THE EFFECTIVENESS OF MIRROR IMITATION TRAINING ON THE GENERALIZATION OF IMITATION SKILLS FOR CHILDREN WITH AUTISM SPECTRUM DISORDER

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ABSTRACT

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The ability to imitate is a foundational skill related to multiple aspects of social, play, and language development in children. However, many children with autism spectrum disorder (ASD) do not imitate as effectively as their typically developing peers and therefore need direct instruction to acquire imitative repertoires. The current study investigated the effectiveness of Mirror Imitation Training: a relatively novel instructional procedure which uses a mirror as a tool to teach imitation skills. Three children with autism spectrum disorder who did not demonstrate a generalized imitation repertoire despite exposure to conventional imitation training methods were selected for participation. For all three participants, mirror imitation training was effective at producing skill acquisition across two sets of imitation targets and increased responding to the remaining untrained sets of imitation targets. Supplemental findings also showed 2 of the 3 participants required fewer sessions to criteria on set 2 after meeting criterion for their set 1 with MIT. These findings identify mirror imitation training as a promising teaching method to promote generalized imitation skills in children with ASD who do not demonstrate generalized imitation skills when taught with more traditional methods of imitation instruction.

Keywords: Imitation, autism spectrum disorder, mirror imitation training

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KEY TO SYMBOLS AND ABBREVIATIONS

DTT	Discrete Trial Training
MIT	Mirror Imitation Training
ABA	Applied Behavior Analysis
ASD	Autism Spectrum Disorder
EIBI	Early Intensive Behavioral Intervention
BCBA	Board Certified Behavior Analyst
VBMAPP	Verbal Behavior Milestones Assessment and Placement Program

INTRODUCTION

An imitative repertoire allows children to actively participate in social and play interactions. It provides them with the tools to engage in the learning process, resulting in correlations between imitation performance and skill development in multiple developmental domains such as social communication (Dadgar et al., 2017), cognitive, language, and motor development (Jones, 2009) performance. Children with autism spectrum disorder (ASD) encounter unique barriers acquiring imitation skills compared to their typically developing peers (Williams, Whiten, & Singh, 2004).

In a longitudinal study by Young and colleagues (2011), children with ASD demonstrated discrepancies in imitation skills as early as 12 months of age compared to their typically developing peers. Not only were these deficits present early in life, but they also persisted across multiple time points and resulted in correlated deficits in expressive language and social engagement. These results suggest that deficits in imitation skills can result in a cluster of deficits across multiple areas of functioning for children with ASD.

There are two types of imitation to consider for children with ASD: *specific imitation* and *generalized imitation*. Specific Imitation can be thought of as a child's ability to replicate certain movements, actions, or vocalizations when presented that have been explicitly taught to them, in the context that they were taught. The second type, generalized imitation, can be understood as the ability to imitate untrained actions in a variety of contexts (Brown, Peace, & Parsons, 2009).

Some children with ASD demonstrate specific imitation skills, but if they have not developed a generalized imitative repertoire, they may not be able to use imitative learning to acquire other developmental skills. For typically developing children, generalized imitation emerges through natural interactions because they are constantly attending to their social environment and contacting naturally-occurring reinforcers for engaging in imitative behaviors (Brown, Peace, & Parsons, 2009). For children with ASD who are often less attentive to socially-relevant aspects of their environment, a generalized imitative repertoire may not emerge without explicit instruction (Ingersoll 2008) necessitating the development of interventions to teach imitation.

Discrete Trial Training Approach to Teaching Imitation

A common instructional method for teaching a variety of skills to children with ASD is discrete trial training (DTT) which involves breaking larger complex behaviors into their smaller parts and then teaching each individual part in isolation (e.g. Green, 2001). When using this method to teach imitation, students are often taught to imitate a few specific actions at a time by having an instructor sit across from the student, say “do this”, “copy me”, or something similar, and then performing an action from a set of two to four predetermined actions. The instructor then physically prompts the child to replicate the same action and the process is repeated with one of the other actions in the set. Once the student is able to replicate the modeled action to a predetermined criteria of performance, the set of targets is generally considered mastered and new teaching targets are selected.

Teaching using this method can result in increases in specific imitation skills as the child begins to use the instructor’s demonstration of an action as the cue to reproduce that specific pre-taught action. If a child is taught enough sets of specific imitation actions in DTT instruction they may eventually demonstrate generalized imitation, but it is unknown how many sets need to be taught before a child can imitate novel actions (Erjavec, Lovett & Horne, 2009) or what prerequisite skills need to be present in order to perform generalized imitation skills. Given variations between learners, the DTT approach leaves the potential for any given child to be without generalized imitation skills- resulting in children who do not spontaneously imitate in the natural environment despite successful performance of imitation skills in a DTT setting (Ingersoll, 2008).

Mirror Imitation Training

Common imitation training procedures such as DTT are helpful in increasing some specific imitation skills for some children with ASD, yet other children with ASD are not responsive to these methods or require multitudes of trials before any effect is seen on related developmental domains. Mirror imitation training (MIT) or, the use of mirrors as a tool during imitation instruction, has emerged as a promising new method for teaching imitation to children with ASD (e.g. Miller, Rodriguez, & Rouke, 2015; Du & Greer, 2014)

Mirror imitation training evolved from a combination of prior research investigating mirrors as teaching tool for dance imitation instruction (i.e. Dearborn & Ross, 2006), and research on the development of generalized imitation skills in infants (e.g. Erjavec, Lovett, & Horne, 2009). Du and Greer (2014) applied these research findings by using mirrors as a tool for teaching imitation skills to children with ASD. Du and Greer (2014) investigated this teaching method through a comparison of one group of participants who were taught sets of motor imitation actions using face-to-face DTT instruction and another group of participants who were taught using MIT. Once criterion was met for each set, all participants were probed for the demonstration of generalized imitation and then teaching resumed. Participants in the mirror condition repeatedly demonstrated increased performance on generalized imitation probes, while participants in the face-to-face instruction group maintained low levels of responding across the span of the study.

Participants in the Du and Greer (2014) mirror-trained group also met criteria for all 30 imitation sets at the end of the study suggesting that it was effective in producing specific imitation skill acquisition. On the other hand, participants in the face-to-face instruction group only met criterion for a total of six sets across all participants. This difference in skill acquisition occurred primarily because the participants in the face-to-face instruction group required more instructional trials per set until criteria were achieved. These preliminary findings support the notion that MIT may be more effective than DTT in developing specific and generalized imitative repertoires.

Following Du and Greer (2014)'s findings on the potential effectiveness of mirror training with children with autism, Miller, Rodriguez, and Rourke (2015) compared mirror training with typical face-to-face instruction for a two-year old boy with ASD. The participant was taught one set of gross motor imitation actions in front of a mirror, and one set of imitation actions with the mirror absent. The results indicated that less sessions were required to meet criteria for the set of actions that was taught in the mirror-present condition (28 sessions) than the set that was taught in the mirror-absent condition (54-57 sessions). In this study MIT led to fewer sessions to criterion for the participant, which could identify MIT as a more efficient teaching procedure than DTT if replicated with other children with ASD.

Although encouraging, the results from previous studies involving MIT must be interpreted with caution due to the selection of participants and the experimental designs used. Du and Greer (2014) described their participants in terms of their vocal-verbal abilities and mentioned some assessments of motor abilities but did not specify inclusion criteria for participation or the status of the participants' imitative repertoire before MIT. Similarly, in the Miller and colleagues (2015) study, only one participant was included, and minimal description of the participant's imitation skills and learning history were provided. The ambiguities and omissions in participant description make it unclear if all participants showed similar levels of functioning or if findings represented diverse pre-MIT skill-sets.

The designs of these studies were also somewhat problematic. A limitation of the Du and Greer (2014) study is the inability to analyze individual participants within a between-groups design. The results only show that *overall* participants were more successful in the MIT condition, but it is unclear if there were some participants that were more successful in the face-to-face instruction condition, or if there were participants that performed poorly in the MIT condition. This group-level analysis becomes difficult in considering the application of using MIT in a clinical setting for specific children with ASD. Although the Miller et al. (2015) study did allow for individualized analysis, the adapted alternating treatment design exposed the participant to both conditions simultaneously. This exposure could cause sequencing effects from the face-to-face condition to the MIT condition. Thus, the rapid increase in imitation skills in the MIT condition could have resulted from the combined effect of both conditions rather than MIT alone.

The previous studies examining MIT (i.e. Miller, Rodriguez, & Rouke, 2015; Du & Greer, 2014) have promising implications for the use of MIT in evoking generalized imitation for children with ASD. However, these previous studies were limited in the minimal descriptions of the participants who acquired imitation skills through MIT and the nature of the experimental designs used. Further investigation is warranted into how clinically relevant and effective MIT is as an imitation teaching procedure. Given that common methods of imitation training such as DTT are effective for some but not all children with ASD, it is possible that MIT training may be optimal for those learners that have not been able to acquire generalized imitation skills after being exposed to traditional teaching methods.

The current study examines the use of MIT as an intervention for children with ASD who have been exposed to DTT imitation instruction but continue to demonstrate persistent deficits in generalized imitation. MIT was evaluated using clinically-relevant procedures, a systematic design that allowed for analysis both within and across participants, and the use of objective inclusion criteria to allow for the purposeful selection of participants who did not demonstrate a generalized imitative repertoire before MIT. MIT could therefore be validated as an effective intervention procedure that could be applied in a clinical setting for children like the current participants who do not demonstrate generalized imitation when taught using a traditional DTT approach. The specific research questions were:

a) Does exposure to MIT increase specific imitative responding of trained targets?

b) If MIT results in specific imitative responding, does responding to trained targets generalize to a face-to-face DTT context?

b) If MIT results in specific imitative responding, are there also increases in generalized imitative responding to untrained targets?

METHOD

Participants

A total of eight, 3- to 4-year-old children enrolled in an early intensive behavioral intervention (EIBI) program were referred as potential participants due to their reported lack of generalized imitation skills by each of their Board Certified Behavior Analysts (BCBA). All children had a medical diagnosis of ASD and were currently enrolled and receiving services at one of the three affiliated EIBI centers at the time of participation. Of the eight children originally recruited, three children were selected for inclusion in the study.

The eight referred children were assessed for inclusion in the present investigation using a researcher-created imitation assessment. During the assessment, the researcher presented 20 different actions of varying complexities in a face-to-face DTT format and then recorded data on whether the child independently imitated each modeled action. If the participant imitated greater than 50% correct during the assessment, the participant was excluded from the study. If a participant imitated less than 50% correct, the assessment was repeated for three to five sessions until it was determine that low-levels of responding persisted. Of the 20 actions originally presented in the initial inclusion assessment, the following targets were removed from the teaching sets due to consistently high performance across all participants: Peek-a-boo, arms up, hands on head, fingers to nose, hand tapping wrist, hands on cheeks, and hand covering one eye.

Henry was a 3-year-old boy with a medical diagnosis of ASD in his first year of EIBI at one of the participating sites. In the most recent Verbal Behavior Milestones Assessment and Placement Program (VBMAPP; Sundberg, 2008) assessment prior to participation in the present study, Henry scored a one on level 1 of the VBMAPP indicating that he imitated less than four gross motor movements during the assessment. Henry also did not imitate vocalizations, scoring a zero on level 1 of the VBMAPP for echoic behavior, and primarily communicated with one to two syllable vocalizations and some sign language at the time of assessment, scoring a one on vocal behavior for level 1. Henry's mean responding during the initial inclusion assessment prior to MIT was 38% (range, 10% to 80%). When an imitation trial was presented during the inclusion assessment Henry often responded with an incorrect movement using the same general area of the body as the modeled action. For instance, if any actions involving the face or any part of the head were modeled (e.g. touching their cheeks, covering their ear, touching their head, or covering their eyes) Henry would perform the same response of putting both hands on top of his head.

Henry's BCBA prescribed a treatment goal of imitating a variety of one-step gross motor movements and a DTT procedure was implemented to teach a variety of one-step actions. Henry performed nine gross motor movements during baseline and learned to imitate three additional movements in 20 sessions with DTT instruction for a total repertoire of twelve simple gross motor actions. Despite performance of these specific imitation skills during DTT, Henry's primary behavior technician reported he did not imitate untrained vocalizations, one-step gross motor movements, play actions with objects or spontaneous imitation in the natural environment.

Jack was a 3-year-old boy with a medical diagnosis of ASD in his first year of EIBI at one of the participating sites. He had previously been enrolled in an early special education program. Prior to participation in the present investigation, Jack's most recent VBMAPP assessment (Sundberg, 2008) revealed that he received a score of zero on imitation for level 1 after not imitating any gross motor movements presented by the assessor. He did not echo vocalizations receiving a score of zero for echoic behavior on level 1 and made several one to two syllable vocalizations receiving a score of two on level 1 for vocal behavior. In the inclusion assessment before MIT, Jack's mean responding was 43% (range, 0% to 90%). Each time an action was modeled during the assessment with the instruction "do this". Jack would typically perform several previously trained targets without attending to the modeled action.

Jack's BCBA prescribed a DTT program to teach one-step imitation of gross motor movements and the program was implemented for over a month before MIT was introduced. Jack met site mastery criteria of 80% for nine gross motor actions in DTT teaching, for a total trained repertoire of nine simple gross motor actions but was unable to perform these specific imitation skills reliably and did not demonstrate generalized imitation.

Charlie was a 3-year-old boy with a medical diagnosis of ASD in his first year of EIBI at one of the participating sites. Charlie had previously been enrolled in an early childhood special education program. In the most recent VBMAPP assessment (Sundberg, 2008) prior to participation, Charlie was able to imitate one gross motor movement to receive a score of one on level 1 imitation but did not respond to any other imitation trials. He received a score of zero for echoic behavior on level 1 and only emitted one sound receiving a score of one on level 1 for vocal behavior during the assessment. For the initial inclusion assessment Charlie's mean responding prior to MIT was 21% (range, 0% to 50%). During the assessment Charlie often responded incorrectly to imitation trials by engaging in multiple previously trained targets in rapid succession or did not respond with any gross motor movement at all.

A DTT program teaching one-step imitation of gross motor movements was prescribed by the BCBA. Charlie performed nine gross motor actions during baseline and learned three additional actions in 16 sessions with DTT instruction for a total trained repertoire of twelve simple gross motor actions. Despite meeting site criteria, Charlie was unable to perform those specific imitation skills reliably and did not demonstrate generalized imitation skills.

Setting and Materials

Baseline, probe, and teaching sessions were all conducted in the EIBI centers' treatment rooms at one of the three participating sites. The three sites differ slightly from each other in terms of size and arrangement of furniture, teaching materials, and play materials. However, all sites were structured with a defined play area, snack tables, a group meeting area, and small blue tables with child-size chairs dispersed throughout the room for individual sessions. Baseline and probe sessions took place next to the blue teaching table at each participant's individual work station with the implementer sitting in a child-size chair across from the participant.

During mirror imitation training, a 127 cm tall by 36 cm wide mirror with plexiglass (to avoid potential injury of the child if the mirror were to fall or break) was placed against a wall in the treatment room in the EIBI center. The implementers were instructed to place the mirror in an area of the room that had either a blank wall or at least no other children, adults, toys, or materials across from the mirror to limit the amount of visual information in the mirror. Implementers leaned the mirror up against the classroom fridge, on one side of a small hallway near the bathroom, or next to their individual work station in the back corner of the room. Across all phases, paper and pen were used to record correct and incorrect responses on researcher-developed datasheets (see Appendix).

Implementers

Three currently employed behavior technicians at each site were recruited as implementers to carry out MIT sessions. Implementer criteria included: recommendation from the on-site BCBA, experience working as a behavior technician for at least three months, and 80% fidelity during a procedural integrity assessment immediately following a training session with the researcher. During training, the researcher met with each behavior technician individually and taught MIT using behavioral skills training (Parsons, Rollyson, & Reid, 2012). Training consisted of the researcher providing a description of the procedures and modeling each step for the technician. Each technician then implemented the procedure with a child who was not selected as a participant in the current study and received feedback from the researcher regarding fidelity of implementation. Following training, procedural integrity was assessed by the researcher.

Measurement of the Dependent Variable

The dependent variable was participant performance on correct imitation of modeled gross motor actions. A response was recorded as a correct imitative response if the participant independently engaged in a gross motor response that corresponded with the operational definitions for the class of accepted topographies. Those variations in gross motor movements that were accepted as corresponding sufficiently to the model were predetermined for each of the twelve targets before the start of the study as illustrated in Table 1 of the Appendix. Incorrect responses were recorded if the participant engaged in a topography of responding outside of the accepted variations.

Imitation performance was summarized by the percentage of correct independent imitations of modeled gross motor actions per each 10-trial session. A total of 12 gross motor actions, depicted in Table 1 of the Appendix, were selected from gross motor movements used in prior imitation research studies (Erjavec, Lovett, & Horne, 2009; Miller, Rodriguez, & Rourke, 2015). The 12 movements were divided into four sets, each set with three gross motor movements to be modeled during imitation trials. For teaching purposes, the target responses were grouped together into four sets of three targets. Targets were then assessed during 10-trial sessions for each specific set. During each session two of the three targets were presented three times in a session and one of the targets was presented four times

Setting generalization was measured as the percentage of correct independent responding for trained sets of gross motor actions per 10 trial probe session when implemented DTT in the classroom setting. Response generalization was measured as the percentage of correct independent responding of the untrained set of gross motor actions per each 10-trial probe session.

Interobserver reliability. Across teaching sessions, the researcher collected data on participant performance and compared data with the implementer to evaluate reliability between observers. The implementer then recorded data on participant performance during probe sessions conducted by the researcher. Interobserver reliability was scored for at least 30% of total sessions across all three participants and types of sessions through comparison of interobserver agreement (IOA) between the implementer and researcher.

The percentage of IOA was calculated with a trial by trial evaluation of agreement or disagreement. An agreement was scored for each trial that the implementer and observer recorded the same response. A disagreement was scored for each trial that the implementer and observer recorded differing responses. The number of agreements were divided by the sum of agreements and disagreements, then multiplied by 100 to determine the percentage of agreement.

IOA was 93% (range, 80%-100%) for Henry, 95% (range 80-100) for Jack, and 95% (range 80-100%) for Charlie.

Experimental Design

The experimental design in the proposed study was a multiple probe design across participants as diagrammed in the Appendix. Baseline probe sessions were conducted for all participants at the same time for all four sets of targets, mirror imitation training for the first set then began for the first participant while the other two participants continued treatment as usual. After the first participant met criteria for their first set of MIT, all sets were probed across all participants. These procedures were then replicated with the second and third participants.

Procedure

Probe sessions. The participants were assessed for their baseline levels of imitative performance on an initial baseline probe session involving all four of the gross motor imitation action sets. Once criteria were met for a set of gross motor imitation actions in the mirror imitation training context, the same set of imitation actions was assessed in a DTT face-to-face context to evaluate setting generalization. After criteria were met for each set of imitation actions in the mirror training context by a participant, the remaining untrained sets of gross motor imitation targets that were performed at less than 50% correct independent responding at baseline were probed to evaluate potential increases in response generalization. Probes to assess for generalization were procedurally identical to the initial baseline probes apart from the number of sessions (described below).

Each probe session took place within the EIBI classroom where individual programming with the child would typically take place. The session began with the participant and the researcher both sitting in child size chairs across from one another. The researcher called the participant’s name or waited until the participant looked at the researcher then presented the verbal instruction “do this” while modeling a predetermined gross motor action. Edible reinforcement or tokens were provided non-contingently on a fixed ratio of every third response (correct or incorrect), with social praise provided for sitting and attending.

During each probe session the researcher presented ten trials of targets from each of the four sets of actions. The researcher began with the first set of gross motor actions, presenting each of the four target responses in a semi-randomized order with each target presented at least twice. After one 10-trial session of the first set, the participant was given a brief break to move around the classroom or access a preferred tangible item, and then the implementer began probes for the actions in the remaining three sets in sequential order. Three probe sessions were conducted initially before the introduction of MIT to any participants, and then one probe session was conducted following acquisition of each set using MIT.

Mirror imitation training. Prior to each session, the implementer presented an array of several edibles or tangible items identified as frequently preferred by the participant's current behavior technician at the time of the session. When presenting the array, the implementer instructed the participant to "pick one" and then represented the array without replacing the selected item. This procedure was repeated two more times then the first three selected items were used as reinforcement during instruction. Once a selection order was determined, the participant was given a small piece of a highly preferred edible or token for each independent or prompted correct response along with descriptive social praise (e.g., "you did what I did!").

During MIT, the implementer acquired the lengthwise mirror from the staff office and leaned it up against the wall in an area of the treatment room with minimal distractions. The implementer physically prompted or verbally directed the participant to sit directly in front of the mirror. The implementer then sat behind and to the right of the participant on the floor with both the implementer and the participant visible in the mirror in front of them. The implementer established attending by either calling the participant's name or making eye contact with them in the mirror. Once attending was established, the implementer provided the verbal discriminative stimulus “do this” while modeling one of the four target responses in the training set of gross motor actions. The implementer then provided a physical prompt for the child to complete the modeled action using a most to least prompt fading strategy (Cengher et al., 2016) beginning at an immediate full hand over hand physical prompt and then fading systematically across sessions according to a predetermined prompt hierarchy (see appendix for protocol).

If a physical prompt was provided but the participant did not engage in a correct response or the child made an error before a prompt was provided, the implementer completed an error correction procedure: The error was blocked and the implementer provided an informational “no” in a neutral tone and then the trial was represented with immediate full-physical guidance to complete the modeled action correctly with no reinforcement delivered. The trial was then represented again at the original prompting step with neutral verbal feedback such as “yep, that’s what I was looking for”, again with no delivery of reinforcement. Teaching would then resume with the presentation of a new trial and a different imitation action. Similar to probe sessions, each of the three actions in the training set were presented in a semi-randomized order to ensure all targets were presented proportionately without predictability. The order that each action was presented also was altered from one session to the next to further balance the number of times each target was presented, so that if one target was presented four times, it would only be presented three times in the subsequent session. A participant was determined to be accurately performing imitation skills for each training set when the participant independently responded correctly for 80% of trials per 10-trial session across three sessions occurring over two or more days.

Procedural integrity. The procedural integrity of implementation was documented by measuring the extent to which the implementer performed the procedures as indicated for at least

30% of total sessions distributed across baseline, probe, and teaching conditions. During MIT, the researcher recorded procedural integrity data on each observed session with the use of a checklist (see Appendix). The behavior technicians recorded data on the researcher's procedural integrity during probe sessions. The checklist explicitly stated critical components of the procedure that were each scored relative to the implementer and researcher's performance during the observation. Procedural integrity scores were 91% (range, 82%-100%) for Henry, 98% (range 91%-100%) for Jack, and 97% (range 82%-100%) for Charlie.

RESULTS

Before exposure to MIT, Henry's performance was below 50% correct across all sets (see figure 1 in appendix). After exposure to set 1 with MIT, Henry demonstrated increased correct responding on the first probe session with 80% on set 1, 70% on set 2, 70% on set 3, and 100% on set 4. During the second probe session after exposure to set 2 with MIT, Henry's performance again increased to 100% on set 1, 80% on set 2, 100% on set 3, and 100% on set 4. During the third probe session Henry maintained high levels of correct responding with 90% on set 1, 90% on set 2, 100% on set 3, and 90% on set 4.

Henry demonstrated 50%, 20%, and 40% correct responding on set 1 across the three initial baseline sessions. During MIT, Henry's mean correct responding was 42% (range, 0% to 90%) with rapid acquisition of targets in set 1, meeting criteria in 13 sessions. In the DTT probe for set 1, Henry imitated at 80% accuracy, which met the predetermined mastery criterion.

On all three baseline sessions of set 2 Henry demonstrated 0% correct responding, which then increased during MIT to a mean of 69% (range, 0% to 100%) correct responding. Henry achieved performance criterion in seven, 10-trial sessions for set 2. In the DTT probe following set 2, Henry performed at 70% correct responding which was significantly higher than baseline but lower than criteria. It is notable that he achieved this score because he failed to correctly imitate the same target each time it was presented (crossing his body to touch the opposite shoulder), correctly imitating the other two targets in the DTT probe and being able to reliably perform this target in the mirror. On the second post- MIT probe for set 2 Henry's correct responding increased to 100% on set 3 and maintained at 100% for set 4, despite neither set being explicitly taught.

On the first probe across participants before exposure to MIT, Jack performed at less than 50% correct responding across all sets: performing at 30% correct on set 1, 0% on set 2, 30% on set 3, and 10% on set 4 (see figure 1 in appendix).. After exposure to set 1 with MIT, Jack's scores on the second probe session increased to 100% for set 1, 50% for set 2, 50% for set 3, and 90% for set 4. Following set 2 with MIT, Jack maintained criteria level performance on set 1 with 80%, increased performance on both set 2 and set 3 to 70%, and performance decreased slightly to 70% on set 4.

For set 1, Jack performed baseline scores of 40%, 20% and 50%. MIT was then introduced with set 1 and Jack's mean responding was 46% (range, 0% to 90%), meeting criteria in 12 sessions. In the DTT probe for set 1, Jack achieved 100% correct responding, maintaining criteria-level performance. On set 2, Jack originally achieved 40%, 30%, and 20% correct responding on baseline sessions, but demonstrated a mean performance of 60% (range, 0% to 100%) during MIT- meeting criterion in 8 ten-trial sessions. After meeting criterion for set 2, Jack maintained criteria-level responding by achieving 90% correct in the DTT probe.

Before MIT was introduced, Charlie performed at less than 50% correct responding across all sets (see figure 1 in appendix). On the first probe session, Charlie performed at 20% correct on set 1, 30% on set 2, 10% on set 3, and 0% on set 4. During the second probe session, Charlie maintained low levels of correct responding with 10% on set 1, 20% on set 2, 10% on set 3, and 30% on set 4. Charlie demonstrated the lowest scores for set 1 across participants with 30%, 10% and 10% correct responding during baseline. Set 1 was then taught with MIT and Charlie met criteria in 12 sessions, with a mean performance of 57% (range, 0% to 90%). On the DTT probe, Charlie maintained criteria-level responding by achieving 80% correct responding on set 1. Charlie also demonstrated increased responding on the three untrained sets performing scores of 30% on set 2, 50% on set 3, and 50% on set 4 in the post-MIT probe session.

On set 2 Charlie demonstrated 20%, 10%, and 10% correct independent responding at baseline and then demonstrated a mean performance of 46% (range, 0% to 90%) at the completion of 22 sessions of MIT. After meeting criterion for set 2 in the mirror, Charlie maintained 80% correct in the DTT probe, and increased correct responding on the remaining

Figure 3. Charlie’s Performance on Imitation Targets

untrained sets. In the post-MIT session, Charlie’s correct imitative responding on set 3 increased to 70%, and 70% on set 4.

DISCUSSION

Du and Greer (2014) and Miller and colleagues (2015) hypothesized the emergence of a generalized imitative repertoire following MIT, however the between-groups and alternating treatment designs used in each study limited the extent to which this relationship could be demonstrated. The current study extended previous research on MIT by using a multiple probe research design that allowed for individualized analysis across multiple participants before and after exposure to MIT.

Experimental control can be seen most clearly in Charlie's data because he was in the "treatment as usual" condition for the longest amount of time as he maintains low levels of performance across all probe sessions before MIT, and then an immediate increase in responding is demonstrated following MIT exposure. Similar demonstrations of effect can also be seen in Henry and Jack's data as responding during probe sessions increase contingent on exposure to MIT.

The use of a multiple probe design also provided the opportunity to conduct a systematic investigation across multiple time points. The participant performance in each of the probe sessions demonstrates a functional relationship between MIT and the emergence of generalized imitation. Henry, Jack, and Charlie all demonstrated increases in trained and untrained responding following exposure to MIT and then continued to demonstrate increases in each subsequent probe session. The increase in responding during probe sessions across time, despite only explicitly teaching two of the four sets, is consistent with the development of a generalized imitative repertoire which would allow the participants to contact more naturally occurring imitation trials throughout the day outside of contrived teaching sessions leading to an increase in overall imitative performance.

The functional relation between MIT and the development of generalized imitation suggests using a mirror during imitation training has a unique advantage when compared to DTT which alone, did not result in generalized imitation for any of the three participants. Procedurally, MIT and DTT are very similar- an action is modeled, a verbal instruction "do this" is provided, and physical prompts are systematically provided for the child to perform the modeled action. The main difference between the two teaching procedures is that in MIT the child can see both themselves and the person modeling the action, while in DTT the child can only see the model.

Without the ability to view both themselves and the model in DTT, it may be difficult for the child to derive a matching relation between their movement and the modeled response. In MIT imitation becomes a matching skill, where responses are reinforced based on their correspondence to the provided model. When a child engages in a response that is incorrect, the child can visually see the ways in which his or her response did not match, which can provide a source of instructional feedback. Then, during the error correction procedure they can watch the response that should be performed.

It is hypothesized that the enhanced immediacy and quality of feedback when teaching with a mirror may help the child discriminate what responses are and are not reinforced, resulting in greater stimulus control for imitation trials. During the initial inclusion assessment prior to MIT, all three participants responded to imitation trials by either performing an action other than the modeled action, performing a series of previously trained actions, or not responding with any motor movement at all. These responses may have been reflective of attending to irrelevant features of the environment or not discriminating which responses result in reinforcement indicating weak stimulus control when an imitation trial is presented in a DTT format.

We also examined whether the actions that met criteria during MIT could be performed in a DTT context without the mirror present. For set 1, the targets that met criteria in the mirror were performed at or above criterion level when probed in a DTT context with no mirror present for all three participants. For set 2, Jack and Charlie were again able to perform at or above criterion level in a DTT context. Henry, however, was unable to perform one of the targets in set 2 in a DTT context despite being able to perform the target reliably in the mirror. The orientation-specific challenges that Henry demonstrated with the cross-body target may suggest limitations in generalization for specific targets. Nevertheless, the generalization to another teaching context for most targets across the three participants indicates that using a mirror during teaching is unlikely to limit generalization of most imitation skills to other contexts.

Prior research investigating the effects of MIT (e.g. Du & Greer, 2014; Miller, Rodriguez & Rourke, 2015) were challenging to replicate due to the ambiguities and omissions in participant description which made it unclear who MIT is effective for. Most notably, it was not described how participants were selected for participation or what their imitative abilities were prior to MIT. Contrasting these previous studies on MIT, a comprehensive description of each participant's imitation abilities were provided in the current study including: imitation-relevant VBMAPP skills (gross motor imitation, echoic skills, vocalizations), an anecdotal description of how each participant typically responded to imitation trials, and a specific description of each participant's exposure to DTT (including the specific number of actions that had been mastered) before the start of the study.

In the present investigation, specific and objective inclusion criteria was explicitly stated to identify the process in which participants who demonstrated significant deficits in imitation skills prior to MIT were selected. This thorough identification of participants not only facilitates replication for future research, but also provides the opportunity for clinical practitioners to comparatively identify clients who share similar learning histories and may be ideal for learning imitation using MIT.

Limitations

A multiple probe design was used instead of an alternating treatment design to avoid sequencing effects, however some combinative effects may have still resulted because participants were receiving DTT before and during the study. Although the systematic introduction of MIT and periodic probes across all participants suggest that the increases in generalized imitative responding followed most immediately after MIT was introduced, it is possible that DTT or other imitation training contributed to the development of a generalized imitative repertoire. Therefore, it cannot be claimed that MIT is exclusively responsible for producing generalized imitative repertoires. To make this claim, future researchers should identify participants who had not been exposed to DTT to evaluate if MIT could produce generalized imitation in isolation, or if it is most effective when combined with DTT or other methods of teaching imitation skills.

The varying levels of difficulty between the targets that were selected may be another limitation of the current study. For instance, Henry, Jack, and Charlie all performed most successfully on set 4 and least successfully on set 2 across all probes, suggesting the targets may not have been balanced across all sets. In particular, the cross-body movement of touching the opposite shoulder that was a target in set 2 proved difficult for all three participants: Henry, Jack, and Charlie all were able to reliably perform the other two targets in set 2, but were not able to master the entire set because of unreliable or consistently incorrect responding when the cross-body target was presented. It is possible that if this cross-body target were removed, all participants may have met criteria for the entire set in fewer sessions and Henry may have performed at criterion level in the DTT probe following MIT for set 2. Future research could address this limitation by explicitly evaluating the difficulty of each action that is selected as a target to allow for a more equal comparison across and within sets. Future research may also investigate the special considerations of cross-body imitative movements, and how to facilitate generalization of cross-body movements in an MIT to face-to-face setting.

A third notable limitation is that there was a brief pause in MIT sessions for Charlie and Henry as both participants went through an intensive toilet training program. During this time, other instructional programs, including MIT, were stopped for four days. This gap in implementation may be reflected in the larger number of trials to criteria for Charlie on set 2, as there was a significant dip in the data trend after research sessions resumed following toilet training.

Future Research

The results of the current study identify MIT as effective for teaching both specific and generalized imitation skills to some children with ASD. However, many questions about the boundaries of its application arise. Henry, Jack, and Charlie were all 3- to 4-year-old boys in an EIBI setting with ASD who demonstrated some imitative skill acquisition in a DTT arrangement. It is unknown if similar results would be found with different populations such as older children, children who perform little to no imitative responding in a DTT format, or individuals with a diagnosis other than ASD.

Further research is also needed to analyze how and why using a mirror during instruction facilitates the development of specific and generalized imitation skills. More specifically, participant preference of MIT compared to other procedures could be evaluated. It is possible MIT was more effective for participants because they preferred the mirror context more than DTT with the novelty of a mirror or the increased social attention and physical contact resulting from the positioning of the behavior technician behind the student during MIT sessions. Another aspect of MIT to evaluate is if it facilitated attending to the model. If participants demonstrated better attending during imitation trials with the mirror, they may learn more efficiently. Finally, the hypothesis presented in the discussion that the mirror may provide additional visual information and immediate feedback to the child on how well their movement matches the model could be investigated empirically.

Conclusion

Findings from the current study demonstrate that MIT appears to be an efficient and effective method of teaching imitation skills to some children with ASD. Beyond its ability to produce specific imitation skill acquisition, it was effectively used as an intervention for three children with ASD who were not demonstrating reliable imitation skills despite exposure to common teaching methods. The possibility of inducing a generalized imitative repertoire as demonstrated by the gains in imitative responding for untrained sets across all three participants establishes the use of a mirror as a powerful tool for teaching imitation.

APPENDIX

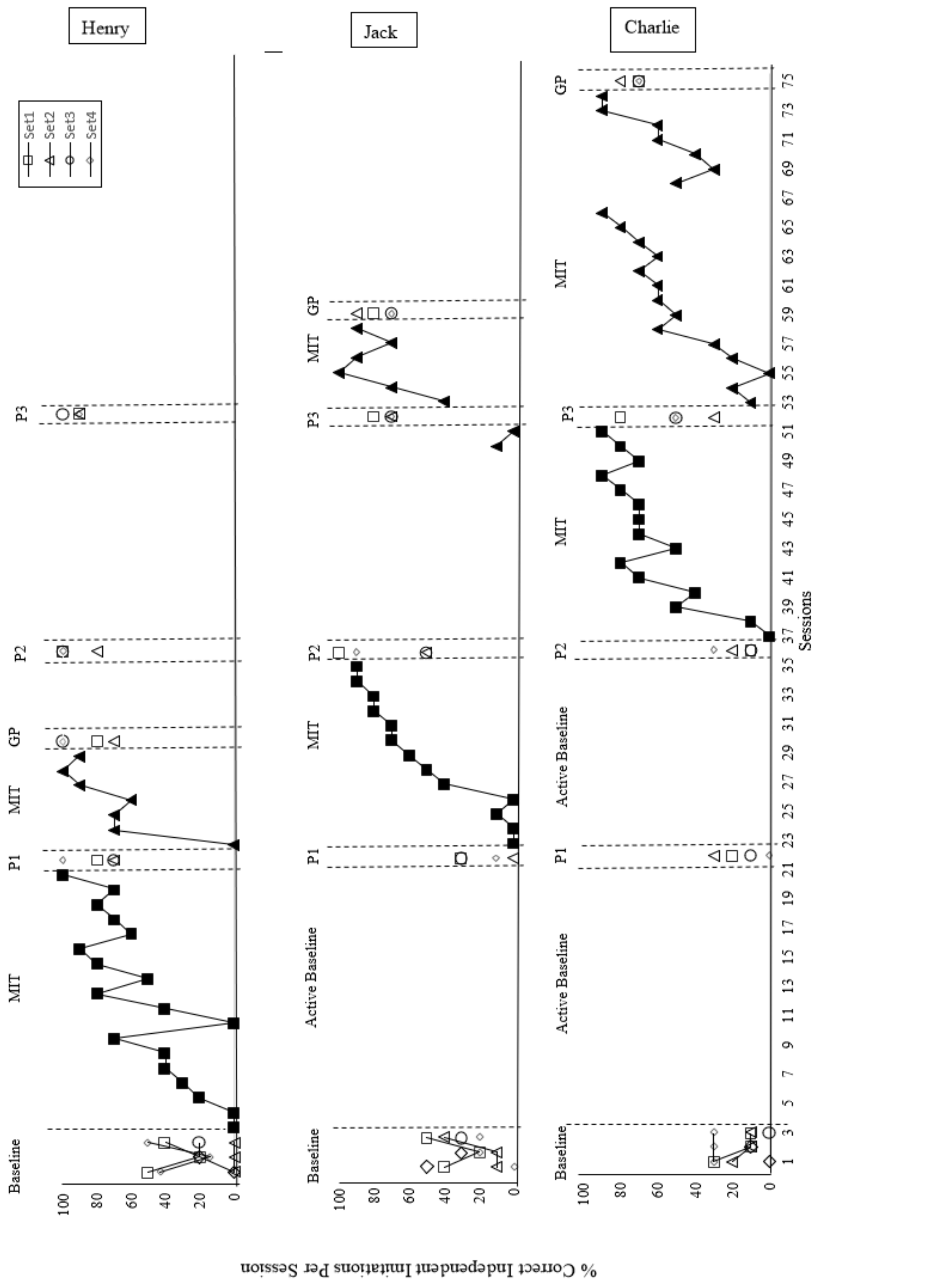

Figure 1. Imitation Performance Across Participants
MIT= mirror imitation training, P1=first probe session, P2= second probe session, P3= third probe session, GP= generalization probe

Definitions of Imitation Targets				
Targets	**Action**	**Behavior To Model**	**Correct Response**	**Incorrect Response Examples**
Set 1 Actions				
Action A	Tap Fists Together	Both hands formed into fists repeatedly tapping at the knuckles	Both hands formed into fists with any part of the front of the fist making contact with the front of the other fist	Open palms clapping together, fist tapping back of hand, fist tapping any part of the arm below the wrist
Action B	Hands to tummy	Both hands tapping stomach	Both hands touching stomach or lower chest	Hands touching shoulders, hands out to side, hands tapping legs
Action C	Open and Close Fist	One hand held up with palm outward with fingers repeatedly extended outward and curled into a first	One open hand held upwards with fingertips closed to touch palm	Both hands held up with closing and opening firsts, shaking hands back and forth, fingers moving but not touching palm

Definitions of Imitation Targets				
Targets	**Action**	**Behavior To Model**	**Correct Response**	**Incorrect Response Examples**
Set 2 Actions				
Action A	Body Side to Side	Sitting straight upwards move upper torso to the left and then to the right repeatedly	Student sits straight upwards and then makes a visible movement at least three inches to the left and then at least three inches to the right from the upwards sitting position	Moves head from side to side but their body remains sitting upwards, leans all the way to one side only, wiggles in sitting position without visible outward movement
Action B	Hand cross to shoulder	Right hand reaches across to left shoulder	One hand touching the side, front, or top of the opposite shoulder	Hand touching same shoulder, hand touching head, both hands crossed to opposite shoulders
Action C	Hand over ear	Right hand cupped over right ear	One hand is touching the ear on the same side of the body	Hand touching opposite ear, hand touching chin, hand raised towards ear but not touching any part of the head, hand touching back

Table 1. Imitation Action Definitions for Set 1 and Set 2

Definitions of Imitation Targets				
Targets	**Action**	**Behavior To Model**	**Correct Response**	**Incorrect Response Examples**
Set 3 Actions				
Action A	Rub Stomach	One hand with palm pressed to the stomach moving in a circular motion	One hand touching stomach or lower chest and moving in a circular motion	Both hands rubbing the stomach, one hand moving in front of the stomach but not touching, hand moving back and forth on stomach in a non-circular motion
Action B	Arms out to side	Both arms lifted outward	Both arms are raised in an outward motion	Hands raised upwards above the head, hands raised in front of the child
Action C	Palms Up Bowl	Both hands held out with palms facing up and brought together until all parts of the pinki finger and inside palm are touching	Both hands held out with palms facing up with at least part of the inside palm touching the other hand	Both hands held up with back of hands touching, hands brought inwards but not making contact with each other, hands up with only fingertips touching

Definitions of Imitation Targets				
Targets	**Action**	**Behavior To Model**	**Correct Response**	**Incorrect Response Examples**
Set 4 Actions				
Action A	Cross Arms in Front	Both arms fully extended out in front then brought inwards to cross at the wrists	Arms lifted out in front with arms crossed making contact between the elbow and wrist	Arms hugging body, arms in front with hands together, hands crossing but not making contact with any part of the arm
Action B	Rub Hands Together	Both hands pressed palm to palm repeatedly sliding forwards and backwards in a sliding motion	Both hands with most of the palms touching sliding against each other in a back and forth motion	Hands moving back and forth but not touching, fists or back of hand sliding against each other
Action C	Hand to mouth	Right hand tapping open mouth	Either hand touching mouth	Blowing a kiss, hand touching under chin, finger inside of mouth, hand tapping nose

Table 2. Imitation Action Definitions for Set 3 and Set 4

Child initials:
Objective: Child will imitate motor movements
Condition: MIRROR IMITATION TRAINING
Prompt type: Physical (Graduated Guidance)

Motor Actions	
SET 1	
A	**Tap Fists Together :** Both hands formed into fists repeatedly tapping at the knuckles
B	**Hands on Tummy:** Both hands tapping stomach
C	**Open and Close Fist:** Make a fist with right hand, open to show palm and then make another fist

Condition: MIT		
Date:		
Start prompt:		
Trial	**Action**	**Data**
1	Tap Fists Together	NR E P- P+ +
2	Hands on Tummy	NR E P- P+ +
3	Open and Close Fist	NR E P- P+ +
4	Tap Fists Together	NR E P- P+ +
5	Open and Close Fist	NR E P- P+ +
6	Tap Fists Together	NR E P- P+ +
7	Hands on Tummy	NR E P- P+ +
8	Hands on Tummy	NR E P- P+ +
9	Tap Fists Together	NR E P- P+ +
10	Open and Close Fist	NR E P- P+ +
End Prompt:		
P + Correct:		
% Independent:		
BT initials:		

Condition: MIT		
Date:		
Start prompt:		
Trial	**Action**	**Data**
1	Hands on Tummy	NR E P- P+ +
2	Tap Fists Together	NR E P- P+ +
3	Open and Close Fist	NR E P- P+ +
4	Hands on Tummy	NR E P- P+ +
5	Open and Close Fist	NR E P- P+ +
6	Tap Fists Together	NR E P- P+ +
7	Tap Fists Together	NR E P- P+ +
8	Open and Close Fist	NR E P- P+ +
9	Hands on Tummy	NR E P- P+ +
10	Open and Close Fist	NR E P- P+ +
End prompt:		
P + Correct:		
% Independent:		
BT initials:		

Condition: MIT		
Date:		
Start prompt:		
Trial	**Action**	**Data**
1	Tap Fists Together	NR E P- P+ +
2	Hands on Tummy	NR E P- P+ +
3	Open and Close Fist	NR E P- P+ +
4	Hands on Tummy	NR E P- P+ +
5	Open and Close Fist	NR E P- P+ +
6	Tap Fists Together	NR E P- P+ +
7	Hands on Tummy	NR E P- P+ +
8	Tap Fists Together	NR E P- P+ +
9	Hands on Tummy	NR E P- P+ +
10	Open and Close Fist	NR E P- P+ +
End prompt:		
P + Correct:		
% Independent:		
BT initials:		

Condition: MIT		
Date:		
Start prompt:		
Trial	**Action**	**Data**
1	Open and Close Fist	NR E P- P+ +
2	Hands on Tummy	NR E P- P+ +
3	Open and Close Fist	NR E P- P+ +
4	Tap Fists Together	NR E P- P+ +
5	Hands on Tummy	NR E P- P+ +
6	Hands on Tummy	NR E P- P+ +
7	Tap Fists Together	NR E P- P+ +
8	Open and Close Fist	NR E P- P+ +
9	Tap Fists Together	NR E P- P+ +
10	Hands on Tummy	NR E P- P+ +
End prompt:		
P + Correct:		
% Independent:		
BT initials:		

Figure 2. Sample Datasheet for Mirror Imitation Training

<table>
<tr><td>Student</td><td>Jack</td></tr>
<tr><td colspan="2">Program: Imitate one-step gross motor actions with Mirror Imitation Training</td></tr>
<tr><td colspan="2">Objective Child will imitate one-step actions for 80% correct for 3 sessions at across 2 days</td></tr>
<tr><th>Prompting Hierarchy</th><th>Error Correction Procedure</th></tr>
<tr><td rowspan="3">Most to least using graduated guidance: Always provide the least intrusive prompt necessary for the student to respond correctly using the following hierarchy:
Full physical prompt: Immediately after modeling the action, prompt the student with your hand over their hand to complete the modeled action
Partial physical prompt: Immediately after modeling the action, prompt the student <u>at their wrist</u> to complete the modeled action
Semi-Partial physical prompt: Immediately after modeling the action, prompt the student <u>at their forearm</u> to complete the modeled action
Brief Time Delay: Model the action and then allow the student the opportunity to respond. After 3 seconds provide a full physical prompt for the student to complete the modeled action
Independent: Model the action and then allow the student the opportunity to respond without any physical prompting provided
If student beats the prompt and makes error, run error correction procedure</td><td>Block the error as early as possible and provide a verbal informational “no” in a neutral tone

Step 1: Represent trial with immediate full-physical guidance. Provide neutral verbal feedback (e.g. “yep. That’s what I was looking for.”) with no reinforcer delivered

Step 2: Present trial again at prompting level originally errored on. Again, no reinforcer is delivered

No data collected on Steps 1 or 2</td></tr>
<tr><th>Data Recording</th></tr>
<tr><td>+ = correct unprompted
+p = correct prompted
- = incorrect unprompted
-p = incorrect prompted
NR = no response</td></tr>
</table>

<table>
<tr><th colspan="2">Teaching Procedures</th></tr>
<tr><th>Teacher Action</th><th>Student Action</th></tr>
<tr><td>Baseline/Probe: Sit in a chair across from the student. Provide imitative model. Record + if child correctly imitates model. Record - for any other response. Run 10 unprompted trials for each of the four sets (but not the novel actions set) of stimuli ensuring all targets within a set are probed at least twice within the session.</td><td>Student correctly imitates BT (see coding chart)</td></tr>
<tr><td>Mirror Imitation Training:

Preparation: Acquire the full-length mirror and lean it up against the wall lengthwise in an area of the room with minimal distractions.

Positioning: Physically or verbally prompt the child to sit down in front of the mirror, and then sit on the floor positioned directly behind and slightly to the right of the student

Instruction: Obtain attending by calling the students name and making eye contact in the mirror. Say, “Do this” and model the target action in the mirror</td><td>Student correctly imitates BT (see coding chart)</td></tr>
</table>

Figure 3. Sample Protocol Page for Mirror Imitation Training

OBJECTIVE:			
Researcher:	**Implementer:**	**Date:**	**% Achieved:**

Procedures			
Antecedent condition	**Prompt Hierarchy**	**Consequence**	**Error Correction**
1. Student sits on the floor facing the mirror with the therapist positioned behind and to the right of the student 2. Therapist obtains eye contact from the student in the mirror 3. Therapist says "do this" while modeling the target response in the mirror	1: Immediate full physical prompt 2. Immediate partial physical prompt (forearm) 3. Three sec delay then full physical prompt. 4. Six Second delay then full physical 4. Independent	Praise ("you did what I did!") and token reinforcement delivered contingent on correct imitation	1. Informational "no" 2. Represent model with verbal SD "Do this" 3. Provide immediate full physical prompt of correct imitation *No reinforcement provided*
Criteria to fade prompts:	Two consecutive sessions at 80% correct		
Return to previous prompt:	Three or more Errors or No Response per session		
Criteria to master:	Three sessions at or above 80% correct independent across at least 2 days		

Procedural Fidelity CHECKLIST		
☐	Implementer gathered required procedural materials	Mirror, token strip, individualized reinforcer
☐	Implementer obtained data materials	Relevant datasheet, pen
☐	Implementer positioned student in front of them and slightly to the left in front of the mirror	
☐	Implementer obtained attending by calling the students name or making eye contact in the mirror	
☐	Implementer provided the verbal SD "Do this" within 5 seconds of obtaining attending	
☐	Implementer modeled the relevant gross motor action	The gross motor action listed on the datasheet for the set being currently taught
☐	Implementer provided the appropriate prompt prescribed for the session	Immediate prompt, no prompt, or at the correct time delay
☐	Appropriate consequence is implemented	
	☐ *Incorrect response*: Error correction procedure is implemented	
	☐ *Correct Response:* Tangible/edible/conditioned reinforcement and social praise is immediately provided	
☐	Data is recorded on the datasheet following reinforcement delivery	
Score total: __________ / _________ = _________ x 100 = ____________		

Figure 4. Sample Procedural Integrity Checklist for Mirror Imitation Training

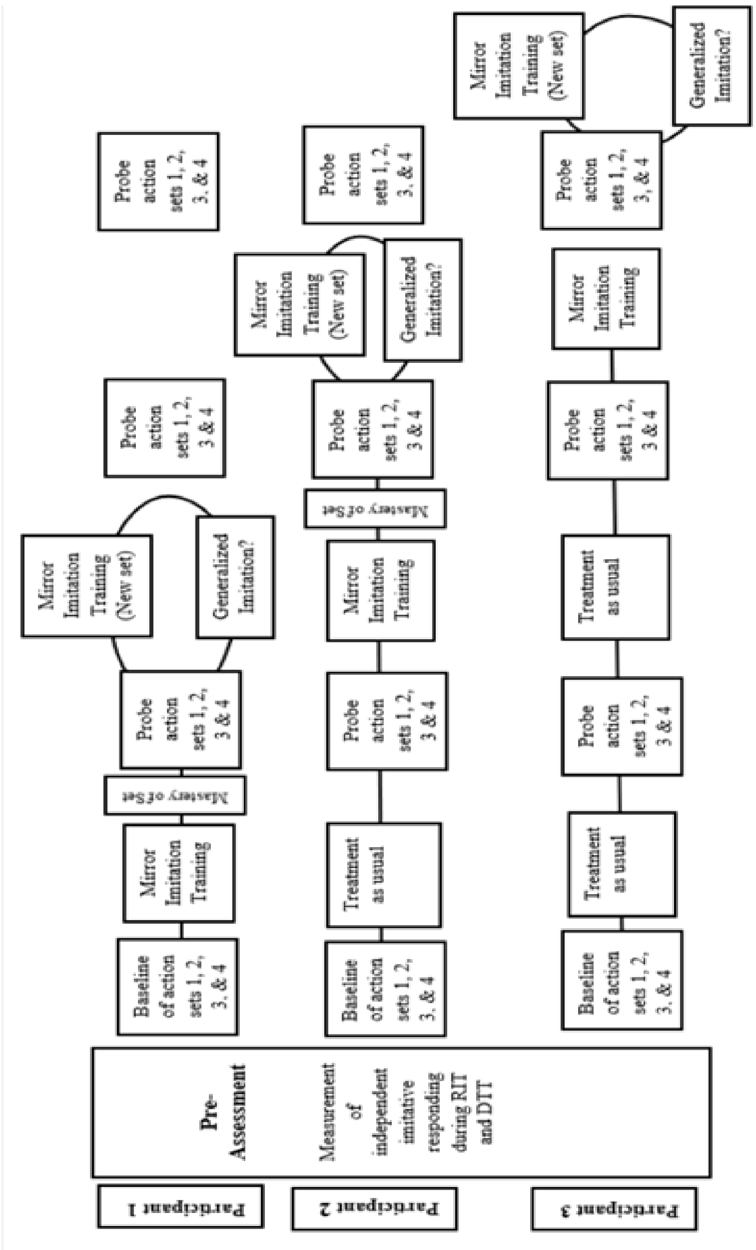

Figure 5. Diagram of Experimental Design and Procedure

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REFERENCES

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