JOURNAL OF APPLIED BEHAVIOR ANALYSIS 2007, **40,** 15–23 NUMBER 1 (SPRING 2007)

ENHANCING EARLY COMMUNICATION THROUGH INFANT SIGN TRAINING

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Existing research suggests that there may be benefits to teaching signing to hearing infants who have not yet developed vocal communication. In the current study, each of 4 infants ranging in age from 6 to 10 months was taught a simple sign using delayed prompting and reinforcement. In addition, Experiment 1 showed that 2 children independently signed in a variety of novel stimulus conditions (e.g., in a classroom, with father) after participating in sign training under controlled experimental conditions. In Experiment 2, crying and whining were replaced with signing when sign training was implemented in combination with extinction.

DESCRIPTORS: communication training, extinction, infants, modeling, physical prompting, reinforcement, sign language, delay

Sign language systems have been used successfully with individuals who have difficulty learning to communicate through vocal language. In addition to individuals with hearing impairments, individuals with developmental disabilities such as autism and mental retardation have learned to communicate through signs (Bryen & Joyce, 1986). Signing may be a good alternative to vocal communication for individuals who have poor oral motor control but adequate manual control. For these individuals, sign language may be easier to teach than oral language because signing can be physically prompted by a caregiver (i.e., a child's hands can be molded to form a sign; Tabor, 1988).

These advantages have led some researchers and clinicians to recommend that signing also be taught to typically developing children during their first 2 years of life (Acredolo & Goodwyn, 1996; Garcia, 1999). This recommendation is supported by studies showing that infants exposed to sign language acquired first signs at an earlier age than typical first spoken words. Bonvillian, Orlansky, and Novack (1983) studied 11 hearing children of deaf parents and reported that children produced their first recognizable sign at a mean age of just 8.5 months, with the earliest first sign at 5.5 months. Similarly, Goodwyn and Acredolo (1993) found that, when hearing parents were trained to encourage the use of symbolic gestures (e.g., palms up for "Where is it?"), their hearing infants began to use gestures a mean of 0.69 months before their first vocal words.

A concern associated with the early use of sign language is the potential for a delay in the onset of vocal language; however, results of a study by Goodwyn, Acredolo, and Brown (2000) suggest that sign training might facilitate rather than hinder the development of vocal language. In this study, hearing infants whose parents encouraged symbolic gestures outperformed children whose parents encouraged vocal language on follow-up tests of receptive and expressive vocal language.

These results provide preliminary evidence suggesting that there may be benefits to teaching sign language to young children who have not yet developed vocal language. However, these studies provide little guidance regarding effective sign training procedures because parents and children were not directly

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doi: 10.1901/jaba.2007.23-06

observed during sign training. By contrast, Thompson, McKerchar, and Dancho (2004) described a set of procedures that was effective in producing signing in 3 infants (6 to 13 months). Training consisted primarily of delayed physical prompting and reinforcement for prompted and independent signs, and each child acquired the target sign after less than 4 hr of training. However, a limitation of this study was that signing was taught and measured only under controlled experimental conditions. Therefore, it is unclear whether sign training resulted in functional communication for these children. Experiment 1 of the current study was designed to extend Thompson et al. by evaluating the extent to which signs trained under experimental conditions would occur independently under more natural conditions.

Although infants begin communicating with their caregivers at an early age through facial expressions, gazes (e.g., Yale, Messinger, Cobo-Lewis, & Delgado, 2003), and vocalizations such as cooing, crying is the primary mode of communication for infants. Crying is effective at evoking a variety of caregiving responses, but a limitation of this form of communication is that caregivers must often rely on contextual cues to determine the appropriate response (Costello, 1976; Petrovich-Bartell, Cowan, & Morse, 1982). For example, when an infant cries immediately following a meal, parents may be less likely to feed the child and more likely to put the child to sleep. However, in some cases, contextual cues may be absent or ineffective at occasioning the appropriate form of caregiving, resulting in persistent crying. By contrast, one advantage of sign language is that signs, like vocal responses, have the potential to specify their reinforcers; thus, signing may occasion more effective caregiving. In addition, despite the fact that crying is a developmentally normal form of communication for infants, data on parental behavioral and physiological responses suggest that crying is an aversive event (Brewster, Nelson, McCane, Lucas, & Milner, 1998; Donovan, 1981; Frodi & Lamb, 1980); thus, for caregivers, signing may be a more preferred form of communication for their infants. Therefore, in Experiment 2, we attempted to replace infant crying and whining with signing.

EXPERIMENT 1

The purpose of Experiment 1 was to evaluate the effects of delayed model and physical prompts and reinforcement on the acquisition of signs in 2 infants. These procedures were similar to those described by Thompson et al. (2004); however, a model prompt was used in addition to physical prompting. Following acquisition, we sought to determine whether signs acquired under controlled experimental conditions would occur in more natural settings, in the presence of multiple listeners, and under the control of multiple reinforcers.

Method

Participants and Setting

Participants were Heather, a 10-month-old infant with Down syndrome, and Betty, a 6-month-old infant of typical development. Both children attended a full-day infant and toddler program, and neither child communicated consistently through vocal or signed communication. Sessions were constructed to teach children to request items or activities that parents or teachers had identified as preferred. Heather was taught to request an assortment of toys (e.g., balls, musical toys) and experimenter attention, and Betty was taught to request a bite of baby food and brief experimenter attention. Betty's sessions were conducted during her regularly scheduled mealtime, and the classroom menu determined the foods (e.g., rice cereal, pureed fruit or vegetable) presented in session. Initially, experimental sessions were conducted in a small therapy room equipped with a one-way observation window. Later, the intervention was extended to home and school settings. Sessions were 5 min in length and were conducted one to three times per day, 5 days

per week. Sessions were scheduled so they did not interfere with children's daily routines (e.g., naps).

Response Measurement and Interobserver Agreement

Observers recorded the frequency of independent and prompted signs. The target sign for Heather was a modified form of the American sign language (ASL) sign "please," defined as the palm of one hand touching the chest while moving back and forth. The target sign for Betty was a modified form of the ASL sign "more," scored when both hands moved toward her midline and touched together. For both participants, prompted signs were those that were physically prompted and those that occurred within 5 s of a model prompt, and independent signs were those that occurred prior to an experimenter prompt.

Interobserver agreement was assessed by having a second observer simultaneously but independently record data during a minimum of 33% of sessions for each participant. Agreement percentages were calculated by partitioning the session into 10-s intervals and comparing observers' records on an interval-by-interval basis. For frequency and duration measures, the smaller number of responses (or duration of the response) in each interval was divided by the larger number; these fractions were then averaged across intervals and multiplied by 100% to obtain a percentage agreement score. Mean agreement across participants was 95% (range, 84% to 100%) for independent signing and 98% (range, 82% to 100%) for prompted signing.

Procedure

Initial baseline. During baseline sessions, the reinforcer (toys or food, paired with experimenter attention) was presented according to a time-based schedule, independent of the participant's behavior. For Heather, the experimenter presented the toys and attention every 1 min for 30 s. For Betty, the experimenter presented one bite of baby food at the beginning of the sessions and 10 s after Betty swallowed the previous bite of food. Schedules of reinforcer delivery were established arbitrarily during the initial baseline phase.

Sign training. When sign training was initiated, a model prompt was delivered immediately at the start of each session and after the termination of each subsequent reinforcer delivery. If signing did not occur within 5 s of the model prompt, the participant was physically prompted to perform the target sign. In addition, if the participant performed an approximation to the sign (e.g., if Betty brought her hands toward her midline but did not touch them together), a physical prompt to perform the sign accurately was provided (e.g., the therapist gently guided her hands together). The designated reinforcer was delivered following all prompted and independent signs. The delay to the model prompt was gradually increased from 0 s to 80 s, or until high levels of independent signing occurred for several sessions. A physical prompt (if necessary) was delivered 5 s after the model prompt throughout all training conditions. With some exceptions (noted below), participants were exposed to five consecutive sessions at each level of delay (e.g., 0 s, 5 s, 10 s) during the initial sign-training phase and three (Betty) or five (Heather) consecutive sessions at each level during the subsequent sign-training phase.

Reversal to baseline. Procedures were similar to those in the initial baseline phase, except that schedules of reinforcer delivery were designed to match the rate of reinforcer delivery during sign training. The schedule of reinforcer delivery was based on the mean interresponse time from the last five sessions of the sign-training condition. Heather received toys and attention 60 s after their removal, and Betty received a bite of food 5 s after consuming the previous bite.

Sign-training extension. To evaluate whether independent signing taught under experimental conditions would occur under more natural

conditions, sign-training sessions were conducted with additional experimenters, in additional settings, and with other reinforcers. Otherwise, procedures were similar to those used in the sign training conditions. For Heather, sessions were conducted with different experimenters (a novel researcher and an early childhood educator) and in different settings (classroom and indoor playground), and signing "please" resulted in access to different reinforcers (Goldfish® crackers and a riding toy). For Betty, sessions were conducted with additional experimenters (a classroom teacher and her father) and in different settings (classroom, father's office, and home).

Experimental Design

The effects of sign training were evaluated by comparing baseline and sign-training in a reversal design.

Results

Heather's data are depicted in Figure 1. She did not sign during the initial baseline phase. Sign training began at the 0-s delay to the model prompt, and the delay was gradually increased to 35 s, with no independent responses. We chose to keep the delay constant at 35 s to expose Heather to frequent prompting. Beginning at Session 57, we observed a gradual increase in independent signing. High and stable levels of independent signing were achieved, with no prompts, at the 40-s delay. An immediate decrease in independent signing was observed during the return to baseline, and Heather displayed high levels of independent signing when sign training was reinitiated at the 40-s delay to the model prompt. A disruption in independent signing was observed beginning in Session 90, which followed a 5-week break (for surgery). However, independent signing recovered when the delay to the model prompt was reduced to 30 s. Beginning with Session 99, sign training was extended across listeners, reinforcers, and settings. Sessions 99 to 101 were conducted by Experimenter 2 in the

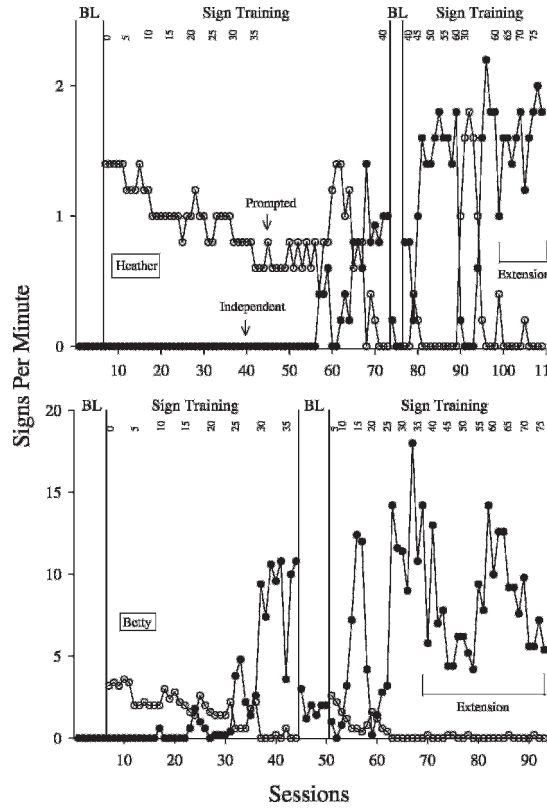

Figure 1. Heather's and Betty's prompted and independent signs per minute during baseline, sign training, and sign-training extension. Numbers indicate the delay to the model prompt. Sign-training extension sessions are marked with a bracket.

session room. During Sessions 102 to 104, Experimenter 2 conducted sessions in Heather's classroom. Her early childhood educator conducted Sessions 105 to 107 in the classroom. Session 108 was conducted by Experimenter 1 at an indoor playground, and signing resulted in access to a riding toy. Session 109 was conducted by Experimenter 1 in the classroom, and signing resulted in access to crackers. Independent signs remained high, with very few prompted signs, as new experimenters, reinforcers, and settings were introduced.

Betty's data also are depicted in Figure 1. Betty did not sign during the initial baseline phase. During sign training, independent signing was first observed at the 10-s delay to the

model prompt, and high levels of signing emerged and were maintained with very little prompting as the delay to the model prompt increased to 35 s. Independent signing decreased immediately during the return to baseline. Sign training was then reinitiated at the 5-s delay to the model prompt, and Betty's independent signing increased and was maintained at high levels, with very little prompting, as the delay to the model prompt was increased. During Sessions 69 to 93, sign training was extended across listeners and settings. Sessions 69 to 81 were conducted by Experimenter 1 in Betty's classroom. Sessions 82 to 85 were conducted by her classroom teacher in her classroom. During Sessions 86 to 89, Betty's father conducted sessions in his office. Sessions 90 to 93 were conducted by her father in their home. Independent signing remained high, with very few experimenter prompts, as different experimenters and settings were introduced.

EXPERIMENT 2

In this experiment, we attempted to replace infant crying and whining with signing. Signs were trained using procedures similar to those described in Experiment 1, and crying and whining were placed on extinction.

METHOD

Participants and Setting

Participants were 2 typically developing infants who attended a full-day infant and toddler program. Geoffrey was 10 months old and did not communicate consistently through vocal or signed communication. Geoffrey was chosen for participation based on teacher report that he frequently cried when not receiving attention in the classroom. Therefore, sign training was conducted to teach Geoffrey a signed request for experimenter attention and an assortment of toys (e.g., balls, musical toys). Lyle was 9 months old and independently signed "more" for access to preferred items (i.e., toys or food). Lyle was chosen for participation because his mother reported that (a) he frequently cried when not being held and (b) she frequently responded to the crying by picking him up. Baseline was constructed to replicate these conditions, and sign training was conducted to replace the crying with a sign ("up") that specified its reinforcer. Lyle's mother served as the experimenter in all of his sessions. Sessions were conducted in a small therapy room equipped with a one-way observation window. Sessions were 5 min in length and were conducted one to four times per day, 5 days per week. Sessions were scheduled so they did not interfere with children's daily routines (e.g., naps, meals).

Response Measurement and Interobserver Agreement

Observers recorded the frequency of independent and prompted signs. The target sign for Geoffrey was a modified version of the ASL sign "please" (defined as in Experiment 1). The target sign for Lyle was the ASL sign "up," recorded when his left or right arm moved into a vertical position using an upward motion, with his fingers pointing towards the ceiling. Independent signs were those that occurred prior to an experimenter prompt. Observers also recorded the duration of crying and whining displayed by each of the participants.

Interobserver agreement was assessed by having a second observer simultaneously but independently record data during a minimum of 32% of sessions for each participant (range, 32% to 39%). Agreement percentages were calculated as in Experiment 1. Mean agreement across participants was 96% (range, 84% to 100%) for independent signing, 97% (range, 84% to 100%) for prompted signing, and 87% (range, 63% to 99%) for crying and whining.

Procedure

Baseline. Baseline was constructed to replicate naturally occurring conditions in which whining and crying served as a primary form of communication. Thus, in these sessions, the

reinforcer was presented contingent on crying or whining. For Geoffrey, experimenter attention and toys were delivered for 30 s on a fixed-ratio (FR) 1 schedule for crying or whining. For Lyle, maternal attention (i.e., his mother held him and spoke to him) was delivered for 15 s on an FR 1 schedule for crying or whining.

Sign training. When sign training was introduced, crying and whining no longer resulted in the designated reinforcer (i.e., extinction). Otherwise, Geoffrey's sign-training procedures were identical to those described in Experiment 1. Lyle's sign-training procedures were similar except that only physical prompts were delivered (i.e., no model prompts were used) during initial training sessions. Beginning with Session 45, the model prompt was added at the 5-s delay, and thereafter, procedures were the same as those used with all other participants.

Experimental Design

The effects of sign training were evaluated by comparing baseline and sign-training conditions in a reversal design.

Results

Geoffrey's data are depicted in Figure 2. Geoffrey rarely signed during the initial baseline, and crying and whining occurred in every session. According to the programmed contingency, the experimenter provided attention immediately when any crying or whining was observed, and these responses typically ceased when experimenter attention was delivered. Therefore, crying and whining episodes were generally brief and of low intensity. After exposure to 55 sign-training sessions with the delay to prompting increasing in 5-s increments and inconsistent independent signing, we increased the delay to the model prompt in larger increments. We hoped that this modification would increase the reinforcing value of toys and attention because these events would be presented less frequently as a result of the decrease in prompted signs. A gradual increase in independent signs was observed at the 2-min delay. A decrease in crying and whining occurred throughout the condition, with no crying and whining when independent signing was established at high rates (Sessions 80 to 88). The return to baseline resulted in a decrease in independent signing and an increase in crying and whining. Independent signing gradually recovered when sign training was reinitiated at the 5-s delay, and crying and whining decreased

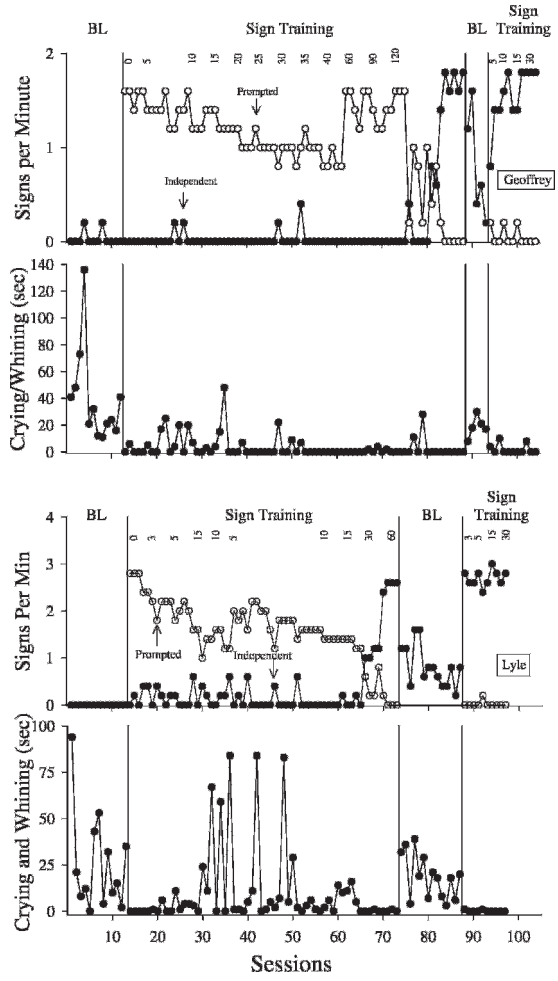

Figure 2. Geoffrey's prompted and independent signs per minute and duration (in seconds) of crying and whining Lyle's prompted and independent signs per minute and duration (in seconds) of crying and whining during baseline and sign training. Numbers indicate the delay to prompting.

to very low levels. The delay was subsequently lengthened, and high rates of independent signing were maintained with very few prompted signs. In comparison to baseline, Geoffrey showed very low levels of crying in sessions in which he signed independently at high levels.

Lyle's data are depicted in Figure 2. During baseline, variable levels of crying and whining occurred, with no independent signing. As with Geoffrey, Lyle's crying and whining episodes were generally brief and of low intensity during experimental sessions, but the duration and intensity of crying increased as the delay to the physical prompt increased to 15 s. Therefore, we returned to the 10-s and 5-s delays, and crying and whining decreased temporarily. Subsequently, we added a model prompt (as with the other participants) to the prompting sequence, and eventually crying decreased. Independent signing gradually increased at the 30-s delay to the model prompt and remained high at the 1-min delay. The duration of crying and whining decreased to very low levels when independent signing emerged. During the reversal to baseline, there was a gradual decrease in independent signing and an immediate increase in crying and whining. When sign training was reinstated at the 3-s delay to the model prompt, independent signing immediately increased to high levels and remained high through the 15-s delay to the model prompt. Crying and whining immediately decreased to very low levels and remained low throughout the entire condition. Lyle's crying occurred at near zero only when (a) he was prompted to sign immediately (i.e., 0-s delay) and (b) he signed independently at high levels.

GENERAL DISCUSSION

In this study, delayed model and physical prompts and reinforcement of signing produced independent signing in 4 infants, including 1 infant with Down syndrome (Heather) and 1 infant who was just 6 months old (Betty). Sign training may have been particularly advantageous for Heather and Betty, for whom vocal communication was not expected for several months. The results of the present study and the Thompson et al. (2004) study indicate that it is possible to teach an infant to perform a simple sign using delayed prompting and reinforcement.

The sign-training procedures used in the current study differed from those in the Thompson et al. (2004) study only in that model prompts were delivered in addition to physical prompts. Given that only physical prompts were used in Thompson et al., a preexisting imitative repertoire is not necessary for acquisition of signing. Although model prompts are not an essential component of sign training, we chose to include this form of prompting to capitalize on children's emerging imitative capabilities. In addition, in practice, it may be wise to include model prompts when teaching preimitative children because the procedures used here for sign training closely resemble those shown to be effective in producing imitative behavior (e.g., Baer, Peterson, & Sherman, 1967). Despite these practical advantages of a multicomponent approach, a limitation of the study is that the experimental design does not allow the isolation of the functional components of the intervention.

The Thompson et al. (2004) study was limited in that children were observed only under experimental conditions and with a single listener (the experimenter). Thus, 3 participants acquired signs, but the degree to which these responses served as functional communication was not demonstrated. Following sign training in the current study, children readily performed the target signs under a variety of relevant stimulus conditions, and these data provide more convincing evidence that these simple motor responses served as functional communication. However, these data remain limited in at least two ways. First, each child acquired only one sign. Future research should be aimed at

teaching multiple signs, with each under control of relevant discriminative stimuli (e.g., tacts) or establishing operations and consequences (i.e., mands). Second, the conditions necessary for signing to occur under a variety of conditions are unclear because (a) signing was measured only under conditions in which sign training was programmed and (b) baseline sessions were not conducted under all assessment conditions. Therefore, it is unknown whether the effects of sign training generalized across listeners, settings, and evocative events.

Results of Experiment 2 showed that, when sign training was combined with extinction, a decrease in crying and whining was observed. Given that sign training and extinction were combined, it is not possible to isolate the effects of these individual components. However, existing research suggests that extinction was likely a functional component of of the intervention (Hagopian, Fisher, Sullivan, Acquisto, & LeBlanc, 1998; Wacker et al., 1990). In addition, it seems most appropriate to extinguish crying and whining only when an alternative form of communication is taught, and it is likely that potential negative side effects of extinction were minimized through this combined approach (Lerman, Iwata, & Wallace, 1999).

A vast body of research identifies language delays as a risk factor for the development of behavior problems (e.g., Beitchman et al., 1996; Benasich, Curtiss, & Tallal, 1993; Toppelberg & Shapiro, 2000). Given that children can learn signs as early as 6 months of age, sign training may contribute to the prevention of behavior problems for young children at risk (e.g., developmental delays, language delays, sensory impairment). For typically developing children, sign training may simply provide an effective means of communication several months earlier than those who rely solely on vocal communication. In addition, teaching young infants to sign may prove to be scientifically valuable in that it gives researchers an additional method of evaluating a child's language abilities at a very young age. For example, developmental studies of symbolic behavior have generally measured gestures or words displayed by children in the 2nd year of life (e.g., Bretherton et al., 1981; Nanny & Waxman, 1998; Snyder, Bates, & Bretherton, 1981), presumably because gestural and vocal vocabularies do not typically develop until this time. By introducing communication at a much earlier age, researchers will have the ability to monitor more closely infants' emerging capabilities.

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Received February 24, 2006
Final acceptance June 28, 2006
Action Editor, Louis Hagopian