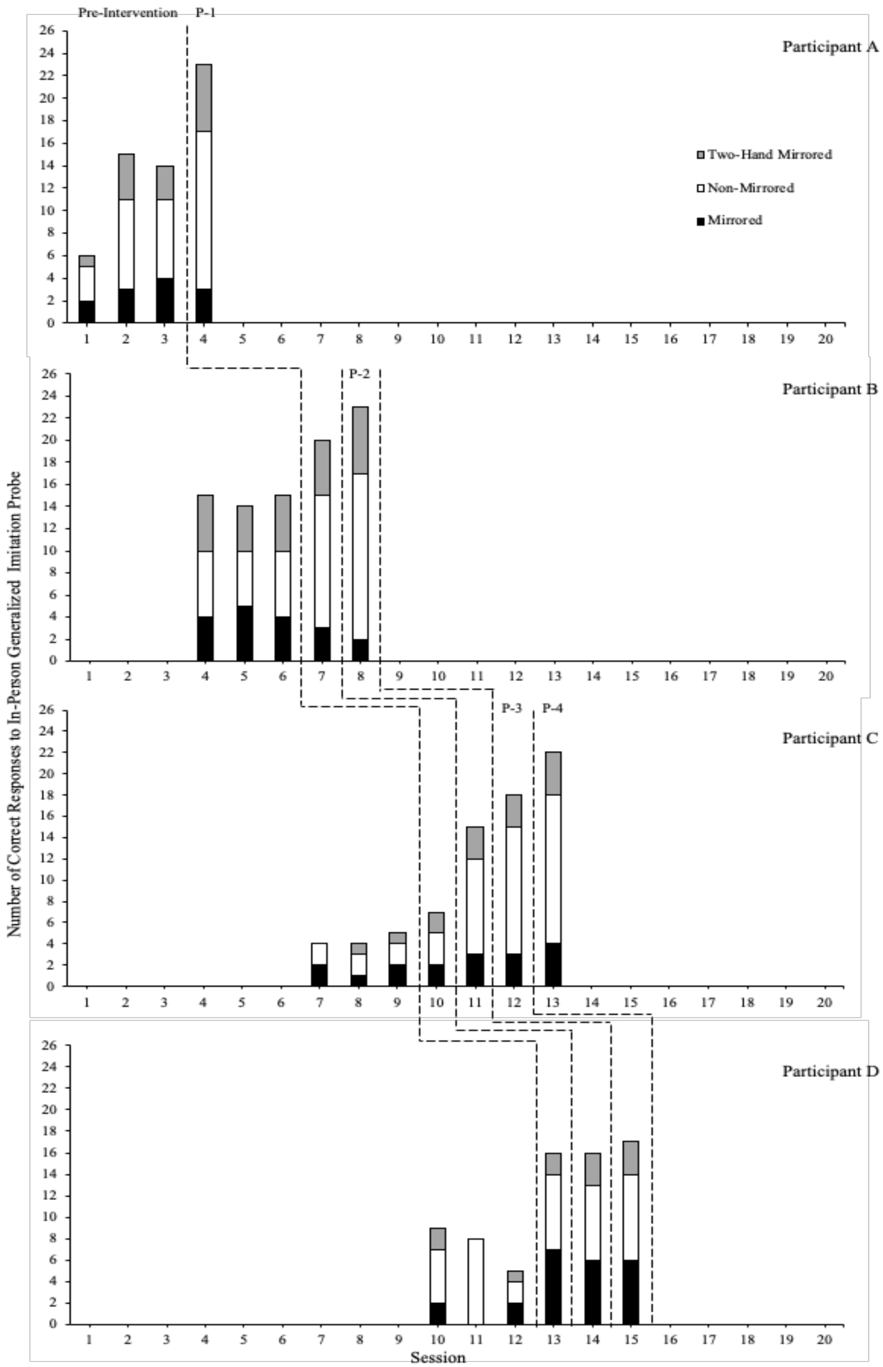
For his baseline, Participant B emitted a mean of 4.33 mirrored responses, with a range of 4 to 5. For the non-mirrored responses, Participant B emitted a mean of 8.5 non-mirrored responses, with a range of 5 to 6. For the two-hand mirrored responses, Participant B emitted a mean of 7 two-hand mirrored responses, with a range of 4 to 5. In his 2 in-person post-intervention Generalized Imitation probes, Participant B emitted 3 and 2 mirrored responses, respectively. He emitted 12 and 15 non-mirrored responses, respectively. Finally, Participant B emitted 5 and 6 two-hand mirrored responses, respectively.

During baseline, Participant C emitted a mean of 1.67 mirrored responses, with a range of 1 to 2. For the non-mirrored responses, Participant C emitted 2 non-mirrored responses across all 3 probes. For the two-hand mirror responses, Participant C emitted 0.67 mirrored responses, with a range of zero to 1. In his four in-person Generalized Imitation post-intervention probes, Participant C emitted 2, 3, three, and 4 mirrored responses, respectively. He emitted 3, 9, 12, and 14 non-mirrored responses, respectively. Finally, Participant C emitted 2, 3, 3, and 4 two-hand mirrored responses, respectively.

For his baseline, Participant D emitted a mean of 1.33 mirrored responses, with a range of zero to 2. For the non-mirrored responses, Participant D emitted a mean of 5 non-mirrored responses, with a range of 2 to 8. For the two-hand mirrored responses, Participant D emitted a mean of 1 two-hand mirrored responses, with a mean of zero to 2. In his 3 in-person post-intervention Generalized Imitation probes, Participant D emitted 7, 6, and 6 mirrored responses, respectively. He emitted 7, 7, and 8 non-mirrored responses, respectively. Finally, Participant D emitted 2, 3, and 3 two-hand mirrored responses, respectively.

Figure 10

Number of Correct Responses to the In-Person Generalized Imitation Probe represented by Response Type



Note: Black bar represents number of correct mirrored responses. White bar represents number of correct non-mirrored responses. Gray bar represents number of correct two-handed mirrored responses.

Virtual Generalized Imitation Probe Results based on Response Type

Figure 11 shows the participant's number of correct responses based on response type to the Generalized Imitation probes during the virtual conditions. During baseline, Participant A emitted a mean of 1.67 mirrored responses, with a range of 0 to 4. For the non-mirrored responses, Participant A emitted a mean of 1.33 non-mirrored responses, with a range of 0 to 2. Then she emitted a mean of 1.33 two-hand mirrored responses, with a range of 1 to 2. In her post-intervention probe, Participant A emitted 7 mirrored, 12 non-mirrored, and 6 two-hand mirrored responses during the virtual Generalized Imitation probe.

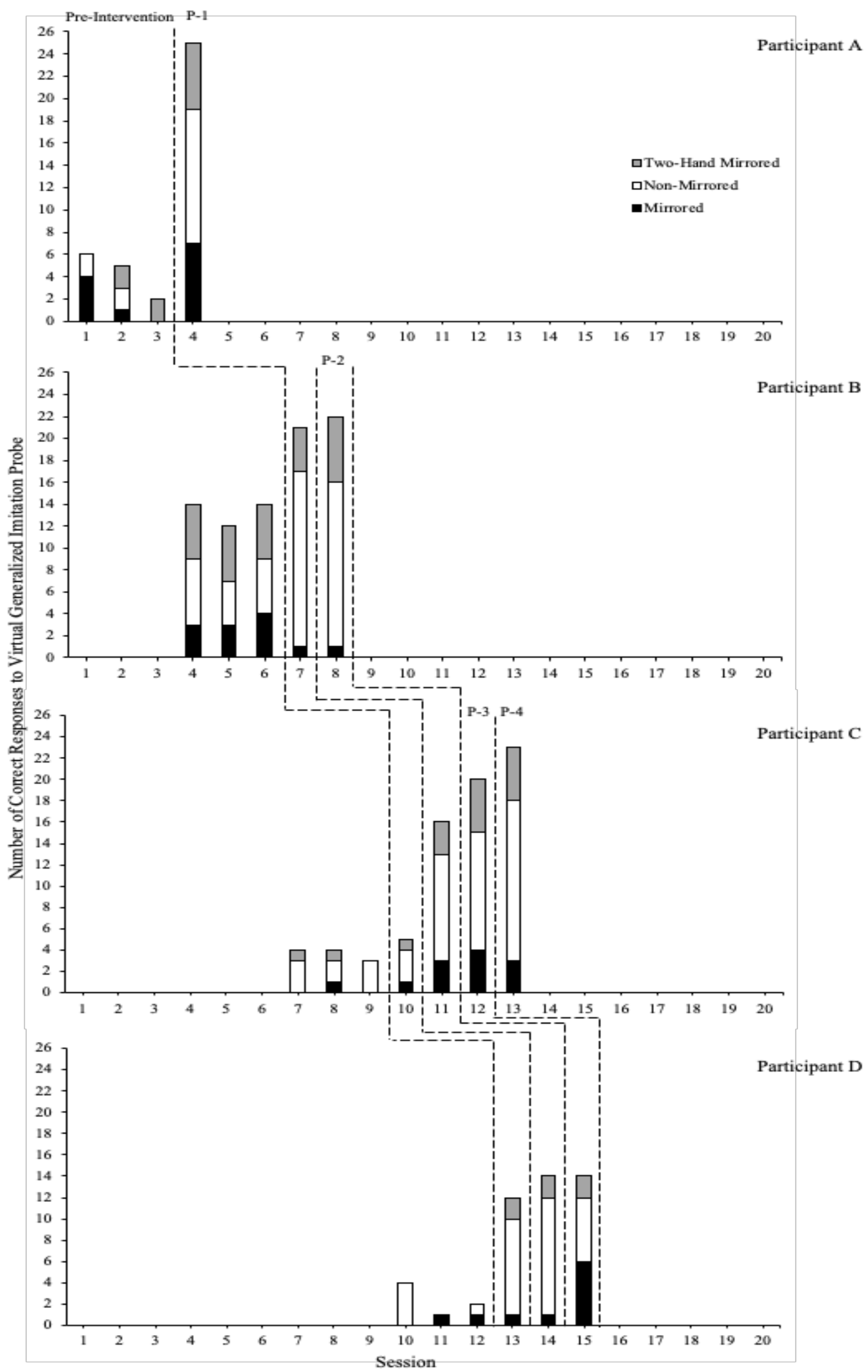
For his baseline, Participant B emitted a mean of 3.33 mirrored responses, with a range of 3 to 4. For the non-mirrored responses, Participant B emitted a mean of 5 non-mirrored responses, with a range of 4 to 6. For the two-hand mirrored responses, Participant B emitted 5 two-hand mirror responses across all 3 probes. In his 2 virtual post-intervention Generalized Imitation probes, Participant B emitted 1 mirrored response. He emitted 16 and 15 non-mirrored responses, respectively. Finally, Participant B emitted 4 and 6 two-hand mirrored responses, respectively.

During baseline, Participant C emitted a mean of 0.33 mirrored responses, with a range of 0 to 1. For the non-mirrored responses, Participant C emitted a mean of 2.67 non-mirrored responses, with a range of 2 to 3. For the two-hand mirror responses, Participant C emitted 0.67 mirrored responses, with a range of 0 to 1. In his 4 virtual Generalized Imitation post-intervention probes, Participant C emitted 1, 3, 3, and 3 mirrored responses, respectively. He emitted 3, 10, 11, and 15 non-mirrored responses, respectively. Finally, Participant C emitted 1, 3, 5, and 5 two-hand mirrored responses, respectively.

For his baseline, Participant D emitted a mean of 0.67 mirrored responses, with a range of 0 to 1. For the non-mirrored responses, Participant D emitted a mean of 1.67 non-mirrored responses, with a range of 0 to 4. For the two-hand mirrored responses, Participant D emitted 0 two-hand mirrored responses across all 3 probes. In his 3 virtual post-intervention Generalized Imitation probes, Participant D emitted 1, 1, and 6 mirrored responses, respectively. He emitted 9, 11, and 6 non-mirrored responses, respectively. Finally, Participant D emitted 2 two-hand mirrored responses across all 3 probes.

Figure 11

Number of Correct Responses to the Virtual Generalized Imitation Probe represented by Response Type



Note: Black bar represents number of correct mirrored responses. White bar represents number of correct non-mirrored responses. Gray bar represents number of correct two-handed mirrored responses.

Discussion

The purpose of Experiment II was to determine the effectiveness of a synchronous mirror training protocol with young developmentally delayed children. I sought to answer two research questions: (1) can a synchronous mirror training protocol function to teach educationally classified preschoolers with a disability to emit various Imitation responses? and 2) As a result of undergoing the synchronous mirror training protocol, will there be observable differences in the participant's echoic behavior and observing responses?

Prior to the intervention, all four participants did not demonstrate having Imitation as a foundational learning capability in their repertoires across either the in-person or virtual conditions. As a result of undergoing the synchronous mirror training protocol, three out of the four participants had established the Imitation verbal developmental cusp and foundational learning capability across both in-person and virtual conditions. Participants A, B, and C all demonstrated a 97.1%, 56.8%, and 408% increase in their number of topographically correct responses during the in-person Generalized Imitation probes, respectively. Similar gains were observed during the virtual Generalized Imitation probes, where the participants emitted a 477%, 65%, and 527% increase in their topographically correct responses, respectively. These substantial increases in the number of correct responses to untaught imitations are indicative of the acquisition of a foundational learning capability (Du & Greer, 2014; Greer, et al., 2017; Greer & Ross, 2009; Greer & Speckman, 2009).

Participant D was the only participant to not meet the criterion of 80% accuracy in imitating the responses found in the Generalized Imitation probe across either condition. However, when analyzing his pre-intervention and post-intervention data Participant D consistently was unable to imitate the responses that required the use of both arms. If the imitative response was for both arms to cross to shoulders, he would only use one arm to cross to his shoulders. The same response was observed if the imitative response was for both arms to touch the same ear, only one arm would touch his ear. The researchers spoke with his Physical Therapist, who provides services in school, and stated that Participant D has dyspraxia—a physical disability that affects a person's ability in coordinating the movements of their upper and lower limbs in space. After considering the participant's phylogenetic condition and the notion that the participant emitted unilateral responses when the response required staying on one side of the body and a cross-modal response when the response requirement was to cross the midline of his body, Participant D did establish Imitation through the synchronous mirror training protocol.

Interestingly, when analyzing the pre-intervention and post-intervention data for the response type (i.e., mirrored, non-mirrored, two-hand mirrored) in the Generalized Imitation probe, all four participants emitted more non-mirrored responses across both in-person and virtual conditions. Participant A emitted eight and 10.67 more non-mirrored responses in her post-intervention probe across both in-person and virtual conditions, respectively. Participant B emitted 9.33 and 10 more non-mirrored responses in his post-intervention probe across both in-person and virtual conditions, respectively. Participant C emitted 12 and 12.33 more non-mirrored responses in his post-intervention probe across both in-person and virtual conditions, respectively. There were observable increases in the participant's mirrored responses across both conditions, but they were not as large when compared to the non-mirrored responses. Given the standard set out by Du and Greer (2011), it does not matter whether the imitative response is mirrored or non-mirrored, what is important is whether the imitative response requires the participant to cross the mid-line of their body (e.g., right hand cross to shoulder), then the participant must cross their mid-line in order for the response to be counted as correct.

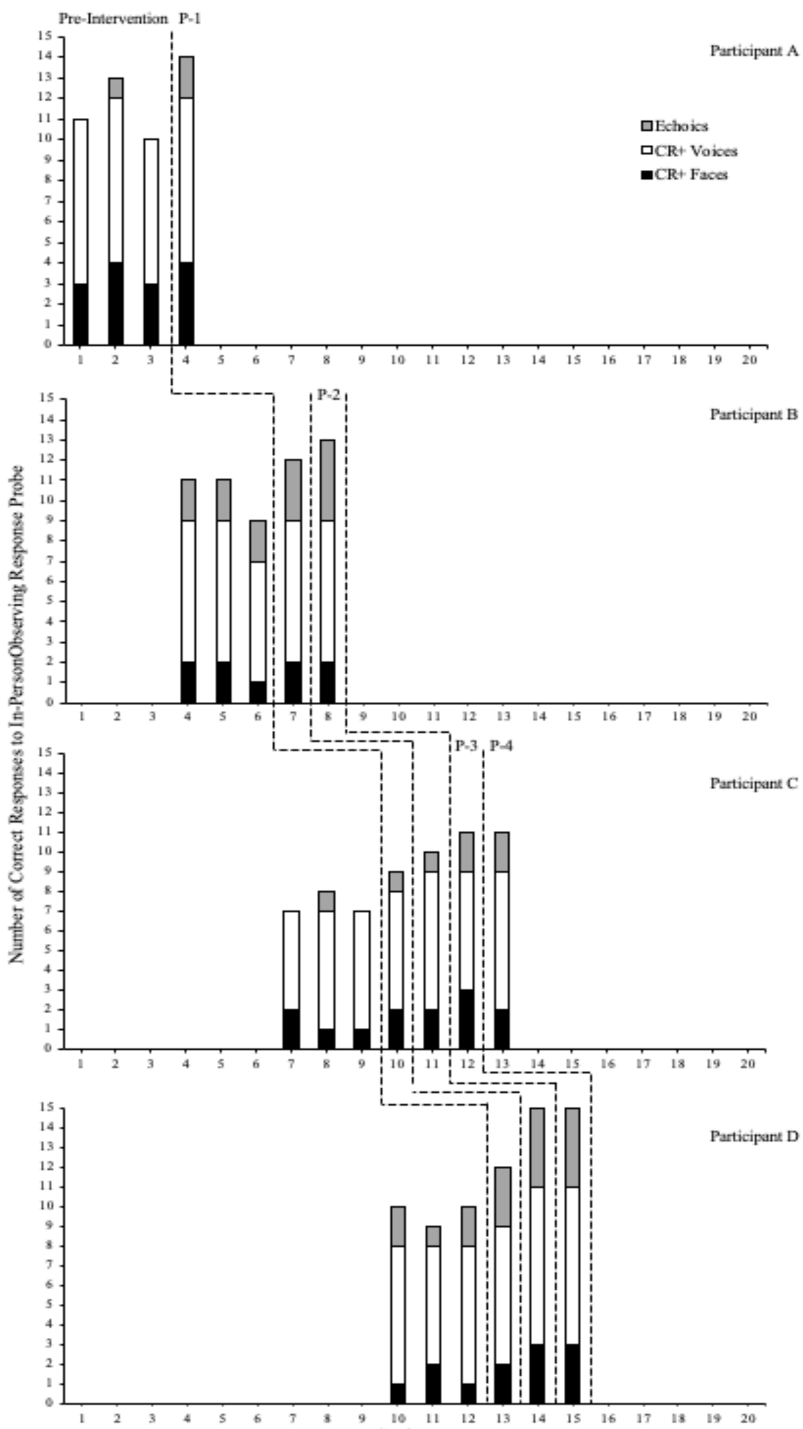
The baseline data for the number of prompts to attend to the researcher that were delivered to the participants during the Generalized Imitation probe across both virtual and in-person conditions, were high across all four participants. In the in-person pre-intervention probes, all four participants required an average of 28.833 prompts. After undergoing the intervention, the participants all required a mean of 20.5 prompts delivered during their last in-person post-intervention probes. For the virtual pre-intervention probes, the participants required an average of 59.5 prompts. After undergoing the intervention, the participants all required a mean of 15.5 prompts delivered during their last virtual post-intervention probes. There was a 28.9% decrease in the number of prompts delivered in the in-person Generalized Imitation probes and an impressive 74% decrease for the virtual Generalized Imitation probes.

When looking at the other imitation classes (e.g., object imitation, simple fine motor, complex fine motor, copying marks), all four participants demonstrated increases in their ability to emit various untaught imitation responses across both conditions. For object imitation, all four participants demonstrated approximately 50% accuracy or higher in their in-person pre-intervention probes. This may be indicative of an instructional history, or a history of reinforcement paired with imitating adult actions using various objects either at home or at school. For the simple fine motor imitations, only Participant B emitted all five responses during his second post-intervention probe across both in-person and virtual conditions. The other three participants all emitted three simple correct imitative responses during their in-person post-intervention probe. For the virtual post-intervention probe, Participant A emitted three correct imitative responses and Participants C and D both emitted two correct responses. Similar results were obtained for the complex fine motor imitations across both in-person and virtual conditions. Given that all four participants receive Occupational Therapy during school hours, the small muscles in their fingers may be weaker; thus, making it more difficult to imitate the fine motor imitative responses. It is important to note that the participants may have a lack of an instructional history with emitting simple and complex fine motor imitations. The possibility exists that these participants were not ever directly taught to manipulate their fingers by making various movements given how young they are; therefore, may be lacking an instructional history. This finding supports the results from Moreno (2012), where her data suggested that Imitation develops within topographically determined boundaries and that correspondence between seeing and doing must be conditioned separately for each imitative response.

Returning to the second question, which was whether there are changes in the participants echoic behavior and observing response probes as result of undergoing the synchronous mirror training protocol. All four participants emitted 100% accuracy in orienting to three-dimensional and two-dimensional stimuli across both in-person and virtual conditions. Therefore, the researchers isolated the observing response data to include only conditioned reinforcement for observing adult faces, conditioned reinforcement to observing adult voices, and conditioned reinforcement for phonemic discrimination. See Figure 12 and Figure 13.

Figure 12

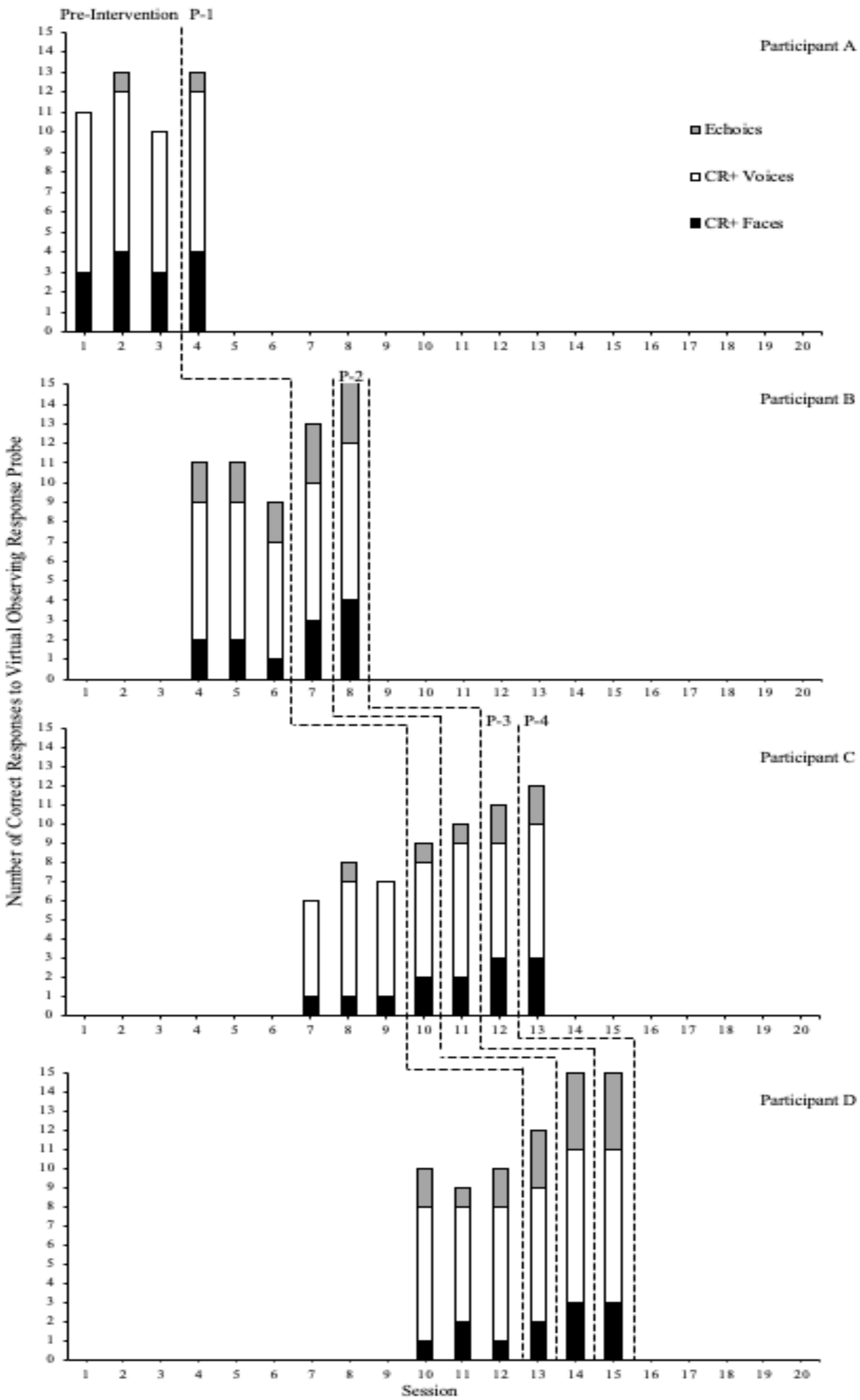
Number of Correct Responses to the Isolated In-Person Observing Response Probe



Note: CR+ represents conditioned reinforcement. Black bar represents number of correct responses to CR+ for observing adult faces. White bar represents number of correct responses to CR+ for observing adult voices. Gray bar represents number of correct responses to echoics.

Figure 13

Number of Correct Responses to the Isolated Virtual Observing Response Probe



Note: CR+ represents conditioned reinforcement. Black bar represents number of correct responses to CR+ for observing adult faces. White bar represents number of correct responses to CR+ for observing adult voices. Gray bar represents number of correct responses to echoics.

Isolated In-Person Observing Response Probes

No clinically important differences were noted after undergoing the intervention during the in-person condition for observing adult faces for Participants A, B, and C. Participant D increased in his accuracy in orienting towards adult faces in the in-person condition, where he increased from a mean of 1.33 correct responses to three. No clinically important differences were noted during the post-intervention in-person condition for observing adult voices for Participants A, B, and D. Participant C increased from a mean of 5.67 correct responses to seven. All four participants demonstrated increases in their echoic behavior during the in-person post-intervention probes. Participants A and C increased from a mean of 0.33 accurate echoics to two accurate echoics. Participant B increased from a mean of 0.67 accurate echoics to two accurate echoics. Participant D increased from a mean of 1.33 accurate echoics to four accurate echoics.

Isolated Virtual Observing Response Probes

No clinically important differences were noted after undergoing the intervention during the virtual condition for observing adult faces for Participant A. Participant B increased in his accuracy of observing adult faces from a mean of 1.67 correct responses to four. Participant C increased from a mean of 1 correct response to three correct responses for observing adult faces. Participant D increased in his accuracy in orienting towards adult faces from a mean of 1.33 correct responses to three. No clinically important differences were noted during the virtual condition for observing adult voices for Participants A, B, and D. Participant C increased from a mean of 5.67 correct responses to seven. All four participants demonstrated increases in their echoic behavior during the in-person post-intervention probes. Participant A increased from a mean of 0.33 accurate echoics to two accurate echoics. Participant B increased from a mean of 0.67 accurate echoics to two accurate echoics. Participant C increased from a mean of 0.33

accurate echoics to two Participant D increased from a mean of 1.33 accurate echoics to four accurate echoics.

In summary, the most significant increases were observed across all four participants accuracy in emitting echoics with either approximations or point-to-point accuracy, across both conditions. Each observing response probe provided the participants with four opportunities to emit an echoic response, where Participants B and D had emitted 100% accuracy in their echoic behavior. More gains were made in observing adult faces during the virtual condition following the intervention. The increases in Participant C's responses to observing adult faces occurred across both conditions after undergoing the virtual mirror protocol.

Implications.

The results of this study support the findings of Du and Greer (2014), where the in-person mirror training protocol functioned to establish Imitation as a foundational learning capability in all three preschool-aged participants. Changes in the behavior of the participants were observed during the intervention phases, where in each successive phase the number of learn units required to master the objective decreased. When comparing the number of learn units needed for mastery from the first intervention phase to the last, the number of presentations decreased by 33.3% for Participant B, and 60% for Participants C and D. Rosalez-Ruiz and Baer (1997), Greer and Speckman (2009), and Greer and Du (2015) all state that the onset of a *verbal developmental cusp* is represented in a subtle change within the individual allowing them to contact the environmental contingencies in a new way. The individual comes under a new stimulus control and acquires its relevant reinforcer as a newly conditioned reinforcer. One of the "subtle changes" is exhibited in requiring fewer and fewer trials to master an objective, because one is coming under the relevant stimulus control for that given behavior. Therefore, an intensive protocol designed to aid in the acquisition of verbal developmental cusps and foundational learning capabilities may be just as effective when presented on a virtual platform.

The subsequent decreases in the number of vocal and visual prompts delivered by the researcher also affirm the notion of the establishment of the see-do correspondence that functions as the reinforcer for Imitation (Du & Greer, 2014; Greer, et al., 2017; Greer & Ross, 2008; Greer & Speckman, 2009). The behavior of the participant's was brought under the control of the higher-order observation-production copying class, or under the control of duplicative responding (Catania, 1995; Greer & Speckman, 2009; Michael, 1982).

The increases in the participant's number of non-mirrored responses to the Generalized Imitation probe across both settings also supports the findings of Du and Greer (2014). In this instance the participants of my Experiment 2 lacked *perspective taking,* or the "ability to adopt the perspective of another individual" (Du, 2011, p. 43). In Du and Greer's (2014) first experiment, they sought to determine if 128 typically developing adults emit mirrored or non-mirrored responses during the Generalized Imitation probe. The results of their study found that there were no statistically significant differences between the mirrored and non-mirrored responses and that most of the adult participants did not discriminate between the left and right perspective (Du and Greer, 2014). This statistical finding affirms the notion that perspective-taking should not be a deciding factor in determining whether Imitation is one's learning repertoire. If typically developing adults do not consistently emit mirrored responses, then why should we expect preschoolers who have a disability to do so?

The increases in echoic behavior for all four participants, across both in-person and virtual conditions, support and extend the findings of Clement (2019) and Tsiouri and Greer (2003; 2007). Tsiouri and Greer's (2003;2007) use of the rapid motor imitation antecedent intervention was successful in inducing the first instances of functional speech in developmentally delayed preschoolers. Prior to that intervention, no functional speech was observed. Due to the high rates of reinforcement that the participants received during the intervention, the presentation of a low-probability behavior (i.e., the emission of functional speech) was brought under the control of the higher-order observation-production class (Greer & Speckman, 2009). Following the synchronous mirror training protocol, the intervention successfully established a stronger stimulus control of the emulative cusp of point-to-point vocal correspondence (i.e., echoics) (Greer & Ross, 2008; Greer & Speckman, 2009; Tsiouri & Greer, 2003; Tsiouri & Greer, 2007). These results add support the findings of Philp (2016) where the participants first acquired imitative responses followed by the emulative responses.

Limitations and Suggestions for Future Research.

One limitation to note was the ascending trend in Participant C's pre-intervention data for his object imitation probe. His responding increased by one correct response for the third pre-intervention probe. The researchers should have conducted one more pre-intervention probe for object imitation to determine if the participant's behavior was increasing while in baseline and establish steady-state responding. Future studies should aim to ensure that steady state responding is reached, before entering the potential participant into the intervention.

Another limitation was that the researcher did not distinguish imitative responses from emulative responses. Specifically, during Participant B's post-intervention probes for the complex fine motor imitations, he physically manipulated his fingers in order to reach the same end-goal/end-result as the experimenter. For example, when the experimenter emitted the response of the two-finger extension Participant B physically put his pinkie, ring finger down towards his palm and then pushed his thumb onto those fingers. Philp (2016) and Clement (2019) collected data on their participant's responses to imitative tasks, particularly whether the participants imitated versus emulated. If data were collected on the participant's imitative versus emulative responses, more information may have been available as to if and/or when the shift in reinforcement occurs.

Future research should aim to replicate this study with a larger number of participants to truly determine whether the intervention is a viable method of presenting the mirror training protocol, in terms of effectiveness and efficiency. A potential external factor that may have affected the data is that the participants each received virtual instruction every Friday and virtual instruction every other week for 30- to 60-minute sessions. This was due to their school's COVID-19 prevention measures, in particular the hybrid schedule that was in place. The participants may have habituated to the use of virtual instruction, since they were receiving their special education services and all related services via a virtual platform on a consistent basis for approximately one school year.

Chapter IV: General Discussion

The purpose of this paper was to determine the role of Imitation in the verbal behavior development trajectory, including the verbal developmental cusps associated with its establishment, and determining whether presenting the mirror training protocol through a virtual platform can establish gains in the participant's overarching class of duplicative responding. In Experiment I, a statistical analysis demonstrated strong relations between demonstrating the foundational learning capability of Imitation with the preverbal developmental cusps of conditioned reinforcement for observing adult faces, conditioned reinforcement for observing adult voices and listener literacy and the emulative verbal developmental cusp of parroting/vocalizations, and echoics. The statistical analysis also demonstrated that Imitation as a foundational learning capability is strongly associated with toys, puzzles, coloring materials, and Play-Doh all functioning as conditioned reinforcers. Thus, the results suggest that the aforementioned verbal behavior cusps may function as either prerequisites or corequisites to Imitation and that the presence of Imitation is related to appropriate, functional toy play. In Experiment II, Imitation was established via the synchronous mirror training protocol, which demonstrated increases in non-mirrored responses across both conditions, fewer prompts being delivered, increases in the emission of accurate echoics, and increases in observing adult faces in the virtual condition.

The Prerequisites and/or Corequisites of Imitation

The significant statistical relations between the foundational learning capability of Imitation and conditioned reinforcement for observing adult faces and voices, listener literacy, parroting/vocalizations, and echoics support and extend the findings of Clement (2019) and Edwards (2014). Our results suggest that the presence of these verbal developmental cusps is necessary for Imitation to be present as a foundational learning capability. The early observing responses and observe-produce correspondences associated with Imitation, echoics, and listener literacy must function as reinforcers first. If the individual's behavior does not come under the relevant stimulus control and if the source of reinforcement does not shift, then the individual is unlikely to come under the control of the higher order operant of duplicative responding (Greer & Speckman, 2009). Refer to Table 2 for a list of the various observe-produce correspondences alongside the associated verbal developmental cusp, stimulus control, and new reinforcer that is acquired as a result of its establishment. Our analysis also suggests the notion that all of these verbal developmental cusps may function as corequisites with Imitation, where the likelihood of one verbal developmental cusp being in repertoire might be an indicator of the presence of the developmental cusp and foundational learning capability. However, more research is warranted because VBDT clearly states that there is a sequence in the acquisition of verbal developmental cusps and that certain cusps are true prerequisites for other developmental cusps and learning capabilities. If we were to state that by demonstrating Imitation as a cusp and capability, then one has demonstrated point-to-point vocal correspondence (i.e., echoics) is misleading. We can suggest that if one has the reinforcer associated with Imitation, see-do correspondence, then they also may have other observe-produce correspondences functioning as reinforcers and are under their relevant stimulus control. The question becomes how can researchers measure the shift in reinforcement across the various developmental cusps? Or is it one reinforcer that shifts across the relevant verbal developmental cusps?

The Joining of the Observation-Production Correspondences

The results from Experiment I question as *what* is the commonality between Imitation and all of the verbal developmental cusps it is statistically associated with? In short, all these verbal developmental cusps establish correspondences, or relations, between stimuli in the environment and ones' senses. The joining of the visual, auditory, olfactory, tactile, and gustatory senses might be the basis of Imitation and cross-modal responding (Greer & Ross, 2008; Howarth, et al., 2015; Keohane, et al., 2006). The joining of the senses is known as the *capacity for sameness*, which may allow for one to move along the verbal behavior developmental trajectory as set out by VBDT and learn arbitrarily applicable cross-modal responses. In order to discriminate stimuli, one must have a capacity for sameness and where learning is facilitated through abstraction, where the reinforcement shifts from one sensory response to the next sensory response (Engelmann & Carnine, 1991; Greer & Ross, 2008; Keohane, et al., 2009). Capacity for sameness allows for the first relational frames, or the first instances of derived relations to form (Howarth, et al., 2015). The Rational Frame Theory posits that individuals acquire complex language through a process known as arbitrary applicable relational responding, which allows for relational frames to form between stimuli through contextual cues in environment (Hayes et al., 2001).

Shifting from Imitative Responding to Emulative Responding

As stated in the discussion of Experiment I regarding the presence of Imitation being strongly related to having toys, puzzles, coloring materials, and Play-Doh function as reinforcers, it is through modeling procedures and imitation that children are initially taught to play with these various items (Greer, 2002). By having an imitative repertoire and being under the control of higher-order operant of duplicative responding, children can observe the teacher use play items and then produce the same results on their own. If a child prefers to emit stereotypy when a play activity is available, then conditioning procedures are a likely intervention to decrease stereotypy and replace it with appropriate play behaviors (Greer, et al., 1985). These conditioning procedures systematically shift the reinforcement from the kinesthetic automatically reinforcing stereotypical behaviors to engaging in the play activity without emitting stereotypy and allow the child to contact reinforcement for appropriate play (Greer, 2002; Greer, et al. 1985). Once a child can play appropriately and the play item is successfully conditioned as a reinforcer, a shift occurs. The shift is in the reinforcement associated with the activity, it is no longer the see-do correspondence (the need to do the same as the model) but rather the function of the activity itself or the outcomes associated with it. For example, a child may initially play with Play-Doh using the same materials and create the same constructions that their teacher did, but then they begin to create untaught constructions, use new tools, and may engage in imaginative play (i.e., creating a pizza and pretending to eat it) with the activity. The question for future research becomes *when* does this shift from imitative to emulative reinforcement occur?

Establishing See-do Correspondence as a Reinforcer

In Experiment II, the researchers successfully established Imitation as a preverbal developmental cusp and foundational learning capability as a function of the synchronous mirror training protocol in all four participants. The results support the use of presenting instruction through a virtual platform, where the establishment of Imitation was observed across both in-person and virtual conditions (see Figure 2). The participants emitted similar levels of responding on their post-intervention Generalized Imitation probes in both conditions. There were observed increases in the number of correct responses to imitations across the other imitative classes (e.g., object imitation, simple and complex fine motor, copying marks). This finding provides further evidence that the participants came under the relevant stimulus control of the higher-order duplicative class of responding.

The establishment of the reinforcer, see-do correspondence, is further supported when looking at the participants' learn units to mastery (see Figure 2). With each successive intervention phase, the participants mastered the objective during the training more quickly and their number of correct responses to the post-intervention Generalized Imitation probes were increasing. Similar results are noted with the decrease in number of vocal and visual prompts being delivered across both in-person and virtual Generalized Imitation probes. The decrease in prompting supports the notion that the correspondence between observing the imitator and producing the modeled response was being established and that the behavior of imitation was coming under the control of the copying class of duplicative responding. Our results support and extend the findings of Du and Greer (2014) and Moreno (2012), both of whom were able to establish the reinforcer of see-do correspondence in preschoolers using the mirror training protocol.

Changes in Observing Environmental Stimuli

The results of the participants' observing responses are interesting. Three participants increased in the number of correct responses to observing adult faces in the virtual condition. The implications can be interpreted that the presentation of the synchronous mirror training protocol also functioned as a conditioning procedure, where each intervention session provided the participants with multiple pairing opportunities. The participants were not only reinforced when they imitated the researcher, but they were also provided with vocal reinforcement (i.e., praise) for looking at the mirror, emitting in-seat behavior, and maintaining an appropriate volume. Thus, the pairings between observing the researcher during the synchronous mirror training protocol functioned to increase the participant's observation of adult faces in the virtual condition. This is consistent with the results of Greer, et al. (2008), where they conditioned vocal praise to function as a reinforcer across both performance and learning tasks, in preschool and school-aged children. Greer, et al. (2008) argued that it was through stimulus-stimulus pairings, or classical Pavlovian conditioning, that praise began to function as a reinforcer and more importantly conditioned reinforcement can emerge through observation.

All four participants increased in their emission of accurate echoics, or the beginnings of speaker behavior across both in-person and virtual conditions. These results extend the findings of Tsiouri and Greer (2003; 2007) and Ross and Greer (2003), and their use of the rapid motor antecedent intervention. Parallel to how the synchronous mirror training protocol provided pairing opportunities between the researcher and the participant, the intervention provided a history of reinforcement for imitating the researchers and established the reinforcer of see-do correspondence. The reinforcer of Imitation creates the need (i.e., the motivating condition) to "do the same." A child imitates the same behavior as their caregiver, due to the history of reinforcement that followed it in the past. Now that Imitation and its reinforcer are established, speaker behavior then can come under the control of the higher-order duplicative response class. This resulted in the increases in the participants' emission of echoics, or the point-to-point vocal correspondence. The shift occurs from one sensory modality (Imitation as the visual modality) to the next sensory modality (echoics as the auditory modality). The shift across the senses (from visual to auditory) adds support to notion of relational frames being formed in order for cross-modal responding to occur (Greer & Ross, 2008; Greer & Speckman, 2009; Howarth, et al., 2015; Keohane, et al., 2009).

Limitations

Most of the literature surrounding the topic of imitation and the relevant interventions to induce Imitation have chosen participants who have medical diagnoses of ASD. Only Participant

D had a medical diagnosis of ASD. One may argue that the results of this study may not be extrapolated to the ASD population, due to a lack of participants who have that specific medical diagnosis. However, in the state that this study took place, once a student who has been receiving special education services at preschool is scheduled to enter kindergarten, they must receive an educational classification in order to continue to receive special education. Thus, many students from the school that these participants are from, and are in more restrictive classroom settings, receive educational classifications of ASD.

Future Research

Future replications should look at presenting the synchronous mirror training protocol via Zoom or Google Meets, where the participants and the researcher will share the same screen. Both the researcher and the participant should see one another, where the computer screen can function as the "mirror." This may allow for a more efficient and cost-effective manner of collecting data and presenting the mirror training protocol—without the need to go out and buy a mirror. Future researchers should investigate whether we can present the synchronous virtual mirror training protocol where the parents replace the teachers in presenting the corrections and ultimately presenting the mirror training protocol on their own in-situ.

Future replications should also look at collecting data on items traditionally used to condition as reinforcers before, during, and after the intervention. This may help in determining when the shift in reinforcement occurs from *imitating* to *emulating*. Philp (2016) found that her typically developing participants shifted to emitting emulative responses after a delay of five to seven days. Thus, future researchers can look at conditioning data on a similar schedule and conduct follow-up assessments to determine if the shift occurs later in time. These data may aid in answering the question as to whether certain items are more successfully conditioned as reinforcers, as a result of the strength of stimulus control across all the preverbal developmental cusps.

Future research can look at having a control group, where one group received the intervention in the traditional in-person format and the other received the intervention virtually. By adding a control group, implications can be made as to whether one modality is more efficient versus the other or whether the differences are based on the strength of the participant's current verbal developmental cusps and verbal learning capabilities.

Conclusions

In sum, the present study provides contributions to the study of Imitation, the verbal behavior development trajectory, and role of observation-production correspondences. Specifically, empirical evidence supports the presentation of the mirror training protocol through a virtual platform in acquiring not only the preverbal developmental cusp and learning capability of Imitation, but also the higher-level operant of duplicative responding. Not only can the participants learn in a new way, but they also can contact the contingencies and a higher-level operant that they could not before. As researchers and teachers, it is our responsibility to identify any missing verbal developmental cusps and learning capabilities, so that our students may learn from their environment and improve their educational outcomes.

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Appendix A: Pre- and Post-Intervention Data Collection Form for Generalized Imitation for Experiment II (List 1 of 4)

Number	Probe List 1	# Prompts	Code
1	Right hand cross to shoulder		
2	Right hand to same shoulder		
3	Left hand cross shoulder		
4	Left hand same shoulder		
5	Both hands same shoulders		
6	Both hands cross shoulders		
7	Right hand cross to elbow		
8	Left hand cross to elbow		
9	Right hand cross to wrist		
10	Left hand cross to wrist		
11	Palms up bowl		
12	Arms crossed in front		
13	Right hand cross to knee		
14	Right hand same knee		
15	Left hand cross to knee		
16	Left hand same knee		
17	Right hand cross to ankle		
18	Right hand same ankle		
19	Left hand cross to ankle		
20	Left hand same ankle		
21	Right hand cross to ear		
22	Right hand same ear		
23	Left hand cross to ear		
24	Left hand same ear		
25	Both hands same ear		
26	Both hands cross ears		

*PRE/POST #*________________

Circle One: Face-to-Face / Virtual

Student Name:___________________

Experimenter: ___________________

IOA: __________

Code	Response	Example
1	Mirrored	Researcher models “Right hand cross to knee” and the participant taking their left hand and tapping his/her right knee.
2	Non-Mirrored	Researcher models “Right hand cross to knee,” and the participant taking their right hand and tapping his/her left knee
3	Two-hand Mirrored	Researcher models “Both hands same ears,” and participant does the same.
4	Incorrect	Incorrect, No point-to-point correspondence

Appendix B: Pre- and Post-Intervention Data Collection Form for Experiment II

*PRE/POST #*________________
Circle One: Face-to-Face / Virtual

*Student Name:*____________________
Experimenter: ____________________

Simple Finger IMI.	**Probe 1**		**Probe 2**		**Probe 3**		**Probe 4**		**Probe 5**	
Palm down/ open										
Four finger extension										
Thumb extension										
Index extension										
Pinkie extension										
TOTAL		IOA		IOA		IOA		IOA		IOA

OBJ. IMI.	**Probe 1**		**Probe 2**		**Probe 3**		**Probe 4**		**Probe 5**	
Fly Pen										
Roll Car										
Feeding Baby										
Roll Bottle										
Stir Spoon										
Stack Blocks										
Open Book										
Rock Baby										
Write a Pen										
Pop up Toy										
TOTAL		IOA		IOA		IOA		IOA		IOA

Complex Finger IMI.	**Probe 1**		**Probe 2**		**Probe 3**		**Probe 4**		**Probe 5**	
Two finger extension										
OKAY sign										
Pinkie & Thumb extension										
Three finger extension										
Index & Thumb extension										
TOTAL		IOA		IOA		IOA		IOA		IOA

Appendix C: Teacher Performance Rate and Accuracy Form

CABAS® Teacher Performance Rate/Accuracy

Observer: ___________ Date: _____________
Teacher/Student: _______________________
Program: ______________STO: _____________
ELCAR Domain/Matrix Component: ____

Elapsed time: ______________ Week _______

LU	Approvals	Comments
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		
16.		
17.		
18.		
19.		
20.		

Teacher+: _____ Teacher-: ______
RPM correct: _______ RPM Incorrect: ________
Errorless TPRA: Yes No (please specify)

- Correct Materials: Yes No
- Correct Objective: Yes No
- LU in Place (A-B-C): Yes No
- Error Pattern: Yes No
- EO in Place: Yes No
- Missing Instructional History: Yes No

CABAS® Teacher Performance Rate/Accuracy

Observer: ___________ Date: _____________
Teacher/Student: _______________________
Program: ______________STO: _____________
ELCAR Domain/Matrix Component: ____

Elapsed time: ______________ Week _______

LU	Approvals	Comments
1.		
2.		
3.		
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20.		

Teacher+: _____ Teacher-: ______
RPM correct: _______ RPM Incorrect: ________
Errorless TPRA: Yes No (please specify)

- Correct Materials: Yes No
- Correct Objective: Yes No
- LU in Place (A-B-C): Yes No
- Error Pattern: Yes No
- EO in Place: Yes No
- Missing Instructional History: Yes No