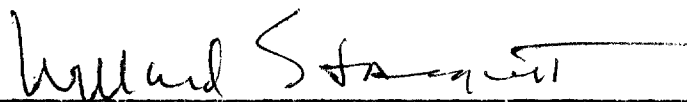
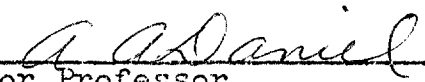



SELECTIVE REINFORCEMENT OF INFANT VOCALIZATIONS

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SELECTIVE REINFORCEMENT OF INFANT VOCALIZATIONS

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CHAPTER I

BABBLING AND OPERANT CONDITIONING

Introduction

Through observation of young children much has been learned regarding elementary word acquisition and ordering, sentence formulation, and expansion of verbal experience; but little research regarding what precedes "the word" has been done. The present study was concerned with that period in infancy prior to communicative speech production.

Observation has led psycholinguists, psychologists, and speech pathologists interested in normal speech development to assign names to the various periods in an infant's vocal behavior. In each group of such names that follows, the first name is that of an author's designation for vocal behavior in the first few weeks after birth; each successive term indicates advancement or more mature vocal behavior. "Reflexive vocalization," "babbling," "lalling," and "echolalia" were designations suggested by Berry and Eisenson (1, pp. 18-21). Lewis offered "discomfort-cries," and "comfort-sounds [comparable to the previously mentioned 'reflexive vocalizations']," "babbling," and "imitation (12, pp. 16-26)." Hurlock listed the prespeech forms of vocal development as "crying [again the same as 'reflexive vocalization']," "babbling," and

"gestures (8, pp. 95-97)." Because definitions of the various designations were similar, the terms "crying," "babbling," and "imitation" were selected for use in the present study. "Gestures" were not included because, according to Hurlock (8, pp. 96-97) they are used as a substitute for speech and might not be accompanied by vocalization. Of special concern in the current study was the babbling phase because according to Berry and Eisenson, Hurlock, and Lewis (1, 8, 12) infants select from their babbling those sounds necessary for their native language.

How does the baby select the sounds appropriate for his language? Skinner offered the following explanation:

A child acquires verbal behavior when relatively unpatterned vocalizations, selectively reinforced, gradually assume forms which produce appropriate consequences in a given verbal community. In formulating this process we do not need to mention stimuli occurring prior to the behavior to be reinforced. It is difficult, if not impossible, to discover stimuli which evoke specific vocal responses in the young child. There is no stimulus which makes the child say "b," or "ā," or "e," as one may make him salivate by placing a lemon drop in his mouth or make his pupils contract by shining a light in his eyes. The raw responses from which verbal behavior is constructed are not 'elicited.' In order to reinforce a given response we simply wait until it occurs (17, p. 31).

Of concern in the present study is the applicability of Skinner's theory to the babbling stage of development.

Carroll, in 1961, reviewed verbal learning studies and remarked, "Oddly enough, one never seems to think of 'teaching' a child to learn language in the early phases, or of

investigating the effects of specific practices in such teaching (2, p. 335)." Four years later Diebold voiced a similar complaint:

Unfortunately there is little said (except by way of acknowledging that it exists) about the differential reinforcement which fixes the child's language learning propensities onto the code of the particular language spoken in his community (14, p. 248).

Church in writing about language learning attacked Skinner's rationale. He pointed out, first, that the reinforcement by parents during the babbling stage of development is indiscriminate because "most of what he [baby] says does not resemble true language. . . (3, p. 80)." He further argued that whatever reinforcement did occur probably did not serve to stabilize old sounds but to produce new babbling patterns (3, p. 80). Church stated that ". . . there is absolutely no evidence that one can selectively reinforce particular babbles (3, p. 80)."

Statement of the Problem and Purpose of Study

Conflicting views have been presented regarding the role of reinforcement and vocal learning during the babbling phase of development and the lack of research in this area stressed. Skinner (17) stated that selective reinforcement of the baby's babbling is a vital influence in his vocal progress. Church (3) contended that if reinforcement occurred at all, it probably tended to add to an infant's sound repertoire

rather than to retain the old sounds, that reinforcement would not be selective, and that no experimentation with infants had been done to lend credence to Skinner's theory that one could reinforce specific babbling behavior.

The purpose of the present study was to answer the question: Can one selectively reinforce a particular babble?

Definition of Terms

Terms to be defined will be divided into two groups. The first group will be comprised of terms relating to normal speech development prior to production of communicative vocal symbols; the second, terms related to Skinner's learning theory.

Normal Speech Development

The following terms will be defined: crying, babbling, and imitation.

Crying.--Crying appears to be unintentional accompaniment for general muscular tension of the baby (8, 12).

The birth cry, and all the infant's vocalizations during the first two or three weeks of his life are reflexive, total bodily expressions in response to stimuli within and without him. As such, the expression is innate, and takes place without intent or awareness on the part of the infant. Vocalization itself arises as a result of a column of air reflexively expelled from the lungs passing between vocal folds tense enough to produce sound. Though the infant's early sounds are produced without purpose and lack specific meaning, they constitute a response

to a world in regard to which the infant has formulated no intentions and from which he has received no meaning (1, pp. 18-19).

Lenneberg, Rebelsky, and Nichols observed that crying and other sounds in the first three months of life were approximately the same for infants born to normally hearing and speaking parents and to congenitally deaf parents (11). They determined that these were developmental vocalizations and evolved as the infant matured (11). Internal states appeared to elicit the crying response, they reported, rather than environmental factors (11). After the first three months, however, they noted that the vocalizations of the two groups of babies began to differ; and they attributed this difference to the babies' differing environments (11).

Hurlock observed that throughout babyhood crying is always characterized by irregular breathing (8, p. 95). By the time the baby is three to four weeks old, his crying has become differentiated (1, 8, 12), and Hurlock specified differentiation based on intensity of the crying (8, p. 94). Berry and Eisenson stated that the infant is unaware of the differences in his crying, but that he has learned "that crying makes a difference (1, p. 19)."

Babbling.--The second phase of language development is babbling, according to Berry and Eisenson, and Hurlock (1, 8). Harriman defined babbling as "meaningless speech sounds (7, p. 20)." Others, notably Gesell, Lewis, Berry and Eisenson,

have stressed that the infant delights in producing these sounds and that babbling is really a play activity for him (5, 12, 1).

When a child is babbling he gives us the impression that he is making sounds 'for their own sake,' that he derives satisfaction from the utterance itself, that he is 'playing with sounds,' playing with his vocal organs in the same way as he plays with movement of his fingers and his toes (12, p. 20).

Babbling, then, is a pleasureable vocal activity for the infant with no communicative intent (8, p. 96).

According to Gesell and Hurlock babbling begins about the second or third month after birth (7, 8). It is usually initiated by vowel sounds (1, p. 20). Berry and Eisenson continued that "a variety of [a] repeated at length with variations in pitch and loudness will probably be among the first to be heard (1, p. 20)." Lewis related this occurrence to the physiological state of the mouth--open, relaxed, tongue resting gently against the lower gum ridge--when the infant is in a comfort-state (12, p. 18). Hurlock reported that babbling increases with time and practice to a peak at approximately eight months (8, p. 96). Murai (13) noted also the increasing repertoire of infant vocalizations and that sounds began to be repeated at about six months.

Lewis hypothesized that the infant's pleasure in babbling might be experienced at two levels (12, pp. 20-21). First, he may enjoy hearing and feeling the production of each isolated sound. Then he may string several sounds together. Patterns

may result from variations in rhythm, pitch, stress, and sound-groups. These patterns may account for a second level of enjoyment (12, pp. 20-21).

Normal language development of a baby six to eight months of age was described by Gesell, et al, as follows:

The infant has developed from mewling at four weeks, cooing at sixteen weeks to crowing and squealing at twenty-eight weeks. In spontaneous vocalizing he has produced vowels, consonants, diphthongs and even syllables. He is familiar with his home atmosphere and specific persons and is socially aware of facial expressions, gestures, and postural attitudes. He notes tones of voice and inflections, but does not yet understand words (5, p. 23).

It should be noted that the infant can entertain himself with a single toy or with vocal play, enjoys the company of his family, but he does not care to socialize with strangers (5, pp. 23-24).

Of what significance is babbling? Lewis suggested that sound play may be one of the roots of "aesthetic emotion," a beginning of literary appreciation (12, p. 21). He also pointed out that it "opens the way to the intervention of others (12, p. 21)." Berry and Eisenson, Hurlock, and Lewis (1, 8, 12) agreed that in addition to valuable vocal practice, the baby selects from his babbling those sounds needed for his native language.

Imitation.--Imitation may be generally defined as "a behavior sequence elicited by observing a similar behavior sequence in another person (7, p. 86)." Berry and Eisenson

in applying such behavior to language development stated that "at about nine or ten months of age, the child may be heard imitating sounds which others have made, and which are prevalent in his environment (1, p. 21)."

The imitative process was subdivided into three stages by Lewis. These stages, he suggested, were actually initiated at about the time babbling began or slightly before (12, pp. 22-23).

The three stages of imitation, we see, are intimately bound up with the whole development of a child's responses to the meaning of what he hears and his own meaningful use of speech. Stage one is the period when the sounds of human speech are beginning to attract his attention and this sharpening of awareness stimulates him to respond vocally. Then he begins to be aware of the circumstances in which others speak to him, and the sounds he hears become a stimulus for him to attend to these circumstances. The sounds now call forth from him many other kinds of response than the purely vocal. We see this as the lapse of imitation. Then as he begins to attend to heard sounds in relation to circumstances, imitation is reborn. He utters imitated sounds with meaning (12, p. 25).

Lewis's third stage is in harmony with the definition offered by Berry and Eisenson in that the baby's vocal production simulates another's model. However, there is disagreement regarding the attachment of "meaning" to what is uttered. Berry and Eisenson pointed out "that the Mongolian idiot, . . . possesses an amazing ability to echo long, tongue-twisting sound combinations without experiencing the slightest intellectual reaction to what he is echoing (1, p. 21)." Rather they considered imitation as a

demonstration of the baby's "acoustic awareness of other persons (1, p. 21)." ✓

Learning Theory

Operant conditioning, reinforcement, and scheduling of reinforcement will be defined.

Operant conditioning.--Operant conditioning, briefly, means that an act performed was rewarded and tended to occur more often because of the reward. Sometimes referred to as instrumental conditioning, operant conditioning refers to strengthening a behavior exhibited by an organism (17). According to Skinner (17) the stimulus provoking a particular act, or response, by the organism cannot always be identified; nor is it important to identify a cause. What is important is that the organism did something, and consequences followed. The something that the organism performed is the operant behavior or response.

The second half of the term, conditioning, indicates that a response by a subject is made more often than chance occurrence because some sort of learning has taken place. The behavior is said to be strengthened or conditioned.

The basic laws of operant conditioning state that (1) if an operant is followed by the presentation of a reinforcement stimulus, its strength is increased, and (2) if an operant is not followed by a reinforcing stimulus, its strength is decreased. In most situations an operant does become related to the stimulus field. It may come to occur, for example, only in the presence or absence of given stimuli. It is then

termed a discriminated operant, but it is still not elicited. The stimulus conditions merely furnish the occasion for the appearance of the operant (14, p. 30).

Therefore, whatever follows a given operant response tends to influence the recurrence of the response.

Reinforcement.--Reinforcement is "the strengthening of something by adding to it; or that which strengthens when added (4, p. 452)." So far as operant conditioning is concerned, when the operant response leads to a satisfying state, reinforcement has occurred. When reinforcement is accomplished, the response is likely to be repeated. The term, reinforcing stimulus, is sometimes used synonymously with reinforcement indicating that the consequences following a response cause that response to recur.

Gewirtz referred to some kinds of reinforcement used with infants as possessing a "love-like" quality, and stated that it can only be dispensed through physical means: "that is, . . . visual and sound patterns, skin contact, odors and the like (6, p. 226)." He explained that an infant's responsiveness to social reinforcement, or mothering, does not appear to be fulfillment of innate needs; that is, the baby was not born needing love, affection, or social intercourse. Instead, the baby began to desire such social rewards, according to Gewirtz, after he learned about them through "reinforcing stimuli dispensed by people (6, p. 226)." The complex of social reinforcement is of varying effectiveness

with different infants:

But when offered to a child by his mother or primary caretaker, the stimulus complexes involved could be most adequate and potent as reinforcers (6, p. 227).

Gewirtz also noted that the potency of the reinforcement is enhanced by familiarity with the environment (6, pp. 226-228). Therefore, behavior, specifically babbling, which occurs in the home, is more likely to be reinforced at home than in a strange environment.

Again it should be stated that reinforcement must follow the behavior to be conditioned. Otherwise, an association between the response and reinforcement (reward) may not be made. Spielberger referred to the association between the response and reinforcement as the response-reinforcement contingency (18). He indicated that

It was concluded that 'what' is learned in verbal conditioning is awareness of a response-reinforcement contingency and that subjects will act on their awareness provided they are motivated to receive reinforcement (18, p. 197).

Williams disagreed (20). She reviewed reports on verbal conditioning experiments in which an attempt was made to measure awareness of the response-reinforcement contingency on the part of the adult experimental subjects (20, pp. 385-386). In the studies subjects were asked to fill out a questionnaire or to reply to open-ended questions to determine their awareness of reward and which of their responses elicited rewards; Williams questioned the adequacy of the methodology.

She cited Dulaney's conclusion that "awareness on some level is always a factor where the conditioning effect is observed (20, p. 386)." She also noted Postman and Sassenrath's findings "that learning without awareness does occur (20, p. 386)." Although the matter of awareness is gaining in attention, according to Williams, it would not be of significance to one holding with a strictly Skinnerian view (20, p. 386).

Scheduling of reinforcement.--Scheduling of reinforcement indicates how often reward is given (7, 17). Reinforcement may be given each time the specified response is made, or every other time, or every fifth time. Reinforcement might be offered every fifteen seconds, ten seconds, etc., regardless of the number of responses. The scheduling of reinforcement is at the discretion of the researcher.

Related Research

Two studies provide guidelines for further investigation of normal speech development in infancy. Rheingold, Gewirtz, and Ross (16) conducted a study to determine whether or not total vocal output of infants could be conditioned. They used a complex of social acts (to be described later) as reinforcement.

In their study two parallel experiments were carried out, one with eleven subjects, the other with ten subjects. All infants were institutionalized. Their median age was

3.0 months, and age was the main criterion for inclusion in the groups. The babies were "well developed, alert, and socially responsive (16, p. 238)."

During the baseline period, the time when natural frequency of vocalization was determined, experimental days one and two, the experimenter leaned over the infant's crib with his expressionless face about fifteen inches away from the subject and remained in subject's line of vision. An observer tallied vocalizations. Nine three-minute sessions per day were planned and approximately 80 per cent were carried out (16). According to the researchers it was not always possible to work with the babies when they were alert or free from the routine of the institution (16, p. 239).

Conditioning, as previously defined, was attempted on experimental days three and four. The experimenter again leaned over the crib with an expressionless face except that when the subject vocalized, the experimenter delivered the reinforcing stimulus--broad smile, three "tsk" sounds, and a light touch, thumb and fingers opposed, to the infant's abdomen (16, p. 238). The sequence required no more than one second's time. The reinforcement schedule, frequency of reward, varied; less frequent reinforcement seemed to depress vocalization (16, p. 238). Conditions during experimental days five and six, the extinction period, were the same as experimental days one and two.

Results indicated that baseline performance averaged thirteen to fourteen vocalizations per three-minute period. On the first conditioning day, experimental day three, vocalizations increased to eighteen per three-minute period and to twenty-five vocalizations for a three-minute period on the second conditioning day, experimental day four (16, p. 241). These increases were noted as 39 per cent and 34 per cent gains, respectively, in total output. Vocal performance dropped to seventeen vocalizations on the first extinction day and fifteen on the second which approached baseline performance. The authors concluded: infants' vocal behavior can be conditioned or modified; an everyday complex of social acts can be used as reinforcement; vocal behavior can be modified in infants as young as three months old (16, p. 242). Whether conditioning occurred or the adult's presence acted as a "social releaser" for the infants remained questionable (16). (Social releaser was the authors' term meaning that the presence of the adult might have stimulated vocalization.)

As a consequence of the previous study, Weisberg attempted to explore the possibilities of an unresponding adult as a "social releaser" and of varying experimental manipulations (19). Again total vocal output was the quality measured. Subjects for the study were full-term, healthy, three-month-old, institutionalized infants. They were divided into groups of five or six for the following experimental conditions:

1. No experimenter present.
2. Experimenter present. Experimenter sat approximately two feet in front of baby and maintained a "blank expression."
3. Noncontingent social stimulation. The experimenter rubbed subject's chin while producing a broad smile and aspirating a "yeah" sound four times per minute with intervals of more than seven seconds.
4. Noncontingent nonsocial stimulation. Following the same pattern presented in group three, a door chime was sounded with the examiner present but unresponsive.
5. Contingent social stimulation. The social stimulation previously described was performed immediately after each vocalization.
6. Contingent nonsocial stimulation. The door chime sounded following each vocalization (19, pp. 379-380).

The sessions were planned as two ten-minute sessions daily for eight consecutive days. Seventy-six per cent of the sessions actually ran the full time period; the others lasted at least six minutes (19, p. 381). When the subject began to cry or fell asleep or some other such behavior interfered, the session was halted (19, p. 381).

The first and second days demonstrated the infants' rate of vocalization when no adult was present. Days three and four served as indicators of baseline performance for each group with the examiner's presence known to the subjects (groups two through six). Except for group one, the examiner was in sight six of the eight days. Experimental conditions for groups three and four were in effect on days five, six, seven, and eight. Groups five and six received contingent social and nonsocial stimulation, respectively, on the fifth

and sixth days; days seven and eight constituted the extinction period (19, p. 380).

Weisberg determined that only those receiving contingent social stimulation gained significantly in total vocal output (19, 381); thus, Rheingold's findings were upheld.

Although no attention was directed to the specific sounds the infants made, establishment of an effective reinforcement resulted. Such findings were in agreement with Kiss's research indicating "that on the lowest level of biological development the infant's pleasure experiences are connected with food, homeostasis, and certain cutaneous stimuli (10)." Jersild stated that day-to-day acts such as feeding, bathing, picking up and holding" . . . mean far more than just physical manipulation: In connection with each event of this sort there is a communication between the adult and the child, and an interpersonal relationship is established (9, p. 64)." Also demonstrated was the general principle that delay in reward slowed the learning rate (15).

Chapter Summary and Preview

Skinner's operant learning theory with regard to language development has been presented. There has been no research with infants to support his statement. Babbling has been defined as vocal play, and literature regarding vocal conditioning, reinforcement, and reinforcement agents has been reviewed.

A study to test Skinner's operant theory regarding babbling was designed utilizing six- to eight-month-old infants and their mothers. In the succeeding chapters the procedure will be described, the results related, and the findings discussed.

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CHAPTER II

PROCEDURE

The following study was designed to answer the question, "Can a particular babble be reinforced?". Three apparently normal, healthy infants were selected. A thirty-minute tape recording of each baby's spontaneous babbling was made. From each recording one consonant-vowel combination was chosen for reinforcement.

On the first experimental day with each infant a ten-minute recording of spontaneous babbling was made with the mother present but unresponsive to the infant. Following the recording, the mother, acting as the reinforcement agent (dispenser of the reward) sat with her baby on her lap. Each time the selected vocalization occurred the researcher signaled the mother who then responded to the infant with a broad smile, three "tsk" sounds, and a light touch, thumb and fingers opposed to the infant's abdomen. When seven reinforcements were completed the session ended. The time required for seven reinforcements was noted.

The second experimental day was a repetition of the reinforcement session of the preceding day. On the third successive day following the final reinforcement session, another ten-minute recording of spontaneous babbling was made without intervention from the mother. The researcher, recorder, and microphone were concealed from the infant.

Comparisons were made between occurrence of the selected vocalization in the ten-minute recordings prior to reinforcement and following reinforcement. Comparison between time required for seven reinforcements on the first day and time required on the third day was made. A comparison between total vocalizations in the pre- and post-reinforcement recordings was also made.

Subjects

According to Gesell, Hurlock, Lewis, and Murai (2, 4, 6, 7) babbling is well under way by age six to eight months, and consonant-vowel combinations have appeared and some of these have been repeated. From this age group three Caucasian infants residing with their respective, monolingual families in Denton, Texas, were chosen. The average age of the infants at the time of the experiment was 30 weeks. Two babies were female, and one was male. One of the females had a three-year-old sister; the other two infants were singletons.

Requirements for inclusion of each baby and his mother in the study were

1. There was nothing unusual about the pregnancy according to the mother.
2. There was no serious illness or injury in the baby's history. See questionnaire, Appendix A.
3. The baby satisfactorily responded to a modified version of the Gesell Growth Trends Chart. Behavior patterns for 28-weeks-old infants were the standard (1, pp. 436-440). The items utilized are listed in Appendix B.

4. According to the mother's observation the baby was in good health at the time of the experiment.

5. The mother-infant relationship was relaxed and congenial as determined by the researcher's subjective evaluation. This evaluation was based on the manner in which the mother handled the infant, her concern during the Gesell test, and her apparent distress if the infant began to cry during the interview or test.

6. The mother was willing to cooperate.

7. Reinforcement was delivered as planned.

Because of the nature of the current research, i. e. attempting to change specific behavior, a small sample of the population was deemed sufficient. Furthermore, Osgood stated:

Language is so standardized an aspect of culture, . . . that a very small number of informants usually proves to be adequate. If necessary, the linguist will even be satisfied with a single informant in the belief that systematic divergence from the shared habits of the community as a whole are likely to be of minimal significance (8, p. 9).

Environment

The current experiment was carried out in each infant's home with only the mother, the infant, and the researcher present. The researcher's presence during the experimental days was not known to the infant. Care was taken to see that the infant was not in a position to see or hear the researcher enter or leave the home on the experimental days. During the ten-minute recordings the researcher was concealed either in a different room from the one occupied by the infant or behind a large piece of furniture--chair, couch, etc.

Although the selection of time of day for the sessions was left to the individual mother's discretion, an unplanned similarity in procedure occurred. Each of the sessions took place in the afternoon following the baby's nap.

Equipment

Vocalizations were recorded with a Wollensak Model T-1500 tape recorder and the accompanying Model B-162-4 microphone. The recorder and microphone were concealed from the infant's line of vision, but the microphone was never more than three to four feet from the infant's head.

A Chesterfield No. 117 SB Pocket Timer was used to observe the time required for each of the reinforcement sessions. A round mirror, $4\frac{1}{2}$ inches in diameter with a chrome rim was used as a stimulus object during the recording of the babbling sample prior to the experimental days. The mirror was presented to the infant by the mother at the researcher's request if the infant remained quiet for three or four minutes. According to Gesell, a baby 28 weeks of age delights in "talking" to his reflection in the mirror (2, pp. 23-24).

Method

Selection of Vocalization

On the day preceding Experimental Day 1 with each infant the researcher recorded the baby's spontaneous babbling for a period of thirty minutes. During this time the mother was

allowed to respond to the baby if she wished. The researcher subsequently reviewed the tape and phonetically transcribed the vocalizations exclusive of crying and sounds produced during inhalation. Each respiration unit, *i. e.* each phonated exhalation, was counted as one vocalization regardless of the number of individual sounds comprising the unit. This method was initiated by Irwin and Chen (5) and has proved satisfactory. The researcher selected from the transcription one consonant-vowel combination which appeared several times in the infant's spontaneous babbling to be the vocalization to be reinforced. The selected vocalizations were

Subject A-- [bæ]

Subject B-- [hæ]

Subject C-- [gæ].

Type and Schedule of Reinforcement

The reinforcement act of a broad smile, three "tsk" sounds, and a light touch with thumb and fingers opposed applied to the baby's abdomen as described by Rheingold was used (9). The mother delivered the reinforcement. She was used as the reinforcement agent based on Gewirtz's statement, previously reviewed, that the mother could certainly serve adequately as a reinforcement agent (3).

The reinforcement sequence was delivered on a 100 per cent reinforcement schedule (*i. e.* each time the selected sound occurred) until seven reinforcements had been delivered

during the session. One session per day for three successive days was carried out.

Experimental Day 1

Pre-reinforcement recording.--A ten-minute tape recording of spontaneous babbling was obtained from each baby. The researcher, tape recorder, and microphone were out of the baby's visual field. The infants were seated in a high chair, a canvas sling seat which bounced, and an infant walker, respectively. During this period the mother might be present or might pass through the room near the baby, but she was not allowed to speak to, smile at, touch, or react to the baby.

The ten-minute tape was used to determine baseline performance--chance total output and chance occurrence of the selected vocalization. The count was based on the number of phonated exhaled respiration units. Crying was not included.

Reinforcement session.--Within a few minutes after completion of the pre-reinforcement tape recording the mother sat in a chair holding the baby. The mother propped her feet on a low stool or similar object of appropriate height so that her knees were a little higher than her lap. She then placed the baby on his back so that his head rested on her elevated knees, and he could look directly at her face.

The mother had been previously instructed to refrain from making vocal noises and using facial expressions other than to present the reinforcement once she took her position

in the chair. She was also told not to touch the baby with her hands except to prevent his rolling from her lap or to defend herself from the baby's kicking.

The researcher crouched or was seated on the floor behind the chair so that the researcher could touch the mother on the shoulder or back to signal her to deliver the reinforcement act without being observed by the infant. The researcher began timing each reinforcement session when the infant began to babble. The timer was stopped when the seventh reinforcement was delivered. The researcher also noted each reinforcement on paper during the session in order to avoid losing count.

Stopping the recorder produced a signal to the mother to take the baby from the room after the seventh reinforcement. The mother was cautioned to avoid using the reinforcement act other than during the reinforcement period and to continue her daily routine without displaying unusual interest in the baby's babbling. All three mothers reported that they adhered to these instructions.

Experimental Day 2

Procedure on Experimental Day 2 duplicated the reinforcement session of Experimental Day 1. It was unnecessary to record the baby's babbling apart from the reinforcement session on the second day.

Experimental Day 3

Reinforcement session.--Seven reinforcements were delivered on the third day in the manner previously described for Experimental Days 1 and 2.

Post-reinforcement recording.--After the mother removed the infant from the room in which reinforcement was given, the researcher placed the microphone, baby's chair, and toys in the same places they occupied during the pre-reinforcement recording period. The researcher again withdrew from sight. The mother then returned the baby to the room and placed him in his seat. Another ten-minute tape of spontaneous babbling was obtained. Instructions to the mother were the same as for the pre-reinforcement recording.

Results

Raw data included

1. Occurrence of selected vocalization in pre-reinforcement ten-minute recording
2. Occurrence of selected vocalization in post-reinforcement ten-minute recording
3. Time required for seven reinforcements on Experimental Day 1
4. Time required for seven reinforcements on Experimental Day 3
5. Total output of vocalizations in pre-reinforcement ten-minute recording
6. Total output of vocalizations in post-reinforcement ten-minute recording.

The data were treated statistically to determine whether

1. Occurrence of the selected vocalization differed significantly in the two ten-minute recordings
2. Time required for seven reinforcements on Experimental Day 1 differed significantly from the time required on Experimental Day 3
3. Total output of vocalizations during the pre- and post-reinforcement ten-minute recordings differed significantly.

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CHAPTER III

STATISTICAL EVALUATION

Treatment of Data

The raw data were treated statistically through the use of the chi square formula. Chi square may be represented as χ^2 (1, p. 157). According to Ferguson "the statistic χ^2 is used in situations . . . where a comparison of observed and theoretical frequencies is required (1, p. 158)." In the current study the raw data obtained from the first ten-minute recording with each infant provided the expected frequency for comparison with the observed frequency from the second ten-minute recording in the two comparable categories-- occurrence of selected vocalization and total output. The time required for seven reinforcements on the first experimental day provided the expected frequency of seconds to compare with the observed frequency on the third day.

The formula for obtaining χ^2 was defined by Ferguson as follows:

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

where \sum means to sum, and "O" is the observed frequency, and "E" is the expected or theoretical frequency (1, p. 158).

He further explained:

Thus to calculate a value of χ^2 we find the differences between the observed and expected

values, square these, divide each difference by the appropriate expected value, and sum over all frequencies (1, p. 158).

In the present study the value of χ^2 was calculated with one degree of freedom (1 df) because only one frequency was allowed to vary within the respective categories. When the χ^2 procedure is utilized as a test of significance, noted Ferguson (1, p. 160), a null hypothesis is assumed which states that no "actual differences exist between the observed and expected frequencies (1, p. 160)." The value of χ^2 is then calculated. Ferguson stated:

If this value is equal to or greater than the critical value required for significance at an accepted significance level for the appropriate df, the null hypothesis is rejected. We may state that the differences between the observed and expected frequencies are significant and cannot reasonably be explained by sampling fluctuation (1, p. 160).

With 1 df the critical values of χ^2 required for significance at the 5 and 1 per cent levels are 3.84 and 6.64 respectively (1, p. 160). In other words, when the value of χ^2 is 3.84 or greater the difference between the compared frequencies is significant and not attributable to chance. The probability of chance occurrence is indicated by p (1, p. 334).

In one computation in the current study it was necessary to employ Yates's correction for continuity. Ferguson noted that this correction is necessary when the expected frequency is less than 5 (1, p. 171). He stated:

To apply this correction we reduce by .5 the obtained frequencies that are greater than

expectation and increase by .5 the obtained frequencies that are less than expectation. This brings the observed and expected values closer together and decreases the value of χ^2 (1, p. 171).

In all other comparisons in the present study the regular χ^2 computation was used.

Both individual and combined scores were treated. Comparisons were made between

1. The occurrence of the selected vocalization in the pre-reinforcement and post-reinforcement performances during the ten-minute recordings
2. The time required to deliver seven reinforcements on Experimental Day 1 and Experimental Day 3
3. The total output of vocalizations in the pre-reinforcement and post-reinforcement performances during the ten-minute recordings.

Occurrence of Selected Vocalization

Occurrence of the selected vocalization in the pre-reinforcement and post-reinforcement performances was compared. Table I demonstrates the results.

TABLE I

COMPARISON OF SELECTED VOCALIZATION OCCURRENCE IN THE PRE-REINFORCEMENT AND POST-REINFORCEMENT PERFORMANCES

Subject	Pre-*	Post-**	χ^2	With 1 df p =
A	6	9	3.0	.10
B	9	7	.88	.30
C	2	7	20.25***	.001
Total	17	23	4.23	.05

*Pre-, Pre-reinforcement; **Post-, Post-reinforcement;
 *** Yate's correction for continuity applied.

Although Subject A's increase in occurrence of the selected vocalization was not of significance ($p = .10$), it did show a positive direction. Subject B, on the contrary, showed an insignificant decrease ($p = .30$).

Subject C's increase ($p = .001$) was highly significant, and the combined scores indicated at the .05 level that reinforcement of the selected vocalizations did occur.

Time Required for Seven Reinforcements

The length of time to deliver seven reinforcements on Experimental Day 1 was compared to the time required to deliver seven reinforcements on Experimental Day 3. The time was calculated in seconds to facilitate evaluation. Table II presents the findings.

TABLE II

COMPARISON BETWEEN NUMBER OF SECONDS REQUIRED TO DELIVER SEVEN REINFORCEMENTS ON EXPERIMENTAL DAY 1 AND EXPERIMENTAL DAY 3

Subject	Time Day 1	Time Day 3	χ^2	With 1 df p =
A	325	188	115.50	.001
B	275	209	31.68	.001
C	260	215	15.57	.001
Total	860	612	143.03	.001

Table II shows the only consistent findings within the group of subjects. Each subject decreased significantly in time required for seven reinforcements of his particular vocalization to the .001 level of confidence.

Total Output

Results of the total output comparison are shown in Table III.

TABLE III
COMPARISON OF TOTAL OUTPUT IN THE PRE-REINFORCEMENT
AND POST-REINFORCEMENT PERFORMANCES

Subject	Pre-*	Post-**	χ^2	With 1 df p =
A	34	41	2.88	.10
B	54	34	14.81	.001
C	67	61	1.07	.30
Total	155	136	4.65	.05

*Pre-, Pre-reinforcement; **Post-, Post-reinforcement.

It was noted that Subject C decreased in total output ($p = .30$) but not significantly. However, Subject B did decrease significantly ($p = .001$). Subject A's total output increase ($p = .10$) was not of significance. When the scores of the three subjects were combined their decrease in total output was significant at the .05 level.

Summary

The raw data from the current study were categorized in the following manner: occurrences of the selected vocalization in the pre- and post-reinforcement performances; the time (in seconds) required to deliver seven reinforcements on Experimental Day 1 and Experimental Day 3; total output of vocalizations in the pre- and post-reinforcement performances. Comparisons within each category were statistically treated

through application of the χ^2 formula, a test for significant difference between the observed and expected frequency (1). Individual and group results were obtained.

Individual results were inconsistent except for the comparison of time. Each subject decreased significantly in time required for seven reinforcements to the .001 level of confidence. The statistical evaluation revealed that the group

1. Increased significantly in occurrence of the selected vocalization following reinforcement at the .05 level of confidence (i. e. only 5 times in 100 would such a change occur by chance)
2. Decreased significantly at the .001 level in time required for seven reinforcements from the first day to the third indicating very strongly that the time reduction was not by chance
3. Decreased significantly at the .05 level of confidence in total output following reinforcement of a particular vocalization.

An interpretation of these results follows in Chapter IV.

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CHAPTER IV

DISCUSSION, CONCLUSIONS, AND SUMMARY

Discussion

The results of the current study will be discussed in the same order in which the results were reported.

Occurrence of Selected Vocalization

Subject A was consistent in increasing occurrence of the selected vocalization and in increasing total output at the .10 level, but the results lacked significance. It would appear from the results obtained with Subject A that a greater number of reinforcements than seven per day for three days might have increased the probability of the occurrence of the selected vocalization. Subject B decreased ($p = .30$), insignificantly, in utterance of his selected vocalization. It should be pointed out that this particular baby was the one who decreased significantly ($p = .001$) in total output. Subject C's highly significant gain at the .001 level of confidence means that only once in a thousand random samplings would this gain occur by chance.

The subjects' combined scores indicated at the .05 level of confidence that conditioning occurred. Since the combined evaluation was weighted somewhat by Subject C's performance, it might be inferred that a greater number of reinforcements

or more reinforcement sessions were needed to increase significantly the occurrence of the selected vocalization with the other two subjects.

Time Required for Seven Reinforcements

As previously stated the decrease in time from Experimental Day 1 to Experimental Day 3 to deliver seven reinforcements of the selected vocalization individually and for the group was consistent at the .001 level. Again, this statistic means that the probability of a chance decrease in time is one in one thousand. Therefore, it is assumed that the decrease in time required for seven reinforcements is a result of the reinforcement delivered.

Total Output

The total output of the three infants decreased significantly at the .05 level. Why the significant decrease in total output occurred can only be implied. It seems that while one sound unit was stabilizing, others were diminishing in frequency. It is interesting to note that the .05 level decrease in total output of vocalizations matched the .05 level increase in selected vocalization occurrence.

It has become apparent that vocal habits may vary from infant to infant with regard to frequency of vocalization and efficiency of a given reinforcement schedule. Furthermore, the homogeneity of a given language community specified by Osgood (1) does not seem applicable to this babbling.

pre-language group as demonstrated by the irregularity of the individual results. Or perhaps the community in each individual instance is determined strictly by the infant's immediate family. If such is the case, the baby may, indeed, reflect the patterns or vocal habits of his family and still vary from other infants in his age and developmental group.

Conclusions

It may be concluded that

1. One may selectively reinforce a particular vocalization or babble with infants as young as thirty weeks of age.
2. The time required to deliver a given number of reinforcements is likely to decrease as sessions progress.
3. The number of reinforcements necessary to increase a given vocalization significantly may vary with the individual infant.
4. When discrete vocalizations are reinforced, total output of vocalization of many sounds is likely to diminish.

Skinner's theory of operant conditioning (2) may be applied selectively to babbling. It is recognized, however, that selective, diligent reinforcement of every sound necessary for a given language would be an arduous, impractical task for parents and their babies. It does appear feasible to assume that even random reinforcement may be sufficient to retain a sound in the baby's vocal repertoire with only a few sounds predominating at any given time.

Summary

Skinner (2) stated that infants acquire speech because their unpatterned babbling, or vocalizations, are reinforced (strengthened) by the parents' reactions. A review of the literature revealed no research with infants involving reinforcement of specific vocalizations. A test of Skinner's operant learning theory of language acquisition regarding selective reinforcement of infant vocalizations was designed. Three normal infants averaging thirty weeks of age were selected. One consonant-vowel combination was selected for reinforcement from a thirty-minute tape recording of spontaneous babbling from each infant. The respective mothers acted as the reinforcement agents and delivered the reinforcement sequence--a broad smile, three "tsk" sounds, and a light touch from the mother with thumb and fingers opposed to the infant's abdomen. The reinforcements were delivered after each response of the selected vocalization until seven reinforcements were given. Three such sessions were carried out on successive days. A ten-minute pre-reinforcement tape recording of spontaneous babbling was compared to a ten-minute post-reinforcement recording to determine differences between occurrence of the selected vocalization and total output of vocalizations in the two sessions. The time required to deliver seven reinforcements on Experimental Day 1 was compared to the time required on Experimental Day 3.

Statistical evaluation of the results indicated for the group a significant increase in occurrence of the selected vocalization, a highly significant decrease in the time required for seven reinforcements from the first experimental day to the third, and a significant decrease in total output. Individual and group results were shown in tables.

A discussion of the results led to the following conclusions:

1. One may selectively reinforce a particular vocalization or babble with infants as young as thirty weeks of age.
2. The time required to deliver a given number of reinforcements is likely to decrease as sessions progress.
3. The number of reinforcements necessary to increase a given vocalization significantly may vary with the individual infant.
4. When discrete vocalizations are reinforced, total output of vocalization of many sounds is likely to diminish.

There was a positive indication that Skinner's theory (1) is applicable to the babbling phase of speech development.

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APPENDIX A

INTERVIEW QUESTIONS

Mother's Name

Address

Phone

Baby's Name

Sex

DOB

Anything unusual about pregnancy or birth?

Anything unusual in baby's history?

Do you have other children?

Can he sit when propped with pillows?

Does he play in his crib alone at any particular time of day and make sounds?

Do you have "talk" times with him?

Appointment:

APPENDIX B

MODIFIED GESELL GROWTH TRENDS CHART

NAME	DOB	DATE OF EXAM
TASK	COMMENT	

CHAIR

Head steady _____

Trunk erect _____

Grasps toy on TT _____

CUBES: FIRST

Immed. appr. & grasp _____

Radial palmar grasp _____

Cube to mouth _____

Retains cube _____

SECOND

Retains 1st during presents _____

Regards 2nd _____

Appr., contact 2nd _____

Drops cube _____

THIRD

Drops 1 immed. _____

Immed. regard 3rd _____

Immed. appr., contact 3rd _____

Drops cube _____

Resecures dropt cube _____

Holds 2 cubes more than momentarily _____

PELLET

Follows Ex. withdr. hand _____

Delayed intent regard _____

Appr. & contact _____

Whole hand raking _____

BELL

Immed. 1 hand app. & grasp _____

Grasps bowl or junction _____

To mouth _____

Transfers adeptly _____

Bangs _____

Retains _____

SITTING

Sits very momentarily _____

Unsteady _____

Active in sitting _____

LANGUAGE

Smiles _____

Laughs _____

Squeals _____

Grunt _____

Polysyll. vowel sounds _____

Breathes heavily, strains, excites _____

PERSONAL - SOCIAL

Discrim. strangers _____

Feet to mouth _____

Sits propped 30 min. _____

Pats bottle _____

Takes solids well _____

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