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The Role of Automatic Reinforcement in Early Language Acquisition

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The vocal behavior of five children was recorded and analyzed during pre- and post-pairing conditions. Between these conditions there was a pairing condition where a target sound, word, or phrase was paired with an established form of reinforcement (e.g., tickling). In the first experiment all of the children emitted the targeted responses during the post-pairing condition. The results showed that the children acquired new vocal and verbal responses by pairing neutral stimuli with established forms of conditioned or unconditioned reinforcement. Perhaps the most significant aspect of these results was that new vocal responses were acquired by the children without the use of direct reinforcement, echoic training, or prompts. In the second experiment several parameters of the pairing procedure were examined. The results of the two experiments have implications for the analysis of native language acquisition, and for the development of language intervention procedures for individuals who fail to acquire language.

Most children around the world readily acquire their parent's or caretaker's language, despite the fact that no special instruction is provided. This phenomenon, typically identified as native language acquisition, has generated a substantial amount of research and controversy (e.g., Chomsky, 1959; Skinner, 1957). What makes this universal event intriguing is that native language acquisition occurs only early in life, and only for a first language. In addition, multiple languages can be easily acquired by young children in a native bilingual environment. However, acquiring a second language later in life requires intensive study, and a speaker's proficiency may never reach the level of a native speaker.

Central to the arguments of how children acquire their native language is the universal tendency for most infants to begin to babble the phonemes of their parent's or caretaker's language by around 4 to 6 months of age (e.g., de Villiers & de Villiers, 1978). It is common for theorists to attribute this acquisition of vocal behavior to either the human's unique biological structure and genetic endowment (e.g., Chomsky, 1965; Lenneberg, 1967), its intri-

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cate cognitive processing system (e.g., Brown, 1973; Neisser, 1976; Piaget, 1951), or a mixture of these two positions (Pinker, 1994; Savage-Rumbaugh et al., 1993). Environmental variables are usually acknowledged as important in the explanation of the emerged behavior, but the importance of these variables is often overshadowed by proposed cognitive and physiological mediators (e.g., processors, neural networks).

However, from a behavioral perspective (e.g., Bijou & Baer, 1965; Skinner, 1957) there are a number of important environmental variables that seem relevant to the emergence of infant babbling. Bijou and Baer (1965) identify these variables as consisting of a combination of respondent and operant conditioning. These authors point out that an infant's first vocalizations are respondent behaviors (e.g., crying, coughing, screaming) and random movements of the vocal muscles (see also Osgood, 1953). Some of these respondent vocalizations can become operant vocalizations if they are followed by reinforcement. For example, crying may initially be emitted as part of a fear reflex, but once the behavior is followed by reinforcement (e.g., being picked up), the behavior may transfer from the control of conditioned or unconditioned stimuli (CSs & USs), to the control of discriminative stimuli (S^Ds), or establishing operations (EOs). Thus, an infant's crying can be evoked by any of these four different antecedent variables, resulting in an overall increase in the rate of vocal behavior.

This increase in vocal behavior not only strengthens the infant's vocal muscles, but it also improves the chances that vocal behavior will receive further reinforcement. For example, random and recognizable vocalizations are frequently differentially reinforced by parents and caretakers, such as a 3-week-old baby's coos, which are often hard to resist. Also, as a result of reinforcement, the transfer of control to other antecedent variables, and the increases in frequency of vocal behavior, there is a greater probability of response variation. Crying, for example, may begin to change in its topographical form and its operant function, as demonstrated by the universal emergence of "fake crying" (Novak, 1996; Wolff, 1969). Vocal variation is also important in that it further strengthens the infant's vocal muscles, and makes the eventual establishment of differential echoic control possible (for a more detailed treatment of this process see Schlinger, 1995).

The type of reinforcement that has been discussed thus far can be categorized as direct reinforcement. In direct reinforcement the delivery of reinforcement is mediated through another person, and it is easy to observe and document its positive effects on infant vocal behavior (e.g., Rheingold, Gewirtz, & Ross, 1959). There is a second type of reinforcement that is less obvious, and much less researched, but perhaps at least equally potent as an independent variable relevant to the emergence of infant babbling. This type of reinforcement has been identified as automatic reinforcement (Skinner, 1957).

Automatic reinforcement involves a strengthening effect that occurs without the deliberate consequential mediation of another person. But rather, as a result of an antecedent pairing of a neutral stimulus with an established form of reinforcement, the neutral stimulus can acquire reinforcing value. Any response that produces a *response product* that resembles the previously neutral stimulus will be automatically reinforced (Skinner, 1957). For example, a person may persist in singing or humming a song while coming home from a movie, despite no obvious direct reinforcement for singing. In order for this behavior to occur as automatically reinforced behavior, a special two-stage conditioning history is necessary. In stage one, some stimulus (e.g., a song) must be paired with an existing form of conditioned or unconditioned reinforcement (e.g., an enjoyable movie, popcorn, relaxation). As a result, the new stimulus can become a form of conditioned reinforcement (e.g., hearing the song may now be a new form of conditioned reinforcement). In stage two, the emission of a response (for whatever reason) produces a response product (i.e., the auditory stimuli produced by singing the song) that has

topographical similarity to that previously neutral stimulus (e.g., the song), and may now have self-strengthening properties. The stimulus conditions that evoke the song may become somewhat ubiquitous, because each time the song is automatically reinforced it may alter the evocative effect of any stimulus that might be present.

The concept of automatic reinforcement may help to explain why a typical infant engages in such extensive babbling without the apparent delivery of reinforcement. Miller and Dollard (1941) were perhaps the first to suggest that this two-stage conditioning process is partially responsible for an infant's high rate of babbling. Since their initial work, several other psychologists have also suggested that automatic reinforcement plays a significant role in language acquisition (e.g., Bijou & Baer, 1965; Braine, 1963; Mowrer, 1950; Novak, 1996; Osgood, 1953; Skinner, 1957; Spradlin, 1966; Staats & Staats, 1963; Vaughan & Michael, 1982). Skinner (1957), for example, proposed that automatic reinforcement can strengthen an infant's vocal behavior. He states that "The young child alone in the nursery may automatically reinforce his own exploratory vocal behavior when he produces sounds that he has heard in the speech of others. This self-reinforcing property may be merely an intonation or some other idiosyncrasy of a given speaker, or speakers in general" (p. 58).

In their analysis of child language development, Bijou and Baer (1965) conclude that automatic reinforcement, along with direct reinforcement, is a major independent variable responsible for an infant's tendency to babble. These authors explain that

> The normal baby hears his own vocalizations, of course. Such sounds are mildly reinforcing in that they function like other...reinforcers. They gain additional reinforcing effectiveness, however, if they are similar to the mother's vocalizations (generalization). Hence one might say that the sound of the baby's vocalizations "automatically" strengthens the vocalizations themselves. As a result, the infant's vocal responses become both stronger and differentiated into those which more and more closely produce sounds like the mother's speech, since vocal responses which resemble the mother's will be strengthened more than vocal responses which do not. (p. 160)

Despite the work of the many theorists who have addressed automatic reinforcement, there have not been many empirical demonstrations or applications of this concept. Mowrer's (1950) work with mynah birds represents one of the few research projects that directly examines the pairing process that is essential to automatic reinforcement. Mowrer discovered that

> In order for a bird to learn to make a particular word sound, that sound has to first be heard, repeatedly, in a pleasant agreeable context. Varied evidence indicates that if a sound such as "Hello" is uttered as the trainer comes into the presence of the bird after an absence, or if the sound is repeated as the trainer gives the bird food and water, scratches its head or neck or amuses or comforts the bird in some other way, the bird will sooner or later start using the word, both in the absence of and in the presence of the trainer, as a means of securing "services" which the trainer can provide. (p. 73)

Other than Mowrer's studies with mynahs, there do not appear to be any empirical demonstrations in the literature on the effects of the stimulus-stimulus pairing procedure on the emergence of a child's novel vocal behavior. The purpose of the current study was to empirically examine the effects of stimulus-stimulus pairing and automatic reinforcement on human vocal behavior. The first experiment attempted to establish new vocal responses in the babbling (vocal-play) repertoires of five children by using a stimulus-stimulus pairing procedure. The second experiment examined several parameters of the pairing procedure with a single subject.

EXPERIMENT 1

METHOD

Subjects

Five children between the ages of 2 and 4 served as subjects. Four of the subjects had severe to moderate language delays, and one was a typically developing child (Subject 5). Subject 1 was a 4-year-old male with a visual impairment (bilateral colobomos) and mental retardation. The subject could emit over 300 mand, tact, and

intraverbal responses, and engaged in a high rate of vocal play. The subject was a student in a preschool classroom of a special education program.

Subject 2 was a 4-year-old male with a diagnosis of autism. He could emit over 200 mands, tacts, and intraverbals. However, he rarely emitted spontaneous vocalizations or engaged in vocal play.

Subject 3 was a 2-year-old female born to a crack cocaine addicted mother, but raised by her developmentally disabled Aunt. She had been identified as having developmental delays, and by the age of two had acquired only a few words and rarely emitted any vocal responses. She attended a preschool program for four hours each school day.

Subject 4 was a 3-year-old male with a diagnosis of autism. He received an in-home intervention program, and attended a preschool program three days a week. The subject engaged in a high rate of vocal behavior, but had limited verbal skills. He could mand and tact about 100 items, but his vocalizations were often hard to understand. The subject could not emit vowel sounds, yet he could emit most of the consonants and partial words. The subject showed this marked absence of vowels in both his vocal play, and in the words he emitted as echoics, mands, and tacts. However, he occasionally emitted the sounds in combination with other sounds, and to a lesser degree, when he was looking at letters. This deficit persisted despite numerous attempts by speech therapists and others to teach him to echo vowels by the use of echoic prompting, letter prompting, and direct reinforcement.

Subject 5 was a typically developing 2-and-one-half year old female who exhibited age appropriate verbal behavior. The girl lived at home with her natural mother, father, and older male sibling.

Setting and Materials

For Subject 1 sessions were conducted in a play area in the preschool classroom of his school. Materials consisted of a box of plastic kitchen items and other toys, a stopwatch, data sheet, and clipboard. There were other children present in the classroom, but none were in the play area. However, there was an adult observer who accompanied the experimenter during each session.

For Subject 2 sessions were conducted in the subject's home with his parents and in-home trainers serving as observers. Materials consisted of a train set with a number of toys placed on it, a stopwatch, and data sheet.

For Subject 3 sessions were conducted in the subject's home with her Aunt and 5-year-old cousin present (the Aunt served as observer). Materials consisted of a collection of toys, a stopwatch, data sheet and clipboard.

For Subject 4 the session was conducted in the subject's home with his parents and in-home trainer serving as participants and observers. Materials consisted of a number of the subject's toys, an old parachute, a stopwatch, and data sheet.

For Subject 5 the session was also conducted in the subject's home with her mother serving as observer. Materials consisted of a collection of toys, a stopwatch, and data sheet.

Response Definition, Recording System, and Design

The subjects' vocal responses were recorded and classified as either the targeted vocal response, or as a non-targeted response. The non-targeted responses were further identified as echoic, mand, tact, or intraverbal responses, or other vocalizations (e.g., automatically reinforced vocal play, random vocalizations, reflexive vocalizations). Words that were known to be novel or did not occur in the pre-pairing condition, were used as target words. The data sheet contained a space in which to write in the type of verbal operant observed and the controlling variables. Utterances were recorded in time bins of 10 seconds for Subject 1, and time bins of 1 minute for Subjects 2-5. For Subject 1, who had a substantial amount of vocal behavior (mostly classified as automatically reinforced vocal play), responses were measured in functional units (e.g., "That's a book" as one response). For Subjects 2 and

3 who had low rates of vocalizations, and almost no two-word responses, each individual sound and word was scored as a response. For Subjects 4 and 5 who had high rates of vocal play, and other types of verbal behavior, only the targeted sound and phrase was recorded throughout the experiment. The study employed an AB design that compared each subject's performance on pre-test (baseline) and post-test measures, with a replication across subjects.

Procedure

In this experiment an attempt was made to establish new vocal response topographies (dependent variable) in the subjects' vocal play repertoire, by pairing a sound, word, or phrase that the subject had not previously emitted, with an established form of conditioned or unconditioned reinforcement (independent variable). There were three conditions in the study for each subject: pre-pairing, pairing, and post-pairing.

Pre-pairing (Baseline). During the pre-pairing condition the experimenter and the observer(s) sat a few feet away from the subject, and the experimenter recorded all the vocal topographies emitted by the subject and their controlling variables (except for Subjects 4 and 5, for them only the targeted phrase was recorded). The experimenter did not interact with the subject (i.e., there was no prompting or direct reinforcement provided).

Pairing. A familiar adult approached the subject and emitted a specific vocal sound, word, or phrase (the targeted response) immediately followed by the delivery of an established form of reinforcement (e.g., tickles, praise, clapping, bouncing in a parachute held by adults, animated parental attention). The pairing procedure was repeated during a 1 to 2 minute period with approximately 15 pairings per minute. Several different pitches and intonations were used with each sound, word, or phrase. For Subject 1, approximately 30 words and phrases were paired in over 40 sessions during a 6-month period. For Subject 2, three words were paired in 2 sessions. For Subject 3, four words were paired in 10 sessions. For Subject 4, one sound was paired in one session. And for Subject 5, one phrase was paired in one session.

Post-pairing. The adult moved away, and the conditions were the same as in pre-pairing.

Reliability. Reliability was assessed in two ways; observer confirmation and the replication of the observed effects. In all cases the observers agreed that the targeted responses did or did not occur in the pre- and post-pairing conditions. However, the independent observers did not provide reliability as to the specific number of responses that occurred during each post-pairing condition. In addition, in an effort to confirm that the specific manipulation produced the observed behavior change, the pairing procedure was replicated with three of the subjects by several different adults.

RESULTS

For all subjects the pairing of a vocal sound, word, or phrase with reinforcement resulted in the unprompted emission of that response in the post-pairing condition. However, there were a few occasions when the pairing did not produce an increase in vocal behavior. The results for each subject are presented in Figures 1-5.

For Subject 1 the pairing procedure produced an increase in the targeted vocalization in 26 out of the 30 pairings. A representative sample of three successful pairings is presented in Figure 1. This figure shows that during the pre-pairing condition the subject emitted a total of five tacts and four other vocalizations (mostly "Yeah! Good boy!"), but the targeted three words did not occur. The subject's overall rate of vocalization was 10.8 responses per minute. During the pairing condition three words that the subject had never emitted, "mirror," "squeeze," and "sponge," were paired with reinforcement (tickles) approximately five times each over a period of 60 seconds. The subject laughed during the pairing, but did not emit any words. During the post-pairing condition, these three targeted words were emitted (in

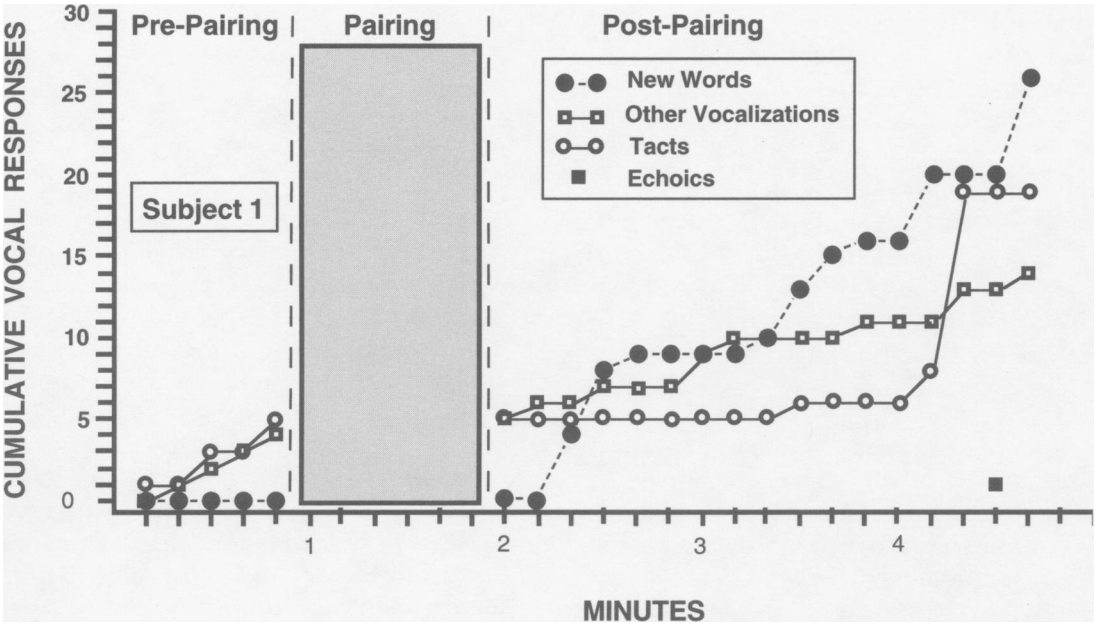

Fig. 1. Cumulative number of all vocal responses for Subject 1 on pre- and post-pairing measures. The shaded area represents the time during which three new target words were paired with tickles.

about equal frequency) a total of 26 times in 160 seconds, with an average rate of 9.75 responses per minute. Also, during that time the subject emitted 12 tacts, one echoic, and eight other automatically reinforced vocalizations, increasing the subject's overall rate of vocalization to 17.62 responses per minute.

All three of the pairings with Subject 2 resulted in an increase in the targeted word during the post-pairing condition. A representative sample of one of these pairings is presented in Figure 2. During the pre-pairing condition this subject emitted four vocal responses over an eight minute period, a rate of 0.5 responses per minute. The four responses were specific one word mands and tacts, and no responses were emitted that could be considered vocal play. This low rate of vocal behavior and absence of vocal play was characteristic for this subject. During the pairing condition the word "apple" was paired with reinforcement (tickles) approximately 15 times in 60 seconds. The subject laughed during the pairing, but did not emit any words. During the following post-pairing condition the subject emitted the word "apple" 17 times in 4 minutes. The response was scored as vocal play and occurred at a rate of 4.25 responses per minute. In addition, the subject emitted seven other vocal responses, all mands for "tickle," and all within the first minute of the 4 minute period. The subject's total vocal response rate increased to six responses per minute, 12 times that of the pre-pairing condition.

For Subject 3 the pairing procedure produced an increase in the targeted vocalization in 8 out of the 10 pairings. Figure 3 shows a representative sample of one of the successful pairings. During the pre-pairing condition this subject emitted 14 vocal responses over a 5 minute period, a rate of 2.8 vocal responses per minute. The 14 vocal responses were phonemes and partial words occurring as mands, echoics, and some vocal play. During the pairing condition the word "rock" was paired with reinforcement (rocking and cuddling) approximately 15 times in 120 seconds. The subject hugged tightly during the pairing, but did not emit any sounds or words. During the following post-pairing condition the subject emitted the word "rock" in the form of "ra" three times in 6 minutes, a

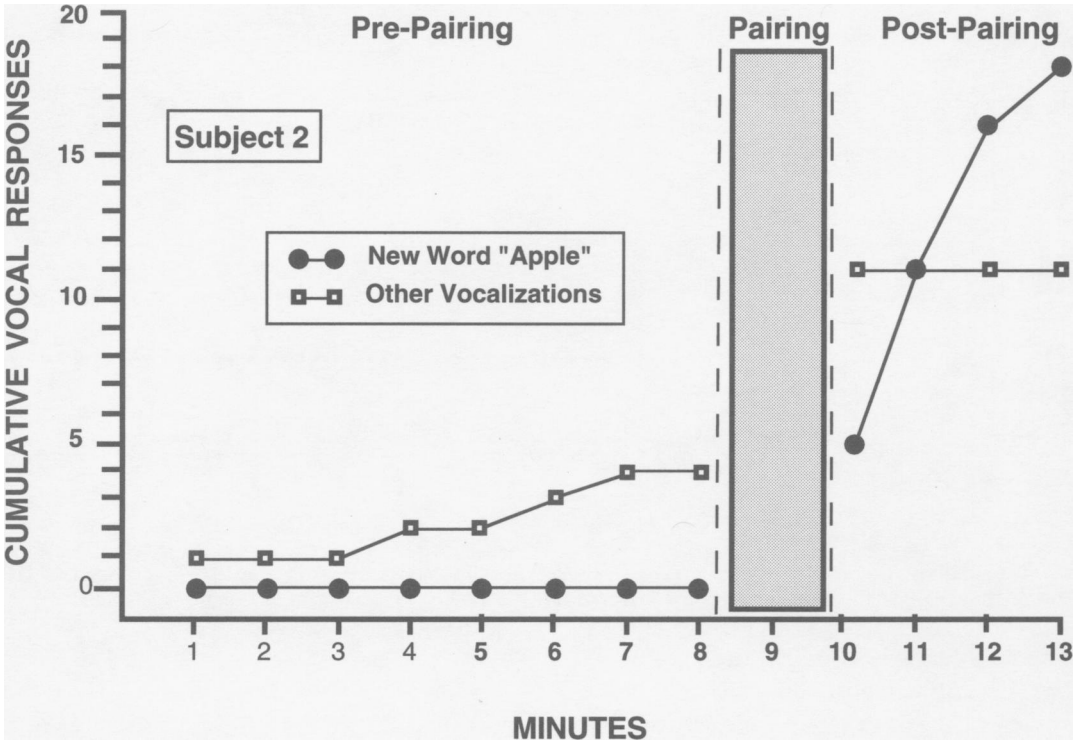

Fig. 2. Cumulative number of all vocal responses for Subject 2 on pre- and post-pairing measures. The shaded area represents the time during which one new target word was paired with tickles.

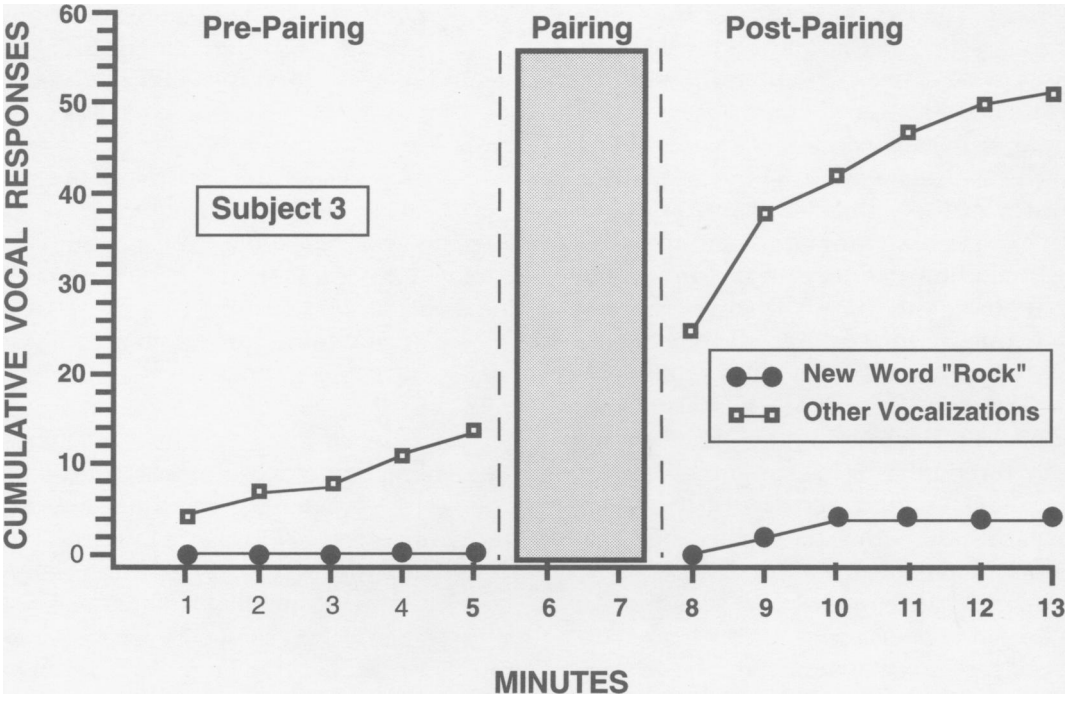

Fig. 3. Cumulative number of all vocal responses for Subject 3 on pre- and post-pairing measures. The shaded area represents the time during which one new target word was paired with rocking and cuddling.

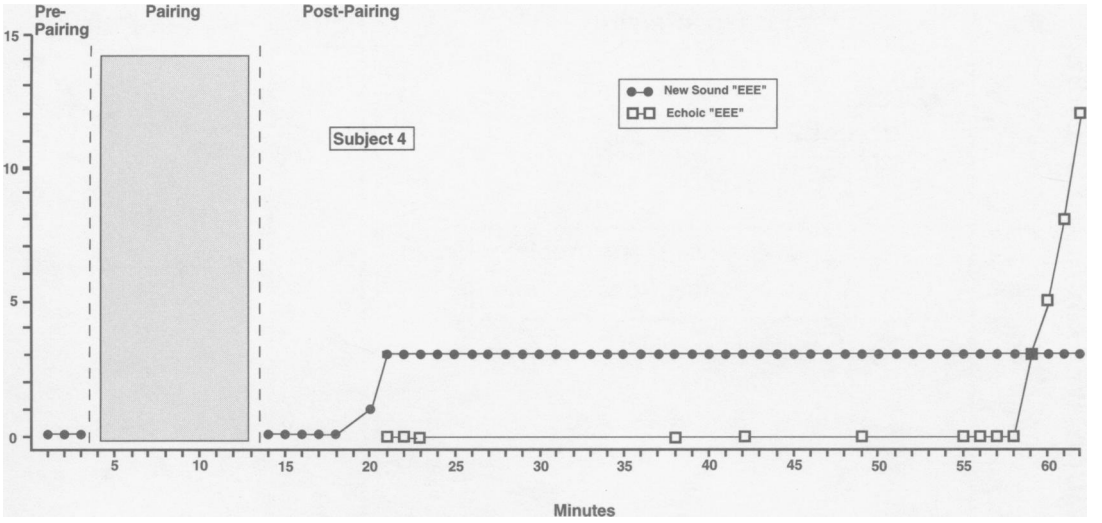

Fig. 4. Cumulative number of only the targeted responses for Subject 4 on pre- and post-pairing measures. The shaded area represents the time during which one new target sound was paired with parachute bouncing.

rate of 0.5 responses per minute. In addition, the subject emitted 37 other vocal responses during that 6 minute period that could be classified as mands, tacts, echoics, or vocal play. Thus, the subject's overall vocal response rate increased to 6.6 responses per minute, more than twice that of the pre-pairing condition.

Figure 4 shows the results of the single pairing with Subject 4. The vowel sound "eee" was chosen because the subject could not emit it, or any other vowel sound echoically, despite a strong ability to echo consonants. During the pre-pairing condition the subject did not emit the "eee" phoneme. During the pairing condition the phoneme "eee" was paired with reinforcement (being thrown up in a parachute by four adults, all only saying "eee") approximately 25 times in ten minutes. During the following post-pairing condition the subject emitted the phoneme "eee" three times 6 to 7 minutes after the pairing. His parents reported that was the first time that they had heard him say "eee" in that manner.

Attempts were made to get him to make an echoic response several times after the three "eee" sounds occurred. The letter E was shown to him in addition to the vocal prompt "say eee." After 42 minutes and 13 separate multi-trial attempts to get him to echo "eee" he correctly responded and was successful 12 more times in the next three minutes. Immediately following this session the other adults attempted to get him to echo "eee" and he did so easily on a number of occasions. In one day it had become as easy to evoke "eee" as it was to evoke consonants. A similar pairing procedure was tried by the in-home staff at a later date for two other vowels, and he acquired these vowels as echoics in a manner similar to the acquisition of the echoic response "eee."

Figure 5 shows the results of the one pairing with Subject 5. During the pre-pairing condition the subject did not emit the targeted phrase. During the pairing condition the novel phrase "Dee dum" was paired with reinforcement (animated head shakes back and forth by the experimenter) approximately 15 times in 60 seconds. The subject laughed during the pairing, but did not emit any words or phrases. During the following post-pairing condition the subject emitted the phrase "Dee dum" 10 times during the next 3 minutes. These responses were initially classified as vocal play responses, but it soon became apparent that they had transferred to control by establishing operations and the subject begin to mand to the experimenter "Baba do Dee dum" (shake his head). These

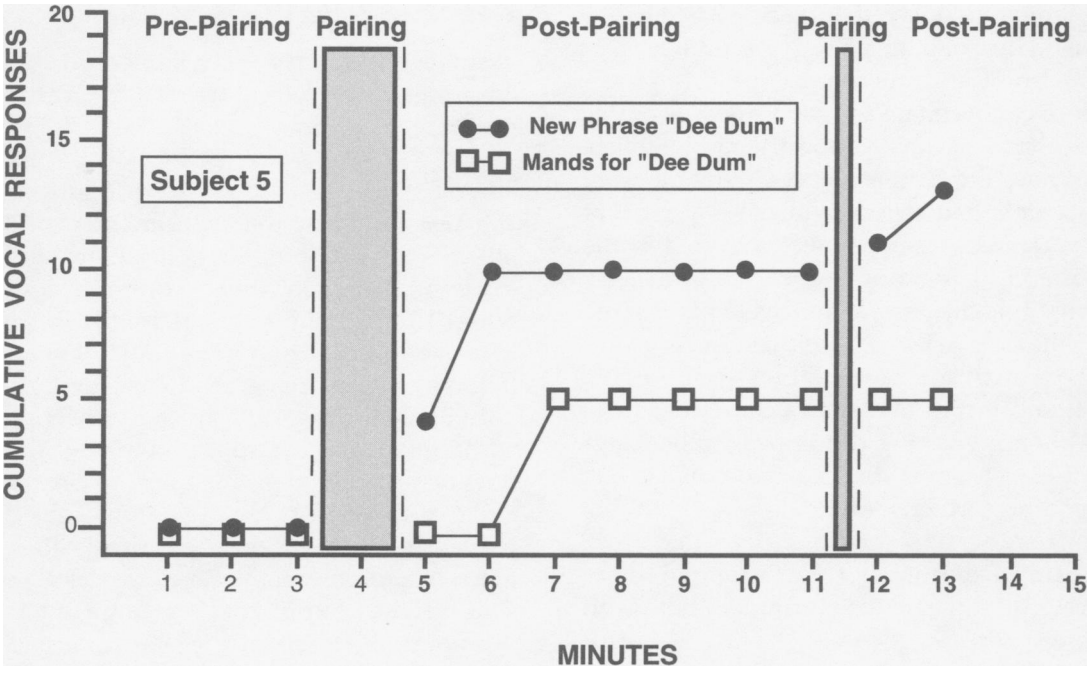

Fig. 5. Cumulative number of only the targeted responses for Subject 5 on pre- and post-pairing measures. The shaded areas represent the time during which one new target phrase was paired with animated head shakes.

mands occurred five times, but ceased when reinforcement was not provided. After 5 minutes of no "Dee dum" responses, the phrase was paired again for three times in 30 seconds, which resulted in the subject emitting "Dee dum" three more times as a vocal play response.

Discussion

The results from Experiment 1 show that children representing a broad range of language abilities can acquire new vocal and verbal responses through a procedure that consists of pairing neutral sounds, words, or phrases with established forms of reinforcement. Perhaps the most significant aspect of these results is that the new responses were acquired by the subjects without the use of direct reinforcement, direct echoic training, or prompts to respond. It was also observed that the newly paired topographies occasionally occurred in the subjects' vocal play at other times throughout the day (especially for Subject 1). In addition, the pairing procedure produced an increase in the subjects' overall vocal responses. However, this effect was probably due to the pairing procedure functioning as direct reinforcement for the pre-pairing vocalizations.

In addition, the results showed that the pairing procedure may lead to the emergence of other types of verbal behavior. For example, mands emerged for Subjects 2 and 5. Subject 5 who was a typically developing subject, began to mand for head shakes with "Dee dum." After a period of emitting "Dee dum" as vocal play, the EO for head shakes became strong and evoked the response as a mand. The new response form, "Dee dum," was embedded in an established mand frame ("Baba, do_____"). Thus, for this subject the mand emerged through the pairing procedure without ever being prompted or specifically reinforced. Subject 2 also began to mand, emitting the known word "tickles" (the form of reinforcement paired with the word "apple"). It is interesting to note the similarities of these results with those of Mowrer (1950) who found that the mynah "will sooner or later start using the word, both in the absence of and in the presence of the trainer, as a means of securing 'services' which the trainer can provide" (p. 73). It may be possible, then to also increase

a language delayed subject's tendency to mand by using the pairing procedure.

Also, it appears that the pairing procedure can facilitate the acquisition of echoic responses as was demonstrated by Subject 4's new ability to echo "eee" after all other attempts had failed. While it is clear that the targeted response was acquired in the session, it remains unclear as to exactly what role the pairing may have played due to the long delay in echoic responding, and the multitude of variables involved in attempting to evoke an echoic response. Although, pairing did appear to be a significant independent variable, this effect requires further study.

There were several questions that arose during Experiment 1. For example, there were times when the pairing did not result in an increase in vocal behavior. This failure seemed to be related to a number of variables, and a further investigation is warranted. Also, it appeared that the new response typically occurred within a minute after pairing, but its effects seemed temporary in that the rate of vocal responses usually decreased over time. Finally, it was observed that some response topographies are altered by others, especially when they are typographically incompatible. Therefore, a second experiment was conducted in order to examine these effects.

EXPERIMENT 2

The primary purpose of this experiment was to further investigate some of the issues that arose during Experiment 1. A number of variations of the pairing procedure were examined during the 30 pairing sessions with Subject 1. Three of these variations are presented below. The first procedure examined the failure to obtain an increase in vocal play as a result of the pairing procedure. The second procedure examined the lasting effects of pairing by using an extended pre- and post-pairing condition. Finally, the third procedure involved an attempt to disrupt a previously paired vocalization by introducing a similar sounding, but incompatible phrase.

Subjects and Setting

Subject 1 was the only subject in this experiment. The setting was the same as in the previous phrase.

Procedure 1

It was noted by the experimenters and others who attempted to replicate the pairing procedure that there were occasions when the pairing did not result in an increase in vocal play. The most obvious failures were pairings conducted by individuals who unfamiliar to the subject. In addition, the pairing appeared to have different effects based on the subject's current emotional state. For example, if the subject was quite and sullen, the pairing often failed to produce an increase in vocal play. The current experiment attempted to examine the effects of the pairing procedure following such periods of silence by the subject. The general procedure was essentially the same as in the previous experiment (i.e., pre-pairing, pairing, post-pairing). The novel topography, "beard" was paired approximately 20 times with reinforcement (tickles) for 100 seconds. Three other words or phrases, "what sound," "squeeze," and "owl," were also paired with reinforcement.

Results and Discussion

The session began after a period of silence by the subject. During the pre-pairing condition the subject did not emit any vocal behavior. The first topography paired with reinforcement was the novel word "beard" and was paired approximately 20 times in 90 seconds. The subject laughed as usual and seemed to enjoy the tickles. But, during the post-pairing condition (see Figure 6) the subject did not emit this word, or any other word. Next (without a specific pre-pairing baseline) a familiar (previously paired) phrase, "what sound" was paired approximately 20 times in 100 seconds. During the following post-pairing condition this phrase was emitted at a rate of 7.5 responses per minute (10 times in 80 seconds). In addition, the subject emitted nine other vocal responses, most of which were "beard," the first

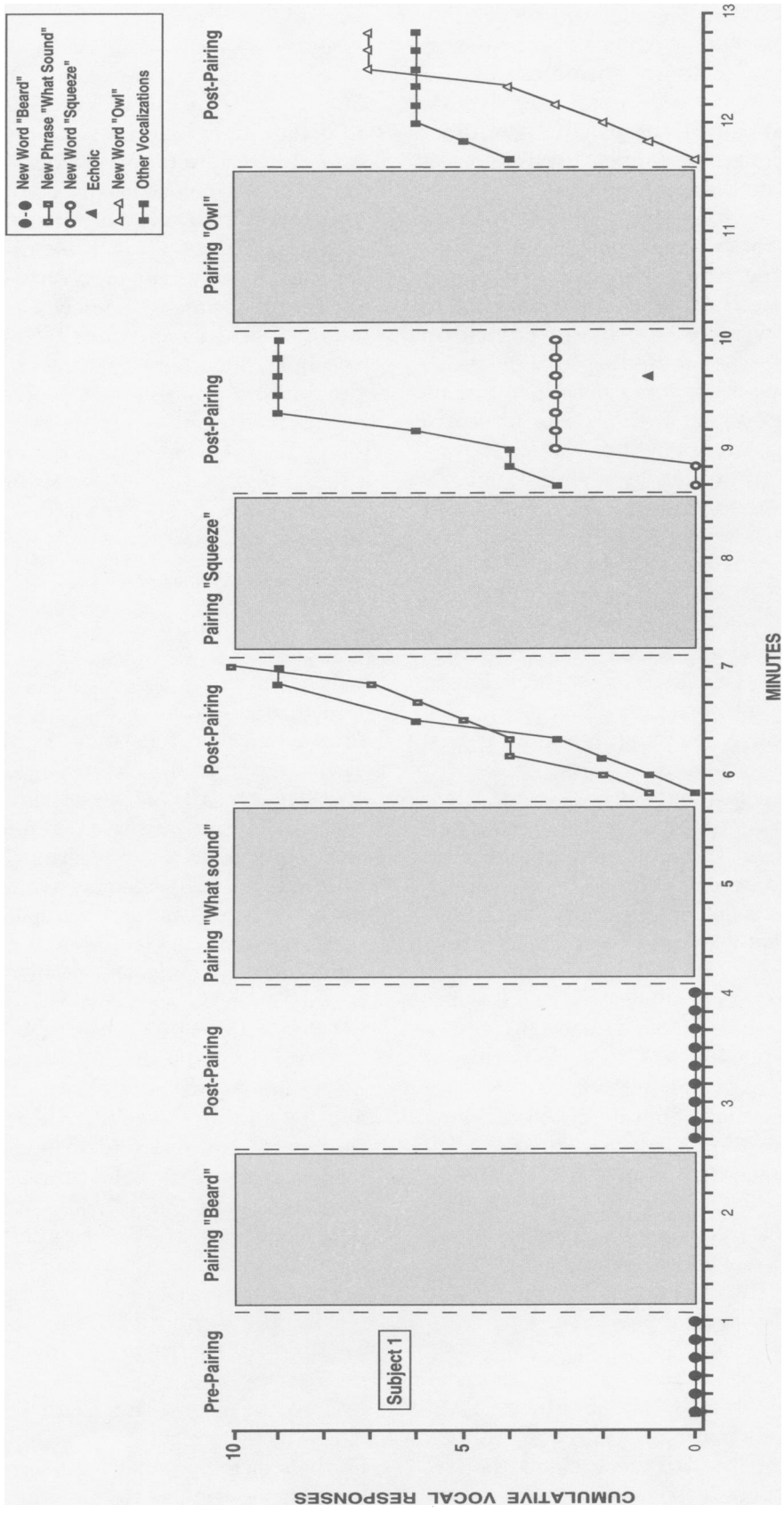

Fig. 6. Cumulative number of all vocal responses for Subject 1 on pre- and post-pairing measures. The shaded areas represent the time during which three target words and one target phrase were paired with tickles.

paired stimulus. This delayed responding was unexpected, but has similarities to behavior typically identified as delayed echolalia. This effect does at least demonstrate that during the pairing condition, despite the subject's quiet disposition, the pairing procedure was effective.

Immediately following the post-pairing condition for "what sound," another previously-paired word, "squeeze" was paired approximately 20 times in 90 seconds. In the following post-pairing condition "squeeze" was emitted eight times in 80 seconds, a rate of six responses per minute. Also, the subject emitted 4 other vocal responses, one of which was an echoic response controlled by a staff member's vocalization occurring on the other side of the classroom. Finally, the word "owl" was paired approximately 20 times in 90 seconds, and in the post-pairing condition "owl" was emitted seven times in 80 seconds, a rate of approximately 5.3 responses per minute. The subject also emitted eight other vocal responses, and it appeared that he was now responding in a more typical manner.

The variables that resulted in the eventual effectiveness of the pairing procedure were unclear. The probability of successful pairing however, seems to be relevant to the subject's current emotional state. It is possible that the pairing of a familiar word played a role in evoking vocalizations. A further empirical analysis of this effect is certainly required. The emergence of the response "beard" following a period of silence, and a pairing with a different topography, was interesting. This delayed responding appeared to be similar to what has been identified as delayed echolalia. It is possible that much of this type of behavior, which is frequently observed in autistic children, may be an effect of automatic reinforcement. This possibility should also be examined in future research.

Procedure 2

In Experiment 1 it was observed that the effects of the pairing appeared to be brief. That is, for most of the subjects the targeted response ceased to occur after a short period of time, but on occasion the response would be emitted by the subject at a later time (this was especially true for Subject 1). The focus of Experiment 1 was to demonstrate that the pairing procedure established new forms of vocal behavior. Once this effect was clearly demonstrated, which was typically within the first few minutes of post-pairing, sessions were terminated. The current procedure examined the length of time that a newly established word would remain in the immediate vocal play repertoire by using an extended pre- and post-pairing condition. The general procedure was again essentially the same as in the previous experiments (i.e., pre-pairing, pairing, post-pairing), except the session was not terminated until the response ceased to occur.

Results and Discussion

Figure 7 shows the results of an extended session with Subject 1. The pre-pairing condition lasted 7 minutes, during which time the subject emitted one tact, four echoics, and 46 other vocalizations. There were a total of 51 responses emitted and an overall response rate of 7.28 responses per minute. The targeted response was not emitted during this condition. During the pairing condition the phrase, "read a book," was paired with reinforcement (tickles) approximately 30 times in 120 seconds. During the post-pairing condition the subject consistently emitted the newly paired phrase, totaling 20 in just over 5 minutes (a response rate of 4.9 per minute). The phrase dropped out for about 3 minutes, and then was emitted four more times. In addition, approximately the same rate of other vocal responses, tacts, and echoics were emitted (a response rate of 7.3 per minute), resulting in an overall increase of the total number of responses to a rate of 12.2 responses per minute during the first five minutes of the post-pairing condition. This unprompted vocalization rate returned to its pre-pairing level after about 9 minutes.

The data from this session replicate the findings of Experiment 1 by showing that the pairing effects are immediate, but in

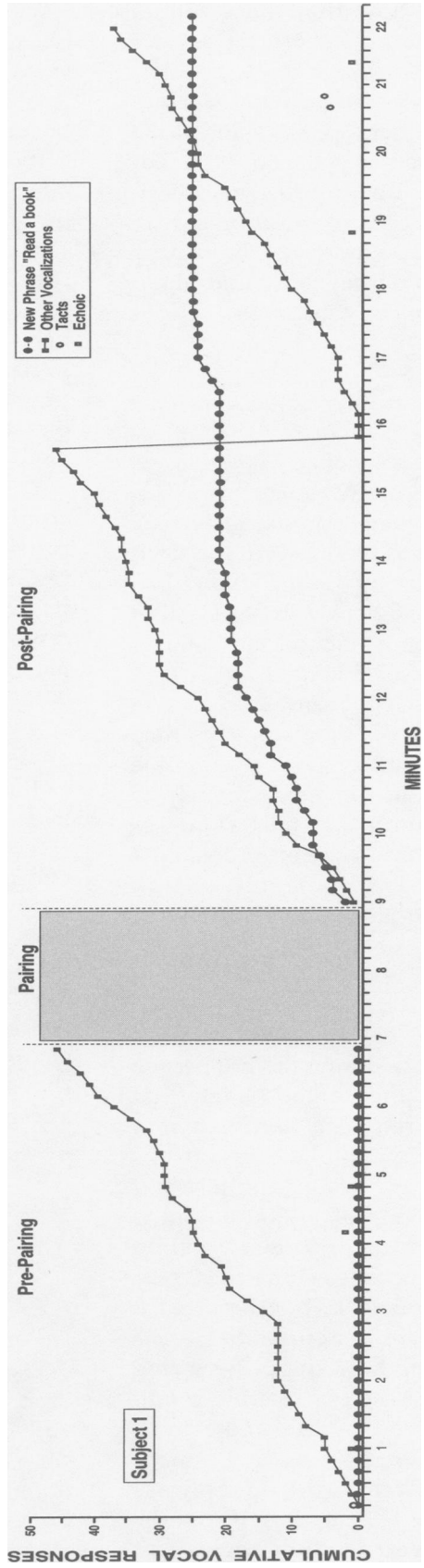

Fig. 7. Cumulative number of all vocal responses for Subject 1 on pre- and post-pairing measures. The shaded area represents the time during which one phrase was paired with tickles.

addition, they show that these robust effects are temporary. There are several variables that could be related to the strength of the new vocalizations, such as the frequency of pairings, the value of the reinforcement used, and the subject's current establishing operations. These variables should be examined in future research in order to more clearly identify their possible role in evoking and maintaining vocal-play behavior.

Procedure 3

An additional variable that seemed to be related to emission of specific responses involved the subject's pairing history. It was noted that after each new pairing this subject also emitted previously paired responses, and on occasion blended the paired responses. The third procedure involved an attempt to alter topographically a previously paired vocalization by introducing a similar sounding phrase. The general procedure was again essentially the same as in the previous experiment (i.e., pre-pairing, pairing, post-pairing). The novel topography, "Name that sound" was paired approximately 25 times with reinforcement (tickles) for 110 seconds. This phrase was selected because it as a unit, seemed incompatible with an already strong vocal-play response "What sound is that."

Results and Discussion

Figure 8 shows that there were no vocal or verbal responses during the pre-pairing condition. After the phrase "Name that sound" was paired with reinforcement three different types of vocalizations emerged. The first vocalization to occur was the old pairing of "What sound is that?" along with other formerly paired sounds and words classified as vocal play (e.g., "yeah," "squeeze"). These occurred at a fairly steady rate of approximately 3.5 per minute throughout the post-pairing condition. During the post-pairing condition there were 18 occurrences of the previously paired phrase, "What sound is that," and 10 occurrences of the new phrase "Name that sound." It appeared that the two phrases were independent and acquired as a unit, in that the subject never blended them or emitted them both in the same 10-second time bin. Thus, the attempt to alter a previous response topography failed.

It is interesting to note that immediately after the pairing with the new phrase the old phrase occurred first and more often. This suggests that the reinforcement history associated with old phrase was stronger than the immediate pairing contingencies associated with the new phrase. In addition, after about 1 and one-half minutes the new phrase dropped out completely, and the old phrase continued to occur at a rate equal to, and for about 1 minute, higher than all other vocalizations combined. However, the new phrase returned about 3 minutes later and replaced the old phrase (except for one response). Then, both phrases dropped out completely, as did all other types of vocal play, and the subject became quiet again as in the pre-pairing condition.

Why the new pairing immediately evoked a specific old topography, as well as the other specifically paired responses, is certainly of interest. It is possible that as a result of the pairing, the responses became members of the same response class, but since one of the members had a longer reinforcement history, and was similar to the newly paired phrase, it occurred at a higher rate. If this is the case, which would certainly require a more thorough empirical investigation to determine, then the formation of this response class appears to have occurred in a manner similar to the way a response class is formed with direct reinforcement (e.g., Skinner, 1935), except the class was formed by antecedent manipulations rather than consequent manipulations.

GENERAL DISCUSSION

The results of this study show that children can acquire new forms of vocal and verbal behavior through a procedure that consists of pairing neutral sounds, words, or phrases with established forms of conditioned or unconditioned reinforcement. Perhaps the most significant aspect of

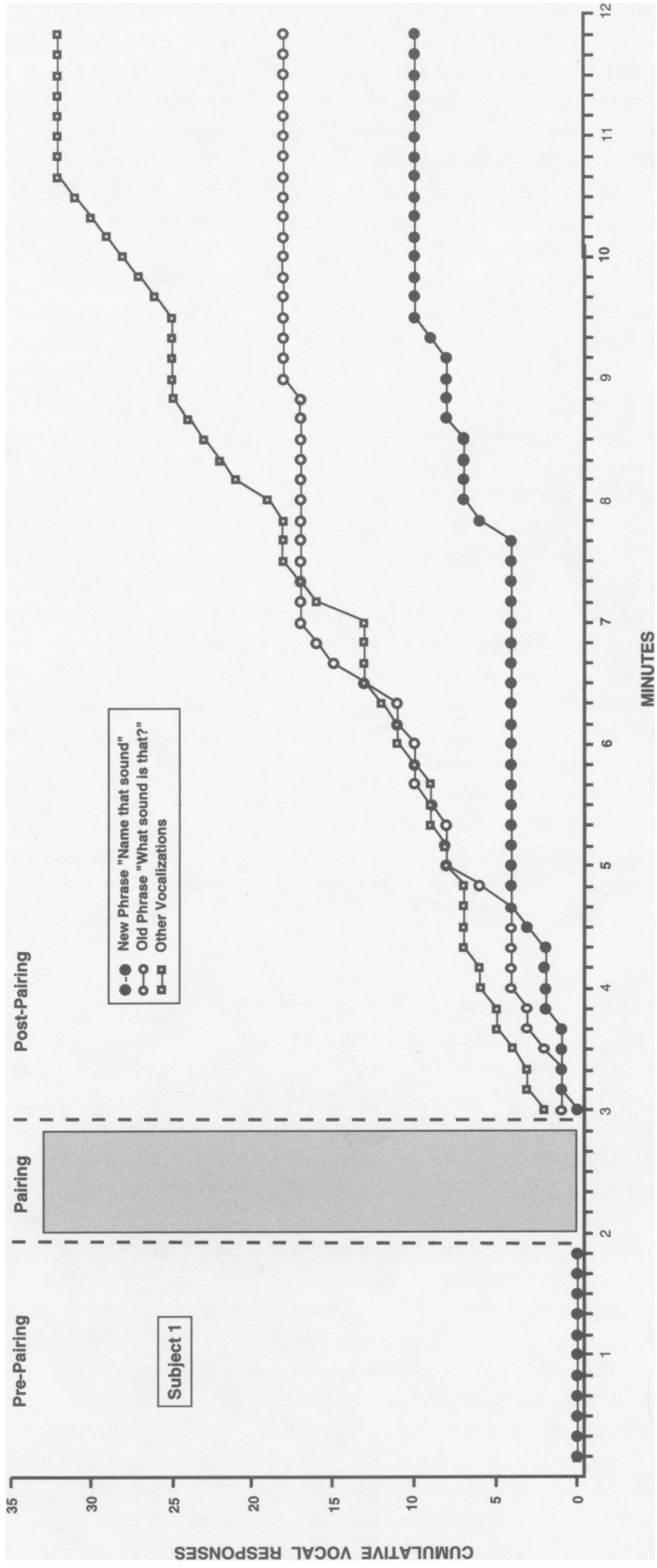

Fig. 8. Cumulative number of all vocal responses for Subject 1 on pre- and post-pairing measures. The shaded area represents the time during which one phrase was paired with tickles.

these results is that new vocal responses were acquired without the use of direct reinforcement, direct echoic training, or prompts to respond.

In explaining this behavior, it seems possible that the vocal responses increased in frequency because the auditory product of these responses functioned as a new form of conditioned reinforcement and automatically strengthened the responses. These empirical results support that conceptual analysis of automatic reinforcement (e.g., Bijou & Baer, 1965; Miller & Dollard, 1941; Osgood, 1953; Skinner, 1957). These results also have implications for the analysis of how humans so readily acquire their native language, and implications for the development of techniques for teaching language to individuals who fail to acquire verbal behavior.

Psycholinguists have argued for years that reinforcement is not a significant independent variable in native language acquisition (Brown, 1973; Chomsky, 1959; Ervin-Tripp,1964; Pinker, 1994; Slobin, 1979). This argument is based on the observation that much of an infant's vocal and verbal behavior is not immediately followed by an observable form of reinforcement. This failure to identify a direct reinforcer is then used to reject the behavioral position on language acquisition (e.g., Brown, 1973; Savage-Rumbaugh et al., 1993). However, the problem lies in the common misunderstanding that the behavioral principle of reinforcement consists of only direct and observed events. Skinner wrote frequently about the role of automatic reinforcement in language acquisition, in fact he used the term close to 100 times in his books to explain the emergence and maintenance of a wide variety of behaviors (Vaughan & Michael, 1982). The data from the current study support Skinner's (1957) assertion that automatic reinforcement is a significant independent variable relevant to the explanation of why human infants around the world "naturally" acquire the language of their parents or caretakers.

The results of the current study may also clarify the role that imitation (echoic behavior) plays in language acquisition. In a review of the literature on imitation, Whitehurst and Vasta (1975) point out that "opinion on the matter ranges from suggestions that imitation plays, at most, a very limited role to suggestions that it may, indeed, be critical for language learning" (p. 38). The current data suggest that not all of a child's novel vocalizations are acquired through imitation, in that at least some responses are acquired through automatic reinforcement. However, these newly acquired vocalizations are still a function of environmental variables, rather than the frequently proposed cognitive and physiological variables (e.g., Chomsky, 1959; Ervin-Tripp, 1964; McNeill, 1970).

The current results also suggest a number of possible applications for language intervention programs for autistic and developmentally disabled children who fail to acquire language. For example, a major problem faced by many language delayed children is that their vocalization rate is too low to acquire the muscle control necessary to emit echoic responses. Speech and language pathologists frequently stress that vocal play and babbling are critical for the strengthening of the vocal muscles, and parents of language delayed children should encourage this behavior. The current data suggest that in addition to direct reinforcement and echoic prompting procedures, parents should make every attempt to pair their own vocalizations with the delivery of items and actions that serve as strong forms of reinforcement for the child. The amount of pairing necessary to increase vocalizations does not seem to be excessive, but it may vary substantially for individual children.

There are a number of possibilities for further research on automatic reinforcement. Perhaps most interesting would be an examination of the effects of the pairing procedure with younger subjects, such as 6 to 12 month old infants. It seems possible that the effects of pairing may differ from those of language delayed children and older typical children. Future research might examine a number of key issues relevant to the establishment of automatic reinforcement, such as the frequency of

pairing, the value of the reinforcement used, and the existence of competing establishing operations and behaviors. In addition, because pairing does not always produce an increase in the targeted response, it would be of interest to pursue an understanding of the variables relevant to this failure.

The analysis of automatic reinforcement also appears relevant to a number of complex human behaviors, such as thinking and creativity (Vaughan & Michael, 1982), the acquisition of syntax and grammar (Braine, 1963), equivalence relations (Palmer, 1996), and self-stimulation (Lovaas, Newsom, & Hickman, 1987). It also has implications for a wide range of topics frequently discussed in linguistics and psychology such as accents, bonding, problem solving, perception, academics, literature, performing arts, and pathologies (Vaughan & Michael, 1982). Further research in these areas could prove to be beneficial for the understanding of these issues.

In conclusion, it appears that automatic reinforcement plays an important role in language acquisition, and may have a number of applications to human language disorders. It is interesting to note that the recently published data on parent-child interactions and language development by Hart and Risley (1995), point out that a major variable in language acquisition is the frequency of verbal stimuli emitted by parents and caretakers in the presence of their children. It may be that this higher frequency of adult verbal behavior increases a child's verbal behavior because, in part, there are more occasions for positive stimulus-stimulus pairing and the establishment and maintenance of behavior through automatic reinforcement.

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