A COMPARISON OF SOCIAL AND NONSOCIAL REINFORCEMENT IN THE CONDITIONING OF INFANT VOCALIZATIONS

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A COMPARISON OF SOCIAL AND NONSOCIAL REINFORCEMENT IN THE CONDITIONING OF INFANT VOCALIZATIONS

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ABSTRACT

The present study was designed to investigate several stimulus properties of the reinforcers used in the conditioning of infant vocalizations: (a) social and nonsocial value, (b) modality (auditory and visual), (c) the effect of the adult presence on the social and nonsocial reinforcers, and (d) the sex of the Ss. The Ss were 48 home-reared infants ranging from 75 to 118 days old. The result demonstrated that the rate of infant vocalizations can be increased by contingent responses from the infant's environment, both social and nonsocial. Sex and modality were found to be the important factors in the conditioning of infant vocalizations. Visual reinforcers appeared to be the most effective for males, while for females, visual and auditory reinforcers were equally effective. Possible explanations for this finding were hypothesized on the basis of the differential developmental rates of the sensory systems and the differential developmental rates of the sexes.

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INTRODUCTION

The vocalizations of the infant begin with crying sounds, and by the sixth week of life babbling sounds have appeared (Lenneberg, 1964; Lewis, 1963). These babbling sounds seem to emerge in vocal play (McCarthy, 1954) and are the sounds from which the speech sounds of the child are molded (Siegel, 1969). Two processes are assumed to be responsible for the transition from babbling to speech sounds: phoneme expansion and phoneme contraction. Phoneme expansion is controlled by maturation, while phoneme contraction is influenced by social interaction with individuals in a particular language culture (Thompson, 1962). At the onset of the babbling period the infant produces a few sounds and as he matures physiologically, more and complex sounds ensue (Rebelsky, Starr and Luria, 1967). During the first year of life the infant produces almost all conceivable sounds (Bever, 1961; Cohen, 1952; Jespersen, 1952; Sanford, 1891; Tischler, 1957). These sounds include French vowels, trills, German umlaut, gutteral sounds, and many others which can only be described in phonetic notation (Osgood, 1953). Hence, through the process of phoneme expansion the infant develops an extensive repertoire of sounds, not all of which form part of his natural language. Through the process of phoneme contraction the inappropriate sounds are eliminated, while the sounds of the child's particular language culture are refined and strengthened (Gregoire, 1933; Siegel, 1969). The infant vocalizations become more like those of the adults

in the infant's environment (Irwin, 1948, 1952).

A learning theory of speech development proposed by Mowrer (1952) and elaborated by Staats (1962) posits that the progression from babbling sounds to speech sounds can be accounted for by operant conditioning principles. Initially the sounds produced by the infant are neutral. But the sounds that occur frequently in the speech of the parents, often while the parents are delivering positive reinforcers, become positive conditioned reinforcers for the infant. The vocalizations of the infant, which are similar to those of the parents, become reinforcing through generalization. The closer the correspondence between the vocalizations of the infant and those of the parents, the greater is the reinforcement for the child. Other vocalizations, having no particular consequences, are deleted from the infant's sounds repertoire (Mowrer, 1952).

After a series of such differentiations, the vocalizations of the infant become more and more like the syllables that occur in the adult speech of his natural language (Staats, 1962). Continued differentiation leads to the development of the first few language-appropriate speech sounds. Gradually the infant's vocalizations approximate word sounds, thereby increasing the opportunity for direct reinforcement of these vocalizations by the parents (Staats, 1968).

The learning theory of speech development has generated considerable research on the operant conditioning of infant vocalizations. The research has been concerned mainly with manipulating the quantity and quality of the vocalizations of infants 3-4 months of age. Social reinforcement procedures

have been used which are consistent with the learning theory of speech development and which are considered comparable to environmental consequences by which infant vocalizations are reinforced.

The operant conditioning studies of Rheingold, Gewirtz, and Ross (1959), Weisberg (1963) and Routh (1969) have demonstrated that infant vocalizations are conditionable with social reinforcers administered contingent on the vocalizations. The first such study, by Rheingold, et al. (1959), attempted to increase the frequency of vocalizations of 3-month old institutionalized infants contingent on the social response of an adult. The social response consisted of a broad smile, three 'tsk' sounds, and a light touch of the infant's abdomen, executed simultaneously. Vocalizations did increase during conditioning and decreased during extinction. Although the results implied that vocal conditioning did take place, the experimenters did not dismiss the possibility that the social stimulation might have acted as a releaser of the infant vocalizations whether or not it had been contingent.

Weisberg (1963) carried out a study of 3-month old institutionalized infants to investigate the social releaser alternative proposed by Rheingold, et al. (1959). Weisberg used two types of stimulation; social and nonsocial. The social stimulus consisted of rubbing the infant's chin, a broad toothy smile, and an aspirated 'yeah'. The nonsocial stimulus was a two-tone doorbell. Weisberg used six experimental groups. Group I was the control for the presence of E; the operant rate of vocalizations was recorded by an unseen E.

Group 2 was the control to determine whether the mere presence of E was sufficient to elicit vocalizations; E, visible but immobile and expressionless, recorded the operant rate of the vocalizations. The other four groups experienced experimental procedures with an immobile and expressionless E present. Groups 3 and 4 controlled for the possibility that noncontingent stimulation might elicit vocalizations. Group 3 received non-contingent social stimulation during the experimental period, while Group 4 received noncontingent nonsocial stimulation. Group 5 received contingent social stimulation during the conditioning period and Group 6 received contingent nonsocial stimulation. Vocal conditioning was obtained in the contingent social stimulation condition, but not in the contingent non-social stimulation condition. Since significant increases in vocalizations did not occur in the noncontingent stimulation conditions, the social releaser explanation was not supported.

As the social releaser hypothesis would predict only a general increase of vocalizations, the research of Routh (1969) on the conditioning of vocal response differentiation ended the speculation on the social releaser explanation. Routh's Ss were infants ranging from 2-months to 7-months of age. There were three experimental groups. One group was reinforced for consonant sounds only; the second group was reinforced for vowel sounds only, and the third group was reinforced for any vocalization. The reinforcement was the social response of Rheingold, et al. (1959). All groups significantly increased the production of the appropriate vocalizations from baseline to conditioning. The results,

consistent with the conditioning theory of speech acquisition, indicated that not only can the total rate of infant vocalizations be modified, but also the specific qualitative components of the vocalizations.

The previous studies have demonstrated that vocalizations can be operantly conditioned. The present study, however, is mainly concerned with the stimulus properties of the reinforcers that can be used in vocal conditioning: (a) the social and nonsocial value of the reinforcers, (b) the stimulus preferences of infants, (c) the modality (visual and auditory) of the reinforcers. The relevant research is discussed under those headings.

A. Social and Nonsocial Reinforcers

As the pioneer work in vocal conditioning used a social response of an adult as the reinforcer (Rheingold, et al. 1959), the majority of vocal conditioning studies have used the same social reinforcer or variations of it. Several operant conditioning studies have investigated the different components of the social reinforcer (Banikiotes, Montgomery, and Banikiotes, 1971; Swartz, Rosenberg, and Brackbill, 1970; Todd and Palmer, 1968).

Banikiotes, et al. (1971) studied the differential effect of 3-month old, home-reared infants. Auditory reinforcement was used which consisted of tape recordings of six speakers each reading statements such as 'nice baby', 'good baby', 'what a good baby you are'. There were two tape recordings; one of female voices and one of male voices. The investigators found significantly more vocalizations during

conditioning as compared to baseline periods, but no differences were found between male and female reinforcement conditions.

Two studies designed to analyze auditory, visual and tactile components of the social response of Rheingold, et al. (1959) were completed by Swartz, et al. (1970). The Ss were 3-month old institutionalized infants. The auditory reinforcer was a tape recording of a female voice saying 'nice baby'. The visual reinforcer was E smiling and nodding. The tactile reinforcer was the rubbing of the infant's abdomen with the palm of E's hand. Experiment 1 investigated the effectiveness of the single components of the social response. Experiment 2 investigated the effectiveness of the different combinations of the components of the social response. The results indicated that no one of the reinforcing events in the two experiments was more effective than any other. The investigators concluded that one reinforcing event is as effective as two and two reinforcing events are as effective as three.

Todd and Palmer (1968) carried out a study of 3-month old institutionalized infants to find out to what extent the human presence is necessary in the conditioning of infant vocalizations. The reinforcer was a tape recording of a female voice saying 'hello baby','pretty baby', 'nice baby'. For one group (the AP group) an expressionless E stood at the foot of the crib throughout conditioning. For the second group (the NAP group) there was no E present throughout conditioning. The results showed that the vocalizations of both groups increased significantly during conditioning, but that the AP

group demonstrated a significantly higher increase over the NAP group. Todd and Palmer concluded that while the adult presence is not necessary for the conditioning of infant vocalizations, it does enhance the effectiveness of the human voice as a reinforcer.

The previous studies have obtained vocal conditioning with social reinforcers. However, Berlyne (1966) has suggested that any stimuli that are effective in capturing S's attention can have reinforcing value in suitable circumstances. In addition, Bijou and Baer (1965) have suggested that control of the environment in itself can be rewarding: for example, if an infant discovers that his responses control a stimulus, it is likely that he will exercise that control. If these assumptions are correct, nonsocial stimuli should function effectively as reinforcers in the conditioning of vocalizations provided they either capture the infant's attention or are controlled by him.

One of the above studies, Weisberg (1963), attempted to condition vocalizations using nonsocial reinforcement, a two-tone doorbell: it was found to be ineffective. It is possible that the Ss in Weisberg's study did not attend to the doorbell, the supposed reinforcer. Weisberg, however, did mention that Ss oriented toward the bell during its initial presentation, and he argued that it was unlikely that the bell was undiscriminated.

Tomlinson-Keasey (1972) carried out a recent study of 3-month old home-reared infants to determine whether or not vocal conditioning could be accomplished with a nonsocial

reinforcer. Discriminative stimuli were added to the operant conditioning paradigm. There were two experimental groups. The discriminative stimulus for the first group was a tape recording of the voice of a mother talking to an infant. The discriminative stimulus for the second group was a tape recording of 500cps tone. The reinforcement which consisted of a doorbell and a red light was given only when the discriminative stimulus was on. A control group was included to provide data on the number of vocalizations that could be expected to occur naturally over the experimental period. The results showed that the nonsocial reinforcement increased the number of vocalizations for both experimental groups, and that one group did not learn significantly more than the other group. Comparisons are limited because there was a confounding stimulation component, but the nonsocial reinforcement did seem to function effectively in the conditioning of infant vocalizations.

In summary, the majority of vocal conditioning studies have used social reinforcers. But, if any stimuli that can capture S's attention or over which S can exercise control can function as reinforcers, then, both social and nonsocial reinforcers should function effectively in the conditioning of infant vocalizations.

B. Stimulus Preferences of Infants

In vocal conditioning studies there is sometimes an unresponsive adult present during conditioning using both social and nonsocial reinforcers, and therefore the preferences of the infant for such added stimuli must be considered.

The research on stimulus preferences of infants has repeatedly suggested that infants prefer stimuli with social value over nonsocial stimuli.

Research on auditory stimulus is scant, yet there is some indication that infants prefer social auditory stimuli to nonsocial auditory stimuli. Hutt, Hutt, Lenard, Bermuth and Muntjewereff (1968) recording EMG, autonomic, and EEG responses of newborns found that patterned tones elicited more response than pure tones, and that the most effective stimuli were those tones in the fundamental frequency of the human voice. Friedlander (1968) using a two-choice situation in which the infant could select the kind and amount of stimulation, found that infants at the age of 8-months preferred human voices over a variety of auditory stimuli, including selections of music.

The bulk of the research on stimulus preferences of infants has been concerned with visual stimuli. This research has shown that infants prefer stimuli with social value (human faces or representations of human faces) to patterned nonsocial stimuli (Fitzgerald, 1968). Fantz (1958, 1963, 1965), Moffett (1963), Stechler (1964), Lewis, Kagan and Kalafat (1966), McCall and Kagan (1967), and Haaf and Bell (1967) have carried out visual preference studies with fixation time as their measure of preference and have confirmed this position. The findings of Lewis, Meyers, Kagan and Grossberg (1963), Kagan and Lewis (1965) and Kagan, Henkin, Hen-tov, Levine and Lewis (1966) also have supported the preference for social stimuli. Cardiac deceleration and visual fixation time were the indices of

preference in these studies. Fitzgerald (1968) provided further support for the preference for stimuli with social value. Pupillary dilation was his measure of visual preference. The infants studied in these experiments ranged in age from neonates to 12-months. There appeared to be no differences in preference across ages.

There are a number of explanations in the literature for this preference for social stimuli by infants. Stechler (1964) has suggested that infant preference for social stimuli can be explained by a preference for complexity. Haaf and Bell (1967), however, have found that complexity cannot account for the response to the human face. Haaf and Bell, in an experiment with 4-month old infants, varied stimulus complexity and resemblance to the human face independently. Their results were ordered with degree of faceness only. The study of Kagan, Henkin, Hen-tov, Levine and Lewis (1966), using 4-month old infants, found that fixations to the regular and rearranged faces were equivalent, but that cardiac deceleration was significantly more frequent to the regular face than to the rearranged face. This offers additional support against a complexity explanation. McCall and Kagan (1967a) have suggested that the human face cannot be scaled on the physical dimensions that are appropriate to geometric designs to which it is compared. They have declared that the face has meaning and therefore greater power to attract attention of infants than geometric designs. Moffett (1963) has proposed that the face is genuinely more interesting than geometric designs because of innate preference or learned associations.

Lewis (1965) has offered an explanation of infant preference for social stimuli. He has claimed that the infant develops a schema of an object as he has repeated experience with the object. The face is an object that occurs frequently, therefore, a face schema develops in the first year of life. Lewis predicts that the amount of attention given to a stimulus depends on how closely the stimulus resembles the object on which the schema is developed. When the face schema is developing during the first six months of life, stimuli that are good representations of the face are maximally attractive.

Gewirtz (1961) has claimed that since the face almost invariably accompanies the dispensing of attention, affection, and approval, the face and its variations become conditioned reinforcers for the infant. But the face is not the only social stimulus with reinforcing properties, each of the components of the social response of Rheingold, et al. (1959) has been found to be an effective reinforcer (Swartz, et al. 1970). Miller and Dollard (1941) have suggested that the human adult becomes a conditioned reinforcer for the infant because of his association with the caretaking of the infant. Therefore, the infant comes to prefer all stimuli with social value.

As social stimuli are highly preferred by infants, their presence during conditioning may influence the effectiveness of both the social and nonsocial reinforcers.

The presence of social stimuli may enhance the effectiveness of social reinforcers. Todd and Palmer (1968) have found that adult presence increased the effectiveness of the human voice as a reinforcer.

The presence of social stimuli may also influence the effectiveness of nonsocial reinforcers. The human presence may set up competition with the nonsocial stimuli and interfere with their effectiveness as reinforcers. In Weisberg's study (1963) an unresponsive adult was present throughout unsuccessful conditioning periods with the nonsocial reinforcer - the two-tone doorbell. It is likely that the Ss in Weisberg's study would have attended primarily to the social stimulus (the adult). Although the Ss oriented to the initial presentation of the doorbell, the presence of the highly salient social stimulus almost certainly distracted the attention of the infant from the doorbell. However, nonsocial stimuli that are highly effective in eliciting infant attention should be able to maintain reinforcer effectiveness under conditions where social stimuli are available.

Lewis and Kagan (1965) have found several nonsocial stimuli which seem to be highly effective in eliciting and maintaining infant attention. Lewis and Kagan studied the attention of 6-month old infants to two sets of visual stimuli. One episode of visual stimuli consisted of a film sequence of six chromatic items: (1) a male face, (2) a female face, (3) a black and white bull's eye, (4) a black and white checkerboard, (5) a nursing bottle, and (6) a panda bear. As expected, the response measure of fixation was significantly greater for the faces as compared to the other items. The second episode of visual stimuli consisted of three patterns of blinking lights: (1) a single blinking light moving across a horizontal field, (2) a single blinking light in the center of the field, (3) a blinking light that

described a square helix. For the patterns there were no real differences in fixation time, although the fixation time was greatest to the square helix. Within the study no comparison was made between the two sets of stimuli. The graphs, depicting mean fixation time as a function of trial and stimulus for the two episodes, demonstrated that the mean fixation times for the light episodes were roughly equal to the mean fixation times for the faces (the most preferred items in the film sequence). It seems likely that the relatively complex light episodes are as effective as social stimuli in eliciting infant attention, and consequently may function as effective reinforcers under conditions where social stimuli are present.

Similarly, a complex doorbell may also be highly effective in eliciting infant attention and may be an effective reinforcer. The two-tone doorbell used by Weisberg (1963) did not prove to be an effective reinforcer, although Weisberg claimed that the Ss did attend to it. A complex doorbell sound, however, such as six tones comprising a pleasant melody, may be an effective reinforcer under conditions where social stimuli are available.

In summary, although social stimuli are preferred by infants, nonsocial stimuli that are highly effective in eliciting infant attention should function effectively as reinforcers even when social stimuli are available.

C. Modality

Modality is a property of reinforcers that is related to their effectiveness and so must be considered. In general, research on operant conditioning in infants has suggested that

visual reinforcers are more effective than auditory reinforcers.

On the social dimension Swartz, et al. (1970) have found no differences between visual and auditory reinforcers. Todd and Palmer (1968), however, found that a visual cue enhanced the effectiveness of the auditory reinforcer.

On the nonsocial dimension the data suggest that visual reinforcers are more effective than auditory reinforcers. Visual reinforcers have been effective with infants in the conditioning of non-nutritive sucking (Siqueland and Delucia, 1969), in the conditioning of head-turning (Caron, 1967; Levinson and Levinson, 1967), and in the conditioning of manipulative responses (Lipsitt, 1963). While there is some evidence that auditory reinforcers can be effective, the evidence is quite limited and is not as well-documented as it is for visual reinforcers. Only one study has obtained operant conditioning in infants using auditory reinforcers. Watson (1966) obtained conditioning of eye movements using a tone as the reinforcer. Weisberg (1963) obtained no vocal conditioning using the doorbell as the reinforcer. Smith and Smith (1962) obtained no conditioning of panel-touching in infants using nursery song recordings as the reinforcer. As vocal conditioning would be expected to follow the same rules as other forms of operant conditioning, then visual reinforcers should be more effective than auditory reinforcers in the conditioning of infant vocalizations.

For the purposes of this experiment social reinforcers in the visual and auditory modalities have been clearly defined by previous research. However, nonsocial reinforcers in the

visual and auditory modalities appropriate for this experiment are not as obvious. The nonsocial reinforcers for this experiment must be stimuli to which infants are highly attentive if they are to maintain their effectiveness in the presence of social stimuli. In the visual modality the study of Lewis and Kagan (1965) has revealed a nonsocial stimulus - the flashing light episode - that may be an appropriate visual reinforcer for this study. In the auditory modality there are no data available to suggest an appropriate reinforcer. A complex doorbell sound might be an auditory stimulus to which infants would be highly attentive and therefore may be an appropriate reinforcer for this experiment.

On the basis of the above research and discussion the main hypothesis of this study was that both social and nonsocial stimuli would be effective reinforcers in the conditioning of infant vocalizations. It was also predicted: (a) that the presence of a social stimulus (an adult) would influence the effectiveness of both the social and nonsocial reinforcers, and (b) that visual reinforcers would be more effective than auditory reinforcers in the conditioning of infant vocalizations.

In addition, the hypothesis was tested that: female infants would obtain a higher conditioning rate than male infants. Although sex differences have been ignored, or on analysis have proven not significant by and large in psychological studies of conditioning, the data on maturation and later language development indicates that this variable might contribute to differences in vocalization conditioning. This final hypothesis is based on the following.

Physiologically, females mature faster than males and as certain aspects of development cannot occur until the relevant physical structures are complete, females may develop some abilities earlier than males. At birth the cortical structures relevant to speech are not fully formed and as speech must wait until they are, females may be expected to talk sooner than males (Maccoby, 1966). Oetsel (In Nash, 1970) has reviewed 23 studies which have demonstrated that females are significantly ahead of males in language development and in verbal fluency at an early age. Gatewood and Weiss (1930) have reported a greater frequency of vocalizations among females as early as the neonatal period. Moss (1967) has studied infant behavior at 3 weeks and 3 months and found that at both ages the females vocalized at a higher rate than the males, although the differences were not significant. Moore (1967) completed a longitudinal study of language development in males and females from 6 months to 8 years of age. He found that at the early age of 6 months the females showed verbal superiority over the males. Kimura (1963), in a study of speech lateralization in young children, found that boys lag behind girls in the development of speech perception. Therefore, it there are sex differences in the conditioning of infant vocalizations they would have to be in favour of the females.

METHOD

Experimental Design:

The variables investigated in this study were:

(1) social and nonsocial reinforcement (S and Ns)

(2) auditory and visual reinforcement (A and V)

(3) no E and E present (N and E)

(4) males and females (M and F)

The design was as follows:

TABLE 1

Experimental Design

SOCIAL REINFORCEMENT								NONSOCIAL REINFORCEMENT							
Auditory				Visual				Auditory				Visual			
No E		E		No E		E		No E		E		No E		E	
M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Group															
SAN		SAE		SVN		SVE		NsAN		NsAE		NsVN		NsVE	

Groups SAN and SAE received social auditory reinforcement which consisted of a recording of a female voice saying 'that's a nice baby'. Groups SVN and SVE received social visual reinforcement. For Group SVN the social visual reinforcement was a 3-second chromatic film sequence of E smiling and nodding. For Group SVE the social visual reinforcement was E smiling and nodding for approximately 3 seconds.

Groups NsAN and NsAE received nonsocial auditory reinforcement which consisted of a recording of a six-tone doorbell. Groups NsVN and NsVE received nonsocial reinforcement which was a blinking light matrix which described a square helix for approximately 6 seconds.

For the Ss in Groups SAN, SVN, NsAN, NsVN no E was present throughout the experiment. For the Ss in Groups SAE, SVE, NsAE, NsVE the E was present throughout the experiment and was seated 18 inches from the infant seat.

Groups SAN and SVN, in comparison to Groups NsAN and NsVN, were designed to assess the reinforcer effectiveness of the social and nonsocial stimuli in two modalities. Groups SAE and SVE were included to determine if the presence of E would enhance the effectiveness of the social reinforcers. Groups NsAE and NsVE were included to determine if the presence of E would interfere with the effectiveness of the nonsocial reinforcers.

Subjects:

The Ss were home-reared infants who had been solicited through the Child Welfare Clinic in St. John's. The Child Welfare Clinic is a health care organization patronized by families from all socio-economic levels in the St. John's area. The Ss were selected on the basis of good health and age. All Ss were between the ages of 75 and 118 days. Thirty-four Ss had to be excluded from the study because of excessive crying and fussing. One infant had to be excluded from the experiment because he fell asleep. Relatively equal numbers of males and females were excluded from the experiment.

Forty-eight Ss were included in the study. Six Ss were randomly assigned to the experimental groups with 3 males and 3 females in each group.

Apparatus:

The experiment was conducted in a room at the Child Welfare Clinic. The Ss were tested in an ordinary plastic infant reclining seat.

A four-channel Rustrak event recorder was used to record the occurrence of responses and of reinforcement. During the experimental sessions O (the observer) and E each held panels containing two buttons wired to two channels of the event recorder.

A Tandberg tape recorder was used to deliver the auditory reinforcement. The intensity level was held constant for all the auditory stimulation. The speaker was placed 18 inches from the infant seat. One visual stimulus was a light matrix which consisted of a plywood panel containing six rows of six lights each forming a 6x6 matrix. The light matrix described a square helix. The matrix was placed 18 inches from the infant seat and the light energy reaching the infant was approximately 2 foot-candles. A second visual stimulus consisted of an 8mm chromatic film sequence presented via a Kodak movie projector. The film sequence was projected onto white careboard placed 18 inches from the infant seat.

Procedure:

There was one experimental session which was limited to 13 minutes. In other investigations longer sessions have been used. Two recent studies, however, Banikiotes, et al. (1971) and Ramey and Ourth (1970) used experimental sessions of 12 minutes and 9 minutes respectively, and demonstrated that changes in infant vocalization rates can be effected in short periods of time.

Each S was placed in the infant seat by his mother and the experimental session began after 30 seconds. The experimental session consisted of three periods: one baseline period

and two conditioning periods. It had been planned to have an extinction period, but after eight unsuccessful attempts to detain infants for extinction, it was deleted from the experiment. Longer baseline and conditioning periods had also been planned. However, preliminary work indicated that it was practically impossible to maintain infant attention for much longer than 3 minutes at a time.

The baseline period consisted of 3 minutes during which the operant vocalization rate of the S was recorded by O and E. A vocalization was defined as a discrete, voiced sound produced by S, excluding coughing, squeaking, snorting, and sounds of protest, fusses and cries (Rheingold, et al., 1959). There was a 2-minute rest interval following the baseline period during which the infant was returned to his mother.

The conditioning procedure consisted of two 3-minute periods during which the appropriate reinforcement was presented immediately after S vocalized. O determined if the reinforcement was to be presented. The S was reinforced for every vocalization emitted during the conditioning periods. There was a 2-minute rest interval between the two conditioning periods during which the infant was returned to his mother.

Prior to the experiment, O and E had practised to obtain a high rate of agreement on the infant vocalizations. For the experiment the agreement between O and E on the number of vocalizations produced by Ss was high. The overall agreement for O and E was 93%, while the agreement for the individual sessions ranged from 78% to 100%. The unit of measure used in the statistical analysis was an average of the number of vocal-

izations recorded by O and E per minute.

RESULTS

The unit of statistical analysis was the mean number of vocalizations per minute. Group variances were homogeneous (F_{max}=18.14, p>.05, df=5) as determined by Hartley's test for homogeneity of variance (Edwards, 1960).

The vocalization rates for the baseline and conditioning for all experimental groups are presented in Table 2. The overall vocalization rates increased for baseline to conditioning, demonstrating that conditioning occurred (p<.01) (Table 3). A Newman-Keuls mean comparison test applied to the baseline and conditioning rates for social and nonsocial reinforcement conditions revealed that the vocalization rates increased significantly from baseline to conditioning for both the social reinforcement conditions (q=10.48, p<.05, df=4/30 and the nonsocial reinforcement conditions (q=12.00, p<.05, df=3/30).

However, as the baseline rates of individual Ss varied considerably it was decided that the mean difference scores would be the appropriate statistical unit for further analysis of the data. The mean difference score is the mean vocalization rate for conditioning minus the mean vocalization rate for baseline. The analysis of variance on the mean difference scores is presented in Table 4. There were no significant main effects for social/nonsocial conditions (p>.20) or for No E/E present conditions (p>.20). There was also no significant interaction for No E/E present x social/

TABLE 2

Mean Vocalization Rates during Baseline and Conditioning for all Experimental Groups

Group		Mean Baseline Rate	Mean Conditioning Rate
SAN	Male	2.43	1.77
	Female	0.89	1.30
SAE	Male	0.89	1.22
	Female	0.33	1.44
SVN	Male	1.13	2.00
	Female	1.54	2.06
SVE	Male	1.86	2.66
	Female	0.94	1.53
NsAN	Male	1.22	0.54
	Female	1.44	1.90
NsAE	Male	1.53	1.62
	Female	0.89	1.83
NsVN	Male	0.33	1.38
	Female	0.44	1.22
NsVE	Male	1.12	1.32
	Female	1.44	1.90

TABLE 3

Analysis of Variance on Vocalization Rates for Baseline and Conditioning

Source of Variance	Sum of Squares	df	Mean Square	F
Social/Nonsocial (A)	1.492	1	1.492	1.05
Auditory/Visual (B)	0.261	1	0.261	<1
No E/E present (C)	0.069	1	0.069	<1
Sex (D)	0.361	1	0.361	<1
A x B	2.764	1	2.764	1.95
A x C	2.724	1	2.724	1.92
A x D	3.319	1	3.319	2.34
B x C	1.812	1	1.812	1.28
B x D	0.020	1	0.020	<1
C x D	0.344	1	0.344	<1
A x B x C	0.128	1	0.128	<1
A x B x D	0.109	1	0.109	<1
A x C x D	0.062	1	0.062	<1
B x C x D	0.134	1	0.134	<1
A x B x C x D	4.891	1	4.891	3.46
Error (between)	45.266			
Baseline/Conditioning (E)	4.882	1	4.882	13.03*
A x E	0.038	1	0.038	<1
B x E	0.978	1	0.978	2.61
C x E	0.289	1	0.289	<1
D x E	1.073	1	1.073	2.86
A x B x E	0.015	1	0.015	<1
A x C x E	0.276	1	0.276	<1
A x D x E	0.037	1	0.037	<1
B x C x E	1.532	1	1.532	4.09
B x D x E	1.839	1	1.839	4.91**
C x D x E	0.088	1	0.088	<1
A x B x C x E	0.049	1	0.049	<1
A x B x D x E	0.005	1	0.005	<1
A x C x D x E	0.015	1	0.015	<1
B x C x D x E	0.145	1	0.145	<1
A x B x C x D x E	0.010	1	0.010	<1
Error (within)	11.992	32	0.374	
Total SS	57.258			

*p<.01
**p<.05

TABLE 4

Analysis of Variance on Difference Scores

Source of Variance		Sum of Squares	df	Mean Square	F
Social/Nonsocial	(A)	0.123	1	0.123	<1
Auditory/Visual	(B)	2.163	1	2.163	2.92*
No E/E Present	(C)	0.694	1	0.694	<1
Sex	(D)	2.363	1	2.363	3.20*
A x B		0.000	1	0.000	<1
A x C		0.665	1	0.665	<1
A x D		0.040	1	0.040	<1
B x C		2.818	1	2.818	3.80
B x D		3.408	1	3.408	4.60**
C x D		0.013	1	0.013	<1
A x B x C		0.150	1	0.150	<1
A x B x D		0.001	1	0.001	<1
A x C x D		0.009	1	0.009	<1
B x C x D		0.373	1	0.373	<1
A x B x C x D		0.005	1	0.005	<1
Error (within)		23.7084	32	0.741	

*p<.05 (one-tailed test)
**p<.05 (two-tailed test)

nonsocial conditions ($p>.10$). The analysis of variance revealed significant effects for modality ($p<.05$ on a one-tailed test), sex ($p<.05$ on a one-tailed test) and the modality x sex interaction ($p<.05$). The modality x No E/E present interaction came very close to attaining significance ($p<.08$).

Although the analysis indicates significant statistical main effects for modality and sex, these findings are qualified by the significant modality x sex interaction (Figure 1). Inspection of Figure 1 indicates that both the modality and the sex main effects are attributable to the significant modality x sex interaction. A Newman-Keuls mean comparison test applied to the four groups of the modality x sex interaction demonstrated that the mean difference scores for the males under auditory reinforcement conditions were significantly lower than the mean difference scores for females under auditory reinforcement conditions ($q=11.52$, $p<.05$, $df=2/30$); for males under visual reinforcement conditions ($q=10.44$, $p<.05$, $df=3/30$); for females under visual reinforcement conditions ($q=11.76$, $p<.05$, $df=4/30$); and no other differences were significant.

The modality x No E/E present interaction which was approaching significance is presented in Figure 2. Inspection of this graph indicates that the mean difference scores for the auditory reinforcement group under No E present conditions were appreciably lower than the mean difference scores for the other three groups. This finding, although not significant, suggests that auditory reinforcers for 3-month old infants may require some visual cue to obtain conditioning.

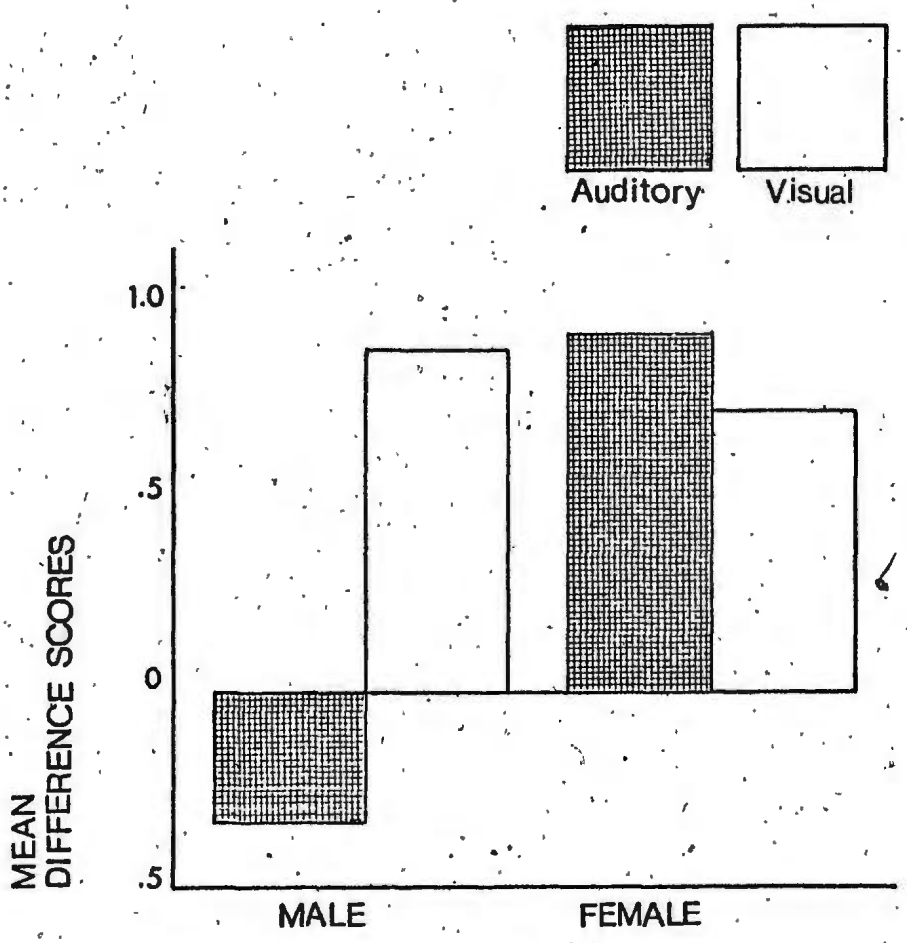

FIGURE 1. Male and female difference scores for auditory and visual reinforcement groups. Modality X Sex Interaction.

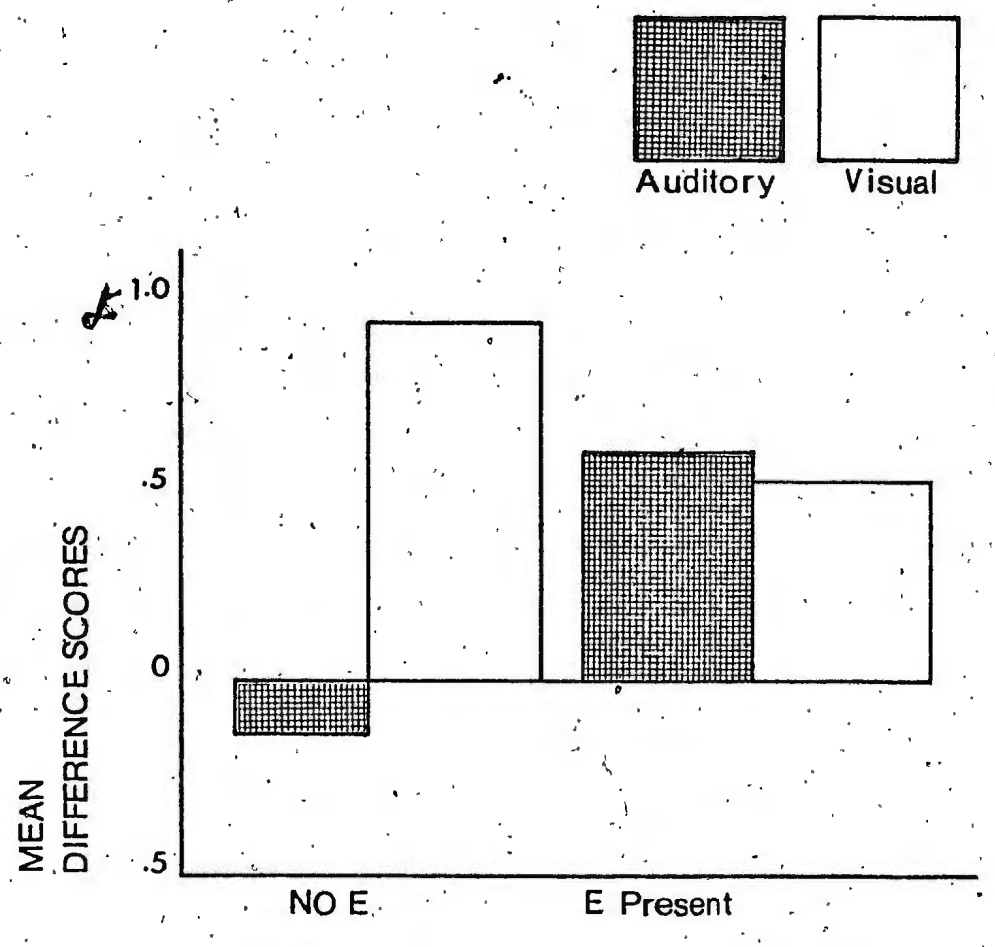

FIGURE 2. Difference scores for auditory and visual reinforcement groups in No E and E present conditions. Modality X No E/E present Interaction ($p < .08$)

In summary this study found a significant conditioning effect, with both social and nonsocial reinforcers effective in obtaining conditioning. No significant differences were found between social and nonsocial reinforcers or between No E and E present conditions, and there was no significant interaction for No E/E present x social/nonsocial conditions. Visual reinforcers appeared to be more effective than auditory reinforcers for males, while for females visual and auditory reinforcers were equally effective.

DISCUSSION

The main hypothesis of the study was demonstrated: both social and nonsocial reinforcers were effective in the conditioning of infant vocalizations. That the social reinforcers were effective is consistent with the previous research on vocal conditioning. That the nonsocial reinforcers were effective is consistent with the suggestion of Berlyne (1966) that any stimuli that are effective in capturing attention can have reinforcing value, and the suggestion of Bijou and Baer (1965) that control of the environment in itself can be rewarding. The nonsocial reinforcers of this study were stimuli which seemed to be highly attention-getting and over which the infant could exercise his control.

On the basis of the research on stimulus preferences of infants and the previous studies of vocal conditioning, social reinforcers might have been expected to be more effective than nonsocial reinforcers in the conditioning of infant

vocalizations. In this study there were no differences between social and nonsocial reinforcers. This finding may be attributed, in part, to the maximation of the nonsocial stimuli used as reinforcers in the study. The nonsocial stimuli were chosen so as to maintain infant attention and, therefore function very effectively - even if social cues were available.

A second factor which may have contributed to the lack of differences between the social and nonsocial reinforcers was the nature of the Ss used in this study. Weisberg (1963) using institutionalized infants did not obtain vocal conditioning with a nonsocial reinforcer. Tomlinson-Keasey (1972) using home-reared infants did obtain vocal conditioning with a nonsocial reinforcer. The Ss of the present study were home-reared infants. As there were no deprivation conditions for the social response as there were in Weisberg's study, social reinforcers were not more reinforcing than the nonsocial reinforcers.

The hypothesis that the presence of E would influence the effectiveness of the social and nonsocial reinforcers was not supported. During conditioning periods whether E was present or not had no influence on the effectiveness of the reinforcers: the presence of E did not enhance the effectiveness of the social reinforcers as it did in the Todd and Palmer study (1968), nor did it interfere with the effectiveness of the nonsocial reinforcers as might be inferred from the study of Weisberg (1963). The presence of E may have been more significant to those two conditioning studies because

the Ss in the studies were institutionalized infants and consequently somewhat socially deprived. The social presence would elicit a great deal of attention from the institutionalized Ss thereby influencing the effectiveness of the contingent stimulation. For the Ss of this study the social presence was a rather common occurrence in their environment. The social presence probably did elicit some attention from the Ss, but not enough to interfere with S's attention to other contingent stimuli.

The results demonstrated that visual reinforcers were more effective than auditory reinforcers for males in the conditioning of infant vocalizations, but, for females, visual and auditory reinforcers were equally effective. This finding must be considered in terms of the differential development rates of the sensory systems and the sexes.

There appears to be a difference in the developmental rates of the two sensory systems. The visual system becomes functional before the auditory system. For the infant, who is most often situated in a crib, visual stimuli appear to be contingent more often than auditory stimuli. If the infant perceives a visual stimulus there is usually a pay-off involved: feeding, burping, changing diapers, comforting, etc. For the infant, however, there is an abundance of noncontingent auditory stimuli: parent conversations, parent-sibling conversations, radio, television, household appliances, etc. Consequently the visual stimuli come to have more relevance for the infant at this particular age. Later, as auditory labels become attached to visual images and the infant begins to develop a

symbolic communication system, auditory stimuli become relevant for the infant.

Moreover, the visual stimuli may be more relevant than auditory stimuli to the infant at this age because of the degree of control the infant may exert over visual stimuli. The infant can direct his gaze and close his eyes, whereas his ears are relatively non-directional and auditory stimuli can not be shut out at the infant's discretion. Also, in the environment of the infant the visual stimuli are more stable and can usually be examined for long periods at will. This does not suggest that the auditory processing system of the infant is not well-developed by three months of age, but that the reinforcing properties of auditory stimuli do not appear to be developed into as functional a system as the visual stimuli.

Another explanation for the auditory/visual differences is that the auditory stimuli used may not have been equivalent to the visual stimuli. This remains a possibility as there were no data available to determine appropriate auditory stimuli as there were for visual stimuli. The finding remains, however, that the females were responsive to both the auditory and visual stimuli, while the males were responsive only to the visual stimuli.

The differential development rate of the sexes is well-documented. Maccoby (1966) has suggested that females mature faster than males, and consequently develop speech abilities earlier than males. The females have an advantage over the males in terms of the availability of the responses

to be reinforced. Females also have an advantage over males in terms of greater opportunity to have their vocalizations reinforced as Moss (1967), in a study of 3-week and 3-month old infants, has found that mothers engage in more vocal interaction with their daughters than their sons. Moss also found that females do not fuss and cry as much as males, giving the females another advantage over males in that the fussing and crying of the males competes with their time for vocalization during the experimental periods. McCall and Kagan (1967b) have suggested that females are more perceptually precocious than males. Therefore the females were probably more responsive to the perceptual reinforcement of the study. Consequently, as the visual system seems to develop before the auditory system, and as females seem to mature faster than the males, the males have developed a functional visual system, but are lagging behind the females in the development of a functional auditory system. The males are responsive to visual stimuli, while the females are responsive to both visual and auditory stimuli.

The results indicated that auditory reinforcement with E present may be as effective as visual reinforcement. The finding is consistent with the previous discussion of the differential development rates of the sensory systems. The visual cue may be an important factor which auditory reinforcers may require to be effective, because at three months the infant is mainly a visual being.

The findings of the present study indicate that (a) the sex of the Ss, and (b) modality of the reinforcer are

important factors in the vocal conditioning of three month old infants. Further studies should give more consideration to the developmental rate of the sexes, rather than assuming that males and females are at the same points in verbal and perceptual development. More research is needed on reinforcer effectiveness of stimuli in the different modalities in infant conditioning.

This study adds further evidence to the theories of language acquisition that stress the role of conditioning in the shaping of the infant's vocal behavior. Increases in vocalizations can be obtained with a variety of contingent responses from the infant's environment: social and nonsocial. This study supports the views of Skinner (1957) that the vocalization is an operant, and that of Staats (1968) that the application of reinforcement at an early age can shape vocal behavior. Staats has pointed to the importance of the prelinguistic vocalization period to later speech development. According to Staats and Staats (1962) the vocalizations of the babbling period progress to speech sounds on the basis of conditioning principles. Haughan and McIntire (1972) suggest that the infant at this stage may be learning to use his vocalizations to alter the contingencies in his world, and it is this awareness - that vocal behavior can have interesting consequences - which may be the first step in the development of language.

SUMMARY

Forty-eight infants between the ages of 75 and 118 days were used to study vocal conditioning with social and nonsocial reinforcers in two modalities - auditory and visual. Two other variables were investigated: (1) the effect of the adult presence on the social and nonsocial reinforcers, and (2) the sex of the Ss. The major finding of the analysis of the difference scores was a significant Sex x Modality interaction. For females auditory and visual reinforcers were equally effective, while, for males only visual reinforcers were effective. This finding was discussed in terms of the differential developmental rates of the sensory systems and of the sexes.

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