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REINFORCEMENT OF VOCALIZATIONS THROUGH CONTINGENT VOCAL IMITATION

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Maternal vocal imitation of infant vocalizations is highly prevalent during face-to-face interactions of infants and their caregivers. Although maternal vocal imitation has been associated with later verbal development, its potentially reinforcing effect on infant vocalizations has not been explored experimentally. This study examined the reinforcing effect of maternal vocal imitation of infant vocalizations using a reversal probe BAB design. Eleven 3- to 8-month-old infants at high risk for developmental delays experienced contingent maternal vocal imitation during reinforcement conditions. Differential reinforcement of other behavior served as the control condition. The behavior of 10 infants showed evidence of a reinforcement effect. Results indicated that vocal imitations can serve to reinforce early infant vocalizations.

Key words: differential reinforcement of other behavior, infant vocalizations, language acquisition, maternal imitation, vocal conditioning

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The development of preverbal skills is highly relevant to successful language acquisition later in development. The literature suggests that parental vocal stimulation plays a role in this connection (Novak & Pelaez, 2004). For instance, speech-sound discrimination has been associated with mother's speech clarity (Liu, Kuhl, & Tsao, 2003), and preverbal skills, such as the ability to discriminate the boundaries between words, have been associated with verbal performance later in life (Benasich & Tallal, 2002; Newman, Ratner, Jusczyk, Jusczyk, & Dow, 2006). In a longitudinal study, Hart and Risley (1995, 1999) showed that preschoolers whose families engaged in high levels of verbal interaction arrived at kindergarten with a more advanced verbal repertoire. These preschoolers also made faster progress in reading during the first years of elementary school.

Adult caregivers display several vocalization topographies that may facilitate social responses and prompt infant vocal responses during face-to-face interactions (e.g., describing ongoing events, imitating, naming objects). Among these forms, maternal imitation of infant vocal sounds has been scarcely studied. Maternal imitation of infant vocalizations is a form of stimulation similar in topography to the responses produced by the child. A number of studies have shown that parents naturally imitate various acoustic features produced by their infants (Field, 1977; Papousek, 1992; Pawlby, 1977). Masur (1987) reported that

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mothers were likely to follow their infants' vocal imitations with a repetition of the imitation. Masur and Olson (2008) analyzed naturally occurring maternal vocal topographies in response to infant vocalizations during routine caretaking tasks (free play and bathtime) in twenty 10-month-old infants and their mothers. These authors reported that mothers responded to infant vocalizations on 86% of the opportunities and that maternal imitations occurred on 21% of these opportunities.

Interestingly, a study by Gros-Louis, West, Goldstein, and King (2006) showed that maternal imitation was associated with particular forms of infant vocalizations during natural mother–infant interactions. Specifically, mothers imitated consonant-vowel vocalizations more often than vowel-like vocalizations (14% vs. 2% of mothers' responses to infant vocalizations). This finding suggests that maternal imitation tends to follow vocalizations of higher articulatory complexity in the infant preverbal repertoire. Given that maternal imitation is influenced by the articulatory complexity of infant vocal sounds, it may be potentially effective in the gradual shaping of increasingly more sophisticated adult-like sounds.

A small body of research suggests the influence of maternal imitation on the behavior of infants. Field, Guy, and Umbel (1985) found that 3.5-month-old infants vocalized and smiled more frequently subsequent to maternal imitative as opposed to nonimitative behavior during both spontaneous and imitative face-to-face interactions. Masur and Olson (2008) showed that infant behavior was highly responsive to maternal imitations (e.g., 90% of opportunities in 10-month-old infants) whether in the form of return vocal imitation or other social responses (e.g., smiles, gaze shifts, object-related behaviors, nonimitative vocalizations). Responsiveness to maternal imitation, in terms of the proportion of occasions on which children used words to respond to maternal imitation, was correlated with children's lexicon at 21 months of age (see also Tamis-LeMonda, Bornstein, & Baumwell, 2001). Gadzag and Warren (2000) investigated the effects of adult contingent vocal imitation on acquisition of vocal imitation in three young children with mental retardation and showed increased spontaneous imitation during generalization sessions. Based on this literature, we sought to investigate the effects of contingent maternal imitation of infant vocal sounds on vocalizations of infants 3 to 8 months of age.

The early operant-conditioning literature indicates that infant vocalizations can be increased through contingent social reinforcement (Rheingold, Gewirtz, & Ross, 1959; Weisberg, 1963). The infant conditioning literature has identified a number of social and nonsocial reinforcing stimuli for infant vocal responses, including tactile stimulation (e.g., lightly rubbing the infant's abdomen and legs), eye contact, smiles, auditory vocal stimulation (e.g., saying "hi baby," "nice baby"), 5-s vibration on the baby's hand, and others (see Pelaez-Nogueras, Gewirtz, et al., 1996; Poulson & Nunes, 1988).

Appropriate control strategies are highly relevant to this line of research. In an early study, Haugan and McIntire (1972) compared the reinforcing effects of maternal vocal imitation to those of tactile stimulation and food with 3- to 6-month-old infants. Maternal vocal imitation was the most effective reinforcer for infant vocal responses. However, these authors used an extinction-like baseline that did not allow isolation of the potential eliciting or evocative effects of the mere presentation of maternal vocal stimulation. The inclusion of controls to isolate reinforcement effects of social stimuli from eliciting effects is critical because researchers have argued that maternal vocal stimulation has eliciting effects on infant vocalizations (Bloom, 1975). In addition to the eliciting effects, the discriminative effects of maternal interactions also should be considered. Therefore, experimental demonstrations of social reinforcement on infant vocalizations require control conditions in which the social stimulus is presented to isolate reinforcement effects from eliciting and discriminative effects. Furthermore, extinction-like baselines (the adult sitting expressionless and nonresponsive in front of the infant; e.g., Bloom, 1977; Routh, 1969) may evoke a high rate of emotional behavior (infant crying, gazing away) as shown by Pelaez-Nogueras, Field, Hossain, and Pickens (1996). To avoid undesirable by-products of extinction-like baselines and to distinguish reinforcing effects from those elicited or occasioned by the mere presence of the stimuli, noncontingent stimulation (NCR) and differential reinforcement of other behavior (DRO) control techniques should be used (Thompson & Iwata, 2005). With NCR and DRO control conditions, stimulus density is kept constant across conditions while the response–reinforcer contingency is manipulated.

Bloom (1975) compared the rate of vocalization in 3-month-old infants across phases of contingent and noncontingent adult social stimulation. Both interventions increased rates of infant vocalizations. The author concluded that infant vocalizations may be elicited, rather than reinforced, by adult social stimulation (see Bloom, 1979, for a discussion). However, her research could not rule out the potential for adventitious reinforcement of infant vocalizations during the NCR control condition. Unlike NCR, DRO schedules reduce the possibility of adventitious or intermittent reinforcement of infant vocalizations.

Although the reinforcing effect of other forms of parental stimulation, including talking, touching, and presenting leisure items, has been demonstrated using adequate reinforcement control conditions (e.g., Poulson, 1983, 1988), the effect of maternal imitation as a reinforcer for infant vocalization has not been explored systematically. Furthermore, previous studies that used maternal vocalization as a reinforcing stimulus did not control for specific forms of adult response to infant vocalizations (e.g., Poulson, 1983). In addition, neither NCR nor DRO controls have been used to test the reinforcing effect of maternal vocal imitation on infants' early vocal sounds.

The existing body of research in this area suggests that specific forms of maternal vocal stimulation could be programmed to maximize the acquisition of preverbal skills among typically developing and language-delayed children, which may have an impact in later language development. We used a DRO control technique to obtain unambiguous data on the reinforcing effect of maternal vocal imitation. The goals of the present experiment were to analyze the reinforcing effects of maternal vocal imitation and determine the extent to which increases in infant vocal responding were due to operant reinforcement rather than the eliciting effects of maternal vocalizations.

METHOD

Participants

Seventeen infants and their mothers participated in this study. Six mother–infant dyads were excluded because the mothers did not implement the protocol consistently. We report the data from 11 infants (3 to 8 months old) of Caucasian, African-American, and Hispanic descent (mean age = 6.1 $\pm$ 1.4 months; 6 girls and 3 boys). These infants were born prematurely and therefore were at high risk for developmental delays. We recruited infants and their mothers consecutively from the waiting room of a pediatric clinic in Miami, Florida. Investigators asked mothers to participate voluntarily in a study on language development in babies. Mothers signed an informed consent form developed according to the Helsinki declaration guidelines. Investigators offered no monetary compensation for participation. Mothers and their babies received a certificate for their contribution to research and science.

Design

Infants were exposed to experimental conditions in a BAB reversal design. The first B phase consisted of contingent maternal imitation (CR_1), and the second phase (A) consisted of a DRO control condition in which mothers delivered vocal sounds that were matched to those previously recorded in A. The third phase repeated contingent maternal imitation (CR_2).

Setting and Apparatus

Each mother–infant dyad was studied in a laboratory in the pediatric clinic. Each infant sat in a high chair facing his or her mother throughout the session. Two camcorders installed in the room monitored infant and mother behavior concurrently. Next to the experimental room, a video monitor displayed mother and infant interaction in split-screen format. Sessions were recorded for later scoring and reliability analyses. From this control room, the experimenter observed the interaction and delivered instructions to the mother. All infant vocalizations and mothers' imitative vocal responses were recorded via a portable tape recorder. This recording machine was connected through earphones to the mother's ears during the DRO condition to allow her to match her own vocal responses from the preceding CR condition. A timer visible on the television screen determined when to begin and terminate each session.

Procedure

Three conditions were implemented in a single 11-min session. Each condition lasted 3 min. Intertrial intervals (1 min) separated conditions. Just prior to contingent reinforcement conditions (CR_1, CR_2), a research assistant instructed the mother to imitate the topography of each of her infant's vocal responses immediately after their emission. Under the DRO condition, the mother listened to and imitated her own vocal responses as recorded from the first CR condition. To prevent adventitious reinforcement, a research assistant, who was sitting away from the sight of both infant and mother, muted the tape player for 4 s each time the infant vocalized. Each mother first practiced imitating the recording after the first CR condition. Practice continued until she implemented the protocol correctly and consistently. Although we attempted to equate reinforcer density and temporal distribution across DRO and CR_1 conditions and to preclude adventitious reinforcement of the target behavior in the control condition, we did not implement the DRO control for the second CR condition.

To ensure that all mothers correctly imitated their infants' vocalizations during CR_1 and CR_2, and also to ensure even distribution of reinforcer density across CR_1 and DRO, we monitored and coded all maternal vocal responses. The first author discontinued the session in the event that the mother did not imitate an instance of infant vocalization correctly. Specifically, if the latency to maternal imitation was more than 2 s or the sequence of sounds by the mother (vowel and consonants) did not match that of the infant, the principal investigator discontinued the session. Research assistants retrained mothers as needed before resuming the protocol. In addition, the dyad was excluded if the mother's performance was inconsistent across CR_1 and DRO more than five times as a result of not following instructions.

When an infant was fussy, the researchers fed the infant, changed the diaper, or rocked the infant in an attempt to soothe him or her. The session resumed as soon as the infant was calm, alert, and awake. If the infant could not be calmed after 45 s or more of protest or crying, the principal investigator terminated the session and rescheduled the participants for a later time.

Measurement

Two trained research assistants recorded the number of occurrences of infant and mother vocalizations from the videotapes. We defined infant and mother vocalizations as discrete voice sounds including cooing and babbling lasting 2 s or more and separated by 1 s, excluding coughing, fussing, crying, belching, hiccuping,

Table 1
Infant and Mother Vocalizations During Contingent Reinforcement (CR_1, CR_2) and Differential Reinforcement of Other Behavior Control Procedure (DRO)

Dyad	Gender (age in months)	Infant vocalizations (count per session)					Mother vocalizations (count per session)			
		CR_1	DRO	CR_2	DRO CR_1	DRO CR_2	CR_1	DRO	CR_2	DRO CR_1
1	M (6)	16	3	24	−13	−21	15	13	25	−2
2	M (6)	12	2	11	−10	−9	16	20	8	4
3	F (6)	20	16	28	−4	−12	13	12	22	−1
4	F (5)	22	13	23	−9	−10	23	21	19	−2
6	M (6)	13	8	45	−5	−37	10	9	40	−1
7	M (6)	37	2	22	−35	−20	39	38	22	−1
8	F (8)	23	15	24	−8	−9	24	24	25	0
9	F (8)	17	15	33	−2	−18	19	17	34	−2
15	M (3)	20	22	28	2	−6	12	9	27	−3
16	F (6)	16	8	22	−8	−14	12	15	22	3
17	F (7)	41	23	65	−18	−42	40	45	60	5
	M 6.1	21.5	11.5	29.5	−10	−18	20.3	20.3	27.6	0
	SD 1.4	9.3	7.5	14.4	9.9	11.7	10.5	11.6	13.5	2.7

sneezing, straining sounds, whistling, squawking, loud breathing, and whining (based on Poulson, 1988). Vocal sounds were composed of identifiable vowel sounds or combinations of consonant and vowel sounds (e.g., ''ee,'' ''meh,'' ''mah,'' ''ag''). Vocalizations with no break between phonemes were counted as one occurrence (e.g., ''dadaba''). For coding and reliability purposes, each minute was subdivided into 30-s intervals for all observations. A split-screen monitor allowed concurrent observation of the infant's and mother's behavior. We did not subtract the periods of access to maternal vocalizations from the total duration of a session.

Interobserver Agreement

The principal investigator trained two independent observers until they reached 90% agreement. The same two observers conducted all reliability observations. Sessions were divided in 30-s intervals. We calculated interobserver agreement through the exact count-per-interval method for both infant vocalizations and maternal vocal sounds. We divided intervals with agreement (both observers coded the same number of occurrences of target behavior) by the total number of intervals (agreements plus disagreements) and then converted this ratio to a percentage. Interobserver agreement was assessed for all sessions and all mother–infant dyads. Mean interobserver agreement for infant vocalizations and maternal vocal sounds was 87% (range, 83% to100%) and 89% (range, 83% to 100%), respectively.

RESULTS

Data on the number of infant and mother vocalizations for all mother-infant dyads are presented in Table 1 and Figure 1. The behavior of 10 of the 11 infants (all but S15) showed a pattern consistent of control by the reinforcement contingency: a decrease in vocalizations when DRO was introduced and an increase in vocalizations during CR_2. In addition, data on maternal vocalizations suggested that elicitation by maternal vocalizations was not responsible for infant responding under the CR conditions. Occurrences of maternal vocal stimuli were similar under DRO and CR_1 conditions.

DISCUSSION

Results suggest that infants' vocalizations are sensitive to contingent maternal speech as a reinforcer. Implementing a DRO control technique helped to discern reinforcing effects

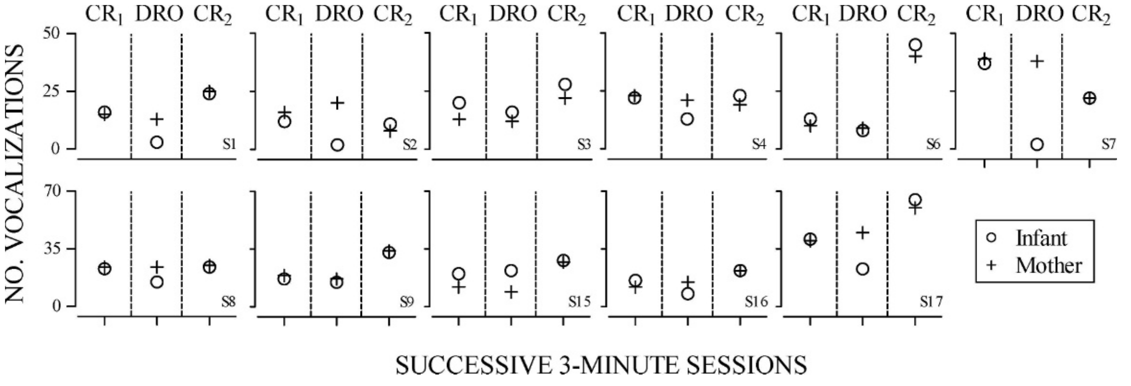

Figure 1. Number of infant and mother vocalizations during contingent reinforcement (CR_1, CR_2) and differential reinforcement of other behavior control condition (DRO).

from discriminative, eliciting, and adventitious reinforcement effects. The results showed that reinforcement could be demonstrated with a single DRO reversal probe for most subjects. However, because we did not program a no-reinforcement baseline, the design did not allow a determination of whether DRO suppressed vocalizations below baseline levels (see Poulson, 1983). In addition, it is conceivable that the use of a multisession design instead of probe reversal design would have strengthened our results significantly. However, between-subjects replication may have compensated for this potential shortcoming.

Future studies would benefit from longer sessions, more sessions within phases, and a second DRO control condition in which mothers' vocalization frequency could be yoked to the second CR condition (Thompson & Iwata, 2005). However, the current results suggest that contingent maternal vocal imitation reinforces infant vocalizations within a few treatment sessions.

Our results do not allow detection of response differentiation of specific vocalization topographies. Our approach implicitly assumes that the stimulus product of the infant responses may differentiate progressively through an incidental process of differential reinforcement. In other words, when the infant said "da" and the mother responded with "da," the frequency of "da" is assumed to increase over other vocalization topographies. Although vocal approximations to conventional verbal behavior are not usually observed until 1 year of age (e.g., Oller, Wieman, Doyle, & Ross, 1976), selective reinforcement of consonant versus vowel sounds has been observed in infants as early as 2 months of age (Routh, 1969). However, measuring this differentiation was not one of the purposes of the present study. On the contrary, the purpose was to instruct mothers to reinforce any infant vocalization; therefore, we expected a potentially unlimited variety of vocalizations followed by the reinforcing stimuli, making detection of response differentiation impractical. The main purpose here was to obtain an overall increase in the rate of infant vocalizations as a response class. Future studies may program a more molecular analysis of infants' response differentiation through the analysis of specific topographies during contingent reinforcement with maternal vocal imitation or other forms of maternal vocal topographies.

Studies have shown a relation between maternal vocal stimulation early in life and subsequent development of the verbal repertoire (Kaplan, Sliter, & Burgess, 2007; Masur & Olson, 2008; Newman et al., 2006; Tamis-LeMonda et al., 2001; Thiessen, Hill, & Saffran, 2005). There is also evidence indicating that mothers and caregivers naturally provide specific forms of vocal stimulation contingent on infants' vocalizations, including but not limited to questions, imitations, naming objects, and giving directives (Gros-Louis et al., 2006). Our study suggests that increased vocalization rates in infants can be demonstrated within very few sessions through contingent maternal vocal imitation. Future studies may establish to what extent the topographic similarity between the infant's own vocal responses and those of their parents and caregivers increases the reinforcing effectiveness of maternal vocalizations compared to other caregiver responses. More research also is needed on the longitudinal effects of maternal contingent vocalizations on verbal development. Reinforcement procedures based on effective forms of maternal vocalizations may bring about practical improvements both for typically developing children and for children with developmental disabilities and language delays. Finally, these lines of research may be instrumental for the expansion of the operant learning approach to human development (Gewirtz & Pelaez-Nogueras, 1992).

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