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BRIEF PRACTICE

Increasing Vocalizations and Echoics in Infants at Risk of Autism Spectrum Disorder

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Abstract

Infant siblings of children with an autism spectrum disorder (ASD) diagnosis (i.e., infants at risk of ASD) are excellent candidates for early interventions based on the principles of applied behavior analysis. This study replicates and extends behavioral research using contingent social reinforcement procedures (i.e., vocal imitation and motherese speech) to increase both vocalizations and echoics among 3 infants at risk of ASD with their mothers in the natural environment. Results confirmed earlier findings that contingent reinforcement, specifically vocal imitation, reliably produces high rates of vocalizations, echoic approximations, and emerging pure echoic repertoires in at risk infants.

Keywords Applied behavior analysis · Autism spectrum disorder · Echoics · Infants at risk · Vocalizations

Today, autism spectrum disorder (ASD) can be detected in children as early as 18 months of age (Ozonoff et al., 2010), but possible behavioral markers can even be identified at 6 to 12 months of age (e.g., nonresponsiveness to one's name, absence of joint-attention and social referencing skills, and limited vocalizations; Ozonoff et al., 2010), and various environmental and parental factors may influence some of these at risk behaviors (e.g., misplaced social contingencies; Neimy, Pelaez, Carrow, Monlux, & Tarbox, 2017). Early behavioral interventions targeting social deficits observed in infancy place practitioners in an advantageous position to develop proactive treatments. Specifically, if language deficits can be identified at 6 months of age, and limited vocalizations are an early indicator of ASD, focusing on shaping communication skills during infancy could potentially mitigate the severity of the deficits observed later during development (Garrido, Watson, Carballo, Garcia-Retamero, & Crais, 2017). From a behavioral perspective, if positive systems can be used to establish verbal skills early in infancy (e.g., reinforcement, prompting, shaping), one may hypothesize that an infant at risk of ASD could develop more closely to a typical trajectory during later childhood (Novak & Pelaez, 2004).

Behavior analysts have found that infants' vocalizations can be increased by altering contingencies in their environment, such as the type and timing of the delivery of social reinforcement (Masur & Olson, 2008; Pelaez, Virues-Ortega, & Gewirtz, 2011a, 2011b). In the natural environment, caregivers often initiate and respond to their infant's vocalizations with either (a) imitative sounds (i.e., vocal imitation) or (b) words or short sentences delivered with a high pitch and rhythmic intonation (i.e., motherese speech; Gazdag & Warren, 2000; Masur & Olson, 2008; Pelaez, Borroto, & Carrow, 2018; Pelaez et al., 2011a, 2011b; Poulson, Kymissis, Reeve, Andreatos, & Reeve, 1991).

Research Highlights

- Extends previously researched evidence-based approaches for establishing early communication skills in typically developing infants and children diagnosed with autism spectrum disorder (ASD) to infants at risk of ASD.
- Demonstrates the efficacy of arranging and delivering contingent reinforcement in the form of motherese speech and vocal imitation to promote increased vocalizations and echoic repertoires in infants at risk of ASD.
- Delineates a brief methodology for quickly and easily implementing behavior-analytic treatment with parent-infant dyads in the context of the natural environment.
- May help improve social interactions between parents and their infants at risk of ASD by encouraging and facilitating the development of important early social behavioral cusps.

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Maternal vocal imitation is among the most effective methods for promoting the vocalizations and echoic behaviors of typically developing infants (Masur & Olson, 2008; Pelaez et al., 2018; Pelaez et al., 2011a, 2011b; Poulson et al., 1991). Specifically, vocal imitation from the parent is used to reinforce the infant's vocalizations and shows acquired discriminative properties, where it serves as both a reinforcer and a discriminative stimulus for evoking infant echoics. Researchers have found that when infants contact the socially reinforcing consequences of vocal imitation from their caregivers, the emergence of echoic responses subsequently increases (Pelaez et al., 2018).

Previously, Pelaez et al. (2011a) analyzed the reinforcing effects of contingent vocal imitation across 17 typically developing infant–parent dyads and found that contingent vocal imitation increased the overall frequency of infant vocalizations in all participants. In a subsequent study, Pelaez et al. (2011b) isolated the reinforcing effects of contingent versus noncontingent motherese speech and vocal imitation with 16 and 19 infants, respectively, and found that contingent reinforcement increased infant vocalizations as compared to baseline and noncontingent reinforcement (NCR) control conditions. Finally, Neimy et al. (2017) extended the use of contingent social reinforcement procedures (i.e., motherese speech and vocal imitation) with infants at risk of ASD within the natural environment and found idiosyncratic preferences for the different types of contingent social reinforcement.

In the present experiment, the hypothesis was that intervening on the precursor communication deficits that appear early during infancy could strengthen the early verbal repertoires of infants at risk of ASD. The present investigation sought to extend the findings of Pelaez et al. (2011a, 2011b), Pelaez et al. (2018), and Neimy et al. (2017) by evaluating and comparing the effects of (a) contingent motherese speech, (b) contingent vocal imitation, and (c) noncontingent motherese speech and vocal stimulation on (a) the rate of infant vocalizations, (b) the rate of infant echoics (matching), and (c) the percentage of infant echoics (matching) among infants at risk of ASD within the context of the natural home environment using parents (mothers) as interventionists.

Method

Participants

Participants were recruited via regional applied behavior analysis (ABA) agencies in Los Angeles, California. Infants qualified as at risk of ASD by having an older sibling with a confirmed ASD diagnosis. Additionally, recruited participants were between the ages of 3 months and 1 year old. An initial parent interview was conducted as part of the preliminary screening process, which included the Developmental Profile, Third Edition (DP-3), and a brief demographic questionnaire.

Three infants met our inclusion criteria: Ellie was a 7-month-old female infant who was the youngest of four children, two of whom had a diagnosis of ASD, and who scored in the 40th percentile on the DP-3; Jack was an 8-month-old male infant whose older sister was diagnosed with ASD and who scored in the 60th percentile on the DP-3; and Leah was an 11-month-old female infant with an older brother diagnosed with ASD and who scored in the <5th percentile on the DP-3.

Setting and Materials

Sessions were conducted in the infant's home in a comfortable, face-to-face arrangement unique to each mother-infant dyad (e.g., in a high chair, in a cradle, or during play). Additionally, for each participant, moderately preferred toys and items were available. All sessions were video recorded using an iPhone to be later coded and scored for reliability purposes.

Experimental Design, Independent Measures, and Dependent Measures

An alternating nonconcurrent multiple-baseline design across participants was used to evaluate the effects of three independent variables—(a) motherese speech, (b) vocal imitation, and (c) NCR control—on three dependent variables: (a) infant *vocalizations*, defined as any single- or double-syllable sound emitted by the infant with a discrete onset/offset of 1–2 s, or continuous vocalizations occurring for more than 3 s in duration, excluding any and all sounds that were physiological in nature; (b) infant *echoics (nonmatching)*, defined as any infant vocalization that occurred following the mother's vocal response with a latency of 1–3 s; and (c) infant *echoics (matching)*, defined as any vocalization that occurred within 1–3 s of the mother's vocal response and that topographically shared one-to-one correspondence with the response. The latter two collateral measures were intended to capture the potential emergence of echoic repertoires as a function of directly intervening on infant vocalizations.

Procedure

Baseline During baseline, mothers were instructed to interact with their infants in a face-to-face or other natural arrangement for a total of five 2-min sessions. Specifically, mothers were instructed to provide the typical amount and type of attention they would normally give their infants, representative of their unique dyadic interactions.

Parent Training Parent training procedures were modeled on previous methods delineated by Pelaez et al. (2011a, 2011b) and were based loosely on the principles of behavioral skills training. The investigator was a Board Certified Behavior Analyst who trained each infant's mother on the procedures to 100% mastery of all components prior to implementation. Following formal parent training, "booster" sessions were conducted prior to each treatment session, in which each condition was role-played to ensure maintenance of treatment fidelity.

Motherese Speech Condition During the motherese speech condition, every time the infant emitted a vocalization, the mother would immediately provide a brief motherese speech statement for approximately 1–2 s, repeating procedures for the entire 2-min session. Motherese speech consisted of infant-directed talk in the form of words and sentences with high-pitched sounds, a songlike prosody, and inflections on verbs and nouns (e.g., "Ohh, HI, sweeeet BABY!")

Vocal Imitation Condition During the vocal imitation condition, every time the infant emitted a vocalization or response, the mother would immediately echo the infant's vocalization (e.g., if the infant says "Baaaaa BAH!" the mother says "Baaaaa BAH!"), repeating procedures for the entire 2-min session.

NCR Control Condition During the NCR control condition, the mother was prompted by the investigator to deliver either (a) a motherese statement (e.g., "Ohh, HI, sweeeet BABY!") or (b) a vocalization previously emitted by the infant (e.g., "Baaaaa BAH!") on a fixed-time schedule of 20 s, repeating procedures for the entire 2-min session. A 3-s changeover delay was included to prevent delivering reinforcement inadvertently. The implementation of the changeover delay was directed by the investigator and was reflected in the timing of the prompt given to the mother as to when to deliver her verbal noncontingent response.

Interobserver Agreement (IOA)

Independent, blinded observers viewed de-identified video recordings for an average of 35% of videos across participants, using a total-count IOA method, and illustrated an average IOA score of 92% for infant vocalizations, 92% for echoics (nonmatching), and 84% for echoics (matching).

Results

Vocalizations

Results of the different social reinforcement procedures on the rate of infant vocalizations are depicted in Fig. 1 across each participant. Ellie emitted an average of 10 vocalizations (5.1 responses per minute) at baseline, 19 vocalizations (9.7 RPM) during the motherese condition, 20 vocalizations (10.1 RPM) during the vocal imitation condition, and 5 vocalizations (2.6 RPM) during the NCR control condition. Thus, for Ellie, contingent social reinforcement was more effective than noncontingent social reinforcement on the rate of her vocalizations, and both motherese and vocal imitation appeared to be relatively equally reinforcing.

Jack emitted an average of 10 vocalizations (5.0 RPM) at baseline, 16 vocalizations (7.9 RPM) during the motherese condition, 23 vocalizations (11.3 RPM) during the vocal imitation condition, and 8 vocalizations (4.1 RPM) during the NCR control condition. For Jack, contingent social reinforcement conditions were more effective than the NCR control on the rate of his vocalizations, but, specifically, vocal imitation was more reinforcing than motherese speech.

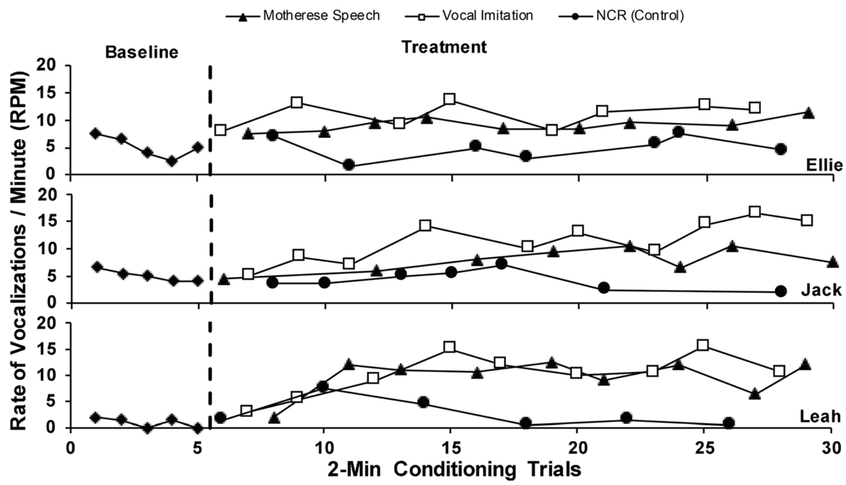
Last, Leah engaged in an average of 2 vocalizations (1.0 RPM) per session at baseline, 21 vocalizations (9.7 RPM) during the motherese condition, 23 vocalizations (10.1 RPM) during the vocal imitation condition, and 6 vocalizations (2.6 RPM) during the NCR control condition. Leah engaged in higher rates of vocalizations during the contingent social reinforcement conditions but did not demonstrate strong differentiation between the motherese speech condition and the vocal imitation condition.

Echoics (Nonmatching)

Results of the alternating treatment on the emergence of echoic approximations (i.e., nonmatching echoics) are depicted in Fig. 2 across each participant. Ellie emitted less than 1 echoic (nonmatching) response (0.1 RPM) at baseline, 3 echoic (nonmatching) responses (1.5 RPM) in the motherese condition, 6 echoic (nonmatching) responses (2.9 RPM) in the vocal imitation condition, and less than 1 echoic (nonmatching) response (0.3 RPM) during the NCR control condition. This suggests that, for Ellie, echoic (nonmatching) responses occurred at a higher rate during the vocal imitation condition in relation to all other conditions.

Jack emitted an average of 1 echoic (nonmatching) response (0.4 RPM) at baseline, 4 echoic (nonmatching) responses (2.2 RPM) in the motherese condition, 14 echoic (nonmatching) responses (7.2 RPM) in the vocal imitation condition, and less than 1 echoic (nonmatching) response (0.4 RPM) in the NCR control condition. Taken collectively, for Jack the contingent vocal imitation condition was an

Fig. 1 Vocalizations. Rate of infant vocalizations per minute across baseline and treatment conditions: (a) motherese speech, (b) vocal imitation, and (c) noncontingent (NCR) control for Ellie, Jack, and Leah



effective reinforcer for promoting not only increased rates of vocalizations but also increased echoic (nonmatching) responses in relation to all other conditions.

Finally, Leah engaged in an average of 1 echoic (nonmatching) response (0.7 RPM) at baseline, 14 echoic (nonmatching) responses (7.0 RPM) in the motherese condition, 10 echoic (nonmatching) responses (5.1 RPM) in the vocal imitation condition, and 2 echoic (nonmatching) responses (1.0 RPM) in the NCR control condition. For Leah, both forms of social reinforcement may have had similar reinforcing effects on her echoic (nonmatching) responding.

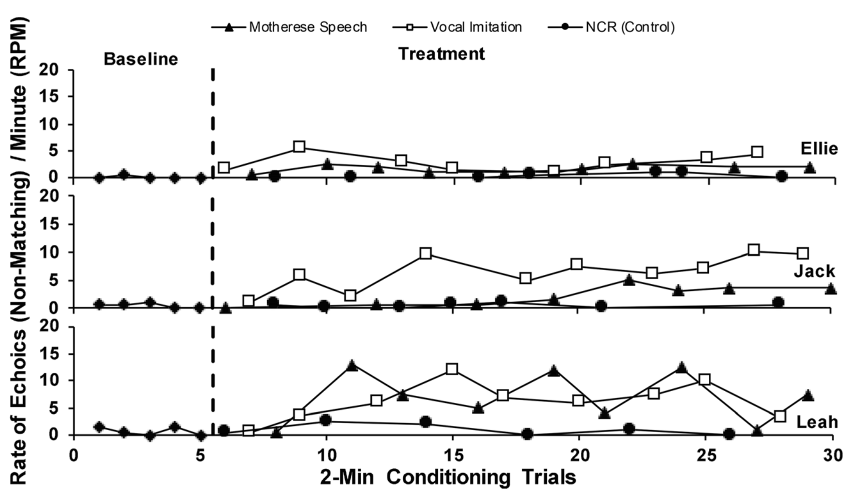
Echoics (Matching)

Results of the alternating-treatments comparison on matching echoics are depicted in Fig. 3. For Ellie, there was 0% accuracy of echoic (matching) responses during baseline, 27% accuracy during the motherese condition, 74% accuracy during the vocal imitation condition, and 0% accuracy during the NCR control condition. Thus, the accuracy of Ellie's echoic (matching) responses was significantly higher in the vocal imitation condition relative to all other conditions.

Jack emitted matching echoics with an average of 50% accuracy during baseline, 43% accuracy during the motherese condition, 85% accuracy during the vocal imitation condition, and 0% accuracy during the NCR control condition. Similar to Ellie, Jack displayed greater overall accuracy in echoic (matching) responses during the vocal imitation condition relative to all other conditions.

Finally, during baseline, Leah emitted 0 instances of matching echoics, and with the introduction of the different treatments, she engaged in echoic (matching) responses with an average of 5% accuracy during the motherese condition, 79% accuracy during the vocal imitation condition, and 25% accuracy during the NCR control condition. Overall, similar to both Jack and Leah, the accuracy of Leah's echoic

Fig. 2 Echoics (Matching). Rate of infant echoic (nonmatching) responses per minute, across baseline and treatment conditions: (a) motherese speech, (b) vocal imitation, and (c) noncontingent (NCR) control for Ellie, Jack, and Leah



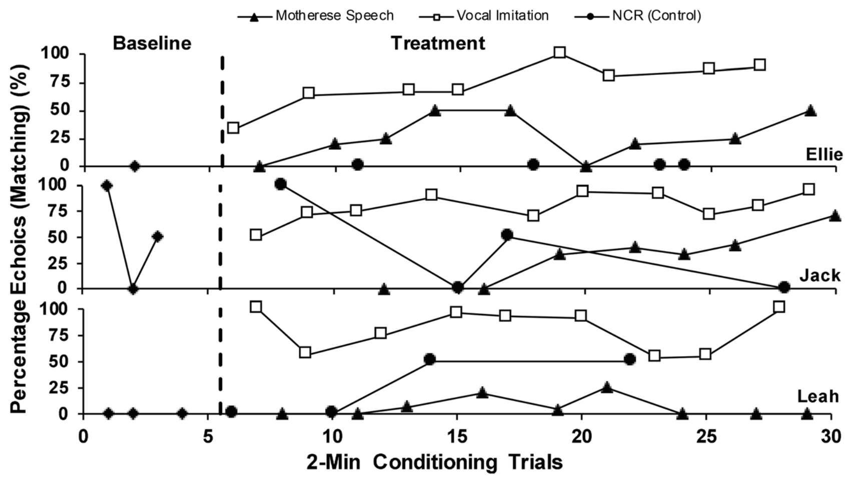


Fig. 3 Echoics (Matching). Percentage of echoic (matching) responses across baseline and treatment conditions: (a) motherese speech, (b) vocal imitation, and (c) noncontingent (NCR) control for Ellie, Jack, and Leah

(matching) responses was higher in the vocal imitation condition in relation to all other conditions.

Discussion

Taken collectively, all infants demonstrated higher rates of vocalizations during contingent social reinforcement conditions compared to both the NCR control condition and baseline. Some minor idiosyncratic differences were observed regarding the efficacy of the specific type of social reinforcement, suggesting preference on an individualized basis. Regardless, contingent social reinforcement was more effective in increasing the vocalizations of all infants at risk of ASD than noncontingent social reinforcement. Additionally, the rate and accuracy of our ancillary measures increased (i.e., nonmatching and matching echoics) and were significantly higher during the vocal imitation condition compared to the motherese condition for all participants. These results confirm previous research that asserts the reinforcing effects of vocal imitation as a contingent consequence for infant vocal behavior. Vocal imitation delivered as early as 3 months of age not only serves as a reinforcer for the infant's vocalizations but also may have putative discriminative functions for evoking subsequent echoic responses (Pelaez et al., 2018).

A few limitations and suggestions for future research should be discussed in the context of these findings. First, though the investigator attempted to conduct sessions on a weekly basis, cancellations often resulted in up to 1 to 2 weeks without sessions occurring, and this may be related to some of the observed variability in responding. Second, there were no formal social validity measures taken as part of the study; however, the mothers were an integral part of the collaborative process throughout treatment and voiced no specific concerns about the treatment procedures. Third, given that the mothers in the present study were recruited via regional ABA agencies, it may be likely that the overall acquisition rate of their skills during parent training was influenced by previous exposure and training in ABA. Finally, long-term outcomes that include normative data on infants at risk of ASD need to be analyzed to confirm the overall efficacy of the present procedures in mitigating the severity or likelihood that the infant later receives a formal diagnosis.

The outcomes of the current experiment support the primary hypothesis that infants at risk of ASD can benefit from brief operant procedures that arrange social consequences to promote vocalizations within naturalistic settings, just like typically developing infants do. The type and timing of the social reinforcement provided by mothers appear to be a low-effort and effective means for increasing vocalizations in infants at risk of ASD. From a behavioral systems perspective (Novak & Pelaez, 2004), addressing the multiple environmental variables and contingencies that influence the behavior of an infant at risk of ASD provides both a pragmatic and optimistic approach to effective and proactive treatment. As expected in this study, the noncontingent vocal stimulation was ineffective at increasing the vocalizations of the infants. This may suggest the potential negative effects of inconsistent or misplaced parental contingencies within the natural environment that could influence the rate of early pivotal behaviors. Alternatively, naturalistic behavior-analytic interventions that target the precursor communication deficits that appear early during infancy can help strengthen and establish critical verbal repertoires among infants at risk of ASD.

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Compliance with Ethical Standards

Conflicts of Interest The authors declare that no relevant conflicts of interest influenced the nature of the present research investigation.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Further, measures were taken to minimize any risks, harms, and/or discomforts. Risks, harms, and/or discomforts were minimized in various ways. First, additional session attendance was not requested of the participant in the event of a cancellation. Second, direct parent training sessions were terminated contingent on the child becoming visibly distraught or agitated (e.g., crying) for no more than 30 s maximum, based on the parent's reported level of comfort at the onset of treatment. Last, if the parent requested to end or withdraw for any reason, the parent training sessions would have been terminated immediately.

Informed Consent Informed consent was obtained from the parents of the infants who participated in the study. Specifically, if the parent's child met the characteristics for participation in the study, and the parent provided consent-to-participation forms for both him- or herself and his or her child (via parental and child consent forms), the child would then begin the assessment procedures. The primary investigator was available and willing to answer any questions that the parent may have had regarding the study and his or her child's participation throughout every session. Further, the consent form stressed that the parent may withdraw his or her child's participation at any time and that all participation is purely voluntary in nature.

References

Garrido, D., Watson, L., Carballo, G., Garcia-Retamero, R., & Crais, E. (2017). Infants at risk for autism spectrum disorder: Patterns of vocalizations at 14 months. *Autism Research, 10*(8), 1372–1383.

Gazdag, G., & Warren, S. (2000). Effects of adult contingent imitation on development of young children's vocal imitation. *Journal of Early Intervention, 23*(1), 24–35. https://doi.org/10.1177/105381510002300107 01.

Masur, E., & Olson, J. (2008). Mothers' and infants' responses to their partners' spontaneous action and vocal/verbal imitation. *Infant Behavior and Development, 31*(4), 704–715.

Neimy, H., Pelaez, M., Carrow, J., Monlux, K., & Tarbox, J. (2017). Infants at risk of autism and developmental disorders: Establishing early social skills. *Behavior Development Bulletin, 22*(1), 6–22. https://doi.org/10.1037/bdb0000046.

Novak, G. & Pelaez (2004*)*. Child and adolescent development: A behavior systems approach. Sage Publications.

Ozonoff, S., Iosif, A. M., Baguio, F., Cook, I., Hill, M., Hutman, T., & Young, G. (2010). A prospective study of the emergence of early behavioral signs of autism. *Journal of the American Academy of Children & Adolescent Psychiatry, 49*, 256–266.

Pelaez, M., Borroto, A., & Carrow, J. (2018). Infant vocalizations and imitation as a result of adult contingent imitation. *Behavior Development, 23*, 81–88. https://doi.org/10.1037/bdb0000074.

Pelaez, M., Virues-Ortega, J., & Gewirtz, J. L. (2011a). Reinforcement of vocalizations through contingent vocal imitation. *Journal of Applied Behavior Analysis, 44*, 33–40. https://doi.org/10.1901/jaba.2011.44-33.

Pelaez, M., Virues-Ortega, J., & Gewirtz, J. L. (2011b). Contingent and noncontingent reinforcement with maternal vocal imitation and motherese speech: Effects on infant vocalizations. *European Journal of Behaviour Analysis, 12*, 277–287. https://doi.org/10.1080/15021149.2011.11434370.

Poulson, C., Kymissis, E., Reeve, K., Andreatos, M., & Reeve, L. (1991). Generalized vocal imitation in infants. *Journal of Experimental Child Psychology, 51*, 267–279. https://doi.org/10.1016/0022-0965(91)90036-R.

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