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Non-nutritive sucking initiation and non-nutritive sucking cessation to four pure tone stimuli varying both in frequency and intensity were investigated in an attempt to discern the usefulness of these two discrete response indices when testing auditory sensitivity in 2½ month old infants. Stimuli were presented contingent upon S's sucking state and variable interstimulus intervals were employed to minimize the occurrence of sucking habituation. Non-stimulus control trials were randomly presented along with experimental trials such that infants could be used as their own controls.

A TSD analysis resulted in the calculation of sensitivity indices (d'), based on the total number of trials each stimulus was presented, averaged across all subjects. Analyses of variance performed on the sensitivity indices yielded a significant main effect for Intensity when non-nutritive sucking cessation was considered. Differential responsivity to stimulus frequency was not evidenced.

The utility of the two response indices under investigation was found to be equivocal and highly conditional, varying as a function of subject, stimulus, and procedural variables.

THE EFFECTS OF PURE TONE STIMULATION ON

NON-NUTRITIVE SUCKING IN THE HUMAN

INFANT

by

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

The literature on the sensory capacities of the human infant stems largely from two frames of reference: neurophysiology and clinical observations. Most frequently, researchers have focused upon psychophysiological phenomena for the clinical assessment of infants at birth (Bridger, 1961). Beyond such clinical assessment however, sensory thresholds and discriminatory capacities have not been studied as extensively as possible for several reasons. One reason for this lack of research has been that quantitative response measures for the assessment of sensory capacities had not been found. This deficiency in research has contributed to one of the most major problems in developmental psychology: "What is the nature of infant responsiveness to sensory stimulation?"

In much of the current psychophysical research with adults, differential responsiveness has been studied through the use of dichotomous response measures (*e.g.*, "yes - no"). It has only been recently that such discrete response measures have been applied to the study of the infant in the areas of vision (Haith, 1966) and audition (Semb & Lipsitt, 1968). The response measures employed have been: sucking suppression (a decrement in total sucking rate over time); sucking initiation (criterion sucking following some prestimulus period of no sucking); and sucking cessation (a criterion level of reduced sucking following some prestimulus criterion level of active sucking). Such measures are thought to provide a useful approach to the study of sensory capacities in the infant. This investigation has focused upon the auditory capacities of the infant, in terms of such quantitative assessment.

CHAPTER II

BACKGROUND

The orienting reflex, investigated by Pavlov, is the most basic primitive aspect of response to a new stimulus, or response to a change in an old stimulus. The orienting reflex has been synonymously called attention by some investigators, and has also been assumed to be one of the initial steps in responding to sensory information. The reflex is a set of responses, either somatic, autonomic, or electrophysiological, to the presentation of a novel stimulus. As a novel stimulus is increased in intensity beyond its physiological threshold, the orienting or unconditioned reflex is elicited (Sokolov, 1963). The reflex is assumed to have several components, each having a different probability of occurrence, depending upon many different factors (e.g., stimulus intensity, value of the stimulus, age and state of the organism, etc., Brackbill, 1968).

The classic study of orienting in infants was done by Bronshtein & Petrova (1952), using cessation of sucking as the dependent variable. The rationale for using this measure was the observation that organisms first orient, then inhibit ongoing activity in the presence of a novel stimulus. Bronshtein & Petrova's subjects were ten infants between one and five months of age, and 33 subjects ranging in age from two hours to three days. All Ss were presented with stimuli generated by an organ pipe, a harmonica, or a tapping pencil. The stimulus intensity was approximately 60 - 70 dB SPL (re: .0002 microbar) and each stimulus was presented most often in four short bursts (500 msec.) with inter-stimulus intervals of one sec. The intervals between separate stimuli ranged from one to two minutes. More specific procedural details were not reported.

Inhibition of sucking (decrement in response rate when compared to a pre-stimulus level) was reported. In a few cases, cessation of sucking was not complete, rather, the rate and pattern of sucking decreased, indicating a suppression of response. In a few cases, (numbers not reported), however, an increase of frequency and amplitude (measuring of strength of sucking) was reported.

Bronshtein, Antonova, Kamentshaza, Luppova and Sytova (1958) reported that with the first presentation of an auditory stimulus to newborns, sucking suppression proportional to the intensity of the stimulus was produced. Although it was argued that such a procedure was a new and fruitful method of approaching the measurement of auditory sensitivity in infants, Brackbill (1962) reported that only 34.7% of the neonates in the Bronshtein _et al_. study between the ages of 1.5 hours and 17 days, actually showed sucking suppression.

As a follow up to the Bronshtein _et al_. (1958) study, Kaye & Levin (1963) initiated a series of investigations. In these studies, reliable sucking suppression to sine-wave auditory stimulation during the first four days of life was not found. Moreover, it was reported that when a 500 Hz tone of moderate intensity (actual value not reported) and 15 sec. in duration was noncontingently presented (i.e., the stimulus was presented independent of the child's sucking behavior) to 20 three day old _Ss_, no difference in absolute rate of sucking or in the rate of change in sucking were observed between an experimental and a matched control group.

In a second study (Kaye & Levin, 1963) a shorter (2 sec.) and more intense tone was presented contingent upon the third suck of the second burst in the second minute of sucking. An inter-suck time of two sec. or more determined the end of one burst and the beginning of a second one. No differences were found between 15 experimental and control subjects when comparing the total number of sucking responses in the 12 sec. following the tone, or in between-group changes for 2-sec. segments within this period. In both these studies, Kaye & Levin (1963) have worked with absolute number of responses per time, rather than using a different discrete response: viz., suppression or no suppression. While these data do not necessarily disconfirm the suppression hypothesis, they do point to the observation that the suppression effect may be procedure bound (Kaye, 1967).

Keen (1964) has criticized the earlier work by Bronshtein, et al. (1958) for not having specified the criterion used for a response, and for not having reported how soon after stimulus onset the response was recorded. Stimuli were not recorded at pre-determined intervals and it was possible, therefore, that the stimulus presentations may have coincided with the natural bursts and pauses characteristic of sucking. Controlling for these variables, Keen (1964) investigated the effects of intertrial interval and stimulus duration on the rate of sucking habituation in three day old infants. She varied stimulus frequency (400, 4000 Hz), stimulus duration (2 sec. and 10 sec.), and intertrial interval (2 sec. and 10 sec.). The response measures were cessation and initiation of nonnutritive sucking. Subjects were randomly assigned to one of four tone-presentation groups: Group 2I-2D, 10I-2D, 2I-10D, 10I-10D, where I = intertrial interval, D = the duration of stimulus presentation, and 2 and 10 represent time in seconds. For half the Ss in each group, the 400 Hz tone was presented on the first 20 trials, the 4000 Hz tone was presented on trials 21-40, and the 400 Hz tone was presented on trials 41-50. For the other Ss, the frequency presentations were reversed. The procedure consisted of presenting a 2-min. no-tone period, 50 test trials of tone separated by appropriate intervals, and a final 2-min. post test, no-tone period.

Sucking cessation was defined as a response to a tone if a pause in sucking of at least 2 sec. in duration interrupted a sequence or burst of at least two sucks. Initiation was defined as a response to a tone if no sucking had occurred for at least 2 sec. prior to a tone, and at least three sucks were made following the tone. In both cases of cessation and initiation, a response was defined only if the change in sucking behavior occurred within 2 sec. after stimulus tone onset. Comparisons between 2-min. base rate periods, 2-min. tone periods, and 2-min. post-tone periods were made for each group to investigate whether changes in sucking behavior were under the control of the independent variables, or whether they were natural variations in sucking found under no-stimulus periods. The results indicated that the 2I-10D group both had significantly greater proportions of initiations and cessations during the first two minutes of tonal stimulation than during the base rate period. The 10I-10D group showed significantly lower numbers of combined cessations and initiations during the post-test period than during the base rate period.

Kaye (1967) has criticized these interpretations for several reasons. He argues that the 2I-2D procedure is too short to allow for the first and last two minutes of the test period to yield independent data. He has also made several statistical objections to the data analysis. Also criticized was the observation that the pre-test period was composed of the first two minutes of sucking opportunity, the time when the longest bursts of a continuous sucking opportunity are to be found. Kaye questions whether these proportions should be used as a baseline, "or as representative of the expected level of sucking during the later intervals." In light of these criticisms, it is not clear that Keen's data lends unambiguous support to the Bronshtein suppression effect.

More supportive data can be found when examining Haith's (1966) results of the effects of visual movement upon sucking suppression in three to five day old infants. Each S was given 24 10-sec. sucking trials with ITIs of 10 sec., 12 test and 12 control trials, presented in random order, such that no more than two experimental or control trials were presented in succession, with an equal number of trials in each 6-trial block. The nipple was placed in S's mouth prior to the start of each 10-sec. trial, and removed during the ITIs. Two sucks on the nipple initiated the trial. Experimental and control trials consisted of allowing S to suck for 5 of the 10 sec. in the presence of a single stationary panel light on a multiple stimulus array panel. During the second 5-sec. of the 10 sec. period, the procedure was the same as for the first 5-sec. of the control trials; whereas, for the experimental trials, the lights in the array panel were operated clockwise from lower right, for approximately 5 sec. This procedure allowed S to act as his own control (seconds 1-5) within blocks of six trials, where the second 5-sec. period was either the treatment, or the control segment. Difference scores were obtained by subtracting the sucking rate in the 6-10 sec. segment from the rate in the 1-5 sec. segment, and means were computed separately for the three experimental and three control trials of each 6-trial block. Ss were found to suck less when visual movement occurred, than during control trials of sucking to a stationary light.

Kaye (1966) attempted to extend Haith's findings, using 2 to 4 day old infants. He used Haith's discrete trials method. Stimuli presented were two square-wave tones of about 94 dB SPL, having basic frequencies of 30 and 600 Hz (low and high respectively). The low-high group received the low tone during the first eight 10-sec. trials, followed by eight 10-sec. trials of the high tone. The high-low group received the tones in reverse order. A third group received tones between trials, but not during the sixteen 10-sec. trials. The first 5 sec. of the 10-sec. trials were used as controls; the last 5 sec. were experimental periods of stimulus presentations. Data in terms of absolute sucking rates in the control and experimental periods, as well as percentage change, showed a decrease in sucking during the second 5-sec. of the trial for all three groups; however, the differences between experimental and control groups did not reach significance.

A second study (Kaye, 1966) using visual stimulation, produced similar results; there was a decrease in responding from the first to the second 5-sec. but the differences did not reach statistical significance, when experimental and control groups were compared.

Kaye (1967) has suggested that possible reasons for the discrepancies found when comparing his data (1966) to that of Haith (1966) include differences in interstimulus intervals (Kaye's was twice as long : 20 sec.); differences in background noise levels (Kaye's was higher); and differences in ITIs.

Sameroff (1967) continued this line of investigation by presenting three lights (pilot light, 50 Watt frosted white bulb, and 150 Watt frosted white bulb) and a sound (60 dB, 500 Hz) stimulus, of 1-min. durations to ten newborns on days 1-5 and observed differential effects on the frequency of sucking "bursts". The number of seconds to sucking cessation was recorded following each stimulus change occurring during a sucking burst, and was compared to the number of seconds to cessation of sucking following a point 30 sec. after stimulus change. No differences in time to cessation were found. Time spent sucking was also compared before and after stimulus change, and again no differences were found. Although a measure of total sucking was found to be insensitive to stimulus variation, the patterning of sucking was found to be a sensitive measure. The burst immediately preceding a stimulus change was compared with the burst in which the stimulus change occurred, or, when the change occurred in an interburst interval, the burst preceding a stimulus change was compared with the first burst in the new stimulus period. There were significant pre-and post-stimulus-change differences, but they were in a direction opposite that reported by Bronshtein _et_ _al_. (1952, 1958). Both burst length and interval length increased. However, this study is not directly comparable to that of Haith, in that stimulus presentations were not contingent upon S being in a sucking state. Sameroff (1971) investigated the effects of auditory stimulation upon sucking, and reported results in the opposite direction. Four stimulus conditions were used, each employing a 500 Hz tone varying in intensity: a 65 dB continuous tone; a 65 dB alternating tone, switching off and on at 500-msec. intervals; a 65 dB tone alternating at 250-msec. intervals; and a 75 dB continuous tone. In this study, stimulus onset and stimulus offset shortened sucking bursts for 3 out of 4 sessions.

Semb & Lipsitt (1968) using neonates, demonstrated sucking initiation and cessation to sound. Rather than using a time-locked stimulus presentation procedure (Kaye, 1964, 1966; Keen, 1966; Sameroff, 1967) stimuli were presented only if S was (a) in an active sucking state, or (b) in a non-sucking state. Each infant served as his own control and control trials of no sound were randomly presented throughout the series of stimulus presentations, such that changes in the state of sucking would be equally weighted in both control and in experimental conditions. Subjects were randomly assigned to one of three groups: (a) those receiving a 150 Hz square-wave signal, (b) those receiving a 1000 Hz square-wave signal, and (c) those receiving both the 150 and 1000 Hz tones. All stimuli were one sec. in duration and intensity was measured at 91 dB SPL (re: .0002 microbar).

During the experimental session, all three groups received acoustic stimulation in 40 of the 60 trials. Twenty no-signal control trials completed the session. Trials were not initiated unless S had been in one of two discrete sucking states for at least 2 sec. (active sucking or no-sucking). Thus, the state of S's sucking dictated whether or not a trial was to be initiated. Results agreed closely with those of Haith (1966) on sucking suppression. The data pointed to the presence of two definate responses: response initiation to a stimulus if S had not been sucking prior to stimulation, and response cessation to the stimulus, if S had been sucking prior to stimulation.

Sameroff (1970) studied non-nutritive sucking as a function of auditory stimulation in older infants (1, 2 and 3 months). Stimulus trials were initiated as a function of the sucking state of the infant, as in the study by Semb & Lipsitt (1968). Stimulus presentations consisted of : (a) a 500 Hz, 65 dB continuous tone, (b) a 65 dB 500 Hz tone which alternated at 500-msec. intervals; (c) a 65 dB, 500 Hz tone alternating at 250-msec. intervals, and the representation of the 65 dB, 500 Hz continuous tone. A trial consisted of five bursts and five interburst intervals; Ss were stimulated either during a burst (Burst Stimulation - BS), or during an interburst interval (Interval Stimulation - IS). During the IS condition, the stimulus was applied after one sec. of no sucking in the second interval and turned off after one sec. of no sucking in the fourth interval. During BS stimulation, the stimulus was applied after the second suck in the second burst and turned off after the second suck in the fourth burst. The first, third and fifth sucking units served as controls for the onset and offset effects of the stimulation. The 65 dB continuous tone served as the baseline condition against which sucking in the other stimulus conditions was compared. Although the responses of the younger Ss seemed ambiguous, the responses of the older infants showed reliable shortening of sucking bursts and lengthening of the interval, during stimulus onset and offset for the two conditions. When stimulus onset occurred during a burst (BS), the burst was shortened; when stimulus onset occurred during an interval (IS) the next burst was shortened. For the three month old infants, in the IS condition, stimulus onset had the effect of increasing interval length.

CHAPTER III

SUMMARY

The Bronshtein suppression effect, in terms of total sucking inhibition under the control of a novel stimulus, has not received support from all the aforementioned research (Kaye & Levin, 1963; Kaye, 1964, 1966; Sameroff, 1967, 1970, 1971) but has been extended by the work of Keen (1964), Haith (1966) and Semb & Lipsitt (1968). These discrepant findings may be attributed to several possible variables, the two most cogent of which seem to be the particular dependent variables employed, and the independent stimulus variables applied. When measures other than response initiation or suppression were used, such as rate of sucking or time to sucking cessation, results seemed to be inconsistent with the effect. When stimulus presentations were not applied contingent upon S's behavior, that is, when they were applied on a time locked schedule, results were also negative. Sameroff's (1967) research, although indicating that total sucking rate was insensitive to tonal on- and off-set, did indicate that sucking pattern was affected by auditory stimulation. He showed differential stimulus effects in frequency of bursts of sucking when newborns were presented 1-min. durations of light and sound stimuli. When stimulation was applied during a burst, the burst was lengthened in relation to the prestimulus burst length; when stimulation was applied during an interval, the interval was lengthened in relation to the pre-stimulus interval, suggesting that tonal stimulation (500 Hz, 60 dB) had the effect of prolonging the activity in which the infant was engaged (sucking or not sucking). This study used a time-locked procedure; however, when response contingent procedures were employed (Sameroff, 1970, 1971), reliable shortening of sucking bursts were reported in the presence of tonal stimulation. However, when Ss were stimulated during a non-sucking interval, the interval was still reported to have been lengthened. This result may or may not have been predicted from the Bronshtein data, since stimulation during a non-sucking interval was not experimentally investigated.

On the other hand, where discrete response measures have been employed, (Keen, 1964, Haith, 1966; Semb & Lipsitt, 1968) findings have been compatible with those of Bronshtein (1958). Brown (1972) has discussed some of the disadvantages associated with the use of sucking rate as a dependent measure. Some of these include (a) sucking rate often depends upon the specific sucking elicitor used (i.e., type of pacifier), (b) sucking on a regular nipple occurs in bursts and puases which makes it difficult to evaluate whether pauses occur naturally or are due to experimental manipulations, (c) sucking rate may be partially dependent on sucking opportunity time (i.e., a sucking opportunity time which coincides with the natural burst length tends to increase the rate). Moreover, questions still remain as to the value of calling an isolated suck the minimal unit of response, or, whether the sucking burst, per se, should be considered the minimal unit of analysis.

In lieu of these conclusions, the discrete response measures of initiation or cessation seem to reflect a more reliable indication that some systematic change in behavior is occurring as a function of systematic changes in stimulation. It appears more useful therefore, to define sucking behavior in terms of membership in one of two states, sucking or non-sucking, rather than using a rate analysis when investigating the effects of environmental stimulation upon sucking behavior.

Data discrepancies found across researchers may also be a function of the different stimuli employed, both in complexity (square-waves vs pure-tones), and value (frequency and intensity differences). Method of stimulus presentation has also varied across researchers (continuous tone vs. repeated tones), and may be another source of variance. Table I summarizes the different stimulus characteristics used by researchers which have been cited in the foregoing introduction.

Another possible variable responsible for some of the discrepant findings may be subject age. All of the aforementioned studies, save Bronshtein (1952) and Sameroff (1970) have explored auditory functioning in neonates. While the data on non-nutritive sucking has indicated that the occurrence of sucking inhibits and reduces arousal level (Bruner, 1973) Kesson et al. (1970) have suggested that "non-nutritive sucking may play different roles for the newborn and for the older infant. The newborn sucks most when highly aroused, and is, in general, soothed through the sucking act. In the older infant, thumbsucking seems, except for the hunger drive, to occur most frequently when the infant is in a low state of arousal" (p. 339).

A study by Bruner (1973) has shown that infants in the first three months of life were able to orient toward films for a longer time period, and with seemingly less tension when they were sucking on a non-nutritive pacifier than when they had no pacifier available to them. This phenonomen has been termed "pacifier-produced visual buffering". Although many forms of discomfort seem to be relieved by sucking (i.e., infants suck more when

AUTHORS	CONTINGENCY	FREQ.	INTENS.	DURATION
Kaye & Levin (1963)	R - Indep.	500 Hz		15 sec.
Kaye (1966)	R - Indep.	30 Hz; 600 Hz Square	94 dB SPL	05 sec.
Sameroff (1967)	R - Indep.	500 Hz	60 dB SPL	01 sec.
Kaye & Levin (1963)	R - Depen.	500 Hz		02 sec.
Keen (1964)	R - Depen.	400 Hz; 4000 Hz	90 dB SPL	02 sec.; 10 sec.
Sameroff (1971)	R - Depen.	500 Hz	65 dB Continuous	Variable
		500 Hz	65 dB; 500 msec. on-off	Variable
		500 Hz	65 dB; 200 msec. on-off	Variable
		500 Hz	75 dB Continuous	Variable
Sameroff (1970)	R - Depen.	500 Hz	65 dB Continuous	Variable
		500 Hz	75 dB Continuous	Variable
		500 Hz	65 dB; 500 msec. on-off	Variable
			65 dB; 250 msec. on-off	Variable
		500 Hz	65 dB Continuous	Variable
Semb & Lipsitt (1968)	R - Depen.	150 Hz, Square	91 dB	01 sec.
		1000 Hz, Square	91 dB	01 sec.

Table I. Summary of Cited Literature : Stimulus Variables.

tired, when faced with novel stimuli, and when in pain (Lipsitt, 1967; Bruner, 1973), it is not clear that infants of different ages respond to the presentation of a novel stimulus similarly, when non-nutritive sucking is used as the dependent measure.

In consideration of the previously reviewed literature, it appears that the use of discrete response measures such as sucking initiation and cessation may be a more useful approach in the examination of infant responsivity to sound, than are the measures which have been more often used in the past (rate, percent change in sucking, time to sucking cessation, etc.). The exact conditions under which reliable changes in response may be obtained, however, have yet to be identified. It is evident that response - contingent presentations of stimuli are necessary to obtain changes in responsivity, and, in this respect, the present investigation was designed to extend the work of Semb & Lipsitt (1968) in discerning the effects of acoustic stimulation upon the response indices, non-nutritive sucking cessation and initiation, in older infants. The stimulus frequency values employed in the present study were based on the observations made by Wedenberg (1956) on newborn infant's thresholds for pure tones. The pattern of mean thresholds as a function of frequency for infants less than 10 days old were similar to those found for adults (minimum threshold near 1000 Hz and higher thresholds above and below 1000 Hz).

CHAPTER IV

METHOD

Subjects

Eight infants (4 boys and 4 girls) ranging in age from 2 mo. 12 days to 3 mo. 19 days (mean age = 3 mo. 2 days) from the Greensboro, N.C. area served as subjects. Their names were obtained from the births announcements section of a local Greensboro paper, and checked against Public Health records to guarantee the following criteria: (a) Caucasion (b) birth weight greater than six pounds (c) mother's age less than 35 years (d) parents had at least a four year high school education (e) parents had a telephone and lived within a fifteen minute radius of the college campus. Parents were then contacted by letter informing them of the present research interests. Interested parents calling the university were then asked to bring their infants into the laboratory where the following two criteria were guaranteed: (a) infants had no reported history of inner ear infections according to background information received from the parents, and (b) Ss met a minimal sucking requirement during baseline assessment (20 sucks or more/minute, during the first two min. of baseline). All but one of the Ss was an only child.

Five Ss were eliminated from the study for the following reasons: (a) onset of teething and increased discomfort during experimental sessions as evidenced by crying and pacifier rejection, (b) failure to become acclimated to the experimental chamber after several days of attempted testing, and (c) failure to accept the pacifier after the first few days of testing.

The remaining three Ss (2 boys and 1 girl) ranged in age from 2 mo. 12 days to 3 mo. 1 day (mean age = 2 mo. 21 days). Two Ss completed all experimental sessions; one S completed two thirds of two conditions and one third of one of the three conditions. Although all mothers were originally asked to bring their babies to the laboratory 1½ hrs. prior to a regularly scheduled feeding, it was found that testing within ½ hour following the normally scheduled feeding was more conducive, for all but one of the Ss. Daily sessions were terminated when S exhibited a major state change (crying or sleeping), or at the completion of the experimental session. Parents were awarded a $25.00 participation fee upon completion of the experiment; partial payment was awarded those parents whose babies did not complete the study.

Apparatus

Lehigh Valley and Coulbourn Solid State programming equipment in conjunction with a Grass Model 7 Polygraph and PT-5 Pressure Transducer were used to control the experiment and to record the data. A Schmitt Trigger converted analog signals from the pressure transducer to logic level signals, permitting the digitalization of sucking events. Stimuli were generated by a Hewlett Packard Model 201 Audio Oscillator and attenuated by a Hewlett Packard Model 350 - D Attenuator. A Coulbourn Shaped Rise/Fall Audio Gate (Model S 84-03) controlled rise and decay of the signal (5 msec.) and a Coulbourn Interval Timer (Model S 53-10) controlled signal duration (100 msec.). A Grason Stadler Impedence Matching Transformer (Model E 10589-A) matched impedences antecedent to the loudspeaker. Measurements of signal level were made prior to each experimental session with a General Radio 1551-C Sound Level Meter (A - weight). The Grass Model 7 Polygraph recorded both signal and non-signal trials as well as all sucking behavior, stimulus onset, and stimulus duration. Figure 1 shows a schematic representation of the apparatus.

Independent Variables

The following sinusoidal stimuli were presented to each S: 3000 Hz at 60 dB SPL (re: .0002 microbar); 3000 Hz at 80 dB SPL; 1000 Hz at 60 dB SPL; and 1000 Hz at 80 dB SPL. Each S received 20 presentations of one of the above stimuli as well as receiving 20 no-signal (control) trials. A typical session consisted of three blocks of three different stimuli, totaling 60 experimental and 60 control trials (noise trials).

Each stimulus presentation consisted of five 100-msec. bursts of tone having an interburst interval of 300 msec. Thus, the stimulus began with a burst of 100-msec. and ended with the final 300-msec. interval, resulting in a total stimulus diration (including interburst time) of 2000 msec. (2 sec.). Rise and decay times for each tone burst was 5 msec. The stimuli were presented as tone bursts rather than as one continuous 2-sec. tone, to increase the novelty value of the stimulus and to maximize infant responsiveness.

Dependent Variables

The dependent variables under investigation included both non-nutritive sucking cessation and sucking initiation. Infant sucking records have been characterized by two distinct states (Semb & Lipsitt,

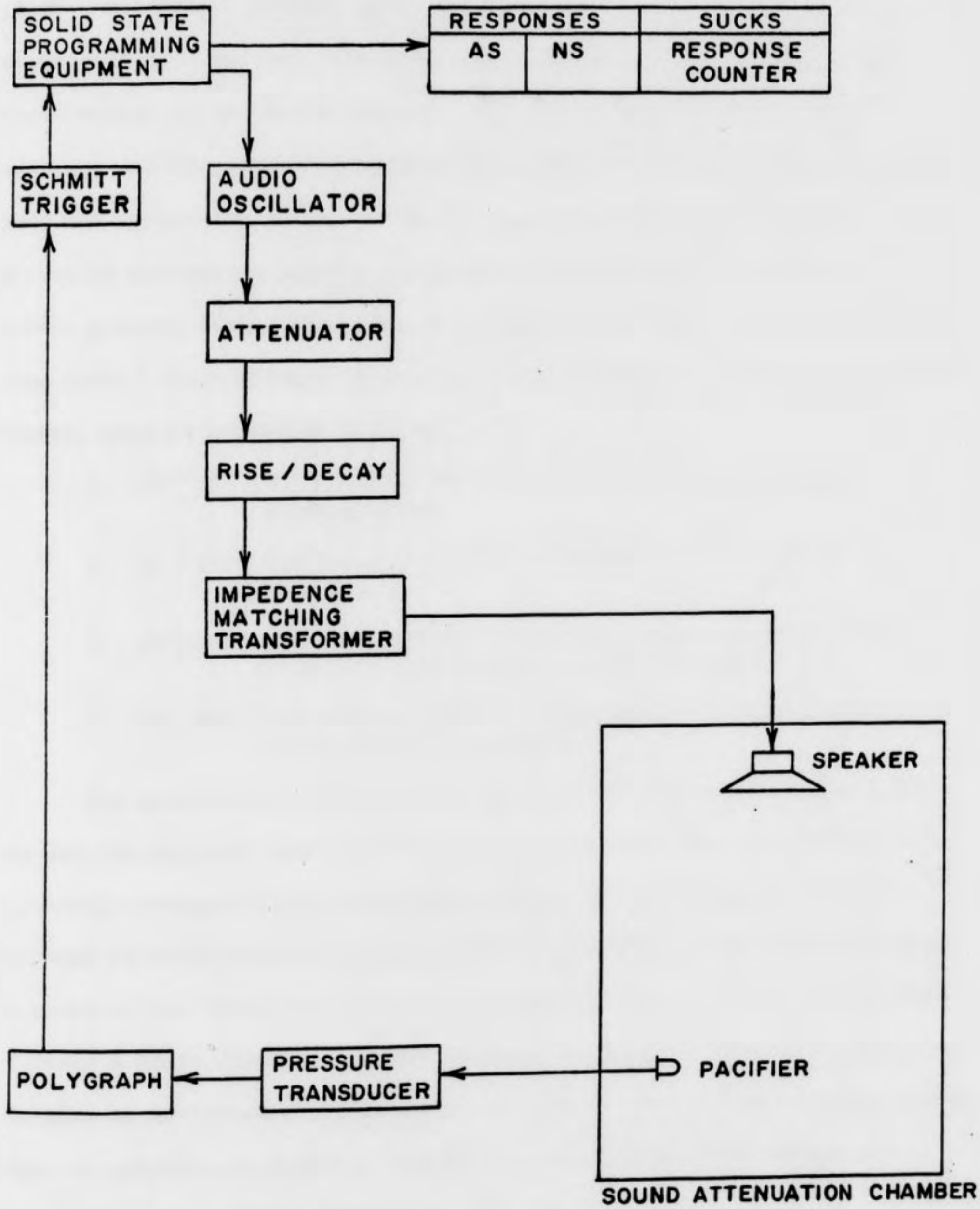

FIGURE 1. **Schematic Representation of Apparatus.**

1968): (a) Active Sucking (AS); three or more sucks emitted by S during a 2-sec. period of observation, and (b) Non-Sucking (NS); zero sucks within a same 2-sec. period. For the present investigation, a suck was defined as a 5-mm minimum deflection of the polygraph recording pen, and membership in one of the two sucking states was defined by active or non-active sucking (AS or NS, respectively). On any given trial, S could change his state of sucking or he could remain in the same state. Such changes in sucking behavior resulted in four conditional events, conceptualized as follows:

1. AS | AS: Continuation of Active Sucking, given that S was in an AS state
2. NS | NS: Continuation of Non-Sucking, given that S was in an NS state
3. NS | AS: Cessation of Active Sucking, given that S was in an AS state [(A Change of State Response) = CS]
4. AS | NS: Initiation of Active Sucking, given that S was in an NS state (A CS Response)

The presence of two discrete responses during non-nutritive sucking (AS and NS) and their reliable change from one state to another with a reliable change in the environment (AS| NS, NS |AS), becomes a useful indicant of differential responsiveness which lends itself to an analysis in terms of the Theory of Signal Detectability (TSD), discussed elsewhere by Green & Swets (1966). The TSD analysis is designed to measure sensitivity to environmental change that is independent of any possible variations in response criterion. Sensitivity to environmental change is measured in terms of the index d'.

This index of sensitivity was derived from a signal detection model which treats the detection of threshold signals in noise as a statistical decision problem. The model operates upon the assumption that the sensory events affecting decisions vary in magnitude from trial to trial according to a normal distribution. The addition of a signal to a background noise increases the mean of the hypothetical noise distribution by an amount d', expressed in standard deviation units of the noise distribution. Finally, d', is determined by the ratio of HITs to False Alarms (F/A), defined below.

The theory yields a four-way contingency matrix, where responses falling within each cell are defined as:

1. HIT: Detection of a signal, given that a signal occurred
2. MISS: Non-detection of a signal, given that a signal occurred
3. FALSE ALARM (F/A): Incorrect report of signal presence, given that no signal occurred
4. CORRECT REJECTION: (C/R): Correct report of signal absence, when no signal occurred

Inspection of such a matrix (Figure 2) indicates that only two values can be freely entered; the other two values can be determined since the rows must add to one (Green & Swets, p. 34). In this way, d' is adequately determined by the proportion of HITS in relation to the proportion of F/As. The combination of TSD concepts and the two Change of State conditions [(AS|NS) and NS|AS)] yields the following response contingency analysis, shown in Table II. First, given that a CS will occur with the onset of a novel stimulus (S), a HIT may be defined as CS|S, where CS is the sum of the conditional responses (AS|NS and NS|AS). Second, a F/A may be defined as a CS, given that no stimulus was presented, (N), viz., CS|N. That is, a change in state [(AS|NS + NS|AS)] following no stimulus presentation (N), yields a F/A.

For the present investigation, sucking states were defined as the presence or absence of sucking (AS = 3 sucks; NS = 0 sucks, respectively), during a 2-sec. observation period prior to stimulus onset (experimental trials) or prior to the activation of the event marker (noise trials). Responses were defined during the 3-sec. response interval which was initiated concurrently with and followed either stimulus onset or the event marker activation. The responses AS and NS which occurred during this 3-sec. response interval were operationally defined as three or more sucks, and the emission of zero or one suck, respectively.

The Sucking State and the responses defined by the 2-sec. observation period and the 3-sec. response period, respectively, differed only in terms of the criterion for NS. That is, in the response interval, both zero sucks and one suck were accepted as NS responses; whereas, in the observation interval, NS was defined as zero sucks exclusively.

Because CS is the combined sum of (AS|NS + NS|AS), it was necessary to assess the effects of each behavioral state change [(AS|NS -- initiation and NS|AS -- cessation)] separately, to determine the extent to which each state contributed to the overall state change. Table III represents the separate Initiation and Cessation contingencies in terms of TSD. Sensitivity indices (*d*') for Initiation were determined by the proportion of Initiation HITS in relation to the proportion of Initiation F/As, or:

$$\frac{(AS|NS)|S}{(AS|NS)|N} = (d')_I$$

STIMULUS ALTERNATIVES	RESPONSE ALTERNATIVES: (S) "Signal"	RESPONSE ALTERNATIVES: (N) "No Signal"
(s) Signal	$P(S \mid s)$ HIT	$P(N \mid s)$ MISS
(n) No Signal	$P(S \mid n)$ F/A	$P(N \mid n)$ C/R

$P(S \mid s) + P(N \mid s) = 1$ $\quad$ $P(S \mid n) + P(N \mid n) = 1$

FIGURE 2. TSD Stimulus Response Matrix

CONDITIONAL BEHAVIORAL RESPONSE	RESPONSE CLASSIFICATION	TSD RESPONSE ANALYSIS
AS | NS NS | AS AS | AS NS | NS	Change of State (CS) Change of State (CS) No State Change No State Change	CS S* = HIT CS N** = F/A *S = Novel Stimulus **N = No Stimulus

Table II. Overall Response Contingency Analysis

CONDITIONAL BEHAVIORAL RESPONSE	RESPONSE CLASSIFICATION	TSD RESPONSE ANALYSIS
AS|NS (Initiation)	Change of State (CS)	AS|NS / S* = HIT
NS|AS (Cessation)	Change of State (CS)	NS|AS / S = HIT
		AS|NS / N** = F/A
		NS|AS / N = F/A
		*S = Novel Stimulus **N = No Stimulus

Table III. Sucking Initiation and Sucking Cessation Contingency Analysis.

Similarly, the Cessation HIT to Cessation F/A ratio yielded a d' for Cessation:

$$\frac{(NS|AS)|S}{(NS|AS)|N} = (d')_C$$

In the separate analyses of Initiation and Cessation, criteria for AS and NS responses differed from those used in the overall analysis for CS, where AS=3; NS=1+0. For Initiation, AS was defined as either (a) 3 sucks, (b) 4 sucks, (c) 5 sucks, (d) more than 5 sucks. These four separate response-criteria analyses were performed to determine whether changing the operational definition of AS had any effect in terms of differences found in respective d' values.

For response Cessation, NS was defined as either (a) 1 suck, or (b) zero sucks. The logic for employing these separate criteria follows that for response Initiation.

Procedure

Each infant was individually tested in a 5½ foot square sound attenuation chamber illuminated by a 25 Watt bulb. Depending upon S's preference, during any session, S was either (a) seated in his own infant's seat on a small table situated in front of his mother, (b) placed supine, facing away from his mother or (c) placed prone, facing away from his mother. In all cases, the mother was seated out of S's view. A 52A1 QUAM Speaker was suspended from the ceiling, approximagely 24 inches directly above the infant's head.

Mothers presented S a non-nutritive pacifier (long or short Binky or orthodonic, depending upon S's preference). A polyethelene tube coupled the pacifier to the pressure transducer, which in turn, provided sucking information for polygraphic recordings of all sucking behavior. The mother held the pacifier in S's mouth for the duration of each 40 trial block. All Ss and their mothers were monitored over a Webster Teletalk System. Mothers were instructed to avoid eye and physical contact with their babies, and to remain silent for the duration of each experimental session.

A complete experimental trial, as shown in Figure 3, consisted of:

A: Onset of the 2-sec. observation interval; S's sucking state was determined as either AS (3 sucks) or NS (0 sucks). One or two sucks were ignored by the wiring circuitry and the 2-sec. observation interval was reinstated until S reached criterion for membership in one of the two sucking states.

B: Offset of observation interval, and the simultaneous onset of both the 2-sec. signal (or the activation of the event pen) and the 3-sec. response interval.

C: Offset of signal (or the end of the no-signal interval)

D: Offset of 3-sec. response interval and simultaneous onset of 13-sec. intertrial interval.

On the first day of the experiment the pacifier was dipped in honey and S was allowed to suck for two minutes. The following two minutes of sucking behavior was recorded and the infant's eligibility as a subject was assessed. Ss who either did not accept the pacifier, or accepted the pacifier but sucked at a rate less than 20 sucks per minute during the 2-min. baseline period, did not participate further in the study.

Following this assessment, Ss received one of four possible

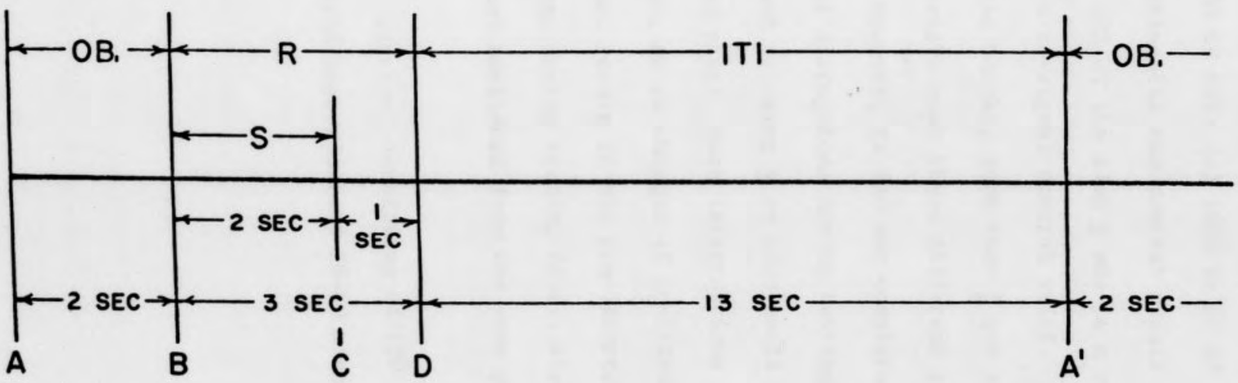

FIGURE 3. Representation of a Complete Trial, where A-B = Observation Interval; B-C = Stimulus; B-D = Response Interval; D-A' = Intertrial Interval.

acoustic stimuli in a block of 40 trials (20 experimental and 20 control trials). The four possible stimuli were (a) 3000 Hz at 60 dB SPL; (b) 3000 Hz at 80 dB SPL; (c) 1000 Hz at 60 dB SPL; and (d) 1000 Hz at 80 dB SPL. Experimental and control trials were randomized in each block such that 50% of the time S was in a signal trial and 50% of the time, he was in a no-signal control trial. An experimental session consisted of three blocks, such that S got as many as 60 experimental and 60 control trials over three different stimuli per session. In some instances, however, Ss did not complete a full session of 120 trials.

Behavioral disruptions during testing were handled by turning off the equipment, and allowing S to rest until sucking could be reinstated at the prescribed rate. Such interruptions usually resulted in diaper changes, feedings, or in changes of position on the testing table. If the infant did not return to his pre-interrupted state, or exhibited a major state change during testing (i.e., sleeping or crying) the session was terminated and continued from the same point on the following day of testing.

A typical session, consisting of 120 trials, with no behavioral disruptions, lasted approximately 50-60 minutes.

CHAPTER V

RESULTS

Behavioral responses were determined by averaging over trials and subjects for each of the four signal values. Thus, sensitivity indices (d') were based on the total number of trials each stimulus was presented, averaged across all three subjects.

Sensitivity indices

The first analysis was concerned with Overall Changes in State, that is: $P(CS) = P\left[(AS|NS) + P(NS|AS)\right]$. In terms of TSD,

$$d'_{OA} = \frac{\text{proportion of HITS}}{\text{proportion of F/As}}$$

$$= \frac{\text{Change in State/ Total Signal Trials}}{\text{Change in State/ Total No-Signal Trials}}$$

$$= \frac{AS|NS + NS|AS\text{/ Total Signal Trials}}{AS|NS + NS|AS\text{/ Total No-Signal Trials}}$$

A 2x2 (Frequency x Intensity) repeated measures ANOVA was performed, where only one response criterion for each state was used in the computation of d' (AS=3, NS=0+1). This analysis yielded no significant main effects, nor a significant interaction.

Sensitivity indices for Initiation were based on the following calculations :

$$P(AS|NS) = \frac{\text{Number of trials AS occurred, given S was in an NS state prior to stimulation}}{\text{Total trials S was in an NS state prior to stimulation}}$$

where, $P(AS|NS)$ is the conditional probability of response initiation.

In terms of TSD:

$$\frac{\underline{d}'}{I} = \frac{\text{Proportion of HITS}}{\text{proportion of F/A}}$$

$$= \frac{AS|NS/\ \text{Total Signal Trials}}{AS|NS/\ \text{Total No-Signal Trials}}$$

The four different Initiation response criteria yielded four separate $\underline{d}'$ values for: AS=3 sucks, 4 sucks, 5 sucks, and more than 5 sucks, given that S made zero sucks during the observation interval.

A 3 factorial ANOVA for repeated measures was performed on the Initiation date (Frequency x Intensity x Response-Criterion) yielding a significant Response-Criterion main effect ($p < .05$). There were no other significant effects. A Scheffe' post hoc test on the significant effect indicated that the AS = 5 response criterion was significantly less than the other criteria ($p < .05$). However, the utility index, (ω^2), indicated that the criterion main effect accounted for only 3% of the total variance.

Sensitivity indices for Cessation were calculated as follows:

$$P(NS|AS) = \frac{\text{Number of trials NS occurred, given that S was in a pre-stimulus AS state}}{\text{Total number of trials S was in an AS state, prior to stimulation}}$$

where, P(NS|AS) is the conditional probability of response cessation. In terms, of TSD:

$$\underline{d}' = \frac{\text{Proportion of HITS}}{\text{Proportion of F/As}}$$

$$= \frac{NS|AS\ /\ \text{Total Signal Trials}}{NS|AS\ /\ \text{Total Non-Signal Trials}}$$

Values for $\underline{d}'_C$ were obtained for both NS = 0 and NS = 1 criteria. A 3 factorial ANOVA for repeated measures (Frequency x Intensity x Response-

Criterion) performed on the Cessation data yielded a significant main effect for intensity ($p < .001$). This effect accounted for 40% of the total variance. The d'_C values were found to be highest at 80 dB SPL, regardless of stimulus frequency or criterion value (see Figure 4). The response-criterion main effect was also found to be significant at the .05 level, accounting for only 1% of the total variance. A significant Frequency x Response-Criterion interaction ($p < .05$) indicated that the NS = 0 criterion yielded higher d'_C values at 3000 Hz than at 1000 Hz, regardless of the intensity level of the stimulus. This interaction, however, accounted for only 5% of the total variance.

Latencies and Burst Durations

Following the computation of the sensitivity indices (d'_{OA}, d'_I, and d'_C) a further analysis compared mean latencies and mean burst durations between signal and noise trials across all stimulus conditions for the Initiation data (AS|NS). Latency was defined as the temporal interval between trial onset and the first suck of the first initiated burst. A burst was defined as two or more sucks. If no burst occurred, the trial was ignored. When a burst was initiated concurrent with trial onset, a "0" latency was recorded.

Burst duration was defined as that time required to complete the burst, measured from the first defined suck of that burst to the end of that burst, which sometimes extended into the observation interval of the next trial. A 2-sec. or more difference between sucks determined the end of that burst. Burst onset and offset was easily determined by visual inspection, and only rarely required more exact measurement.

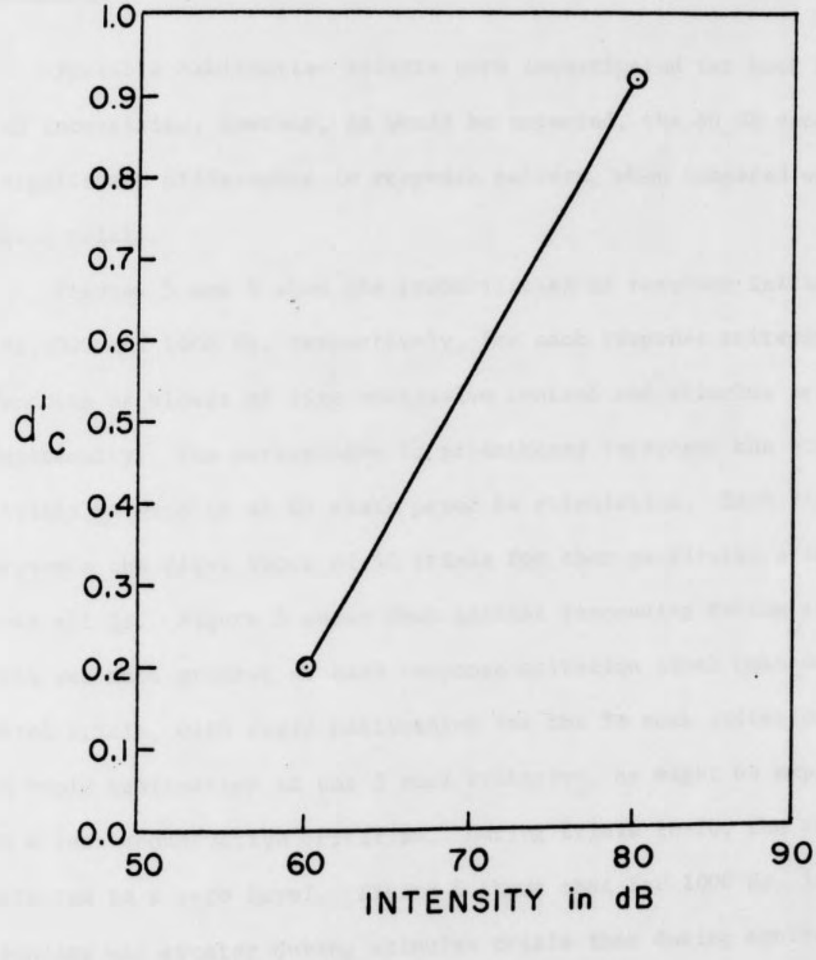

FIGURE 4. Significant Main Effect for Intensity derived from Cessation Data.

Neither the latency nor the duration measures yielded a significant difference between stimulus and no-stimulus conditions.

Habituation

Possible habituation effects were investigated for both 60 and 80 dB intensities, however, as would be expected, the 60 dB data showed no significant differences in response pattern, when compared with control trials.

Figures 5 and 6 show the probabilities of response Initiation at 80 dB,3000 and 1000 Hz, respectively, for each response criterion, as a function of blocks of five successive control and stimulus trials, independently. The percentages in parentheses represent the proportion of trials Ss were in an NS state prior to stimulation. Each figure represents the first block of 40 trials for that particular stimulus, across all Ss. Figure 5 shows that initial responding during stimulus trials was much greater at each response-criterion level than during control trials, with rapid habituation for the 5+ suck criterion, and less rapid habituation at the 3 suck criterion, as might be expected with a less conservative criterion. During trials 16-20, the response habituated to a zero level. Figure 6 shows that for 1000 Hz, initial responding was greater during stimulus trials than during control trials, with the exception of responding occurring at the 5+ criterion. Initiation during stimulus trials habituated somewhat at all criteria values but recovered during trials 16-20. During these latter trials responding reached a probability level higher than the initial level of response for all but one of the criteria; the exception being the 3 suck criterion.

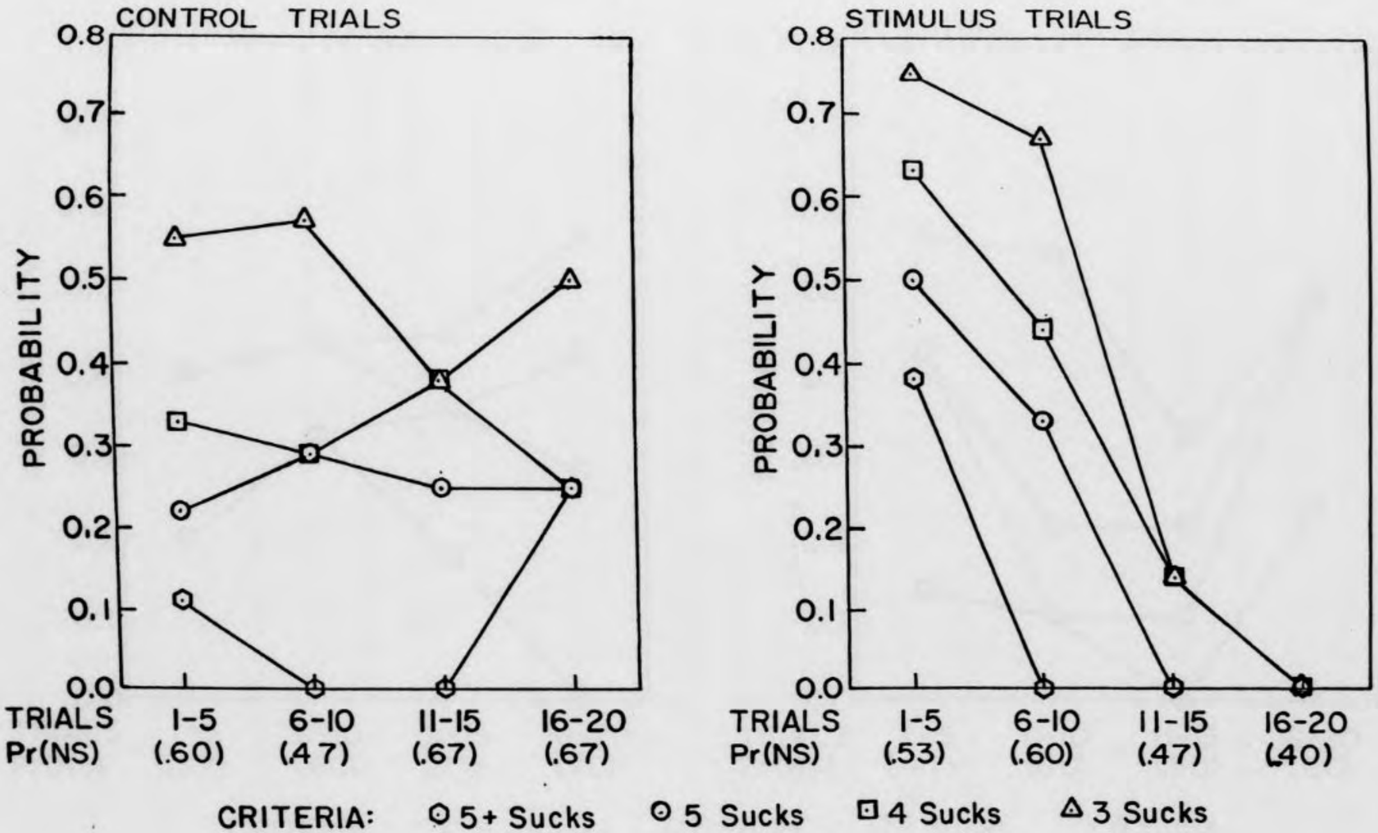

FIGURE 5. Probability of Response Initiation for 80 dB, 3KHz in blocks of five successive stimulus and control trials.

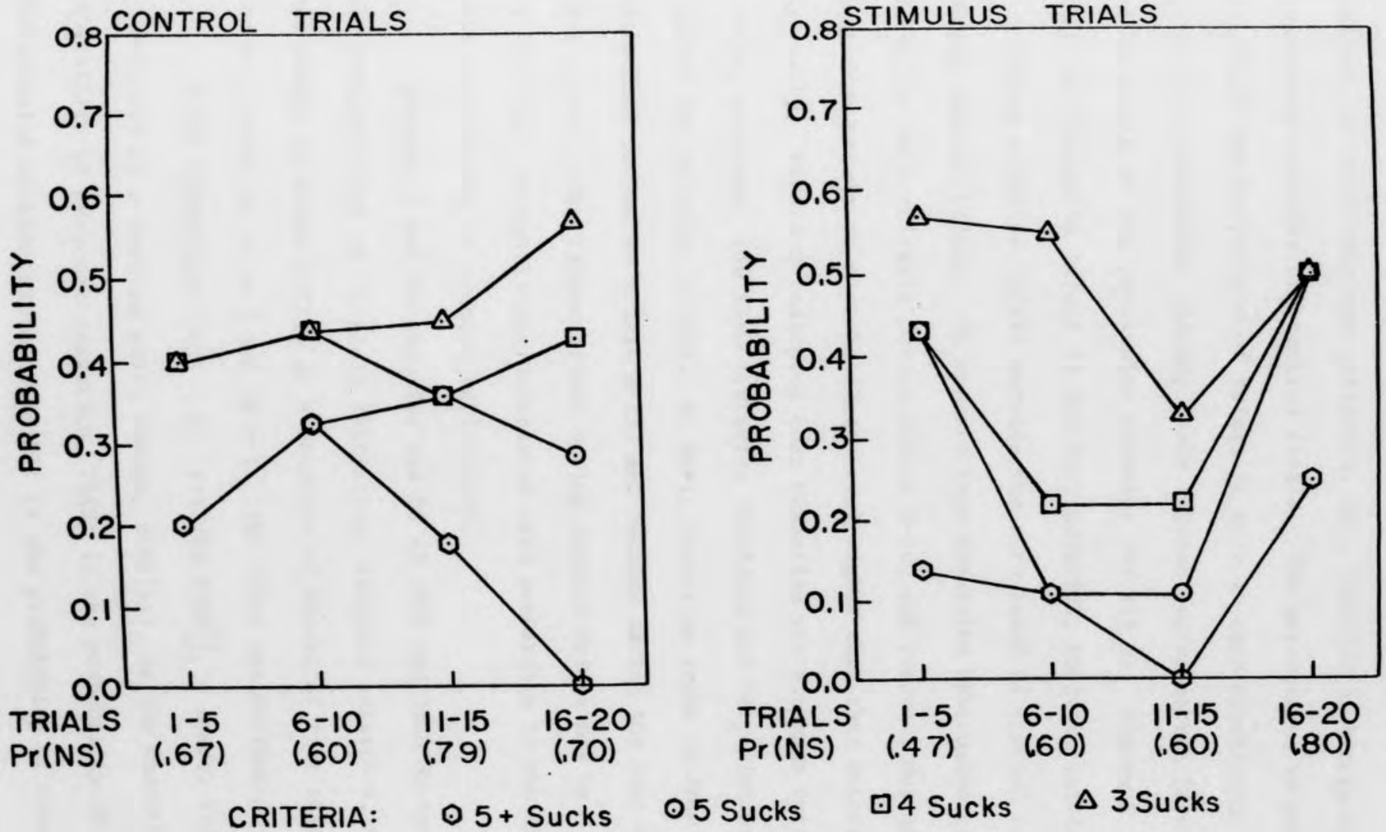

FIGURE 6. Probability of Response Initiation for 80 dB, 1KHz in blocks of five successive stimulus and control trials.

Figures 7 and 8 show the probabilities of response Cessation (NS|AS) for each response criterion, as a function of blocks of five successive stimulus and control trials. The percentages in parentheses represent the proportion of trials Ss were in each conditional state prior to stimulation. Again, these figures represent the first block of 40 trials of the particular stimulus for all Ss. Figure 7 indicates that the Cessation effect is not very powerful; however, initial responding during stimulus trials exceeds the zero level of initial responding during control trials. It appears that Cessation habituates to a zero level for both criteria during trials 6-10, and recovers during the next five trials to a probability level higher than that existing initially. Figure 8 indicates that Cessation was stronger during control trials; moreover, the NS=0 criterion functions are very similar for both control and stimulus trials. At NS=1, Cessation seems to drop out altogether (stimulus trials 6-15) and recover during the last block of five trials. The larger effect during control trials may be a function of the lower probabilities associated with membership in the AS state, thus attributing to greater variability.

Figures 9 and 10 show for the 80 dB 1000 and 3000 Hz conditions, the probabilities of response initiation, response cessation, and overall change in state P(CS), as a function of blocks of five stimulus and control trials at AS = 3 and NS = 1. The P(CS) was derived as follows:

$P(CS) = [P(NS|AS \cdot P(AS) \quad + \quad P(AS|NS \cdot P(NS)]$, where, P(CS) is the probability of a sucking state change, P(NS|AS), is the conditional probability of response cessation, P(AS) is the probability of an active pre-stimulus sucking state, P(AS|NS) is the probability of response initiation, and P(NS) is the probability of a non-sucking pre-stimulus

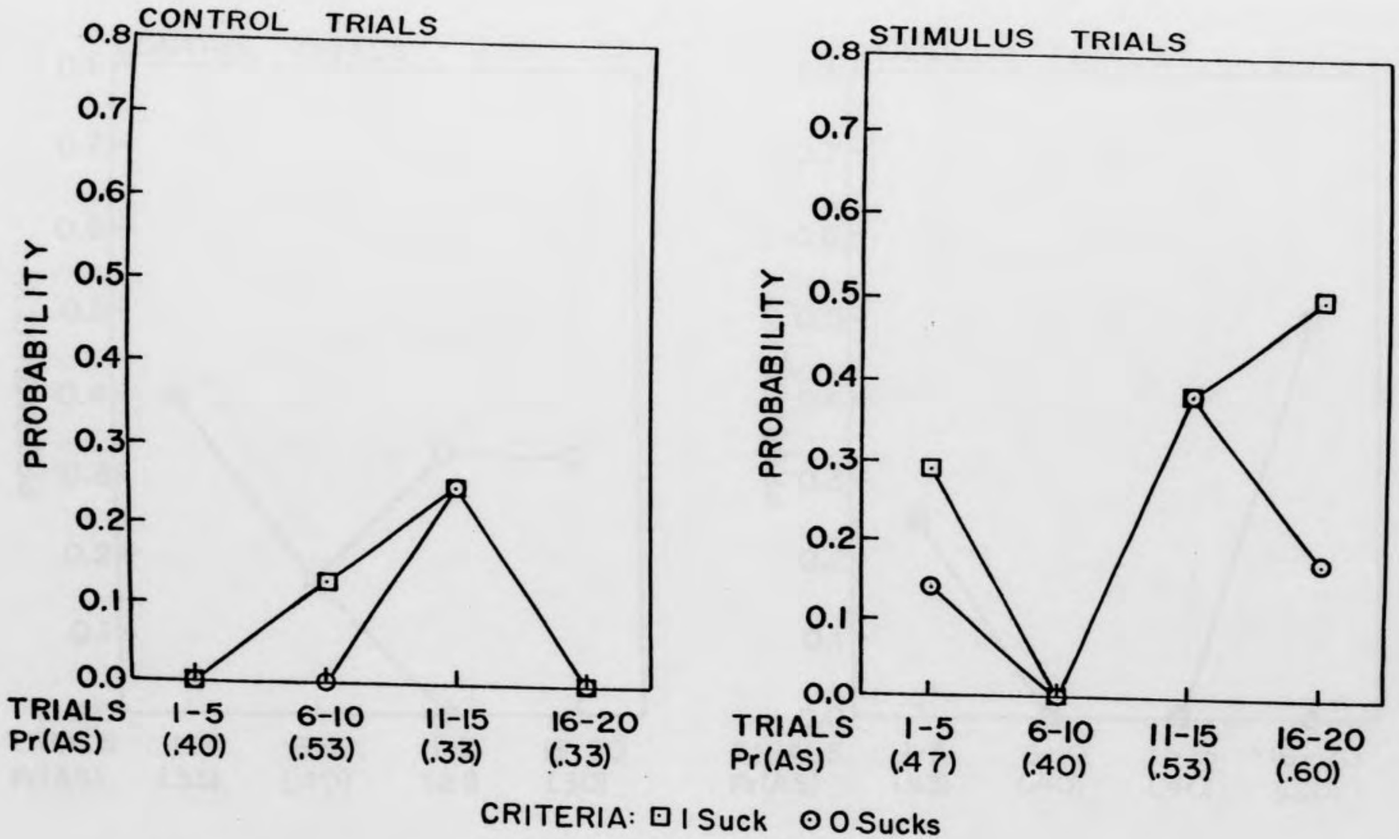

FIGURE 7. Probability of Response Cessation for 80 dB, 3KHz in blocks of five successive stimulus and control trials.

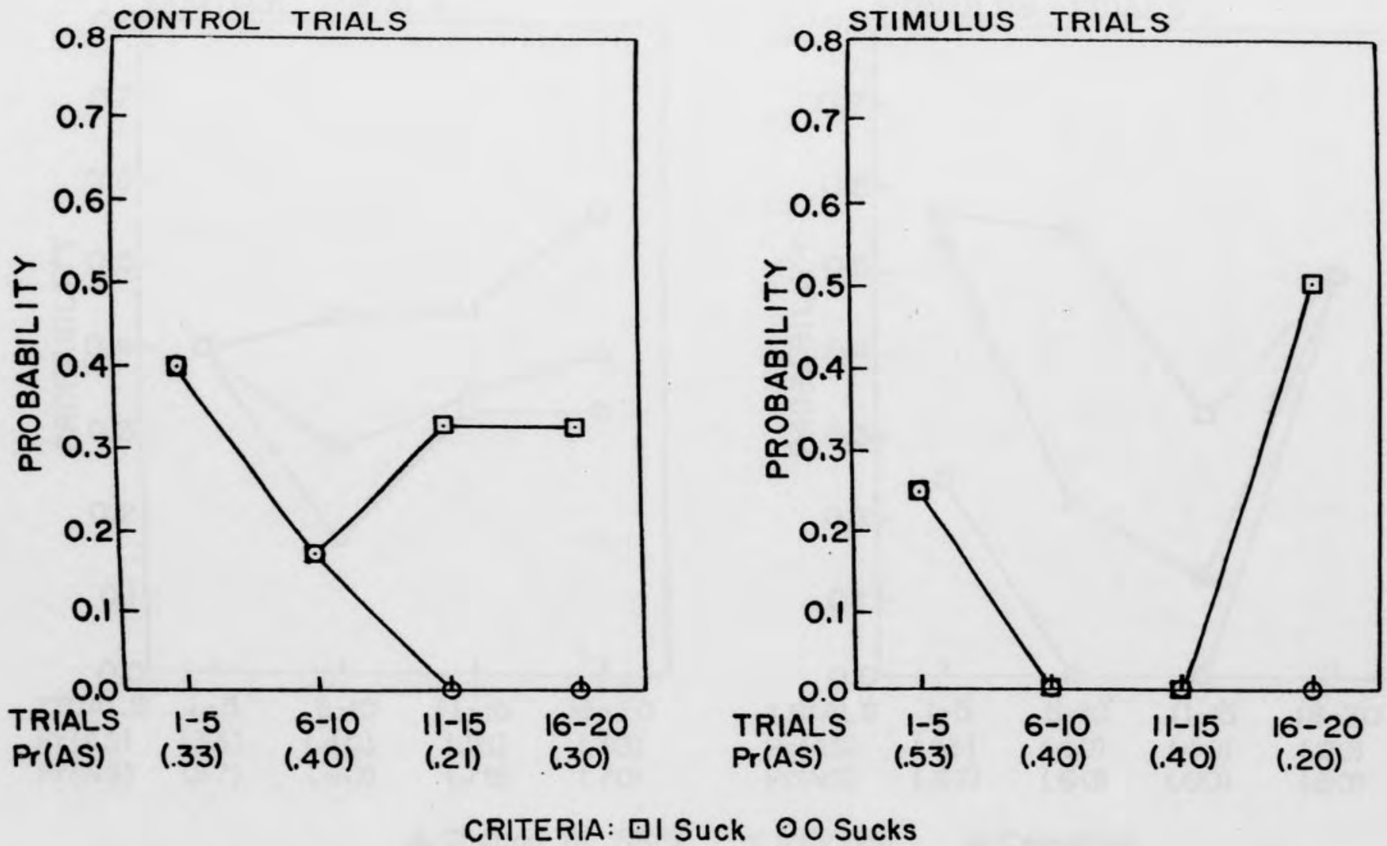

FIGURE 8. Probability of Response Cessation for 80 dB, 1KHz in blocks of five successive stimulus and control trials.

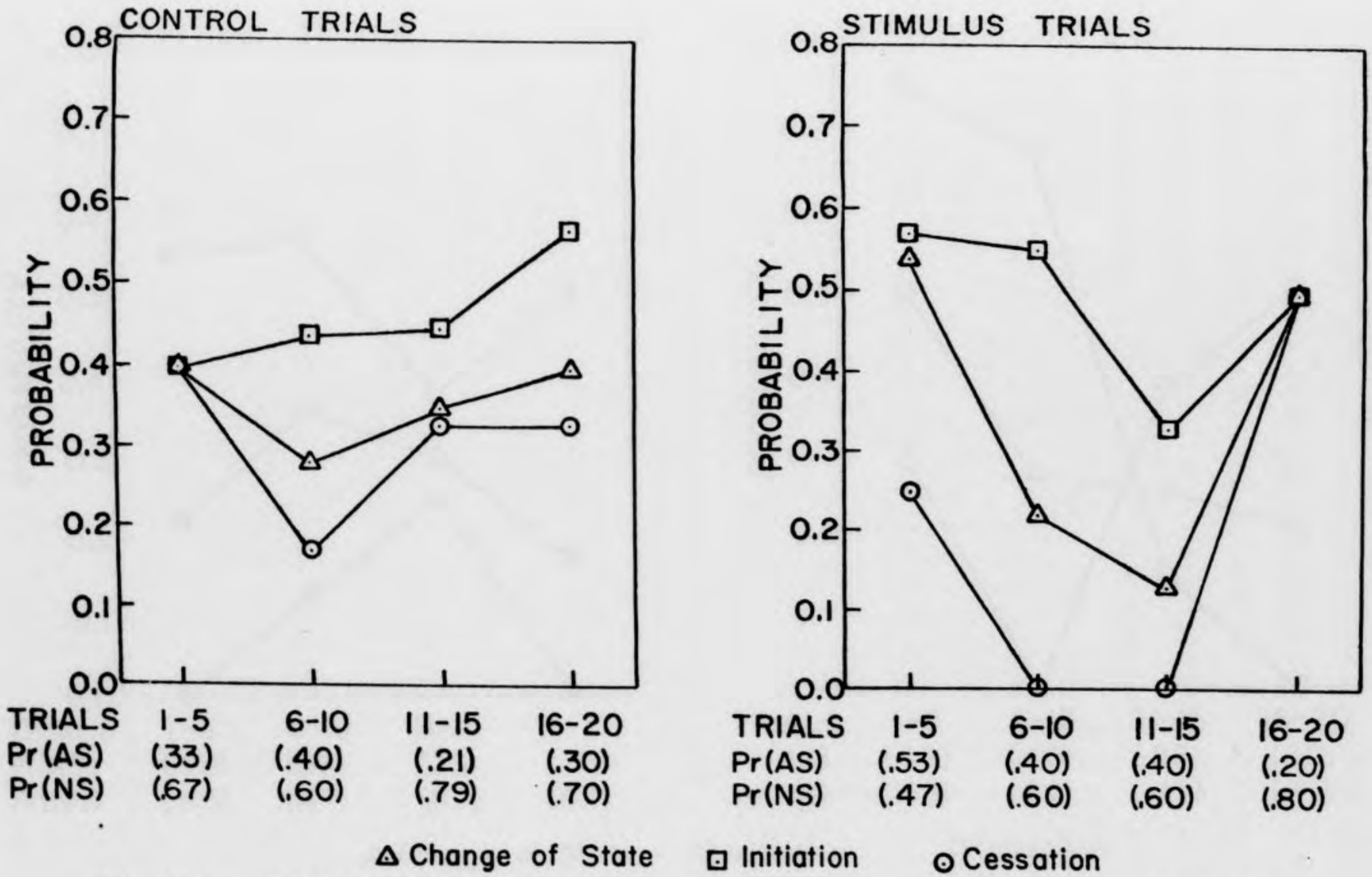

FIGURE 9. Probabilities of Response Initiation, Cessation, and Overall Change in State for only one criterion at 80 dB, 1KHz in blocks of five successive stimulus and control trials. AS=3 sucks; NS= 1 suck.

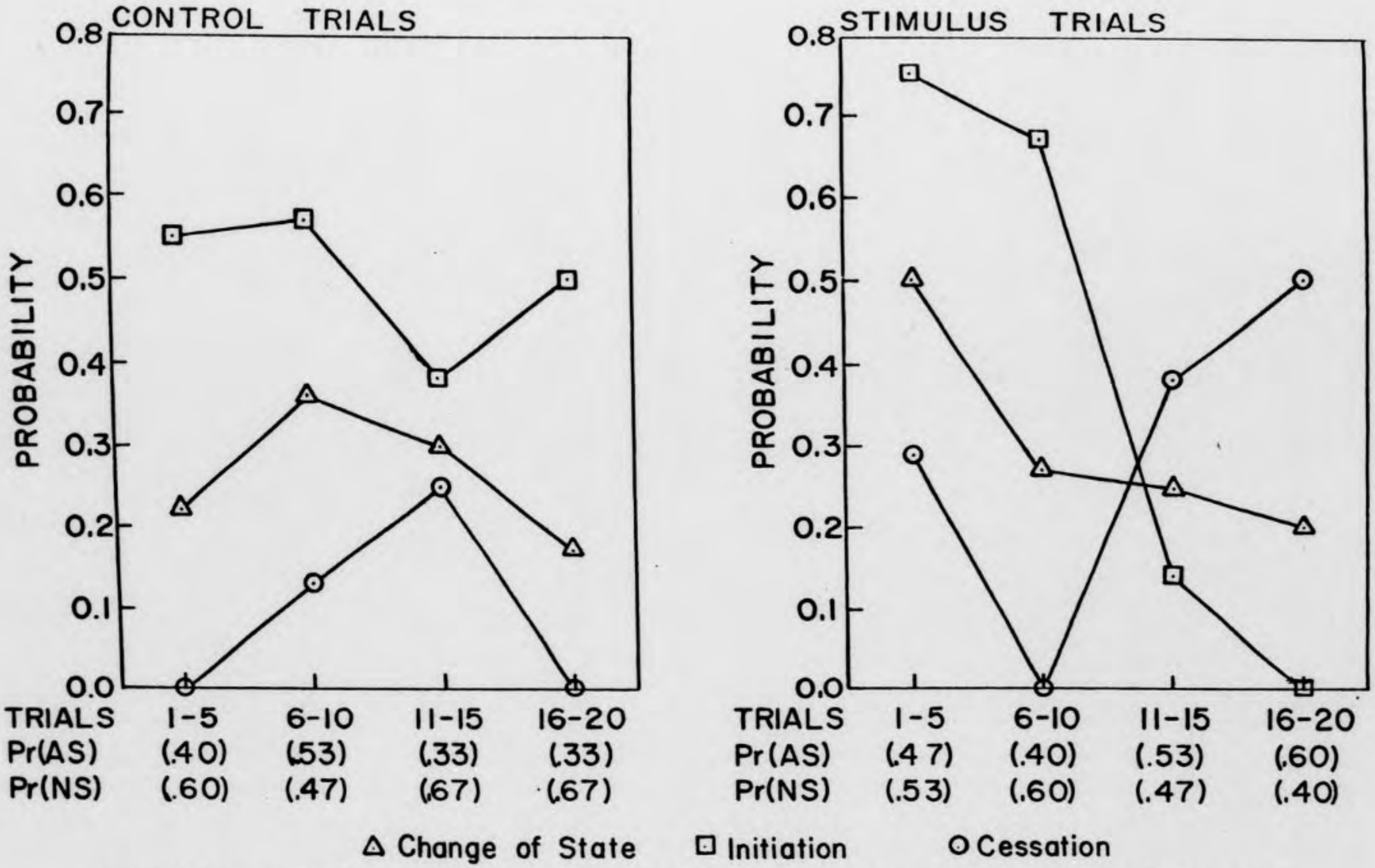

FIGURE 10. Probabilities of Response Initiation, Cessation, and Overall Change in State for only one criterion at 80 dB, 3KHz in blocks of five successive stimulus and control trials. AS=3 sucks; NS=1 suck.

state. Figure 9 shows that P(CS) for 1KHz is greater during control trials than for stimulus trials. For stimulus trials, both initiation and cessation functions seem to vary together. At 3KHz (Figure 10), P(CS) is greater during stimulus trials, and cessation seems to be increasing over trials following its original habituation (trials 6-10), while initiation seems to decrease as a function of trials.

CHAPTER VI

DISCUSSION

The present results are not in full agreement with those reported by Semb & Lipsitt (1968), who report data which support the usefulness of non-nutritive sucking cessation and initiation as discrete response indices in assessing auditory sensitivity in the neonate. Agreement between the current study using 2½ month old infants and that of Semb & Lipsitt is found, however, when only the Cessation data is considered.

Although the d' values found in the current study were lower than would be expected from the data reported by Semb & Lipsitt, differential responsivity to intensity was evidenced. In accord with Semb & Lipsitt's results, moreover, these response indices were not found to be sensitive in determining discrimination between the two stimulus frequencies employed. Further, even though a significant Frequency x Response-Criterion interaction was found ($p. < .05$), the utility index strongly suggests that it is neither a powerful nor a critically important effect. Semb & Lipsitt's comment:

> Because the groups did not respond differentially to qualitatively different stimuli does not mean that response initiation and cessation are insensitive to variation in stimulating conditions. More intense stimuli would probably produce larger liklihood ratios for both measures than less intense stimuli (p. 595, 1968).

was borne out in the present study, where d' values were higher for 80 dB than for 60 dB conditions. One might have expected the d' values in this study to have been somewhat lower than the liklihood ratios reported by Semb & Lipsitt (as well as their d' values, had they been calculated) due to an 11-dB intensity difference between the two studies. However, such large discrepancies were not expected, since the infants used in the present study were considerably older than were Semb & Lipsitt's neonates.

The sucking suppression data reported in this study, as well as its habituation and recovery after repeated stimulus presentations, seem to support the findings of Bronshtein et al. (1958). They are, however, in disagreement with the findings of Kaye & Levin (1963) and Kaye (1964, 1966), who were unable to find a reliable suppression effect. The present data are, moreover, in partial disagreement with the finding of Haith (1966) and Semb & Lipsitt (1968) who produced reliable sucking suppression effects but reported no habituation over trials. The habituation of sucking cessation found in the current study is in agreement with the findings of Keen (1964). However, Keen found less rapid habituation of sucking cessation when using a 2-sec. stimulus duration than when using a 10-sec. stimulus duration, although the latter stimulus involved a greater amount of cessation than did the 2-sec. stimulus during the earliest trials. Since stimulus duration was not manipulated in the present study, such comparisons are not possible. However, a discrepant finding is that the generally rapid habituation found in the present research, and found to an even greater degree by Bronshtein (1958) was not found by Keen; furthermore, a zero cessation level of responding was never reported. This inconsistency may be a function of the smaller amount of variability associated with the smaller number of subjects used in the present study, as well as the relatively small number of times Ss were in an AS state prior to stimulation.

Comparison of the present results with those reported by Sameroff (1970) is difficult because of several procedural differences. Sameroff defined a sucking burst (comparable to AS) as two or more sucks, where the present research considered two sucks as neither AS nor NS. Sameroff's "interval stimulation", although analogous to the present NS state, was one sec. shorter, and his experimental procedures and stimulus conditions were not comparable. Although Sameroff reported reliable shortening of sucking bursts in three month old infants following stimulus onset, he reported no habituation across trials, subjects or sessions. However, close inspection of his data (Sameroff, 1970, p. 116) seems to indicate that although the burst concurrent with the stimulus was shortened (stimulus onset), average responding returned to a baseline level during the next burst (while the stimulus was still in effect). It might be concluded that suppression habituated within each trial.

The habituation of cessation reported in the present study was not expected in light of the procedure employed. By using a relatively long inter-trial interval, as well as by varying the times between signal trials, one would have expected to reduce the occurrence of habituation over trials (see Bridger, 1961). The habituation data presented here was based on only one block for (40 trials) all three Ss. Combining the data for all three blocks for each subject was not possible however, due to incomplete data for one S.

The present results on sucking Initiation seem to be in strong disagreement with those of Semb & Lipsitt (1968), who found that response initiation in the presence of NS was more prevalent than response cessation in the presence of AS. Procedural differences between this and other reported research may account for some of these inconsistent findings. The paucity of good developmental studies on auditory sensitivity in infants opens the question concerning the importance of the age variable. With a few exceptions (Bronshtein, 1958; Sameroff, 1970), research using the sucking response in determining the effects of acoustic stimulation have used neonates as subjects. Thus, the question of whether developmental factors may be responsible for data discrepancies across researchers is still left unanswered.

Closely related to developmental factors in neural organization and consequent responsivity in older infants, is the idea that the investigation of two discrete responses under the control of the same stimulus may be a complicated form of learning for the infant, and therefore, it is possible that independent investigations of the responses of cessation and initiation would have yielded higher d' values for the older infant (Erickson, 1973).

Finally, stimulus differences across researchers may yet be the most critical variable in explaining the discrepancies found in regard to other reported research. There exists a large body of evidence which supports the notion that using pure tones to investigate auditory sensitivity in infants may be a less fruitful approach than the use of a more complex stimulus. That infants from birth onward are capable of responding to complex tonal arrays has been well documented (Eisenberg, 1970; Turkewitz, Birch, Moreau, Levy & Cornwell, 1966; Turkewitz, Moreau, Birch & Davis, 1971). However, in attempting to identify the specific aspects of the auditory spectrum to which infants are most responsive, Turkewitz, Birch &

Cooper (1972), using the dependent variables of directional eye turning, finger movements, and cardiac acceleration, compared the effects of white noise and a variety of pure tones (250-8000 Hz) at 90 dB SPL and found that the control of responsivity is not that well identifiable. The white noise stimulus was more effective in eliciting all three responses than were any of the pure tones. None of the pure tones had any effect on the dependent measures with the exception of a weak effect of the 250 Hz tone on finger movements. When the same pure tone stimuli were produced at lower intensities (50-80 dB SPL), the results were identical. From these data the authors concluded that "although the newborn is responsive to complex auditory stimuli (such as white noise), pure tones at equal sound pressure levels are not effective in eliciting responses." These results are supported by a great deal of research (Eisenberg, Griffin, Coursin, & Hunter, 1964; Hutt, Hutt, Lenard, Bernuth, and Muntjewrff, 1968; Lenard, Bernuth, and Hutt, 1969) which indicate that complex stimuli and square-wave stimuli are more effective than sine-wave stimuli in the production of auditory sensitivity. Furthermore, for newborns and infants up to one year old, pure tones have been found to be consistently weaker in the production of responses, when compared to speech or other complex stimuli, regardless of the intensity level at which the stimuli were compared (Thompson & Thompson, 1972; Hoverston & Moncur, 1969; Eisenberg, 1965). None of the aforementioned research, has however, used the sucking response as a dependent variable.

It is significant to note, however, that problems do arise when using complex tones (such as the square-wave stimuli employed by Semb &

Lipsitt, 1968): it is not clear which aspects of the tone are effective, since a change in frequency alters the harmonics as well as the fundamental. To add to the complexity of the problem, recent research has indicated that pure tones may in fact be effective elicitors of auditory responsivity in newborns,when prolonged rise times are employed in stimulus generation. This becomes more interesting in light of the fact that pure tones having very short rise/decay times produce perceptual and physical clicks, which directly, yet unintentionally may control responding (Kearseley, 1973). This is due to the fact that a pure tone becomes a complex tone when the rise and decay time is fast. Such artifactual control has been evidenced by the work of Leventhal & Lipsitt (1964).

The Cessation results found in the present research take on more significance when one considers responsivity under the control of sinusoidal-stimuli. Since past researchers have been more successful with complex stimuli, when younger Ss were used, an obvious question is, when developmentally, are pure tones as effective as complex tones, and what type of auditory experience is necessary on the part of the infant, to insure such effectivenss.

Less obvious differences extant in the conflicting research include the mode of stimulus presentation: Semb & Lipsitt presented a single brief stimulus; Bronshtein (1958) and the present investigators presented a brief repeating stimulus; Sameroff (1970, 1971) presented a continous tone over a long time interval. It is not clear that the same results should be expected when comparing these three methods of stimulus presentation, yet comparisons among investigators have been made without this consideration being foremost in the contrasts.

At the present time, it must be concluded that the usefulness of almost all the previously discussed response indices is extremely conditional. It is certainly procedure and stimulus bound, when neonates are used as Ss (i.e., response contingent presentations of complex tones), and is at best, equivocal when using older infants. Obvious questions which require consideration include: (a) the usefulness of sucking initiation and cessation when using complex tones testing older infants, (b) the separate and independent consideration of the responses of initiation and cessation, when using older infants, and(c) the determination of the limits of the utility of these response indices with neonates and older infants, by a rigorous investigation of various stimulus parameters.

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