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Repeat after you: Contingent vocal imitation increases children's vocalizations and orienting responses

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Abstract

Previous research has shown that contingent vocal imitation has a reinforcing effect on vocalizations emitted by children. Nevertheless, the precise contingencies that have a reinforcing effect on vocalizations remain unclear. This study examined the effects of five conditions (contingent vocal imitation, contingent interaction, noncontingent vocal imitation, noncontingent physical touch, and a no-interaction control condition) on the vocalizations emitted by three children with developmental disabilities. We evaluated the effects of these conditions using an alternating-treatments design embedded within a multiple-probe-across-participants design. Contingent vocal imitation led to greater increases in the vocalizations emitted by all three participants than by those in all the other conditions, and the size of this effect was large. We also found increases in orienting responses during the contingent imitation condition and increases in echoic responses postintervention for two of the participants. We discussed implications for practitioners who work with young children with language delays.

KEYWORDS
contingent imitation, orienting, vocal imitation, vocalizations

Over the past few decades, human language has captured the interest of scientists across disciplines including psychology, neuroscience, paleontology, anthropology, linguistics, molecular biology, and genetics (Mithen, 2024). Researchers have pursued intriguing lines of scientific inquiry into language from diverse theoretical perspectives. For example, chimpanzees have been shown to emit several grunts and manual signs with different functions (Soldati et al., 2023), songbirds seem to exhibit species-typical song (Doupe & Kuhl, 1999), African grey parrots have been trained to discriminate between numbers (Pepperberg, 2006), and dogs have been trained to exhibit a vocabulary seen among 2-year old human toddlers (Pilley & Reid, 2011). However, none of these animals produce a wide variety of completely novel utterances characteristic of verbal behavior often demonstrated by toddlers (e.g., Lipkens et al., 1993; Peláez et al., 2000; Sivaraman et al., 2021). Although it has captured the interest of myriad scientists, fundamental questions persist about the contingencies operating in a young child's social environment and their influence on verbal behavior.

From a behavioral perspective, early language develops as a function of contingent interaction between infants and their caregivers. Infant communication begins with crying and cooing, which may initially be respondent behavior elicited by food deprivation or a caregiver's physical touch (Alcaraz et al., 1998; Pelaez & Novak, 2024). Fairly early in development, however, these behaviors come under operant control, as consequences follow infants' cries or coos. For example, caregivers soothe, feed, or change a crying infant, leading cries to become differentiated according to specific motivating conditions (Alcaraz et al., 1998). Between 9 and 12 months of age, infants demonstrate a variety of behaviors such as orienting, canonical babbling, joint attention, social referencing, and generalized motor imitation (Mundy et al., 2007; Pohl et al., 2018; Walden & Ogan, 1988). Of particular relevance to the current study is canonical babbling (i.e., the emission of prespeech photophones such as "baba" or "kaka"), which is thought to refine vocal speech (Yoo et al., 2024). During the first year of life, protophones (speech-like sounds emitted by infants) have been shown to outnumber cries and shrieks by a factor of five and disruptions in their production are associated with an increased likelihood of language disorders (Oller et al., 1998, 2021). Infants seem to emit babbles when they are alone, as a form of vocal practice, and when they are interacting with adults (Long et al., 2020).

To identify the environmental variables influencing speech production, one aspect of early infant–caregiver interactions that has gained attention is caregivers' contingent vocal imitation of their infant's babbles (e.g., Field et al., 1985; Gros-Louis et al., 2006; Masur & Olson, 2008). Researchers have noted that during everyday interactions, caregivers often imitate their child's motor and vocal responses. Maternal imitation[1] of infant babbles resulted in more vocalizations, smiles, and complex articulations emitted by infants aged 3 to 8 months than nonimitative interactions (Field et al., 1985). In the behavior analysis literature, Peláez et al. (2011) demonstrated that contingent vocal imitation increased infant vocalizations. This study, although instrumental for the expansion of the operant learning approach to speech development, did not investigate the effects of contingent imitation on other behaviors such as orienting and echoing or the effects of other reinforcement contingencies such as contingent social interaction on infant vocalizations.

The seminal study by Peláez et al. (2011) demonstrating the effects of contingent imitation on increasing the vocalizations of human infants has since been replicated with other populations including young children with speech difficulties, children with Down syndrome, and those at elevated likelihood for autism spectrum disorder (Fiani et al., 2021; Ishizuka & Yamamoto, 2016; Neimy et al., 2020; Pelaez et al., 2018). What remains less clear is how this approach compares to other reinforcers, such as nonimitative social interaction or physical touch, when delivered contingently or noncontingently. The effects of physical touch have been shown to be critical for infants' sociocommunicative development (Cascio et al., 2019; Provenzi et al., 2020) and specifically in increasing infants' orienting responses toward the caregiver (Peláez-Nogueras et al., 1996). However, the effect of physical touch on vocalizations remains largely unexplored.

Additionally, several studies have highlighted the positive effects of contingent interaction on neurotypical infants' vocalizations (e.g., Elmlinger et al., 2019; Goldstein et al., 2003, 2009; Gros-Louis et al., 2014). However, only a few studies have compared contingent social interaction with contingent imitation, and findings have been mixed. For example, Neimy et al. (2020) investigated the effects of three mothers using contingent imitation versus motherese speech (e.g., contingently saying, "Hii sweet babyyy") and found that two of the children produced more vocalizations with contingent imitation, although one child showed similar rates of vocalizations across both conditions. In most prior studies reviewed above, mothers conducted the research sessions, making it difficult to distinguish whether vocal imitation functioned as a reinforcer on its own or whether the mother's presence served as a conditioned reinforcer. Although involving mothers may be a practical necessity when conducting sessions with infants, from both theoretical and applied perspectives, separating these effects may increase precision in identifying the specific contingent stimuli functioning as reinforcers.

Before proceeding, it is important to briefly highlight emerging developments in the nonhuman literature because an analysis of verbal behavior development is only complete when both phylogeny and ontogeny are considered (Morris, 1988). Biologists have observed vocalizations by infant bonobos and chimpanzees during early infant–caregiver interactions, similar to the babbles emitted by human infants, suggesting an evolutionary foundation of human language among nonhuman primates (Kojima, 2008; Oller et al., 2019; Sclafani et al., 2023). A critical procedural difference that has been noted is that unlike human caregivers, who are vocally responsive to infant vocalizations (through contingent imitation and other contingent verbal interactions; Masur & Olson, 2008), bonobo and macaque mothers do not emit contingent vocalizations. In addition, although these mothers respond contingently, (e.g., by picking up the infant), there is no increase in vocalizations emitted by macaque or bonobo infants over time (Sclafani et al., 2023). In contrast, human mothers emit contingent vocal responses, both formally matched and unmatched with the sound made by their infant, and they seem to be critical in promoting infants' vocalizations.

Toddlers' vocalizations do not always occur in isolation and may be emitted alongside other behaviors such as orienting toward a caregiver or shifting gaze between an object and a caregiver (e.g., Kovács et al., 2014). Investigating the collateral effects, if any, of reinforcement contingencies that influence vocalizations on other co-occurring behaviors appears to be a worthwhile pursuit. To the best of our knowledge, no prior research has systematically examined this relation. Although several theoretical assertions have been made regarding the importance of early orienting responses including joint attention, social referencing, and more recently, mutually entailed orienting (e.g., Hayes & Sanford, 2014; Sivaraman et al., 2023), more empirical studies that demonstrate the behavioral processes facilitating these critical repertoires are needed. Finally, a few studies have investigated the effects of contingent vocal imitation on children's echoic responding, but they all typically measured whether the child imitated any of the adult's vocalizations during the contingent imitation sessions (e.g., Neimy et al., 2020). It seems important to conduct assessments on children's echoic responses with a predefined set of vocal antecedent stimuli outside of the contingent imitation sessions.

Therefore, the purpose of the current study was to compare the effects of five conditions (contingent vocal imitation, contingent interaction, noncontingent vocal imitation, noncontingent physical touch, and one no-interaction

[1]A more precise description may be contingent vocal *emulation* (Zentall, 2004) because the mother did not copy the movements of the child's vocal cords, only the results of those movements (i.e., the sounds produced). We chose to use the term contingent vocal imitation to be consistent with prior studies on this topic.

control condition), all implemented by an experimenter, on the vocalizations emitted by three toddlers diagnosed with developmental disabilities by using an alternating-treatments design. As a secondary purpose, we investigated whether there were any effects of these contingencies on the children's spontaneous orienting responses toward the researcher and the influence on echoic responses posttraining.

METHOD

Participants

Participants included three male children, Andy, Brad, and Manuel, aged between 28 and 36 months. Based on caregiver reports, all three were White children and Brad was Hispanic. We did not receive ethnicity information from Andy and Manuel's caregivers. Andy and Manuel's families spoke English at home, and Brad's family spoke Spanish. All three participants had been classified with a developmental delay or disability and were enrolled in a district-based early intervention school that implemented the Comprehensive Application of Behavior Analysis to Schooling model (CABAS; Selinske et al., 1991; Singer-Dudek et al., 2021). The experimenter was an Asian female teacher employed at the same school as the participants, and she was also enrolled as a first-year doctoral student in an applied behavior analysis graduate program. She was familiar to all three participants and provided them with regular individualized instruction outside the study.

These participants were selected for the study because they were preverbal (i.e., did not emit any functional vocal-verbal behavior and emitted a relatively low number of protophone vocalizations (e.g., “ba,” “eee”), ranging from 5 to 20 during a 2-minute session conducted prior to the start of the study. During prestudy observations that were part of the regular assessments conducted at the children's school, all participants occasionally (approximately 25%–50% of opportunities) oriented toward a familiar adult when they entered the room or when adults spoke to the child or called out the child's name. The participants typically communicated wants or needs by pulling a familiar adult toward a desired item or pointing to it. None of the participants had a generalized motor imitation repertoire. At the school, they were working on picture exchange (e.g., selecting a picture from a picture board array of nine stimuli) when they wanted one of the items in the array. All three children received sessions with a speech-language therapist. In their applied behavior analysis instructional sessions, only Andy had been exposed to an echoic program, which involved prompting him to repeat a sound made by the instructor. However, these trials frequently resulted in crying, leading to the program's discontinuation. Brad and Manuel had not received echoic instruction prior to the study.

Setting

The study took place at an early intervention school in a suburban area outside a metropolitan city. The school served children between 18 and 42 months of age. All sessions were conducted at child-sized tables in a quiet room that was adjacent to the classroom. The room contained a child-sized desk and two child-sized chairs. A variety of toys without sounds (e.g., Lego blocks, pretend play sets, toy vehicles, animals) and books were available during each session. In addition, the experimenter set up a mobile phone paired with a wireless microphone next to the participants to capture their vocalizations and record the sessions. During the noncontingent vocal imitation condition (described below), the experimenter wore earphones and listened to a recording of all the vocalizations emitted by the participant in a preceding condition. The experimenter also used a timer throughout the study.

Dependent variables and response measurement

We measured each participant's vocalizations during 2-min sessions. We defined vocalizations as voice sounds with a discrete onset and offset including babbling and cooing but excluding coughing, whining, crying, sneezing, and loud breathing. We used a frequency measure and counted the number of vocalizations emitted and each occurrence of vocalization was separated from another by at least 1 s (i.e., consistent with definitions used in Peláez et al., 2011; Poulson & Kymissis, 1988; Neimy et al., 2020). In addition, we measured the participants' orienting responses. We defined orienting as the child making eye contact with the experimenter or looking at the general region of the experimenter's face. We measured orienting using 5-s partial-interval recording during each 2-min session and reported the data as the percentage of intervals with orienting.

Finally, we used the Early Echoic Skills Assessment (EESA; Esch & Sundberg, 2014) to evaluate each participant's echoic responses. We measured correct and incorrect responses and reported the number of correct echoic responses emitted by each participant. We scored a correct echoic response if the child's vocal behavior was emitted within 5 s and shared point-to-point correspondence with the vocal stimulus presented by the experimenter. All other responses and no responses were scored as incorrect echoic responses.

Experimental design and data analysis

We used an alternating-treatments design embedded within a multiple-probe-across-participants design. Each participant underwent a baseline phase and an intervention phase. During the baseline phase, the participants experienced the control condition. During the intervention phase, they each experienced five experimental conditions (i.e., contingent imitation, noncontingent imitation, noncontingent physical touch, contingent interaction, and the control condition) every day. Each of these conditions were separated by at least 20 min. The sequence of the presentation of conditions was determined by block randomization using randomizer.org (Urbaniak & Plous, 2013). However, contingent vocal imitation always preceded noncontingent vocal imitation. We simply assigned these two conditions to be one unit during randomization. All participants experienced the five experimental conditions for a total of 10 times each, following which the most effective condition was alternated with the control condition for four sessions each.

We supplemented the visual analysis of the vocalizations data with statistical analyses. Specifically, we calculated the percentage exceeding the median (PEM) to serve as an overlap index (Ma, 2006; Parker et al., 2011). We computed PEM by comparing the data collected during the contingent imitation sessions for each participant with the median number of vocalizations in the baseline phase. We also evaluated the effects of the intervention sessions on echoics using a concurrent multiple-probe design.

General procedure

All sessions were 2 min in duration. The child sat at a table with access to a few regular classroom toys that were chosen at random and used with all three children, and the experimenter sat next to the child. If the child made any requests such as pulling the experimenter's arm toward a toy, the experimenter helped with opening the toy but did not emit any vocal-verbal behavior toward the child. This only occurred with Manuel a few times when he needed help with opening a box of toy stamps. If the participant was fussy and hard to comfort (i.e., crying or whining), the experimenter terminated the session and resumed a new session once the participant was calm. This happened once for Brad, who was experiencing illness at the time, and we did not plot the data that were obtained for this session.Baseline.

Control

During the baseline phase, we conducted control sessions during which the experimenter did not emit any vocalizations. She simply sat next to the child and pretended to be busy with a datasheet.

Intervention.

During the intervention phase, we rapidly alternated between contingent imitation, noncontingent imitation, noncontingent physical touch, contingent interaction, and control sessions. Control sessions were conducted exactly as described above.

Contingent vocal imitation

During this condition, immediately following each vocalization emitted by the participant, the experimenter imitated the same vocalization in an animated manner while smiling and making eye contact with the child. For instance, if the participant vocalized "shwuwu," the experimenter responded by immediately echoing "shwuwu."

Noncontingent vocal imitation

During this condition, the experimenter emitted all the vocalizations emitted by the child during the previous contingent vocal imitation session, matched in temporal distribution, while making eye contact with the child. The experimenter wore earphones connected to a recording of the previous contingent vocal imitation session and imitated her own vocal responses as in the recording. During this phase, there were no programmed consequences for the child's vocalizations. The experimenter did not emit any sounds for at least 2 s following the child's vocalizations (see Vollmer et al., 1997). We had to delay the delivery of noncontingent vocalization a few times for all participants, and we did not record these instances.

Noncontingent physical touch

During this condition, the experimenter provided physical touches (e.g., pat on the back) to the participants on a 10-s fixed-time schedule. The experimenter smiled and made eye contact with the child when she provided physical touches. As in the noncontingent vocal imitation condition, there were no programmed consequences for the child's vocalizations. If the child vocalized, the experimenter waited 2 s before delivering the next scheduled physical touch.

Contingent social interaction

Following every occurrence of a vocalization, the experimenter immediately provided a vocal-verbal response to the participant (e.g., "I like how you are making the sound," "You have such a beautiful voice," "You are really talkative today," "Great job talking") using an animated tone of voice, accompanied by a smile and eye contact. The experimenter did not imitate or repeat vocalizations produced by the participant.

Pre- and postintervention echoic assessments.

The experimenter used the EESA Group 1 items to evaluate each participant's echoic clarity of simple and reduplicated syllables. During each trial, the experimenters delivered the target syllable using the instruction "Say [sound]" and gave participants 5 s to repeat the sound. Each session consisted of 25 trials. We deviated from the traditional EESA administration in two ways: (a) no prompts, reinforcement, or error correction were provided for correct or incorrect responses and (b) each trial was presented only once.

Interobserver agreement and procedural fidelity

A second, independent trained observer collected data on 30% of sessions to evaluate interobserver agreement (IOA). Both observers practiced collecting vocalization data from videotaped pilot control sessions prior to the commencement of the study until 100% agreement was achieved on three consecutive videos. The total count IOA for vocalizations was 99% for Andy (range: 90%–100%) across conditions and, specifically, was 100% during control, contingent imitation, and noncontingent imitation and 97% each during noncontingent physical touch (range: 90%–100%) and contingent interaction (range: 92%–100%). IOA for vocalizations across conditions was 98% for Brad (range: 86%–100%) and, specifically, 96% during control sessions (range: 86%–100%), 100% during contingent imitation, 93% during noncontingent imitation (range: 88%–100%), and 100% during noncontingent physical touch and contingent interaction. IOA for vocalizations across conditions was 98% (range: 88%–100%) for Manuel and, specifically, 98% (range: 92%–100%) during control sessions, 100% during contingent imitation, 98% (range: 95%–100%) during noncontingent imitation, 96% (range: 88%–100%) during noncontingent physical touch, and 100% during contingent interaction.

Interval-by-interval IOA for orienting across conditions was 97% for Andy (range: 92%–100%) across conditions. Specifically, IOA was 97% during the control condition (range: 96%–100%), 97% during contingent imitation (range: 92%–100%), 93% during noncontingent imitation (range: 92%–100%), 97% during noncontingent physical touch (range: 92%–100%), and 99% during contingent interaction (range: 96%–100%). IOA for Brad's orienting responses was 99% (range: 96%–100%) across conditions, specifically, 100% during the control condition, 97% (range: 96%–100%) during contingent imitation, 99% (range: 96%–100%) during noncontingent imitation, 100% during noncontingent physical touch, and 99% (range: 96%–100%) during contingent interaction. IOA for Manuel's orienting responses was 98% (range: 92%–100%), and, specifically, was 97% (range: 96%–100%) during control sessions, 99% during contingent imitation (range: 98%–100%), 96.7% during noncontingent imitation (range: 92%–100%), 100% during noncontingent physical touch, and 99% during contingent interaction (range: 98%–100%). IOA was 100% for echoic responses for all participants.

In addition, for 30% of sessions, the second author measured procedural fidelity (Ingham & Greer, 1992) by assessing whether the experimenter followed the correct procedure for each condition. Correct execution involved immediately delivering or delaying the consequence if a child vocalization occurred (as applicable for each condition; e.g., 2-s delay for vocalizations in the noncontingent imitation sessions). For contingent imitation and contingent interaction sessions, we recorded whether the experimenter vocally imitated the child or provided a vocal verbal response after each vocalization. For noncontingent imitation sessions, we recorded whether the experimenter made all the same sounds she had made during the contingent imitation sessions. For the noncontingent touch sessions, we recorded whether the experimenter gently touched the child every 10 s. For control sessions, we recorded whether the experimenter remained silent after each vocalization emitted by the child. Procedural fidelity was 100% across these sessions.

RESULTS

Figure 1 shows the number of vocalizations emitted in each 2-min session by Andy, Brad, and Manuel. In the first tier, during the baseline phase, Andy emitted an average of 10 vocalizations (*Mdn* = 10, range: 5–13) during each session. Visual analysis of Andy's data during the intervention phase showed that the number of vocalizations emitted during the contingent vocal imitation sessions was higher than any of the other conditions, averaging 23 vocalizations (*Mdn* = 23, range: 18–27). During the noncontingent imitation, contingent interactions, noncontingent touch sessions, and control sessions, Andy averaged 14 vocalizations (*Mdn* = 14, range: 9–18), 12 vocalizations (*Mdn* = 12, range: 2–19), 10 vocalizations (*Mdn* = 11, range: 3–15), and 9 vocalizations (*Mdn* = 11, range: 4–15), respectively. Subsequently, we alternated between control and contingent vocal imitation for four sessions each, and Andy emitted an average of 29 vocalizations during contingent imitations session (*Mdn* = 25, range: 24–42) and 13.5 vocalizations during the control sessions (*Mdn* = 13, range: 10–18). Andy consistently emitted a higher number of vocalizations during the contingent imitation sessions than during the control and the other conditions.

In the second tier, during the baseline phase, Brad emitted an average of 15 vocalizations (*Mdn* = 15, range: 11–21) during each session. Similar to Andy, visual analysis of Brad's data during the intervention phase showed that the number of vocalizations emitted during the contingent vocal imitation sessions was higher than any of the other conditions. Specifically, during the contingent imitation sessions, he averaged 22 vocalizations (*Mdn* = 23, range: 13–30). During the noncontingent imitation, contingent interactions, noncontingent touch sessions and control sessions, Brad averaged 7 vocalizations (*Mdn* = 8, range: 0–13), 11 vocalizations (*Mdn* = 12, range: 2–20), 7 vocalizations (*Mdn* = 8, range: 3–13), and 11 vocalizations (*Mdn* = 13, range: 2–19) respectively. He averaged 21 vocalizations (*Mdn* = 20,

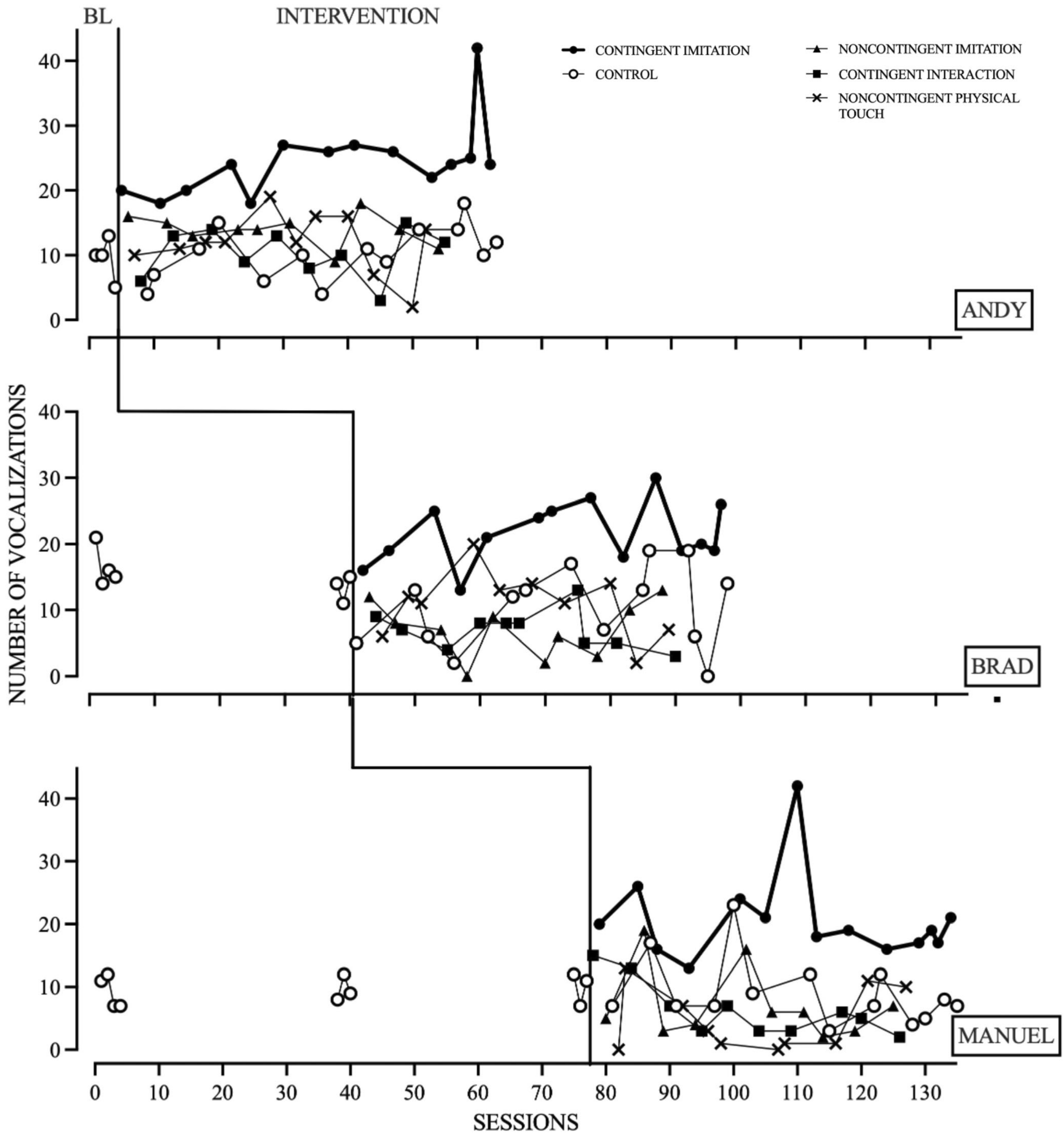

FIGURE 1 Number of vocalizations emitted across conditions. BL = Baseline.

range: 19–26) and 10 vocalizations (*Mdn* = 10, range: 0–19) in the final four contingent imitation and control sessions, respectively. Apart from one noncontingent physical touch session, Brad emitted a higher number of vocalizations during the contingent imitation condition than during the other conditions.

Manuel emitted an average of 10 vocalizations (*Mdn* = 10, range: 7–12) during each session in the baseline phase. Visual analysis of Manuel's data during the intervention phase also showed that the number of vocalizations emitted during the contingent vocal imitation condition was higher than during any of the other conditions. Specifically, during the contingent imitation sessions, he averaged 22 vocalizations (*Mdn* = 20, range: 13–42). During the noncontingent imitation, contingent interaction, noncontingent touch sessions, and control sessions, Manuel averaged 7 vocalizations (*Mdn* = 6, range: 2–19), 5 vocalizations (*Mdn* = 2, range: 0–13), 6 vocalizations ($Mdn = 6$, range: 2–15), and 10 vocalizations ($Mdn = 8$, range: 3–23), respectively. Finally, he averaged 19 vocalizations ($Mdn = 18$, range: 17–21) and 6 vocalizations ($Mdn = 5$, range: 4–8) during the final four contingent vocal imitation and control sessions, respectively.

We supplemented the visual analysis with statistical analyses and compared PEM for the five conditions in the study. For Andy, all 10 contingent imitation sessions were above the baseline median, yielding a PEM of 100%. Using the same approach, PEM for Brad and Manuel's contingent imitation sessions were 90% and 100%, respectively, indicating an overall *large* effect across participants for the imitation sessions relative to baseline (Dowdy et al., 2021; Scruggs et al., 1986). We also computed PEM by comparing the data collected during the contingent imitation sessions for each participant with the median number of vocalizations in the noncontingent imitation sessions, noncontingent physical touch, and the contingent interaction sessions. For all these comparisons, PEM for Andy, Brad, and Manuel was 100%, indicating an overall *large* effect across participants of the contingent imitation sessions relative to all other conditions.

Figure 2 shows the percentage of intervals in which Andy (top panel), Brad (middle panel), and Manuel (bottom panel) emitted orienting responses during each 2-min session throughout the study. Andy emitted no orienting responses during baseline ($M = 0$, $Mdn = 0$, range: 0) during each session. During the intervention phase, in the contingent imitation conditions, he averaged 45% intervals of orienting ($Mdn = 42$, range: 25%–83%). During the noncontingent imitation, noncontingent touch, contingent interaction, and control conditions, Andy averaged 28% intervals of orienting ($Mdn = 25\%$, range: 17%–67%), 7% orienting ($Mdn = 6\%$, range: 0%–21%), 11% orienting ($Mdn = 13\%$, range: 0%–21%), and 5% orienting ($Mdn = 2\%$, range: 0%–17%), respectively. He averaged 64% intervals of orienting ($Mdn = 60\%$, range: 46%–88%) and 6% orienting ($Mdn = 6\%$, range: 0%–13%) in the final four contingent imitation and control sessions, respectively. Overall, Andy emitted a higher percentage of orienting responses during the contingent imitation sessions than during the control and the other conditions. Andy also emitted relatively higher levels of orienting responses during the noncontingent imitation conditions than during the noncontingent physical touch, contingent interaction, and control conditions.

In the second tier, during the baseline phase, Brad emitted no orienting responses during each session. During the contingent imitation conditions in the intervention phase, he averaged 4% intervals of orienting ($Mdn = 0$, range: 0%–17%). During the noncontingent imitation, noncontingent touch, contingent interaction, and control conditions, Brad averaged 1% intervals of orienting ($Mdn = 0$, range: 0%–4%), 1% orienting ($Mdn = 0\%$, range: 0%–4%), 1% orienting ($Mdn = 0\%$, range: 0%–8%), and 1% orienting ($Mdn = 0\%$, range: 0%–13%), respectively. He averaged 7% intervals of orienting ($Mdn = 8\%$, range: 0%–12.5%) and 2% orienting ($Mdn = 0\%$, range: 0%–4%) in the last four contingent imitation and control sessions, respectively. Overall, Brad emitted low levels of orienting responses across all conditions, with marginally higher levels of orienting during the contingent imitation condition. We did observe increased orienting responses in the final four sessions of the study when contingent imitation was alternated with the control condition.

In the final tier, during baseline, Manuel emitted an average of 0% orienting during the baseline phase ($Mdn = 0$, range: 0–4%). In the intervention phase, during the contingent imitation condition, he averaged 23% intervals of orienting ($Mdn = 10$, range: 0%–92%). During the noncontingent imitation, noncontingent touch, contingent interaction, and control conditions, Manuel averaged 4% intervals of orienting ($Mdn = 0\%$, range: 0%–25%), 1% orienting ($Mdn = 0\%$, range: 0%–8%), 1% orienting ($Mdn = 0\%$, range: 0%–4%), and 2% orienting ($Mdn = 0\%$, range: 0%–13%), respectively. He averaged 8% intervals of orienting ($Mdn = 8\%$, range: 0%–13%) in the final four contingent imitation sessions and no orienting responses in the last four control sessions. Overall, he emitted a relatively higher percentage of orienting responses during the contingent imitation condition than during the control and the other conditions, and we found an increasing trend during the contingent imitation sessions. Anecdotally, similar to Andy, we observed that during the initial noncontingent imitation conditions, he emitted a relatively high number of orienting responses and often emitted vocalizations, oriented toward the researcher, smiled, and waited for a few seconds.

Figure 3 shows the number of echoic responses emitted by Andy (top panel), Brad (middle panel), and Manuel (bottom panel) pre- and postintervention out of a total of 25 trials using the EESA. During baseline, on average Andy emitted 9 echoics ($Mdn = 9$, range: 9–10), Brad emitted 0 echoics, and Manuel emitted 0 echoics ($Mdn = 0$, range: 0–1). Postintervention, on average Andy emitted 22 echoics ($Mdn = 22$, range: 20–23), Brad emitted 8 echoics ($Mdn = 8$, range: 7–9), and Manuel emitted 2 echoics ($Mdn = 2$, range: 0–3). Overall, all three participants showed an increase in the number of echoics, although the increase in Manuel's responses was relatively small. These results should be interpreted with caution because we cannot attribute the increase to any specific intervention condition.

DISCUSSION

In the current study, we compared the effects of five specific conditions on the vocalizations emitted by three toddlers with a classification of a developmental delay or disability. We found that contingent vocal imitation produced the highest number of vocalizations for all three

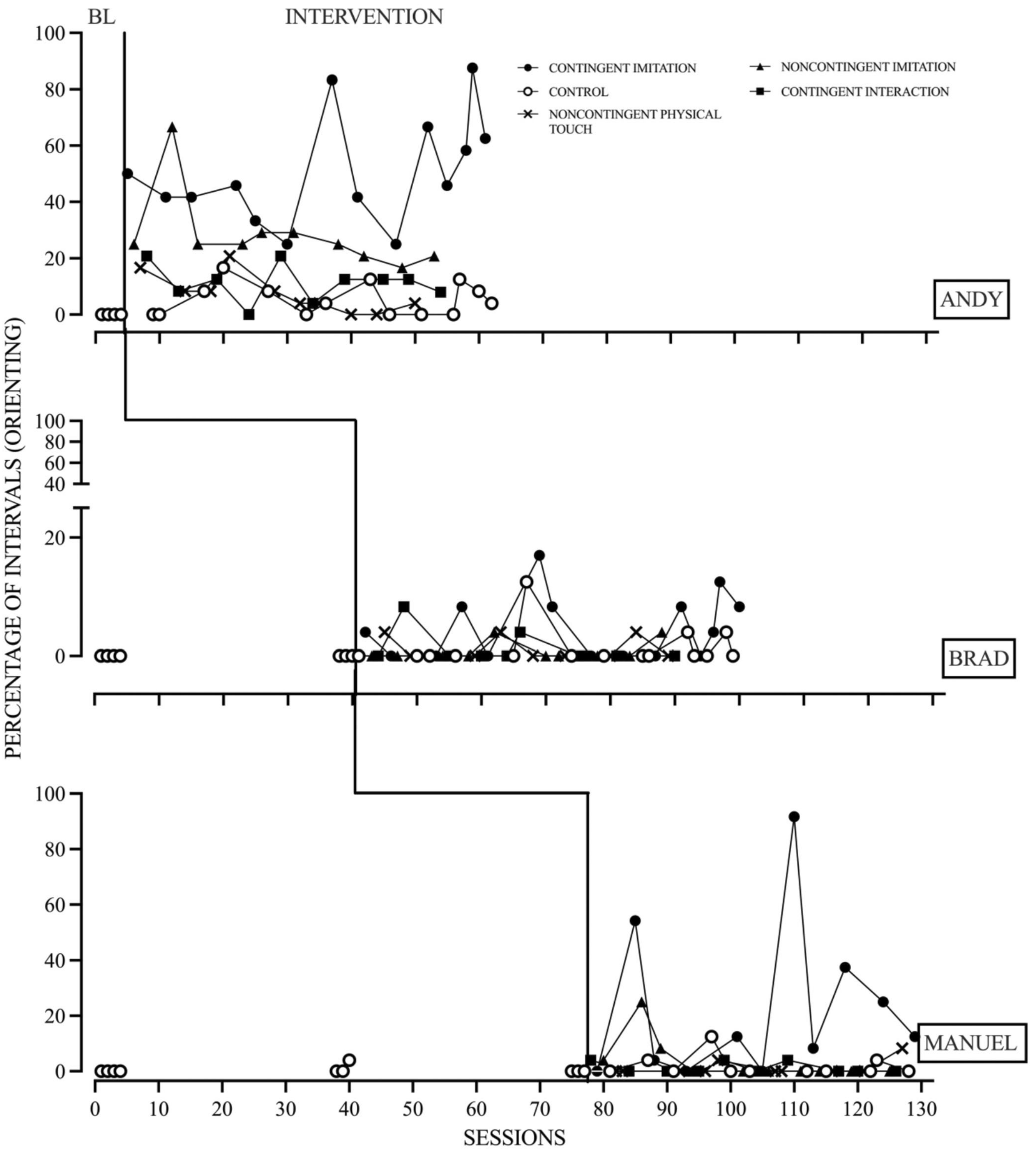

FIGURE 2 Orienting responses emitted across conditions. BL = Baseline.

children relative to contingent social interaction, noncontingent vocal imitation, noncontingent physical touch, and the control condition. The PEM calculations showed that the overall effect of the contingent imitation condition was larger than that in all the other conditions. We also investigated the effects on participants' spontaneous orienting responses toward the researcher and found that contingent vocal imitation sessions produced the highest increase in orienting responses directed toward the experimenter for two of our participants. We found tentative effects on children's echoic responses. Our findings are consistent with prior behavior-analytic research on the effects of contingent imitation on vocalizations (e.g., Fiani et al., 2021; Neimy et al., 2020; Peláez et al., 2011; Pelaez et al., 2018), and the

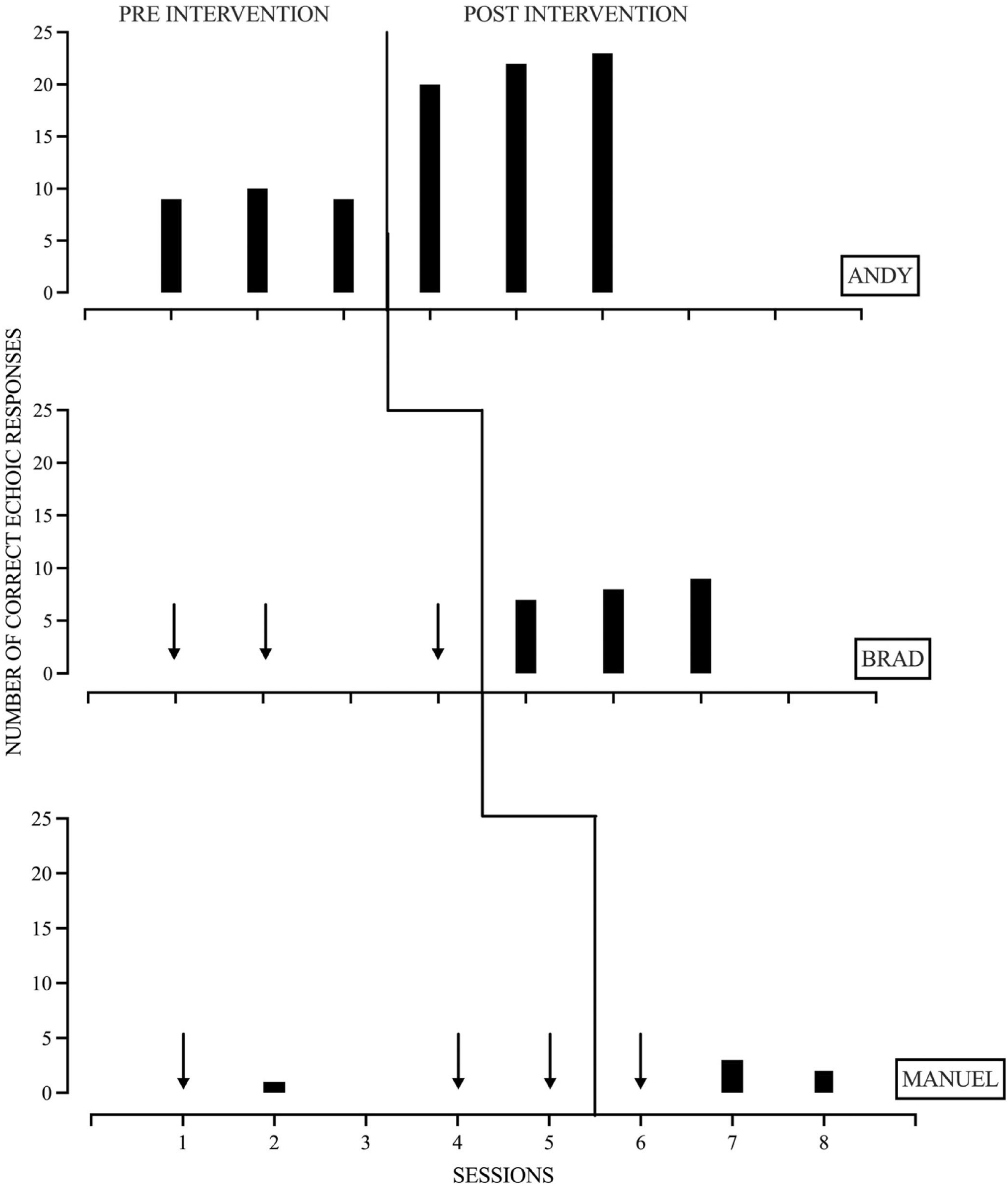

FIGURE 3 Echoic responses emitted during pre- and post-comparison of conditions. Arrows represent zeroes.

current study adds to the extant literature on a verbal behavior approach to language development in children.

Upon close consideration of the contingent vocal imitation sessions, we see that all participants demonstrated increases in vocalizations during these sessions almost immediately. A foundational assumption of behavior analysis is that behavior is controlled by the current context and the organism's learning history (Bordieri et al., 2016).

However, a question remains: Why did contingent vocal imitation function as a reinforcer? Researchers have proposed that a caregivers' vocalizations may be repeatedly paired with unconditioned and conditioned reinforcers early on—such as during feeding or tactile stimulation—thus becoming a conditioned reinforcer (e.g., DeCasper & Spence, 1986). However, this does not explain why similar effects are not observed during contingent interaction and contingent imitation sessions, both conducted by the same individual. An alternative explanation may lie in the evolutionary history of a species, wherein functional reinforcers for diverse species' responses result from survival contingencies (Petrovich & Gewirtz, 1984, 1985; Skinner, 1953, 1966). More recently, Baum (2012, 2018) posited that reinforcement is the selection of behavior that produces phylogenetically important events. A caregiver's contingent imitation of an infant's vocalization may be such an event that seems to allow them to function as a cooperating dyad and serve as a context for verbal behavior (Hayes & Sanford, 2014; Sivaraman et al., 2023). To our knowledge, nonhuman infant–caregiver dyads have not yet been seen to demonstrate this behavioral pattern of contingent vocal imitation (e.g., Sclafani et al., 2023). More research is needed to refine methods to predict and influence children's early vocalizations.

Across behavior-analytic theories, researchers have emphasized the importance of automatic reinforcement in maintaining verbal behavior. For example, researchers have described the correspondence between say-do, hear-say as conditioned reinforcers for verbal behavior (Greer et al., 2017; see also Horne & Lowe, 1996; Schlinger, 1995), coherence or "sense-making" being a powerful reinforcer (Bordieri et al., 2016; Hayes, 1997; Wilson & Hayes, 1996), or parity between one's own behavior and the general practices of the verbal community being a reinforcer (Palmer, 1996). Critically, however, during the contingent vocal imitation sessions, the similarity was between the child's initial vocalization and the adult's subsequent response to that vocalization. Moreover, the adult's responses were not entirely consistent with typical practices of the verbal community—often consisting of simplified or less mature vocalization. Instead, the formal match between the child and the adult's vocalization may have been functioning as a potential reinforcer. There may be several evolutionary advantages to mothers emitting vocalizations that formally match those of their infant. The imitation may function to gain the infant's attention or to increase bonding and may also serve as a context for further interaction. An additional consideration relevant to our study was that the children's classroom teacher served as the experimenter and her prior history with the children potentially influenced the results in the contingent imitation sessions.

We found that contingent interaction was not effective at increasing vocalizations for any of our participants. In contrast, several prior studies have found contingent motherese speech to be effective at increasing vocalizations in young children (Goldstein et al., 2003, 2009; Gros-Louis et al., 2014). Neimy et al. (2020) found that contingent interaction and contingent imitation were equally effective at increasing vocalizations (e.g., participants Ellie and Leah). However, the participants in their study were much younger (7–11 months of age) and perhaps, more importantly, the children's mothers implemented the intervention in all the studies mentioned earlier. See Ishizuka and Yamamoto (2016) for null findings for contingent interaction when a researcher implemented the sessions. An alternative explanation is that contingent interaction was delivered in motherese in all these prior studies and that caregivers may have delivered formally simpler and shorter vocalizations than those included in the contingent interaction condition of the present study (see Elmlinger et al., 2019). Future research should test the length and content of unmatched vocalizations to further differentiate between the effects of the contingent imitation and interaction conditions.

Anecdotally, all three of our participants engaged in an activity that seemed like preverbal turn-taking, with formal similarities to a conversational unit or verbal episode (Schauffler & Greer, 2006; Skinner 1957), during the contingent imitation sessions. That is, we observed instances where the child emitted a vocalization, waited for the experimenter to imitate their vocalization, and then made a new vocalization while orienting toward the researcher and the sequence repeated a few times. Andy and Manuel also showed higher levels of orienting responses in some of the initial noncontingent imitation sessions, which always followed the contingent imitation sessions. These responses subsequently declined over time, possibly because they were not consistently followed by a vocal imitation response. Our findings are consistent with those from several studies in neuroscience and developmental psychology (Field et al., 2001, 2013; Sanefuji & Ohgami, 2011, 2013; Slaughter & Ong, 2014; see also Contaldo et al., 2016, for a review), which reported increased orienting and turn-taking behaviors following contingent imitation. Nevertheless, more behavior-analytic research is needed to replicate and extend these findings on orienting and preverbal turn-taking.

The effects we observed in echoic responses are preliminary and exploratory. Readers should note that there were important differences between the participants in their baseline levels of echoing. Preintervention, Brad and Manuel had almost no echoic responses, whereas Andy emitted nearly 40% correct echoic responses. We found relatively large increases in echoic responses for Andy and Brad and only a marginal increase in Manuel's responses. Although we did not offer programmed reinforcement for echoic responses during the experiment, this may have occurred in the natural environment outside the study context and potentially contributed to the increase in echoic responses. Alternatively, it is plausible that the topographical similarity between hearing one's own vocalization and that of the experimenter during the contingent imitation sessions not only serves as a reinforcer for vocalizations but also might establish discriminative functions for the experimenter evoking subsequent echoic responses (Neimy et al., 2020; Pelaez et al., 2018). Nevertheless, we did not observe a large increase in echoic responses in one of our participants, and because we cannot attribute the improvement of the others to anything specific (given that the intervention involved multiple conditions), these results should be viewed tentatively.

Several clinical implications warrant consideration. First, we conducted 10 sessions, each lasting only 2 min across conditions, for all three participants and observed immediate increases in vocalizations during contingent imitation sessions. The procedures are relatively simple and efficient and could be replicated by behavior analysts and other professionals with some training. We included only those participants who made between 5 and 20 discrete vocalizations during a 2-min session prior to the study, and this may be an important inclusion criterion for successful replication with other children. The sessions with noncontingent vocal imitation were ineffective at increasing vocalizations. This highlights the potential negative or null effects of poorly timed vocal interactions directed toward the child in the natural environment. Finally, the quality and content of contingent vocalizations seems to be an important factor in promoting children's vocalizations. Long interaction statements were ineffective, and formally matched vocalizations were effective in the current study.

Several limitations and areas for future research warrant consideration. The session duration in the current study was 2 min and always conducted in the school, and having longer sessions in a variety of settings may offer a more robust demonstration of the effects of these and other reinforcement contingencies. We did not test the effects of physical touch delivered contingently on children's vocalizations. We measured only total count agreement for ease, which is a relatively weak estimate of interobserver agreement, and we did not measure the social validity of our goals or outcomes, which are all important steps for future research. Next, our design did not allow us to test the individual influence of each condition on children's echoic responses. This would be a critical step for future research. Furthermore, caregivers naturally provide specific forms of vocal stimulation contingent on infants' vocalizations, including but not limited to questions, imitations, naming objects, and giving instructions and nonverbal stimulation such as physical touch (Gros-Louis et al., 2006). We did not include all these conditions in our study, but it seems important to systematically test the effects of more of these consequences. Conducting more systematic analyses in the context of vocalizations seems essential to understanding the operant processes underlying preverbal behaviors, which are said to be critical for children to be truly verbal. Further insight into the contingencies facilitating these repertoires will not only be conceptually useful but also have myriad clinical implications for a science of behavior.

AUTHOR CONTRIBUTIONS

Tianyue Sun contributed to designing the study, data collection, data analysis, and writing and revising the manuscript. Maithri Sivaraman contributed to designing the study, assisting with data collection, data analysis, supervision, and writing and revising the manuscript. Yifei Sun contributed to designing the study, assisting with data collection, supervision, and revising the manuscript.

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All the authors are practicing behavior analysts and stand to benefit professionally and financially from publications attesting to the effectiveness of behavior-analytic interventions.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

Anonymized data are available from the first author upon reasonable request.

ETHICS APPROVAL

The study was approved by the institutional review board of the Fred Keller school, and informed consent was obtained from all participants' guardians.

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