AN EVALUATION OF THE EFFECTS OF ADULT SOCIAL INTERACTION ON INFANT VOCALIZATIONS

BY

MEGAN HAFEN

Submitted to the graduate degree program in Applied Behavioral Science
and the Graduate Faculty of the University of Kansas
in partial fulfillment of the requirements for the degree of
Master's of Arts.

____
Chairperson Pamela L. Neidert

____
Edward K. Morris

____
Claudia L. Dozier

Date Defended: July 19, 2011

The Thesis Committee for MEGAN HAFEN certifies
that this is the approved Version of the following thesis:

AN EVALUATION OF THE EFFECTS OF ADULT SOCIAL INTERACTION ON INFANT VOCALIZATIONS

____

Chairperson Pamela L. Neidert

Date approved: July 19, 2011

Abstract

The results of previous studies suggest that infant vocalizations may be sensitive to social interaction as a reinforcer (e.g., Poulson, 1983, 1988; Rheingold, Gewirtz, & Ross, 1959). The purpose of Study 1 was to conduct descriptive analyses to examine teacher-infant interactions in three early education settings to determine (a) the prevalence of vocalizations, (b) the temporal contiguity between infant vocalizations and adult social interaction, and (c) the nature of adult social interaction. The purpose of Study 2 was to replicate the results of previous experimental analyses by demonstrating higher levels of vocalizations in a reinforcement condition as compared to levels of vocalizations in an extinction (EXT) condition. Results of Study 1 showed that (a) levels of vocalizations were similar across classrooms, (b) potential neutral contingencies between social interaction and vocalizations existed in two of the three classrooms, and (c) the nature of adult social interaction varied across the classrooms. Results of Study 2 failed to replicate those of previous research in demonstrating consistently higher levels of vocalizations in the reinforcement condition as compared to levels of vocalizations in the EXT condition. The author discusses potential reasons for this failure to replicate, including the possibility of automatically maintained vocalizations. Additional experimental analyses are necessary to further explain the inconsistent results obtained in Study 2.

An Evaluation of the Effects of Adult Social Interaction on Infant Vocalizations

Much research exists on the effects of social interaction on infant vocalizations, and several theories attempt to describe the link between infant vocalizations and language development. However, an understanding of the structural changes that occur in infant vocalizations, from birth to age 1, may be beneficial prior to further study in this area.

During the first year of life, infants engage in many prelinguistic sounds (i.e., sounds produced prior to the development of language) that progress rapidly through developmental stages (Goldstein & Schwade, 2008; Kuhl & Meltzoff, 1996). Speech-like sounds are rare immediately after birth, though crying and fussing are common, and some vowel-like sounds are heard. Within the first two months, both vowel and consonant sounds are heard, often in the form of consonant-vowel combinations. Around 4-6 months, marginal babbling emerges in which consonant-vowel and vowel-consonant sequences are combined. Reduplicated babbling (i.e., production of repetitious consonant-vowel sequences) is observed between 7-10 months. During this stage, the timing with respect to vocalization onset and offset becomes more representative of that observed in adult speech. Additionally, consonant-vowel combinations are produced in repetition and in close temporal proximity such that sounds like “mama” and “baba” are heard. From about 10 months to 1 year of age, infant babbling becomes more variegated in nature, that is, a variety of consonant-vowel sequences are combined (e.g., “madaga”). During this stage, the intonation of infant vocalizations is qualitatively similar to that of adult speech, and long strings of variegated babbling occur that resemble adult conversation. This variegated babbling continues into the production of the child’s first words (Pena-Brooks & Hegde, 2000). Given the rapid development of language during the first few years of life, many theories have been developed to describe language acquisition.

In the early 1970s, the conceptualization of language acquisition began to shift from the role of innate linguistic knowledge to the role of the environment on language development (Moerk, 1976). Prior to this time, psycholinguists such as Noam Chomsky held a nativist view that language acquisition was innate and facilitated by the language acquisition device (LAD), an inborn mental structure that allowed infants to acquire and produce language. This LAD contained universal linguistic principles. Linguistic input was necessary to activate the analysis mechanism. The LAD enabled children to process incoming language and develop hypotheses regarding the rules of their native language (Owens, 2005; Poulson, Kymissis, Reeve, Andreatos, & Reeve, 1991). This theory suggested that although environmental stimuli played a role in activating the LAD, such stimuli played little role in the child's subsequent acquisition of language. Although the focus of psycholinguists has evolved over time from a central focus on rules to that of principles and parameters (Gervain & Mehler, 2010), an emphasis is still placed on the structure of language and the role of innate mechanisms (Owens, 2005), despite a heavy reliance on logical arguments as opposed to direct evidence (Palmer, 2000).

Alternatively, continuity theorists believe that infant vocalizations are precursors to adult speech and language acquisition (Oller, Wieman, Doyle, & Ross, 1976; Hamilton, 1977; Poulson & Nunes, 1988) and that infant vocalizations are shaped into verbal behavior (Hamilton, 1977; Siegel, 1969). Although the origin of communicative behavior is reflexive (e.g., the cry), continuity theorists believe that communicative behaviors contact reinforcement and ultimately develop into operant behavior. From a behavioral perspective, infant vocalizations are shaped into language through contingencies of reinforcement arranged by the caregiver and by automatic reinforcement. Numerous descriptive analyses (e.g., Hart & Risley, 1995; Moerk, 1976, 1990; Rondal, 1985) suggest that parents provide a large amount of feedback when their children speak, often in the form of expansions, confirmations, repetitions, or corrections. However, behavioral psychologists agree that this feedback does not occur at a sufficient level to describe all of a child's language development. Thus, behavioral psychologists propose that automatic reinforcement is the primary mechanism by which infant vocalizations are shaped into verbal behavior. In this process, the speech sounds of one's native language become conditioned reinforcers through their pairing with primary reinforcers. Further, when the infant vocalizes, an auditory stimulus is produced. Thus, the infant functions as both speaker and listener and receives immediate feedback regarding the "correctness" of its speech. The infant's production of vocalizations that conform to the speech sounds produced by members of their verbal community is automatically reinforcing. That is, achieving parity is automatically reinforcing (Donahoe & Palmer, 2004; Palmer, 1996; Smith, Michael, & Sundberg, 1996). Thus, unlike psycholinguists, continuity theorists stress the importance of the environment on language acquisition.

In an attempt to empirically evaluate the role of the environment on language acquisition, researchers have conducted experimental analyses to determine the effects of adult social interaction on infant vocalizations. Much research has been conducted to determine whether the delivery of adult social interaction contingent on infant vocalizations functions to increase vocalizations (e.g., Bloom & Esposito, 1975; Masataka, 1993; Poulson, 1983, 1988; Rheingold, Gerwitz, & Ross, 1959; Weisberg, 1963). In other words, researchers have been interested in determining whether adult social interaction functions as a reinforcer for infant vocalizations and in determining specific characteristics of stimuli that influence infant vocalizations. For example, researchers have investigated whether adult presence, adult novelty, or adult gender produce differential reinforcement effects (e.g., Banikiotes, Montgomery, & Banikiotes, 1972;

Todd & Palmer, 1968; Wiegerink, Harris, Simeonsson, & Pearson, 1974). Other researchers have been interested in determining whether infant vocalizations are differentially sensitive to different types of contingent stimuli (e.g., Haugan & McIntire, 1972; Schwartz, Rosenberg, & Brackbill, 1970). In other words, researchers have been interested in determining whether stimulus events such as tactile stimulation, auditory stimulation, and visual stimulation independently function as reinforcers for infant vocalizations. In sum, research in the area of infant vocalizations has attempted to determine (a) the effects of contingent social interaction on levels of vocalizations, (b) the influence of experimenter characteristics on vocalizations, and (c) the reinforcing value of various characteristics of social interaction.

Effects of Contingent Social Interaction on Vocalizations

Several studies have exclusively examined the effects of contingent social interaction on the rate of infant vocalizations. In the earliest experimental analysis of infant vocalizations, Rheingold, Gewirtz, and Ross (1959) found that the delivery of social interaction (i.e., smiling, vocalizing, and physical contact) contingent on vocalizations increased the mean rate of vocalizations above that produced under conditions of extinction (i.e., no contingent social interaction; EXT) for a group of 21 infants. Although Rheingold et al. demonstrated that the delivery of social interaction influenced vocalizations, they did not use a control procedure that allowed them to separate reinforcement effects from elicitation effects. That is, the EXT condition used by Rheingold et al. involved both the termination of the response-reinforcer relationship and the absence of the social stimulus. Therefore, one cannot be certain that the contingency per se was responsible for the behavior change (Poulson, 1983; Thompson & Iwata, 2005). Increases in infant vocalizations under the reinforcement condition may have been due to the mere presence of social stimulation. In other words, although social interaction was delivered contingent on vocalizations during the reinforcement condition, this social stimulus was absent from the control condition. Thus, this stimulus delivery (i.e., social interaction) may have elicited infant vocalizations, characteristic of a stimulus-response relationship.

Given this, several studies on infant vocalizations have varied the control condition in an attempt to separate reinforcement effects from elicitation effects. Bloom and Esposito (1975) and Masataka (1993) compared infants' mean rate of vocalizations in an EXT condition, in which the experimenter leaned over the infant's crib while maintaining a neutral facial expression and providing no social interaction, to mean rates of vocalizations in either a contingent reinforcement condition (i.e., experimenter leaned over crib and provided social interaction immediately following each vocalization) or noncontingent reinforcement condition (i.e., experimenter leaned over crib and provided social interaction on a time-based schedule that was yoked to the delivery of social interaction in the contingent condition; NCR). In the Bloom and Esposito study, infants that were initially assigned to the contingent reinforcement condition experienced the NCR condition following a return to EXT. In the Masataka study, however, two test exposures were conducted, one at 3 months and one at 4 months of age. Each exposure consisted of one, 8-min session. Following a 2-min EXT period, the infants were randomly assigned to either the contingent reinforcement or NCR conditions for the remaining 6 min. Thirty days later, this same procedure was followed and constituted the second text exposure. Thus, given that the group of infants was randomly assigned to the contingent reinforcement or NCR conditions during both text exposures, it was not guaranteed that each infant would experience each test condition. Results of the Bloom and Esposito and Masataka studies found significant increases in vocalizations from EXT to either NCR or contingent reinforcement. They did not, however, show statistically significant differences in vocalizations between the groups that experienced NCR as compared to contingent reinforcement, suggesting that social interaction may not function to reinforce infant vocalizations. Alternatively, given that the amount of social interaction was yoked across the contingent and NCR conditions, these data may suggest that social interaction elicits infant vocalizations.

However, other studies that have used a NCR condition, in an attempt to separate reinforcement effects from elicitation effects, have obtained results inconsistent with those obtained by Masataka (1993) and Bloom and Esposito (1975). Weisberg (1963) conducted a study to analyze the importance of both the reinforcement contingency and the nature of the reinforcing stimulus (social vs. nonsocial) on levels of vocalizations. Weisberg compared mean rate of vocalizations for six groups of infants across the following conditions: no experimenter present (i.e., experimenter remained out of sight and no consequences were delivered for vocalizing), experimenter present (i.e., experimenter faced infant with a neutral facial expression and no consequences were delivered for vocalizing), contingent social stimulation (i.e., experimenter said “yeah” while smiling and stroking the infants chin immediately following vocalizations), contingent nonsocial stimulation (i.e., an expressionless experimenter faced infant, and a door chime sounded immediately following vocalizations), noncontingent social stimulation (i.e., social interaction, described previously, was delivered on a fixed-time schedule), and noncontingent nonsocial stimulation (i.e., a door chime sounded in the presence of an expressionless experimenter on a fixed-time schedule). Weisberg found that the mean vocalization rate for 33 infants was highest during the contingent social stimulation condition, suggesting that both the reinforcement contingency and the nature of the reinforcer may influence vocalizations.

Given that NCR conditions involve the response-independent presentation of the stimulus, researchers can equate the density of reinforcement across test and control conditions and separate the effects of stimulus presentation from those produced by the contingency. For this reason, NCR may be a better control condition than EXT. However, NCR schedules may lead to the problem of adventitious reinforcement (i.e., unprogrammed contiguity between the target response and reinforcer delivery) such that the NCR schedule functions as an intermittent schedule of reinforcement (Poulson, 1983; Thompson & Iwata, 2005), maintaining high levels of vocalizations unintentionally. To avoid this problem, a differential-reinforcement-of-other behavior (DRO) procedure could be arranged in which the delivery of reinforcement is based on the absence of vocalizations; therefore, reinforcement is never delivered in close temporal contiguity to an infant's vocalization. Although DRO and contingent reinforcement conditions contain contingencies of reinforcement, these contingency arrangements should produce opposite effects if vocalizations are sensitive to attention as a reinforcer. In other words, to demonstrate the operant nature of vocalizations, DRO should produce low levels of vocalizations, and contingent reinforcement should produce high levels of vocalizations. Finally, DRO procedures, like NCR procedures, enable researchers to program comparable densities of stimulation across test and control conditions given optimal responding under the DRO condition (Poulson, 1983; Thompson & Iwata, 2005). Thus, one could demonstrate that infant vocalizations are sensitive to social interaction as a reinforcer if levels of vocalizations under a contingent reinforcement condition are differentially higher than levels of vocalizations under a DRO condition, when density of stimulation is equated.

Poulson (1983) was the first to successfully use a DRO control procedure to examine the reinforcing efficacy of social interaction on infant vocalizations. She replicated this finding with a group of infants with Down Syndrome in 1988. Additionally, Poulson was one of the first to employ single-subject methodology to examine the effects of social interaction on infant vocalizations. In both studies, Poulson demonstrated that adult social interaction, delivered contingent on vocalizations, produced consistently higher levels of vocalizations as compared to vocalizations that occurred under a DRO procedure. This effect was observed despite comparable densities of social interaction across conditions. Her results suggest that infant vocalizations are sensitive to adult social interaction as a reinforcer.

Most recently, Pelaez, Virues-Ortega, and Gewirtz (2011) compared the effects of contingent maternal imitation on infant vocalizations to the level of vocalizations observed in a DRO condition. Pelaez et al. examined the frequency of infant vocalizations in a reversal probe BAB design (B=contingent maternal imitation, A=DRO) and showed higher levels of vocalizations in a contingent reinforcement condition as compared to levels of vocalizations in a DRO condition, suggesting that infant vocalizations are sensitive to contingent maternal imitation as a reinforcer. Though these effects are consistent with those obtained by Poulson (1983, 1988), the results from the Pelaez et al. study were obtained within a single, 11-min session. That is, each 11-min session consisted of three, 3-min conditions (i.e., 3-min contingent imitation, 3-min DRO, 3-min contingent imitation), each separated by a 1-min intertrial interval. Stronger conclusions, regarding the reinforcing efficacy of social interaction, may have been drawn given repeated measurement of behavior under these conditions.

In summary, although inconsistent results have been obtained regarding the extent to which social interaction functions as a reinforcer for vocalizations, multiple experimental analyses have demonstrated increases in vocalizations from EXT to social interaction conditions (e.g., contingent reinforcement, noncontingent reinforcement) and from DRO to social interaction conditions, suggesting that the delivery of social interaction influences infant vocalizations.

Effects of Experimenter Characteristics on Vocalizations

Other experimental analyses of infant vocalizations have attempted to answer questions regarding the influence of experimenter characteristics on vocalizations (e.g., experimenter presence, experimenter familiarity). Todd and Palmer (1968) evaluated the effects of experimenter presence on infant vocalizations. For one group of eight infants, the mean level of vocalizations was compared in a group ABA design (A=EXT, B=reinforcement). During the reinforcement condition, a pre-recorded human voice was played for 5 s contingent on vocalizations as the experimenter leaned over the infant's crib (adult-present group). The reinforcement condition was altered slightly for the second group of eight infants. Specifically, contingent on vocalizations for these infants, the pre-recorded human voice played for 5 s, but the experimenter remained out of sight (adult-absent group). For both groups of infants, Todd and Palmer found a higher mean level of vocalizations in the reinforcement condition as compared to the EXT condition, in which the adult was absent and no social interaction was delivered contingent on vocalizations. However, significantly higher levels of vocalizations were observed for the adult-present group, suggesting that human presence may alter the influence of adult social interaction.

Banikiotes, Montgomery, and Banikiotes (1972) examined the effect of experimenter gender on infant vocalizations. Sixteen infants were exposed to four, 3-min conditions. Following a 3-min EXT phase, half of the infants (*n*=8) experienced a 3-min reinforcement phase, in which pre-recorded female vocal stimulation was delivered contingent on vocalizations. The other half of the infants experienced pre-recorded male vocal stimulation contingent on vocalizations. Following this reinforcement phase, all infants experienced a return to the 3-min EXT condition. A 3-min reinforcement condition was then implemented with the opposite gender functioning as the pre-recorded vocal stimulation. Both groups showed higher levels of vocalizations under the reinforcement conditions as compared to the EXT condition; however, differentially higher levels of vocalizations were not observed with respect to the gender of the recording. Strong conclusions cannot be drawn from this study given that repeated measures were not taken under the various conditions; however, the results lend preliminary support to the notion that infant vocalizations are not differentially sensitive to experimenter gender.

In a similar study, Wiegerink, Harris, Simeonsson, and Pearson (1974) examined the effect of experimenter novelty on infant vocalizations. Six infants participated in the study, and the mean level of vocalizations was compared under reinforcement and EXT conditions in an ABAC design (A=EXT, B=reinforcement with one experimenter; C=reinforcement with second experimenter). During all EXT conditions, the novel or familiar reinforcing agent was present but did not interact with the infant. Following EXT, half of the infants (n=3) experienced a reinforcement condition, in which the mother (familiar experimenter) functioned as the reinforcing agent, and the other half of the infants experienced a reinforcement condition, in which a novel experimenter functioned as the reinforcing agent. Following a return to EXT, reinforcement was reintroduced using the opposite experimenter. Results showed a higher mean level of vocalizations during the reinforcement conditions as compared to the EXT conditions; however, no differential effect was observed with respect to the familiarity or novelty of the reinforcing agent. That is, similar levels of vocalizations were observed across reinforcement conditions despite changes in experimenter novelty. Although Wiegerink et al. did not replicate these effects, their data lend preliminary support to the notion that infant vocalizations are not differentially sensitive to experimenter novelty.

Effects of Social Interaction Characteristics on Vocalizations

Many of the early studies examining the role of social interaction on infant vocalizations used a combination of reinforcing stimuli. In other words, auditory, visual, and physical attention were delivered contingent on each instance of vocalizing. Often, this occurred in the form of stroking the infant's chin while smiling and saying "good baby." Several researchers were interested in determining whether infant vocalizations were differentially sensitive to different characteristics of attention delivered as part of the social interaction with the infant.

Schwartz, Rosenberg, and Brackbill (1970) delivered dual-component reinforcement combinations to determine their relative reinforcing effectiveness. Three components were analyzed: auditory (A), visual (V), and tactile (T). The auditory component consisted of a 1-s tape-recorded female voice saying "nice baby," the visual component consisted of the experimenter smiling and nodding his head, and the tactile component consisted of the experimenter rubbing the infant's stomach. Stimuli were delivered in pairs (i.e., AV, AT, TV). Mean levels of infant vocalizations were compared in a group ABA design (A=EXT, B=reinforcement). During the EXT condition, the experimenter leaned over the infant's crib and impassively observed the infant for two, 20-min sessions. During the reinforcement condition, the infant received one of the dual-component combinations of attention contingent on vocalizations. The reinforcement condition continued until the experimenters observed an increase in the level of vocalizations (2.5 times that observed in EXT) that sustained for 5 consecutive min or until three, 20-min sessions passed without meeting this criterion. Increases in vocalizations, to the criterion specified above, were obtained with each of the dual-component combinations in less than 21 min (i.e., the latency to observing a sustained increase in the level of vocalizations occurred within about a single, 20-min session), and the mean difference in vocalization rate from EXT to reinforcement was significant. The EXT condition was then re-implemented for two, 20-min sessions and a significant decrease in the mean rate of vocalizations from reinforcement to EXT was observed. Schwartz et al. conducted a second evaluation, in which they examined the reinforcing effectiveness of each of the three stimuli in isolation. Procedures were similar to those described above. Increases in vocalizations, to the criterion specified previously, were obtained with each of the single components in less than 21 min (i.e., the latency to observing a sustained increase in the level of vocalizations occurred within about a single, 20-min session), and the mean difference in vocalization rate from EXT to reinforcement approached significance. The EXT condition was then re-implemented for two, 20-min sessions and a significant decrease in the mean rate of vocalizations was observed from reinforcement to EXT. Although Schwartz et al. saw increases in vocalizations when social interaction was delivered contingent on vocalizations, they did not find any significant differences between the reinforcing effectiveness of the three stimuli, delivered either singly or in pairs. These data suggest that the nature of the contingent stimulus may not have differential effects on infant vocalizations.

However, Haugan and McIntire (1972) found somewhat different effects. These authors divided 24 infants into three experimental groups based on the stimulus to be provided contingent on vocalizing: vocal imitation, baby food, and tactile stimulation (stroked skin for 2 s). Haugan and McIntire compared the mean rates of vocalizations across the three experimental groups under conditions of EXT and of reinforcement. Although the authors observed increases in vocalizations across all three groups from EXT to reinforcement, only the group that received vocal imitation contingent on vocalizations showed significant decreases in vocalizations when returning to the EXT condition. Given little difference in the level of vocalizations from reinforcement to EXT for the other two groups, one is unable to conclude whether contingent tactile stimulation or contingent food functioned as reinforcers for vocalizations. The authors did show, however, that contingent vocal imitation was effective at producing increases in vocalizations above those observed in EXT. In other words, Haugan and McIntire showed that infant vocalizations were differentially sensitive to the stimuli delivered contingent on responding.

Descriptive Analyses of Infant Vocalizations

Tightly controlled experimental analyses suggest that the delivery of social interaction contingent on infant vocalizations increases the frequency with which infants vocalize. This effect is observed most consistently when levels of vocalizations in a reinforcement condition are compared to levels of vocalizations in an EXT or DRO condition. To increase the frequency of infant vocalizations outside of experimental sessions, these results suggest that high levels of adult social interaction should surround instances of vocalizing throughout the infant's day.

Given this, researchers have used descriptive analyses in an attempt to examine the naturally occurring interactions between infants and their caregivers. Clarke-Stewart (1973) spent nine months conducting repeated observations of 36 mothers and their firstborn infants. During each 30-min observation, the observer recorded mother and infant behaviors during 10-s intervals. The percentage of 10-s intervals in which the mother provided verbal stimulation to the infant, regardless of the infant's behavior (i.e., unconditional probability of verbal stimulation), averaged 25% of intervals. Relatively low levels (14%) of physical contact were observed, and stimulation or engagement with tangible items occurred in fewer than 5% of 10-s intervals. In addition to the observational samples, tests of the baby's language competence, cognitive development, and social and play behaviors were taken. Using multiple regression analyses, Clarke-Stewart found that verbal stimulation was the maternal variable most highly related to children's competence. Within this competence factor, verbal stimulation was most closely related to the child's language ability.

Other descriptive analyses have attempted to determine whether parental interactions occur at differentially higher levels based on the topography of the infant's response. Keller and Schölmerich (1987) examined mother-infant and father-infant interactions during ongoing home routines. Data were collected on four topographies of infant vocalizations: physiological (e.g., throat-closing sounds, clicking, drinking sounds), positive (e.g., babbling, cooing, laughing), negative (e.g., whining, fussing, crying), and effort (e.g., "h" sounds, motor-effort sounds). Parental behaviors were coded according to interactional states (i.e., eye contact) and tactile, vestibular, and verbal/vocal behavior. Frequency of infant vocalizations was recorded, and the 5 s immediately preceding and immediately following each vocalization were analyzed for parental behaviors. Keller and Schölmerich found higher levels of positive vocalizations, and lower levels of negative vocalizations, in the presence of parent eye contact. Differentially higher levels of verbal/vocal parental behaviors were observed surrounding instances of positive vocalizing as compared to other types of infant vocalizations.

Differential caregiver responding to infant vocalizations was also observed by Gros-Louis, West, Goldstein, and King (2006). The authors examined mother-infant interactions across 10 dyads. Observers scored several topographies of infant vocalizations and various maternal responses during a 10-min unstructured play sample. Contingent maternal responses were scored if they occurred within 2 s of the onset of the infant's vocalization. Gros-Louis et al.

found that mothers responded contingently to infant vocalizations during 73% of opportunities. The authors also found that mothers were more likely to respond to their infant's consonant-vowel vocalizations in comparison to vowel-only vocalizations. Additionally, mothers were most likely to produce play vocalizations (e.g., sound effects, singing) in response to their infant's vowel-like vocalizations and imitations, expansions, or acknowledgements (e.g., "Mmm-hmm") contingent on their infant's consonant-vowel vocalizations.

Studies similar to the ones conducted by Keller and Schölmerich (1987) and Gros-Louis et al. (2006) provide important information with respect to the topography of parental interactions surrounding (i.e., as an antecedent or consequent) instances of vocalizing and the extent to which parental interactions surround vocalizations (i.e., conditional probabilities); however, it is unclear from these studies what types of parental interactions occur in the absence of infant vocalizations (i.e., unconditional probabilities of social interaction). This information would be helpful in determining whether parental interactions occur at differentially higher levels surrounding instances of vocalizing as compared to overall levels of social interaction or whether the topography of interaction surrounding instances of vocalizing differs from that provided in the absence of infant vocalizations. Thus, the probability of parental interactions surrounding infant vocalizations may provide more information if one knows the probability of parental interactions that occur regardless of infant behavior (i.e., unconditional probability). That is, the use of descriptive analyses may represent an incomplete analysis of potential response-reinforcer relations without calculating the unconditional probability of the event. More specifically, knowledge of the unconditional probability is necessary to determine potential contingency strength (Vollmer, Borrero, Wright, Van Camp, & Lalli, 2001). Thus, determining the unconditional probability of adult social interaction allows for a more complete analysis of the potential contingency between infant vocalizations and adult social interaction. In addition, previous descriptive analyses have looked at parental interactions surrounding instances of vocalizing (both antecedent and consequent interactions), but few have analyzed these events separately.

In addition to similarities in the methods of data analysis that were conducted, all of the descriptive analyses mentioned above examined parent-infant interactions. Though descriptive analyses examining interactions between parents and their infants is undoubtedly important, approximately 17% of infants in the United States attend some type of organized day care (Moon, Patel, & Shaefer, 2000). Therefore, it seems important that descriptive analyses also be conducted of caregiver-infant interactions in early education environments.

The purpose of Study 1 was to conduct descriptive analyses of infant vocalizations and caregiver interactions in early education infant classrooms to determine (a) the prevalence of infant vocalizations and crying under typical classroom arrangements, (b) the relationship between infant vocalizations and adult social interaction (i.e., to identify common behavioral sequences involving infant vocalizations), and (c) the nature of adult social interaction in typical, early education environments. The purpose of Study 2 was to empirically evaluate the effects of caregiver attention commonly observed during social interactions with infants in early education classrooms (identified in Study 1) on infant vocalizations. Subsequently, if contingent social interaction functioned as a reinforcer for infant vocalizations, we wanted to determine if vocalizations were differentially sensitive to specific characteristics of caregiver attention (e.g., physical, vocal, tangible).

Method: Study 1 (Descriptive Analysis)

Participants and Setting

Twenty-three infants, who ranged in age from 3 to 13 months, and their caregivers participated in this study. Participants were selected from three early education infant classrooms, consisting of one university-based classroom and two community-based classrooms. Sessions were conducted in the infant's classroom. For each participant, a minimum of one, 15-min observation was conducted. Additional observations were conducted until at least 10 intervals with vocalizations were observed for each of the participants. Table 1 provides demographic information for each of the classrooms and lists the total observation time that was necessary to capture at least 10 intervals with vocalizations for each of the infants within a given classroom.

Response Measurement and Interobserver Agreement

Observations were partitioned into 5-s intervals. During each interval, data were collected on the occurrence of infant vocalizations and crying using partial-interval recording. A vocalization was defined as any vocal sound with the exception of crying, burping, hiccupping, coughing, sneezing, or heavy breathing. Crying was defined as prolonged, monotonous droning (i.e., whining) or loud, high-pitched sounds characterized by rapid inhalations and exhalations, accompanied by negative affect to the extent that such affect was viewable to the observers. Data were also collected on the delivery of vocal, physical, and tangible interactions by caregivers using partial-interval recording. Vocal interactions were defined as any vocal statements (e.g., instruction, praise, reprimand, imitation, descriptive statement, etc.) made by a caregiver directed toward the target infant. Physical interactions were defined as any physical contact between a caregiver and the target infant, and tangible interactions were defined as the presentation of toys or manipulation of toys by a caregiver directed toward the target infant. Data were collected via hand-held computers. Multiple events could be scored during each interval. Behaviors were recorded in all intervals in which they occurred. For example, if crying began in one interval and continued into the next interval, it was recorded in both intervals.

A second observer simultaneously, but independently, recorded infant and teacher responses during 35% of sessions. Agreement scores were determined using an interval-agreement calculation in which each 15-min session was divided into consecutive 5-s intervals. The number of agreements was divided by the number of agreements plus disagreements and multiplied by 100. An agreement was defined as both observers scoring the occurrence of the target behavior (e.g., vocalization or type of social consequence) or both observers scoring the nonoccurrence of the target behavior during a given 5-s interval. A disagreement was defined as one observer scoring the occurrence of the target behavior and the other observer scoring the nonoccurrence of the target behavior during a given 5-s interval. Mean interobserver agreement for vocalizations was 91.5% (range, 81% to 100%). Mean interobserver agreement for crying was 96.8% (range, 79% to 100%). Mean interobserver agreement for vocal, physical, and tangible interactions was 90.4% (range, 73% to 98%), 96.2% (range, 92% to 100%), and 96.1% (range, 86% to 100%), respectively.

Data Analysis

Following the observations, several probabilities were calculated to determine correlations between infant behavior and environmental events. Unconditional probabilities of vocalizations, crying, and social interaction were calculated to determine the overall level of these behaviors across settings. Unconditional probabilities were calculated by summing the number of intervals with the target behavior (i.e., vocalizations, crying, or social interaction) and dividing by the total number of intervals in the session. Individual participant data were summed to yield unconditional probabilities for each of the three classrooms.

Conditional probabilities were calculated to determine the relation between infant and adult behavior. To calculate conditional probabilities, antecedent and consequent events were recorded. An antecedent event was defined as social interaction that occurred in the interval preceding an interval with infant behavior (i.e., vocalization or crying). A consequent event was defined as social interaction that occurred in the interval following an interval with infant behavior. Conditional probabilities of antecedent social interaction were calculated by summing the number of intervals with antecedent social interaction and dividing by the total number of intervals with social interaction. Conditional probabilities of consequent social interaction were calculated by summing the number of intervals with consequent social interaction and dividing by the number of intervals with social interaction. Individual participant data were summed to yield conditional and unconditional probabilities for each of the three classrooms.

Finally, the unconditional probability of each type of social interaction (i.e., vocal, physical, and tangible) was calculated to determine the prevalence of each social interaction characteristic across the three classrooms. The unconditional probability of each type of social interaction was calculated by summing the number of intervals in which a given type of social interaction (e.g., vocal) occurred and dividing by the total number of intervals with social interaction. Individual participant data were summed to yield conditional probabilities for each of the three classrooms.

Results: Study 1 (Descriptive Analysis)

Figure 1 shows the unconditional probability of vocalizations (top panel) and crying (bottom panel) in each of the three classrooms. The unconditional probability of vocalizations in Classroom 1 was 0.109. The unconditional probability of vocalizations in Classrooms 2 and 3 was 0.170 and 0.098, respectively. The unconditional probability of crying in Classrooms 1, 2, and 3 was 0.093, 0.025, and 0.114, respectively.

Across all three classrooms, the unconditional probability of adult social interaction exceeded levels of infant behavior. Figure 2 shows the unconditional probability of social interaction in comparison to levels of infant vocalizations (top panel) and crying (bottom panel). The unconditional probability of social interaction in Classrooms 1, 2, and 3 was 0.273, 0.408, and 0.209, respectively.

Figure 3 shows the conditional probability of social interaction as an antecedent event in the top panel and as a consequent event in the bottom panel. Conditional probabilities are shown in comparison to unconditional probabilities of social interaction. With respect to the temporal contiguity of infant vocalizations and adult social interaction, the conditional probability of antecedent social interaction given a vocalization (i.e., the likelihood that social interaction occurred in the interval preceding an interval with a vocalization) for Classroom 1 was 0.275. The conditional probability of consequent social interaction given a vocalization (i.e., the likelihood that social interaction occurred in the interval following an interval with a vocalization) for Classroom 1 was 0.213. Classroom totals suggest that the infants in Classroom 1 were equally likely to receive attention immediately preceding vocalizations as they were to receive attention regardless of their behavior (conditional probability equal to unconditional probability of social interaction); however, individual participant data for the infants in Classroom 1, as shown in the top panel of Figure 4, failed to reveal this pattern of responding. These classroom data were obtained because half of the infants in Classroom 1 showed higher levels of social interaction immediately preceding vocalizations and the other half showed lower levels of social interaction immediately preceding vocalizations. Thus, this division in individual participant data suggested that the infants were equally likely to receive social interaction preceding vocalizations as compared to overall levels of social interaction for the classroom as a whole. With respect to consequent social interaction, the infants in Classroom 1 were less likely to receive social interaction immediately following vocalizations as they were to receive social interaction at other times (conditional probability less than unconditional probability of social interaction). This effect was observed for seven of eight infants in Classroom 1 as shown in the bottom panel of Figure 4.

In Classroom 2 (Figure 5), the conditional probability of antecedent social interaction given a vocalization was 0.466, and the conditional probability of consequent social interaction given a vocalization was 0.489. Thus, the infants in Classroom 2 were more likely to receive social interaction surrounding instances of vocalizing than they were to receive social interaction regardless of their behavior (conditional probabilities greater than unconditional probability of social interaction). Individual participant data, as shown in Figure 5, suggested that five of the seven infants demonstrated this pattern of responding in which social interaction was more likely to occur surrounding instances of vocalizing.

The conditional probability of antecedent social interaction given a vocalization in Classroom 3 was 0.178, and the conditional probability of consequent social interaction given a vocalization was 0.129. In other words, the infants in Classroom 3 were less likely to receive social interaction immediately surrounding instances of vocalizing than they were to receive social interaction regardless of their behavior (conditional probabilities less than unconditional probability of social interaction). This pattern of responding was observed for five of the eight infants in Classroom 3 as shown in Figure 6.

Figure 7 shows the temporal contiguity of infant crying and adult social interaction as an antecedent event in the top panel and as a consequent event in the bottom panel. The conditional probability of antecedent social interaction given crying in Classroom 1 was 0.250; the conditional probability of consequent social interaction given crying was 0.250. Comparing conditional probabilities to unconditional probabilities suggested that the infants in Classroom 1 were less likely to receive social interaction surrounding instances of crying as compared to overall levels of social interaction. This pattern of responding was observed for three of the five infants in Classroom 1 who engaged in some level of crying during the classroom observation as shown in Figure 8.

The conditional probability of antecedent social interaction given crying in Classroom 2 was 0.278; the conditional probability of consequent social interaction given crying was 0.450. These data suggest that the infants in Classroom 2 were less likely to receive social interaction immediately preceding instances of crying, but were more likely to receive social interaction immediately following instances of crying as compared to overall levels of social interaction. This effect, as shown in Figure 9, was observed for one of the two infants in Classroom 2 who engaged in some level of crying during the classroom observation.

The conditional probability of antecedent social interaction given crying in Classroom 3 was 0.289, and the probability of consequent social interaction given crying was 0.305. These data suggest that the infants in Classroom 3 were more likely to receive social interaction surrounding instances of crying than they were to receive social interaction regardless of their behavior. This effect was observed for three of the seven infants in Classroom 3 as shown in Figure 10.

Figure 11 shows the prevalence of various social interaction characteristics delivered by the classroom teachers. We found that vocal interaction occurred most frequently in Classrooms 1 and 2 with unconditional probabilities of 0.765 and 0.738, respectively. The most common social interaction characteristic in Classroom 3 was physical interaction with an unconditional probability of 0.617; vocal interaction followed closely at 0.498. Of the three types of social interaction examined, physical interaction was ranked second in terms of prevalence for Classrooms 1 and 2 with unconditional probabilities of 0.252 and 0.498, respectively. Tangible interactions were low across all three settings with unconditional probabilities of 0.197, 0.050, and 0.042 for Classrooms 1, 2, and 3, respectively.

Method: Study 2 (Experimental Analysis)

Participants and Setting

Two infants, Jake and Jenna (both 8.5 months), who attended a university-based, full-day early education program participated in this study. Sessions were conducted in small session rooms, each equipped with a one-way observation mirror. Toys commonly found in early education programs (e.g., toy car, ball, rattle, etc.) were present across sessions in an attempt to compete with crying. Sessions were 10 min in length during the reversal design. During the multielement design, EXT sessions were 5 min in length, and the reinforcement (Sr+) sessions lasted until 5 min had elapsed in which the EO was present. Thus, the duration of these sessions varied from session to session (range, 7.25 min to 15.5 min). Sessions were terminated early if the child displayed signs of distress or if crying persisted for 2 consecutive min. Sessions were conducted two to three times per day, two to five days per week and were scheduled as to not interfere with the child’s daily routines (e.g., meals, naps).

Response Measurement and Interobserver Agreement

Observations were partitioned into 5-s intervals. During each interval, data were collected on the occurrence of infant vocalizations and crying, as defined in Study 1, using partial-interval recording. Data were also collected on toy engagement using partial-interval recording. Toy engagement was defined as the infant's hand(s) being in contact with a tangible item or the infant orienting toward objects being manipulated by the experimenter or objects that moved independently (e.g., music ball that would light up, sing, and spin after pushing a button). Data were collected on the duration of social interaction by scoring its onset and offset. Social-interaction onset was defined as experimenter initiation of vocal, physical, or tangible interactions (as defined in Study 1). Social-interaction offset was defined as experimenter termination of vocal, physical, and tangible interactions. Data were collected via hand-held computers. Multiple events could be scored during each interval. Behaviors were recorded in all intervals in which they occurred.

A second observer simultaneously but independently recorded infant and teacher responses during 35% of sessions. Agreement scores were calculated as described in Study 1 unless noted otherwise. Mean interobserver agreement for vocalizations, crying, and toy engagement was 91.5% (range, 81% to 100%), 96.8% (range, 79% to 100%), and 96.8% (range, 79% to 100%), respectively. To calculate interobserver agreement for social interaction, we marked the interval in which social-interaction onset was scored. The occurrence of social interaction was marked in each subsequent interval until social-interaction offset was observed, denoting the final interval with social interaction for that episode. Then, we compared primary and reliability records and noted any intervals in which one observer said social interaction was present and the other said social interaction was absent (i.e., a disagreement interval). Interobserver agreement was calculated using the interval-agreement calculation described previously, in which the number of agreements was divided by the number of agreements plus disagreements and multiplied by 100. An agreement was defined as both observers scoring the occurrence of social interaction or both observers scoring the nonoccurrence of social interaction during a given 5-s interval. A disagreement was defined as one observer scoring the occurrence of social interaction and the other observer scoring the nonoccurrence of social interaction during a given 5-s interval. Mean interobserver agreement for social interaction was 96.1% (range, 86% to 100%).

Procedure

The effects of social interaction on infant vocalizations were compared using a combination of reversal and multielement designs. To promote discrimination of the different contingencies, conditions were assigned to session rooms of varying colors. During all sessions, the experimenter and infant entered the session room together and the infant was placed in a seated position. Preliminary data failed to show systematic changes in the level of vocalizations across test (i.e., contingent reinforcement) and control conditions when DRO and NCR procedures were used. Similar inconsistencies have been observed in previous studies when NCR procedures are used as the control condition (e.g., Bloom & Esposito, 1975; Masataka, 1993; Weisberg, 1963). Alternatively, systematic changes in the level of vocalizations across test and control conditions have been consistently reported when EXT is used as the control procedure (e.g., Banikiotes et al., 1972; Bloom & Esposito, 1975; Haugan & McIntire, 1972; Masataka, 1993; Rheingold et al., 1959; Schwartz et al., 1970; Todd & Palmer, 1968; Wiegerink et al., 1974). Given the results of our preliminary data, EXT was used as the control condition in the present study in an attempt to demonstrate systematic changes in the level of vocalizations across test and control conditions, consistent with the findings of previous research, before further evaluating the use of NCR and DRO procedures as control conditions in determining the extent to which social interaction functions as a reinforcer for infant vocalizations.

10-min EXT/5-min EXT. Experimenter sat in a corner of the room, averted eye contact with the infant, and delivered no social interaction for the duration of the session.

10-min Sr+/5-min Yoked EO Present Sr+. Experimenter sat in close proximity to the child. Experimenter made eye contact with the infant and delivered social interaction (combination of vocal, physical, and tangible interactions for about 15 s in duration) contingent on vocalizations according to an FI 5-s schedule.

5-min Yoked EO Present Sr+(tang). Experimenter sat in close proximity to the child. Experimenter made eye contact with the infant and engaged in tangible interactions (e.g., shook rattle, rolled car on floor, pushed buttons to make toys light up or make music) for about 15 s in duration contingent on vocalizations according to an FI 5-s schedule.

5-min Yoked EO Present Sr+(vocal). Experimenter sat in close proximity to the child. Experimenter made eye contact with the infant and engaged in vocal interactions (e.g., sang songs, commented on the infant's clothes, talked about events of the day) for about 15 s in duration contingent on vocalizations according to an FI 5-s schedule.

5-min Yoked EO Present Sr+(phys). Experimenter sat in close proximity to the child. Experimenter made eye contact with the infant and engaged in physical interactions (e.g., tickled the infant, blew raspberries on the infant's tummy, hugged the infant, tossled the infant's hair, etc.) for about 15 s in duration contingent on vocalizations according to an FI 5-s schedule.

The percentage of intervals with vocalizations, when the relevant establishing operation (EO) was present, was compared across 10-min EXT and Sr+ sessions using a reversal design. To ensure that higher levels of vocalizations in the Sr+ condition relative to the EXT condition was not a function of denominator size (i.e., the number of 5-s intervals in which the EO was present during the EXT sessions averaged 115 intervals for Jake and 106 intervals for Jenna; however, the number of 5-s intervals in which the EO was present during the Sr+ sessions averaged 47 intervals for Jake and 50 intervals for Jenna), a multielement comparison of 5-min EXT and 5-min yoked EO present Sr+ sessions was conducted. In other words, Sr+ sessions continued until 5 min, in which the EO was present (i.e., absence of attention), had elapsed. To determine this, a 5-min timer was set prior to each Sr+ session. Throughout the session, the timer was started contingent on social-interaction offset and stopped contingent on social-interaction onset until the 5 min elapsed. During this multielement comparison, the number of 5-s intervals in which the EO was present during the EXT sessions averaged 60 intervals for both Jake and Jenna, and the number of 5-s intervals in which the EO was present during the Sr+ sessions averaged 61 intervals for Jake and 62 intervals for Jenna.

Higher levels of vocalizations continued to be observed in the Sr+ sessions for Jenna. Given this, multielement comparisons of 5-min EXT and 5-min yoked EO present Sr+ sessions were conducted in which a single type of social interaction (i.e., vocal, physical, or tangible) was delivered contingent on vocalizations to determine whether Jenna's vocalizations were differentially sensitive to various characteristics of social interaction. These analyses continued until each type of social interaction had been tested in isolation. No differentiation in Jenna's level of vocalizations was observed across these phases, so a multielement comparison was conducted in which the combination of social interaction (i.e., vocal, physical, and tangible) was once again delivered contingent on each vocalization.

Results: Study 2 (Experimental Analysis)

Figure 12 shows the results for Jake. The percentage of intervals with vocalizations in which the EO was present intervals was highest during the Sr+ conditions, when session length was held constant across the EXT and Sr+ conditions. During the multielement comparison, in which the percentage of intervals in which the EO was present was matched across the EXT and Sr+ conditions, no differences in the levels of vocalizations were observed. These data suggest that the delivery of contingent social interaction had no effect on Jake's vocalizations. Given that moderate, undifferentiated levels of vocalizations were observed in the EXT sessions, these data likely suggest that Jake's vocalizations were either maintained by automatic reinforcement or that the experimenter functioned as a discriminative stimulus for the delivery of social interaction and thus the mere presence of the experimenter occasioned vocalizations. However, vocalizations were present throughout the EXT sessions. If the experimenter served a discriminative function, within-session patterns of responding may have revealed an extinction curve in which high levels of vocalizations would be observed initially; however, low levels of vocalizations may be observed toward the end of the session given repeated contact with EXT for vocalizing.

Figure 13 shows the results for Jenna. The percentage of intervals with vocalizations in which the EO was present was highest during the Sr+ conditions, when session length was held constant across the EXT and Sr+ conditions. Although undifferentiated levels of vocalizations were observed initially during the multielement comparison, in which the percentage of intervals in which the EO was present was yoked across EXT and Sr+ conditions, consistently higher levels of vocalizations in the Sr+ sessions as compared to the EXT sessions emerged across the course of sessions in this phase. These data likely suggest that social interaction influenced the level of Jenna's vocalizations. During the next three phases, when a single type of social interaction (i.e., vocal, physical, or tangible) was delivered contingent on Jenna's vocalizations, undifferentiated patterns of responding were observed. These data suggest that none of these characteristics of social interaction, when delivered in isolation, influenced the level of Jenna's vocalizations. When the characteristics of social interaction were combined during the last phase, variable and undifferentiated patterns of responding were observed, dissimilar to the pattern observed previously. These data suggest that social interaction did not influence Jenna's vocalizations. This lack of replication may have been a function of conducting an insufficient number of sessions during the first multielement comparison to allow undifferentiated responding to emerge, or these data may have captured a change in function over time (from vocalizations that were operant or respondent in nature to vocalizations that were maintained by automatic reinforcement).

Discussion

The present studies aimed to answer several questions about infant vocalizations and adult social interaction. In Study 1, we were interested in examining the relation between infant vocalizations and caregiver-infant interactions in early education infant classrooms for three reasons. First, we wanted to determine the overall level at which infants vocalize and cry under typical classroom arrangements. Results of our descriptive analysis found that infants engaged in relatively low levels of vocalizations and crying, fewer than 20% of 5-s intervals. Although low levels of crying are unlikely cause for concern, it was interesting that levels of vocalizations in Classrooms 1 and 3 did not exceed levels of crying in those classrooms. If vocalizations are precursors to adult language, these results may warrant the identification of procedures to increase infant vocalizations under typical, classroom arrangements.

Second, we wanted to determine the relation between infant vocalizations and adult social interaction. Results of the descriptive analysis suggested that the infants in Classrooms 1 and 3 were less likely to receive social interaction surrounding instances of vocalizing as compared to the unconditional probabilities of social interaction. Numerous experimental analyses (e.g., Poulson, 1983, 1988; Rheingold et al., 1959; Weisberg, 1963) have found that the delivery of social interaction contingent on vocalizations functions to increase vocalizations, suggesting that adult social interaction influences infant vocalizations.

Third, we wanted to identify the types of social interaction that were common in caregiver-infant interactions. Our descriptive analysis identified prevalent characteristics across each of the three classrooms; however, the prevalent characteristic varied across settings. For infants whose vocalizations are sensitive to social interaction as a reinforcer, it may be interesting to determining whether infant vocalizations are differentially sensitive to different characteristics of social interaction. In other words, it may be interesting to conduct studies similar to those of Haugan and McIntire (1972) and Schwartz et al. (1970) to determine the specific type of social interaction or the combination of types of social interaction that would yield the highest level of vocalizations. If differential responding is observed (i.e., differentially higher levels of vocalizations occur in the presence of a particular characteristic of social interaction), it would be important to ensure that caregivers include this potent social interaction characteristic in their interactions with that infant. Descriptive analyses may be used to determine whether the influential characteristic occurs with high probability given instances of social interaction and whether the potent social interaction characteristic occurs with high probability given instances of vocalizing. That is, if social interaction functions as a reinforcer and vocalizations are differentially sensitive to tangible interactions, for example, descriptive data would provide information regarding both the unconditional probability of tangible interactions and the conditional probability of consequent tangible interactions given instances of vocalizing.

With respect to characteristics of social interaction, it was interesting to note in the present study that tangible interactions were low across all three settings. Given this, one may be interested in determining whether tangible items were present and easily accessible throughout these settings or whether low levels of tangible interactions were a function of limited availability. Future researchers may consider taking measures on the presence of tangible items and infant manipulation of tangible items to provide additional information to help answer such questions. Additionally, our descriptive analysis did not capture information on classroom logistics that may influence caregiver interactions. Given that multiple infants were enrolled in each early education setting, one would expect that caregiver interaction would be divided across the infants that were present. One cannot tell from the present study whether multiple infants were present in a given observational sample. Likewise, one cannot determine how caregivers allocated their responding (e.g., time allocated to social interaction with other infants, time allocated to conversations with other caregivers, etc.) aside from the delivery of social interaction to the target infant. Additional measures regarding the number of infants present in a given observation and the delivery of caregiver interaction to non-target infants may provide additional information regarding the classroom arrangement and overall levels of caregiver engagement.

In the present study, the highest levels of vocalizations, lowest levels of crying, and highest levels of social interaction were observed in Classroom 2. Information in Table 1 suggests that the mean age of the participants in Classroom 2 was higher than that of the participants in Classrooms 1 and 3 (11.3 months as compared to 7.3 and 7.2 months, respectively). Similarly, the age range in Classroom 2 was much smaller than that of the other two classrooms. Such differences lead one to question whether infant age and mobility (i.e., maturation) influences levels of vocalizations and crying. Similarly, mobile infants may be more likely and/or able to initiate social interaction with caregivers. Thus, the ability to independently approach caregivers may influence levels of social interaction. Future researchers may be interested in conducting additional descriptive analyses across mobile and pre-mobile infants to determine if different patterns of responding are characteristic across age ranges.

It was also interesting that the caregivers in Classroom 2 were more likely to provide social interactions surrounding instances of vocalizing as they were to deliver social interaction at other times. This may lead one to question whether certain characteristics of these infants' vocalizations (e.g., volume, topography, prosody, etc.) increased their saliency and/or increased the likelihood that caregivers would attend, as opposed to attributing such differences in the level of social interaction surrounding instances of vocalizing to the Classroom 2 caregivers or the training provided to the Classroom 2 caregivers, for example. Future researchers may consider ways to measure not only the quantity, but also the quality of infant vocalizations to try and identify systematic relations.

Although our descriptive analysis was effective at determining the temporal relation between infant vocalizations and adult social interaction, it did not provide information regarding the function of infant vocalizations. We were unable to determine from our data if social interaction elicited vocalizations and thus should be programmed to occur at high levels throughout the infant's day. Alternatively, we were also unable to determine whether social interaction reinforced vocalizations such that it should be programmed to occur at higher levels immediately following instances of vocalizing.

Thus, the purpose of Study 2 was to replicate previous research and demonstrate that contingent social interaction influenced the level of infant vocalizations. Unfortunately, we failed to demonstrate this effect with Jake and failed to replicate the initial effect with Jenna. This failure to replicate the findings of previous research may have been a function of the saliency of the contingency. In previous studies, the infants were brought into the experimental arrangement and placed in a crib (Rheingold et al., 1959; Todd & Palmer, 1968), placed in a baby swing (Weisberg, 1963), or strapped in a car seat (Haugan & McIntire, 1972), which minimized the infant's mobility and perhaps made the delivery of social interaction more salient. To further enhance the saliency of the contingency, Poulson (1983, 1988) strapped the infant in a car seat facing a playhouse. A window on the playhouse would open and close with the push of a button, and the parent would appear in the window during the delivery of social interaction. The experimental arrangement in the present study did not incorporate these procedures, perhaps weakening the saliency of the contingency. In the present study, the infant was brought into the session room and placed in a seated position near the experimenter. However, the infant was able to move freely about the room during session. Thus, when social interaction was delivered contingent on vocalizing, the infant's gaze may have been oriented in a direction away from the experimenter and the infant may have been positioned across the room from the experimenter, requiring the experimenter to move quickly across the room to approach the infant while attempting to quickly orient their attention to the experimenter's delivery of social interaction. Additionally, in previous studies, the duration of social interaction ranged from 1 to 8 s (Haugan & McIntire, 1972; Poulson, 1983, 1988; Rheingold et al., 1959; Weisberg, 1963). The delivery of social interaction in the present study was much longer in duration (approximately 15 s). Given the duration of social interaction, the infant likely engaged in various behaviors during the programmed reinforcement interval. Ultimately, this extended social interaction may have weakened the saliency of the contingency between vocalizations and the delivery of social interaction.

Future researchers may consider conducting functional analyses, as was attempted in Study 2, to identify the reinforcers maintaining vocalizations. They may then use these results to modify the classroom environment to facilitate vocalizations. In other words, if data for one participant suggest that vocalizations are operant, one would like to see caregivers deliver higher levels of social interaction immediately following instances of vocalizing relative to levels of social interaction that occur regardless of infant behavior. Such an arrangement would function to facilitate vocalizations for an infant whose vocalizations were identified to be operant. To determine this, descriptive analyses of infant vocalizations could be conducted to analyze naturally occurring behavior-environment relations. In other words, one could use the results of functional analyses to examine the behavior-environment interactions that exist in the classroom environment to determine whether a therapeutic environment is currently arranged with respect to facilitating vocalizations throughout the infant's day. If the descriptive analysis suggests that appropriate infant-caregiver interactions are lacking, future researchers may consider training caregivers to increase their delivery of social interaction or to deliver high quality social interaction contingent on instances of vocalizing. Following caregiver training, researchers may then conduct a new descriptive analysis to identify levels of infant vocalizations and to see if changes in the temporal relation between adult social interaction and infant vocalizations emerge. In the present study, the probability of social interaction was higher in the absence of vocalizations, particularly in Classrooms 1 and 3. Low levels of vocalizations in these classrooms may have been due to the low levels of social interaction surrounding instances of vocalizing. By training caregivers to respond differentially to infant vocalizations, one may show increases in vocalizations under typical, classroom arrangements.

Ultimately, future researchers may consider using functional analyses in conjunction with descriptive analyses in examining the effects of adult social interaction on infant vocalizations. Procedures such as these would be similar to the suggestion by Samaha et al. (2009) to use descriptive analyses to capture a “snapshot of behavior and environmental events” (p. 465). This snapshot may then be analyzed after using functional analysis methodology to identify the reinforcers maintaining behavior. That is, researchers could use these “snapshots” to examine the contingency strength of naturally occurring behavior-environment relations. If non-therapeutic arrangements are in place, necessary training and modifications could then be made to ensure that the naturally occurring behavior-environment relations are consistent with results from the functional analyses. Given the importance of the environment on language acquisition, such an approach may effectively extend the findings of experimental research to the classroom environment to further facilitate language acquisition.

References

Banikiotes, F. G., Montgomery, A. A., & Banikiotes, P. G. (1972). Male and female auditory reinforcement of infant vocalizations. *Developmental Psychology, 6,* 476-481.

Bloom, K., & Esposito, A. (1975). Social conditioning and its proper control procedures. *Journal of Experimental Child Psychology, 19,* 209-222.

Donahoe, J. W., & Palmer, D. C. (2004). *Learning and complex behavior.* Richmond: Ledgetop Publishing.

Clarke-Stewart, K. A. (1973). Interactions between mothers and their young children: Characteristics and consequences. *Monographs of the Society for Research in Child Development, 38,* 1-109.

Gervain, J., & Mehler, J. (2010). Speech perception and language acquisition in the first year of life. *Annual Review of Psychology, 61,* 191-218.

Goldstein, M. H., & Schwade, J. A. (2008). Social feedback to infants' babbling facilitates rapid phonological learning. *Psychological Science, 19,* 515-522.

Gros-Louis, J., West, M. J., Goldstein, M. H., & King, A. P. (2006). Mothers provide differential feedback to infants' prelinguistic sounds. *International Journal of Behavior Development, 30,* 509-516.

Hamilton, M. L. (1977). Social learning and the transition from babbling to initial words. *The Journal of Genetic Psychology, 130,* 211-220.

Hart, B., & Risley, T. (1995). *Meaningful Differences in the Everyday Experience of Young American Children.* Baltimore: Paul H. Brookes Publishing.

Haugan, G. M., & McIntire, R. W. (1972). Comparisons of vocal imitation, tactile stimulation, and food as reinforcers for infant vocalizations. *Developmental Psychology, 6,* 201-209.

Keller, H., & Schölmerich, A. (1987). Infant vocalizations and parental reactions during the first 4 months of life. *Developmental Psychology, 23*, 62-67.

Kuhl, P. K., & Meltzoff, A. N. (1996). Infant vocalizations in response to speech: Vocal imitation and developmental change. *Journal of the Acoustic Society of America, 100,* 2425-2438.

Masataka, N. (1993). Effects of contingent and noncontingent maternal stimulation on the vocal behaviour of three-to four-month-old Japanese infants. *Journal of Child Language, 20,* 303-312.

Moerk, E. L. (1976). Processes of language teaching and training in the interactions of mother-child dyads. *Child Development, 47,* 1064-1078.

Moerk, E. L. (1990). Three-term contingency patterns in mother-child verbal interactions during first-language acquisition. *Journal of the Experimental Analysis of Behavior, 54,* 293-305.

Moon, R. Y., Patel, K. M., Shaefer, S. J. M. (2000). Sudden Infant Death Syndrome in child care settings. *Pediatrics, 106,* 295-300.

Oller, D. K., Wieman, L. A., Doyle, W. J., & Ross, C. (1976). Infant babbling and speech. *Journal of Child Language, 3,* 1-11.

Owens, R. E., Jr. (2005). *Language development an introduction.* Boston: Pearson.

Palmer, D. C. (1996). Achieving parity: The role of automatic reinforcement. *Journal of the Experimental Analysis of Behavior*, *65*, 289-290.

Palmer, D. C. (2000). Chomsky's nativism reconsidered. *The Analysis of Verbal Behavior, 17,* 51-56.

Pelaez, M., Virues-Ortega, J., & Gewirtz, J. L. (2011). Reinforcement of vocalizations through contingent vocal imitation. *Journal of Applied Behavior Analysis, 44,* 33-40.

Pena-Brooks, A., & Hegde, M. N. (2000). *Assessment & treatment of articulation & phonological disorders in children.* Austin: Pro-Ed Inc.

Poulson, C. L. (1983). Differential reinforcement of other-than-vocalization as a control procedure in the conditioning of infant vocalization rate. *Journal of Experimental Child Psychology, 36,* 471-489.

Poulson, C. L. (1988). Operant conditioning of vocalization rate of infants with Down Syndrome. *American Journal on Mental Retardation, 93,* 57-63.

Poulson, C. L., & Nunes, L. R. P. (1988). The infant vocal-conditioning literature: A Theoretical and methodological critique. *Journal of Experimental Child Psychology, 46,* 438-450.

Poulson, C. L., Kymissis, E., Reeve, K. F., Andreatos, M., & Reeve, L. (1991). Generalized vocal imitation in infants. *Journal of Experimental Child Psychology, 51,* 267-279.

Rheingold, H. L., Gewirtz, J. L, & Ross, H. W. (1959). Social conditioning of vocalizations in the infant. *Journal of Comparative and Physiological Psychology, 52,* 68-73.

Rondal, J. A. (1985). *Adult-Child Interaction and the Process of Language Acquistion.* New York City: Praeger Publishers.

Samaha, A.L., Vollmer, T.R., Borrero, C., Sloman, K., Pipkin, C.S., & Bourret, J. (2009). Analyses of response-stimulus sequences in descriptive observations. *Journal of Applied Behavior Analysis, 42,* 447-468.

Schwartz, A., Rosenberg, D., & Brackbill, Y. (1970). Analysis of the components of social reinforcement of infant vocalization. *Psychonomic Science, 20,* 323-325.

Sheppard, W. C. (1969). Operant control of infant vocal and motor behavior. *Journal of*

Experimental Child Psychology, 7, 36-51.

Siegel, G. M. (1969). Vocal conditioning in infants. *Journal of Speech and Hearing Disorders, 34,* 3-19.

Smith, R., Michael, J., & Sundberg, M. L. (1996). Automatic reinforcement and automatic punishment in infant vocal behavior. *The Analysis of Verbal Behavior, 13,* 39-48.

Todd, G. A., & Palmer, B. (1968). Social reinforcement of infant babbling. *Child Development, 39,* 591-596.

Vollmer, T. R., Borrero, J. C., Wright, C. S., Van Camp, C., & Lalli, J. S. (2001). Identifying possible contingencies during descriptive analyses of severe behavior disorders. *Journal of Applied Behavior Analysis, 34,* 269-287.

Weisberg, P. (1963). Social and nonsocial conditioning of infant vocalizations. *Child Development, 34,* 377-388.

Wiegerink, R., Harris, C., Simeonsson, R., & Pearson, M. E. (1974). Social stimulation of vocalizations in delayed infants: Familiar and novel agent. *Child Development, 45,* 866-872.

Table 1. The following table provides demographic information for each of the classrooms and lists the total observation time that was necessary in order to capture at least 10 instances of vocalizations for each of the infants within a given classroom.

	Classroom 1	Classroom 2	Classroom 3
Participants	N = 8 Mean age: 7.3 months Range: 3 months – 12 months	N = 7 Mean age: 11.3 months Range: 9 months – 12.5 months	N = 8 Mean age: 7.2 months Range: 3 months – 12 months
Total observation time	2700 5-s intervals (225 min)	1464 5-s intervals (122 min)	1657 5-s intervals (138 min)

Figure 1. The probability of vocalizations (top panel) and the probability of crying (bottom panel) for each of the three early education sites is depicted below.

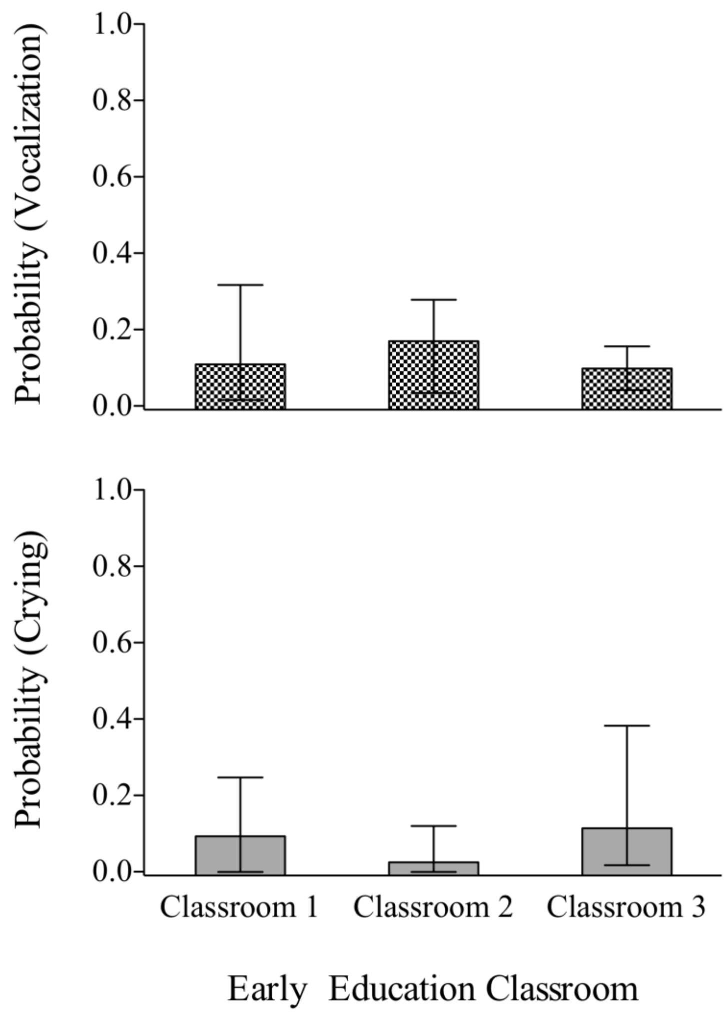

Figure 2. Levels of social interaction compared to levels of infant vocalizations (top panel) and crying (bottom panel) are depicted below.

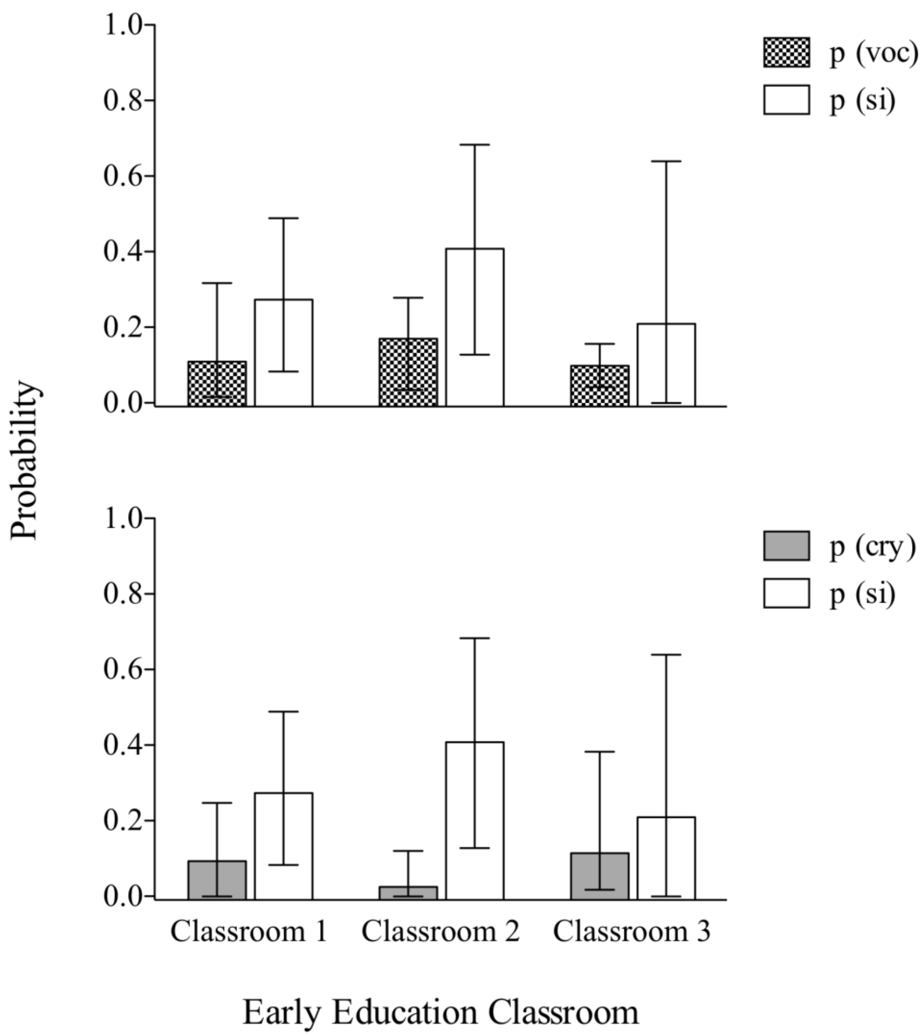

Figure 3. Conditional probabilities of antecedent social interaction given vocalizations (top panel), conditional probabilities of consequent social interaction given vocalizations (bottom panel), and the unconditional probability of social interaction (top and bottom panels) for each of the three classrooms are depicted below.

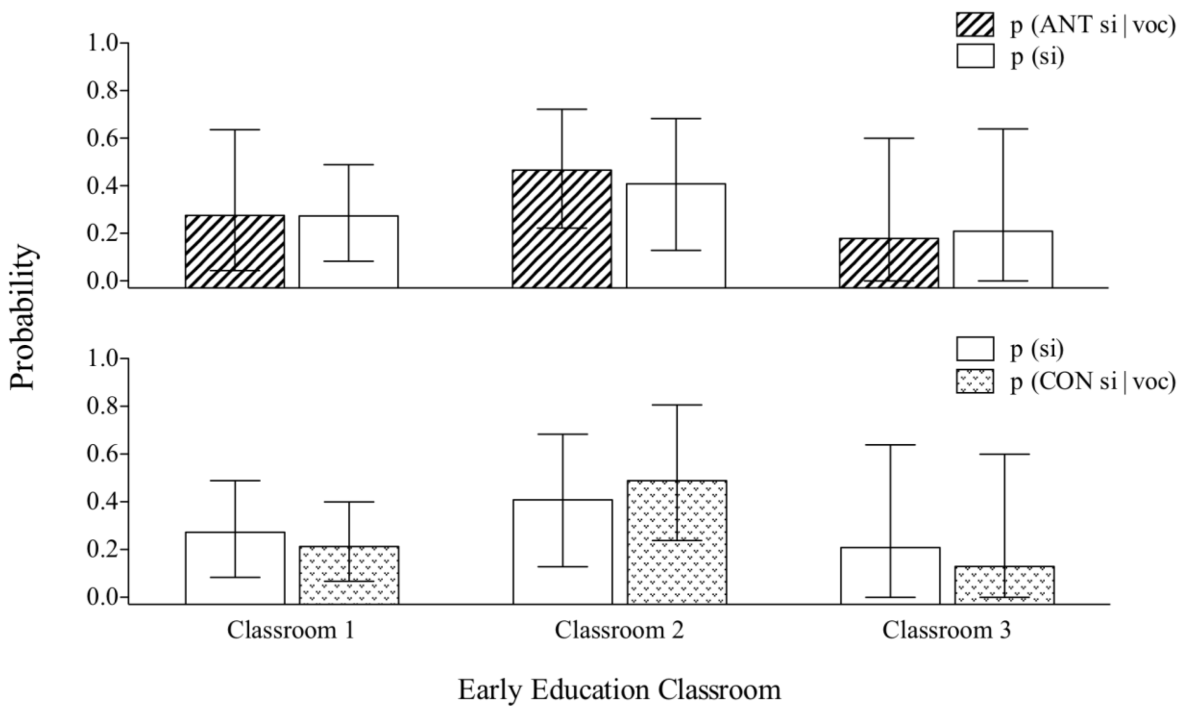

Figure 4. Conditional probabilities of antecedent social interaction given vocalizations (top panel), conditional probabilities of consequent social interaction given vocalizations (bottom panel), and unconditional probabilities of social interaction (top and bottom panels) are depicted below for Classroom 1.

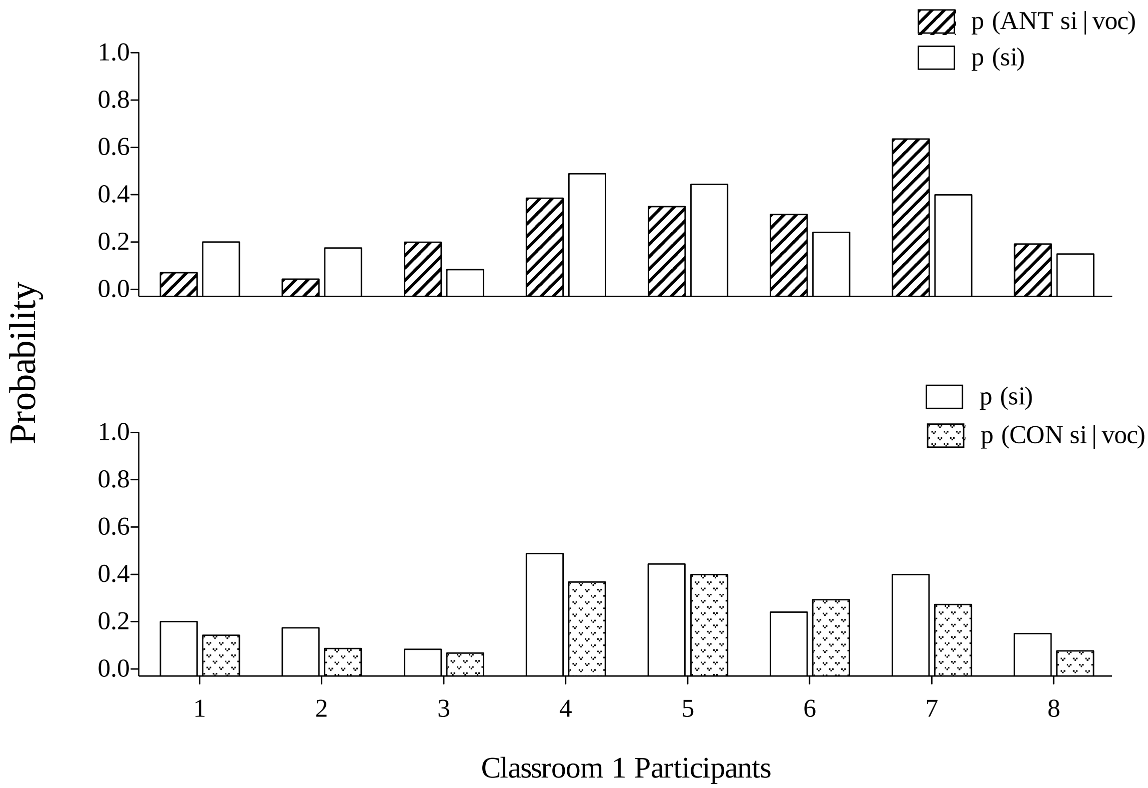

Figure 5. Conditional probabilities of antecedent social interaction given vocalizations (top panel), conditional probabilities of consequent social interaction given vocalizations (bottom panel), and unconditional probabilities of social interaction (top and bottom panels) are depicted below for Classroom 2.

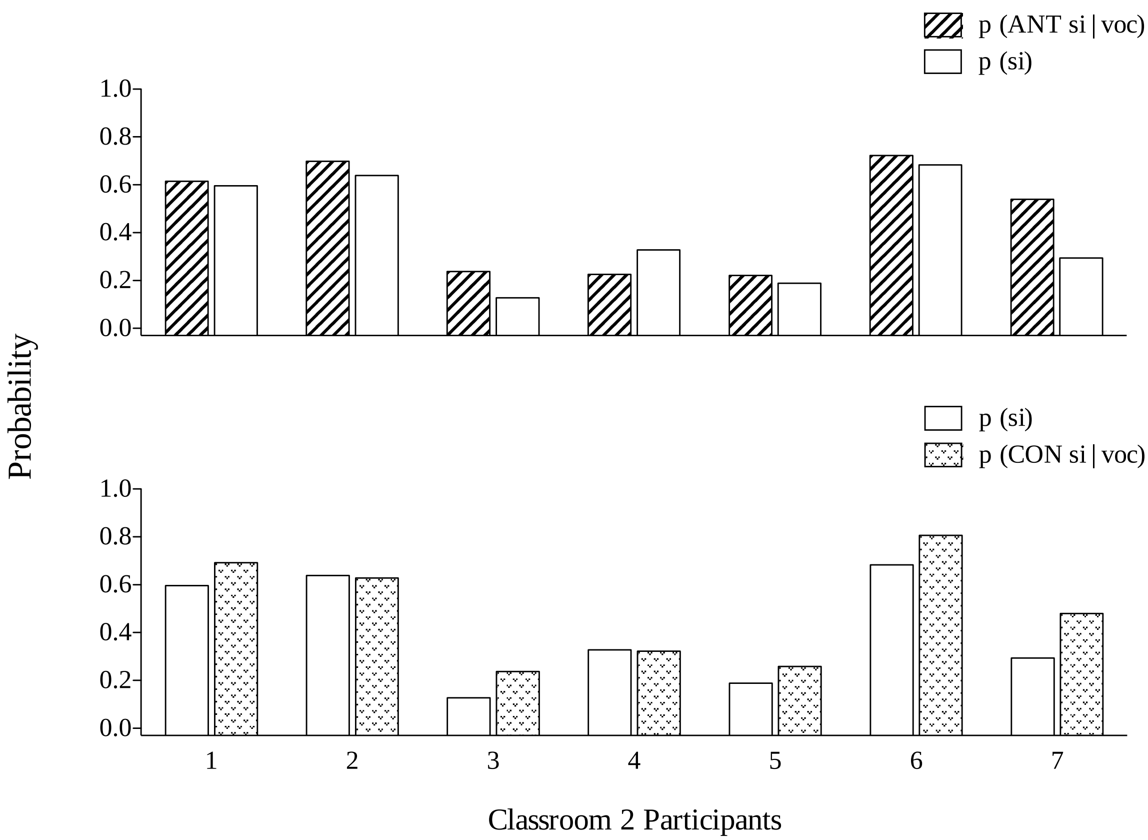

Figure 6. Conditional probabilities of antecedent social interaction given vocalizations (top panel), conditional probabilities of consequent social interaction given vocalizations (bottom panel), and unconditional probabilities of social interaction (top and bottom panels) are depicted below for Classroom 3.

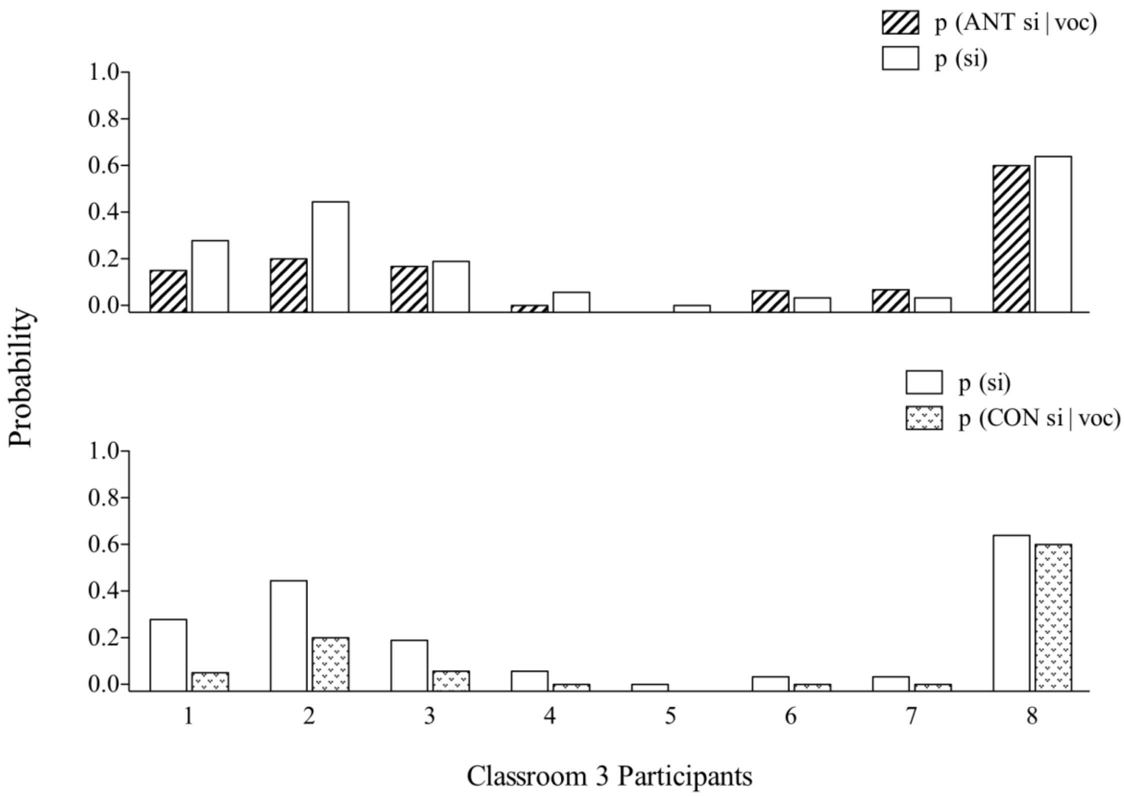

Figure 7. Conditional probabilities of antecedent social interaction given crying (top panel), conditional probabilities of consequent social interaction given crying (bottom panel), and unconditional probabilities of social interaction (top and bottom panels) for each of the three classrooms are depicted below.

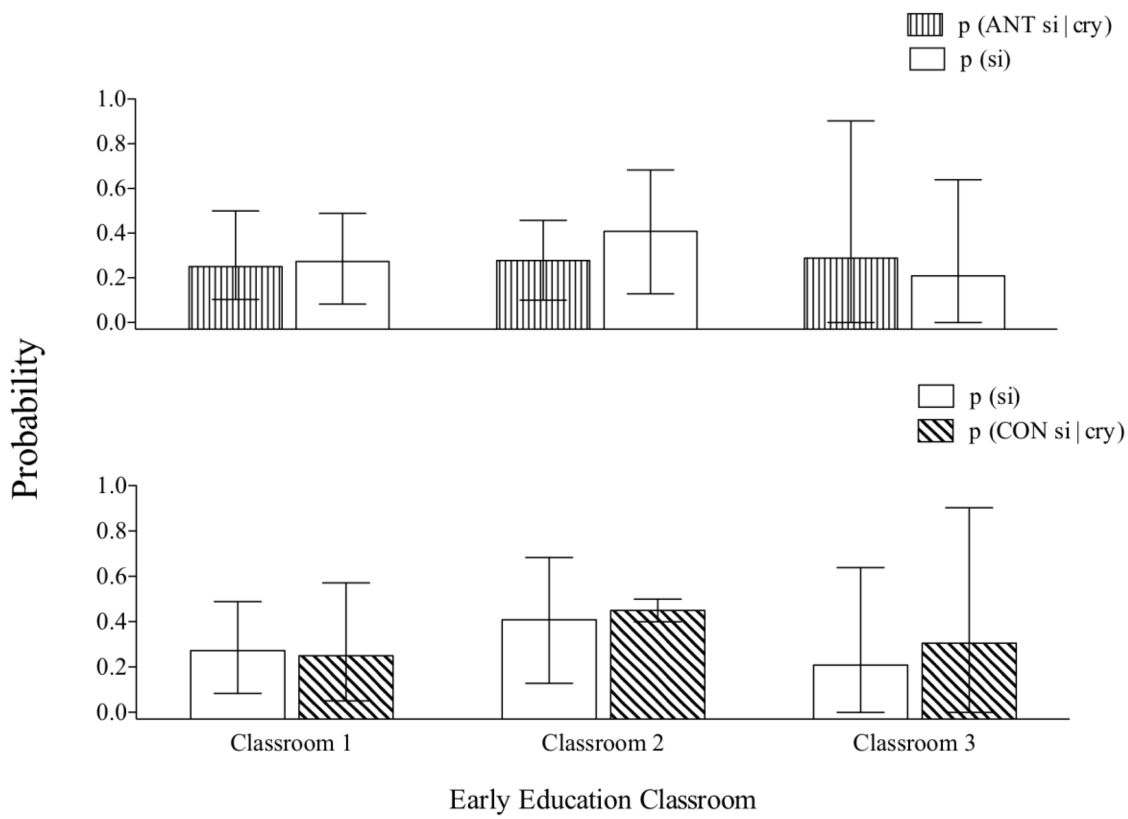

Figure 8. Conditional probabilities of antecedent social interaction given crying (top panel), conditional probabilities of consequent social interaction given crying (bottom panel), and unconditional probabilities of social interaction (top and bottom panels) are depicted below for each of the infants in Classrooms 1.

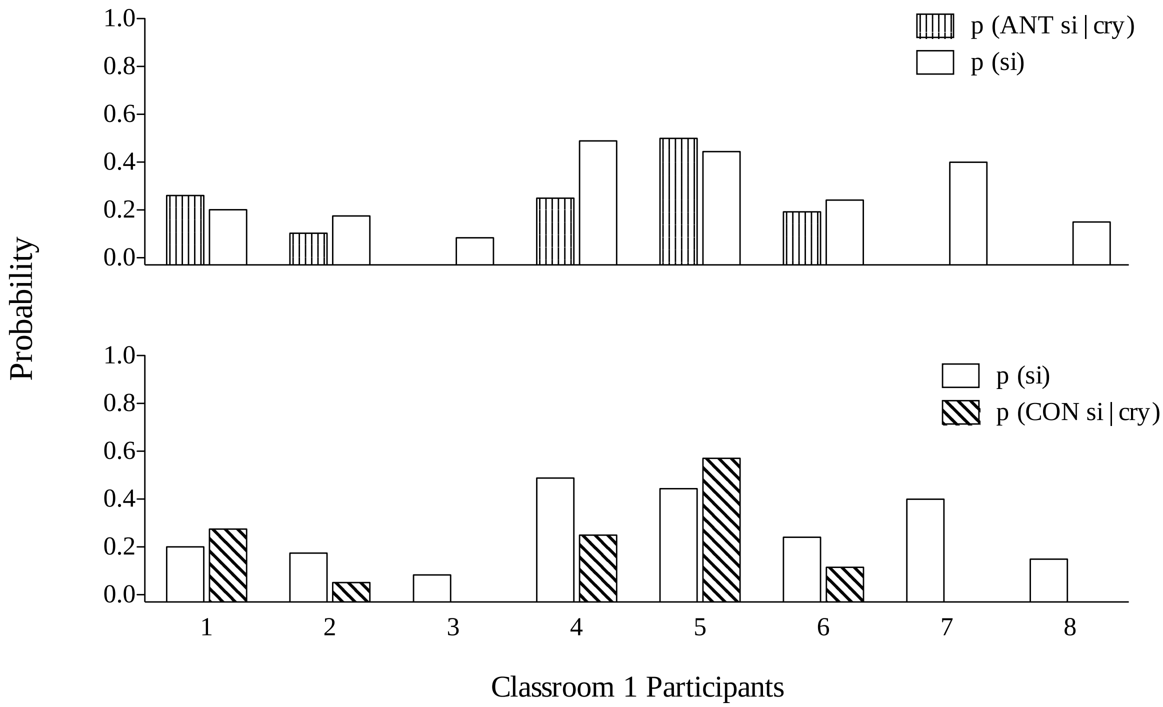

Figure 9. Conditional probabilities of antecedent social interaction given crying (top panel), conditional probabilities of consequent social interaction given crying (bottom panel), and unconditional probabilities of social interaction (top and bottom panels) are depicted below for each of the infants in Classrooms 2.

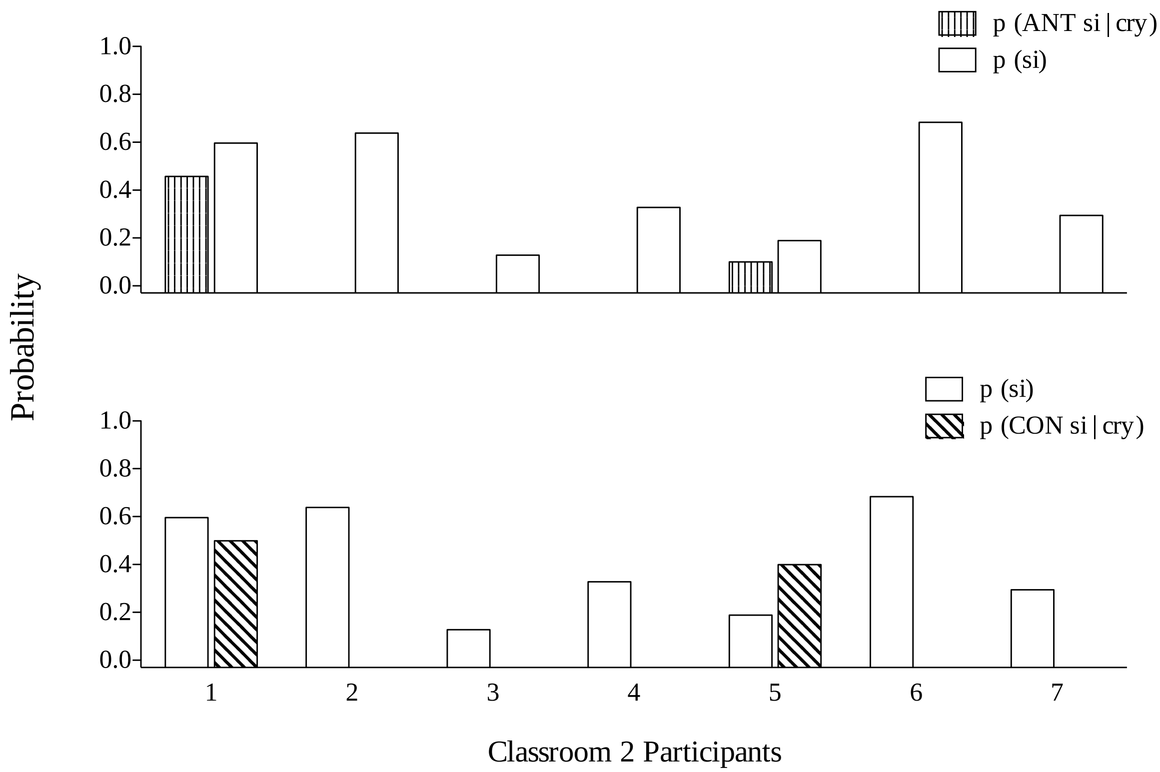

Figure 10. Conditional probabilities of antecedent social interaction given crying (top panel), conditional probabilities of consequent social interaction given crying (bottom panel), and unconditional probabilities of social interaction (top and bottom panels) are depicted below for each of the infants in Classrooms 3.

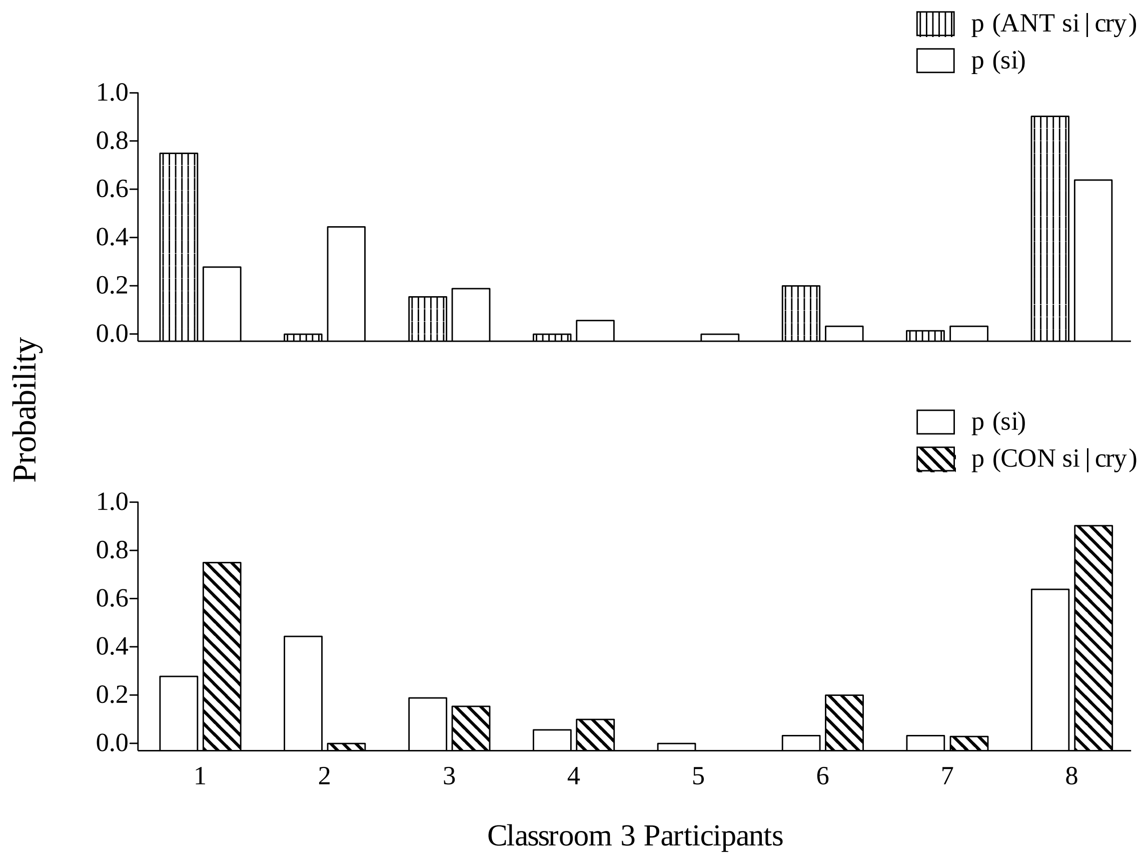

Figure 11. Conditional probabilities of vocal interaction, physical interaction, and tangible interaction given social interaction for each of the three classrooms are depicted below.

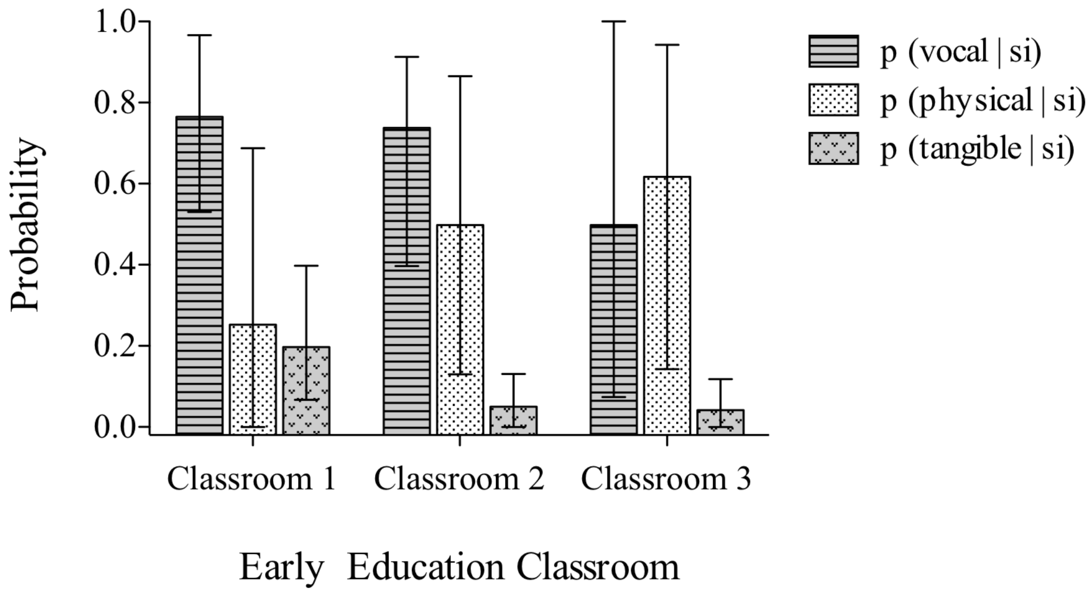

Figure 12. The percentage of EO-present intervals with vocalizations for Jake is depicted below.

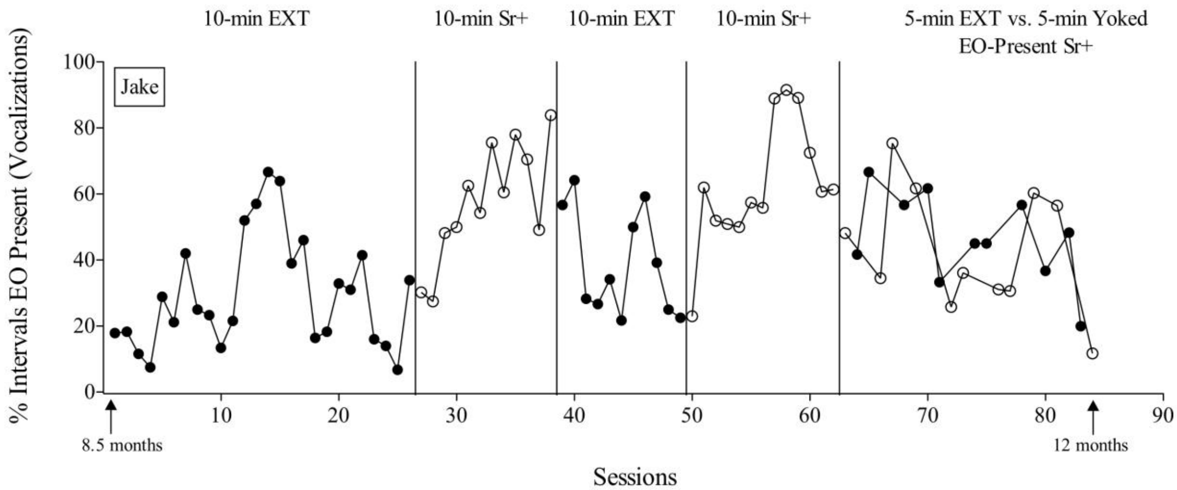

Figure 13. The percentage of EO-present intervals with vocalizations for Jenna is depicted below.