INDIVIDUAL DIFFERENCES IN INFANT ORIENTING AND CONDITIONING

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Individual Differences in Infant Orienting and Conditioning

by

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Abstract

Conditioned discrimination and discrimination reversal of the skin potential response was attempted in three-month-old infants. In addition to conditionability, a major focus of the study was to investigate the extent to which individual differences in orienting response magnitude predicts condition-ability. A delayed conditioning procedure was used in which CS onset preceded UCS onset by 5 seconds, UCS duration was 1 second, and CS and UCS terminated simultaneously. The CSs were 75 db 500 Hz and 1000 Hz square wave tones. The UCS was a 5 psi air puff delivered to the infant's cheek. The results indicated that there were substantial individual differences in conditionability. Moreover, there was a strong relationship between OR magnitude and conditionability. Although there was a lack of a predominate response wave form, both components of the skin potential response showed evidence of conditioning. The results provide strong support for the occurrence of autonomic conditioning in young infants. Moreover, the results also

suggest the existence of a relationship between the magnitude of the OR and individual differences in conditionability.

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Eben Ingram

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This thesis is dedicated to my wife Judy and my daughter Edith.

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Introduction

The concept of the orienting reflex (OR) was introduced by I.P. Pavlov as an investigatory response elicited by novel stimulation or by a change in ongoing stimulation. The OR is "non-specific" in that qualitative, intensive, or temporal changes in stimulation all serve as eliciting stimuli (Sokolov, 1963a). In general, the OR assumes one of two forms, generalized or local. Both forms consist of somatic, autonomic, electroencephalographic, and sensory components (Brackbill & Fitzgerald, 1969). While activation of several sensory analyzers involves the generalized OR, activation of the local OR is confined solely to the analyzers directly stimulated. (Sensory analyzers refer to the whole analyzing apparatus of the nervous system, which includes receptors, transmitting apparatus, and cortical centers).

According to Sokolov, the presence or absence of the OR is a function of cortical matching or mismatching of stimuli. A neuronal model preserves information about the characteristics of a stimulus. Thus, the individual compares at the inferred level, the earlier occurring stimulus. Supportive evidence for Sokolov's neuronal model has been offered by Lovibond (1969), who demonstrated that the rate of OR habituation is negatively related to the uncertainty of stimulation. Moreover, Zimmy and Schwabe (1966) demonstrated that the habituated OR is restored by the appearance of novel stimuli.

The functional significance of the OR is found in the increased discriminatory powers of the sensory analyzers, thus providing optimal conditions for stimulus receptivity. This increase in receptor sensitivity effects the reactivity, the sensitivity, and the lability of both the central and peripheral parts of the analyzers (Sokolov, 1963b), for example, the lowering of sensor thresholds. Because of these functional properties, the OR is held to play important role in learning. For example, Sokolov proposes that elicitation of an OR facilitates conditioning.

Maltzman and Raskin (1965) suggest that extensive pre-adaptation of the OR, resulting in the extinction or habituation of the OR to the CS, retards subsequent conditioning. Their study brings a point of interest to those focusing on the relationship of the OR to conditioning. However, their contention is challenged by Kimmel and Greene (1964) who demonstrated that the OR is disinhibited by the presence of an extra stimulus. Thus, in the conditioning paradigm, the pairing of the CS and UCS produces a novel stimulus situation, restoring the OR. In addition, Zimny and Schwabe (1966) have demonstrated the restoration of a previously habituated OR by the presentation of a novel stimulus. Using a classical discrimination paradigm Zeiner (1970) compared GSR magnitude in a group of Ss that received habituation trials prior to conditioning, with a group that did not. Zeiner found no significant difference between groups on response magnitude to CS+ and CS-. The problem of preadaptation arises for only one reason, habituation of the original response to the CS prevents its being confused with the conditioned response (CR) (Beecroft, 1966). Therefore, considering Zeiner's finding of no effects due to preadaptation, the problem of over extensive habituation prior to conditioning should be approached in terms of the possibility that the OR cannot be habituated to the extent of significantly affecting the course of CR acquisition.

Levels of the OR are related to the ability to discriminate between stimuli rather than as an energizer of performance (Maltzman and Raskin, 1965). Since the OR is an abstract concept not directly measured, the occurrence of an electrodermal response cannot be taken unequivocally as a measure of any abstract concept. The electrodermal responses are only dependent variables elicited by a variety of antecedent conditions (Maltzman & Raskin, 1965). Moreover, there are a variety of OR measures, both behavioral and physiological.

Measures of the OR are not simply specific to peripheral responses, but are presumably reflect central processes (Brackbill, 1971; Maltzman & Mandell, 1968). For example, Brackbill found that although orienting responses were elicited in an anecephalic infant, habituation did not occur.

Presumably the cortex must be functional in order for habituation or response inhabition to occur. Maltzman & Raskin (1965) found reliable differences in OR magnitude between "aware" and "unaware" subjects as differentiated by tests given following semantic conditioning of GSR. The basic premise underlying these findings was first set forth by Pavlov through his concept of nervous system lability. This concept refers to individual differences in the quality of nervous system functioning (Pavlov, 1927). Certain relatively recent studies have found evidence to support this premise. Birch and Demb (1959) found that retardates required a significantly greater number of trials to acquire a conditioned GSR response than did normal subjects. Moreover, lower IQ retardates have been found to demonstrate lesser magnitude GSR responses than higher IQ retardates, and also to be generally less reactive than normals (Grings, Lockhart & Dameron, 1962; Karrer & Clausen, 1964). By using concepts of nervous system function, Pavlov demonstrated the relationship of intelligence to learning. He proposed two levels of nervous function; the first and second signal systems. It is through the interaction of the two systems that intelligence or capacity--associated with the second system--may influence the "vegetative" responses of the first signal system.

In terms of classical GSR conditioning, Stewert, Stern, Winokur, and Fredman (1961) feel that many researchers unsuccessful in demonstrating classical conditioning of the GSR, failed to employ proper controls. They feel that the CR may represent only an augmented response to the CS or the return of the OR. They comment on the lack of a "true" acquisition function, i.e., the failure of the learning curve to increase to an asymptote and remain constant. Stewart _et al_., argue that the galvanic CR is defined by its latency, in that it should appear at or in the neighborhood of the UCS onset on test trials. Nonetheless, latency as the sole criterion for conditioning appears to be inadequate. Lockhart & Grings (1963) computed a correlation coefficient from the data in the Stewart _et al_. study, and found a correlation of .90 between the frequency of ORs which occur early in the CS-UCS interval, and the response considered by Stewart _et al_. to be the true CR, which occurs late in the interval, near UCS onset. However, according to Stewart _et al_. the expected correlation should have been very low, thus the high correlation reported by Lockhart and Grings suggests that anticipatory GSRs are merely another form of sensitized response.

In response to the problem of distinguishing between sensitization and conditioning, Grings, Lockhart and Dameron (1962) have proposed the use of the discrimination paradigm. Grings _et al_. feel that this procedure will permit a more clear distinction among orienting, sensitization, and pseudoconditioning more effectively than is possible to obtain using simple conditioning procedures. The basic assumption involved in the use of the discrimination paradigm is that before pairing, the response amplitude to the test and control stimuli is equal and becomes different only after pairing of the CS and UCS. An additional requirement is placed on the difference in magnitude between the test and control stimuli as a function of increased pairings of the CS and UCS. It is assumed that if the difference between the test and control stimuli (CS+ and CS-) are the same at the beginning of the discrimination conditioning, then as the discrimination progresses, the difference in responding should also increase; this increase is presumably due to learning.

In terms of Stewart et al.'s contention that most researchers have merely demonstrated augmented ORs, Dykman (1967) feels that there is no justification for assuming that an augmented OR is not an effect of conditioning, if the augmentation persists over trials as was the case in the research critized by Stewart et al. Kimmel (1964) notes that the discrimination paradigm allows one to distinguish between specific and non-specific sensitization. He also considers the OR to be a CR should significant changes be demonstrated through the use of control procedures.

In his literature review, Dykman (1967) concluded that the basic mechanism of learning is sensitization, suggesting that the responses that occur depend on the pathways excited. It is apparent, therefore, that the conditioned GSR may take one of several forms. This is illustrated in a study by Lockhart (1966), who found an additional GSR response that occurred in the UCS interval on test trials when the UCS was absent (i.e., a temporarily conditioned response or an OR to signal absence).

Methods of recording electrodermal activity. There are two methods of recording electrodermal activity, and of these, the resistance method has been more widely used than the potential method. This is due in part to the fact that the resistance method yields a unidirectional response. Even though the potential method has not been used as extensively, it is generally assumed that it reflects the same processes as does the resistance method (McCleary, 1950; Woodworth & Schlosberg, 1954). Wilcott (1958) reported high correlations between skin potential and skin resistance responses. He used mental multiplication and word association tests as stimuli. Correlations of .95 were found between the two electrodermal measures. Gaviria, Coyne and Thelford (1969) obtained high correlations between change measurements and prestimulus levels (.87 for males, and .94 for females).

Several studies have demonstrated the relationship of skin potential (SP) to the OR. For example, Raskin, Kotes and Bever (1969) found a direct relationship between stimulus intensity and magnitude of the positive wave of the SP response. Autonomic responses were recorded to a number of stimulus intensities (auditory stimuli), and it was found that the higher intensities (120 db) produced larger positive wave responses and a greater amount of positive wave activity. Previous research (Forbes & Bolles, 1936; Uno & Grings, 1965) has shown that high intensity stimulation more readily evokes the positive wave of the SP response than does low intensity stimulation. Raskin (1969) consider the occurrence of the positive wave in relationship to high intensity stimulation to indicate that the positive wave may be a component of the defensive reflex (DR) since it follows the relationship proposed by Sokolov, between stimulus intensity and the type of response evoked. Sokolov (1960) reported that novel stimuli initially produce ORs which are more resistant to habituation at higher intensities of stimulation. Raskin *et al.* found that consistant with Sokolov's finding, the negative wave of the SP response habituated more rapidly with lower stimulus intensities than with high.

Edelburg (1963) reports findings in support of Raskin's position, that the negative wave is the SP component of the OR. Shaver, Brusilow and Cooke (1962), using microelectrodes inserted in the sweat ducts, found that the SP responses were negative in direction. Edelburg concluded that there was sufficient evidence that the positive and negative components are of independent origins and show stimulus-response specificity.

Infant conditioning. Recent reviews of the literature on infant learning clearly show that human infants are conditionable (see Fitzgerald & Porges, 1971; Brackbill & Koltsova, 1967). However, the data on autonomically conditioned responses is meager in comparison with data on somatically mediated responses. In the classical conditioning paradigm Kasatkin et al., (1953), Koch (1965), Kaye (1965),Lipsitt and Kay (1964) and Lintz, Fitzgerald and Brackbill (1967) have obtained evidence demonstrating conditioning of somatically mediated responses such as the Babkin reflex, sucking, eye blinking, and head rotation. The major extent of the conditioning of autonomically mediated response in infants has been done by Brackbill and Fitzgerald (Brackbill & Fitzgerald, 1969; Brackbill, Fitzgerald & Lintz, 1967; Brackbill, Lintz & Fitzgerald, 1968; Fitzgerald, Lintz, Brackbill & Adams, 1967; Fitzgerald & Brackbill, 1971). Their studies involved conditioning of pupillary reflex dilation and constriction to auditory, tactile and temporal stimuli. Jones (1930) reported conditioning of the GSR in nine-month-old infants using auditory, tactile, and visual stimuli with electroshock as the UCS. Although the combined results of these studies are by no means conclusive, they are suggestive that autonomic conditioning in infants is possible.

Individual differences in infant learning. Two major issues concerning infant conditioning have arisen in the past ten years. The first issue is that Soviet researchers contend that there is an immutable developmental order for CS effectiveness during early infancy (Brackbill & Koltsova, 1967). The second issue concerns the role of the

CS in conditioning. Here again the Soviets define an all important role to the CS in that it predicts the course of conditioning, independent of the response and UCS (Brackbill & Fitzgerald, 1969). Considering the evidence reported in their review, Fitzgerald and Porges (1971) find both Soviet contentions "questionable." In addition to the above issues, a third issue can be identified--largely by the lack of attention it has received--and this is the area of individual differences in early conditioning.

Human infants are bombarded by stimuli in all sensory modalities, thus assessment of the infant's ability to coordinate his behavior around these stimuli would involve examining the relationship between the infant's initial response to stimulation (the OR) and the learning processes underlying his association of his behavior to external stimulus input. Maltzman and Raskin have provided evidence to suggest a relationship between the OR magnitude and condition ability in human adults. For human infants, this question has not even been asked.

Moreover, questions arise as to the existence of individual differences in autonomic activity during infancy as well as the more specific question of the relationship of individual differences in autonomic function to learning. Such questions have not gone completely unnoticed. Several authors have reported observations of differences in autonomic activity in infants (Lipton, Steinschneider & Richmond, 1961; Bridger & Reiser, 1959; Steinschneider, 1957). Lipton *et al*. theorize a relationship between these differences in autonomic function and psychosomatic disorders, activity level and such constructs as "adaptive capacity." Thus, questions as to the relationship of individual differences to other aspects of the infant's performance have been, at most, answered by speculative generalizations rather than by empirical test.

The present study has attempted to provide just such an empirical examination. The method of approach consists of determining for a group of infants, the magnitude of the OR and assessing its relationship to conditioning as a means of testing the hypothesis that individual differences in infant orienting behavior will be related to individual differences in conditioning of an autonomic response.

Method

Subjects

Twelve full-term, clinically normal infants (6 boys and 6 girls), drawn from the resident population of metropolitan Lansing and surrounding townships, served as subjects (*S*s). The infants' ages at the beginning of experimentation ranged from 84 to 135 days (M = 112 days, Md = 102 days). Subjects were brought to the laboratory on five consecutive days for a one hour session. The time of the experimental session for each S on each day was constant in order to avoid any confounding effects due to variation in biological rhythms. Subjects were randomly divided into two groups, with the exception that there were an equal number of males and females in each group.

Apparatus

Skin potential (SP) was recorded on a Grass Model 7 polygraph with Beckman Bio-Potential electrodes. The apparatus for the delivery of the stimuli involved an air tank filled with compressed air, a Hoke regulator valve, and a Hunter Silent Solenoid. The UCS was a 5 psi air puff delivered through a piece of 1/8 inch diameter surgical tubing. The CSs were 500 and 1000 Hz tones delivered at 75 db through a 10 inch Allied speaker. The tones were generated by an Eico noise generator. All intervals, stimulus durations, stimulus onset and offset were controlled by Hunter decade interval timers.

Design and Procedure

The UCS for skin potential discrimination conditioning was an air puff of 1 second duration delivered through a rubber tube at 5 psi to the infant's left cheek, from a distance of two inches. The CSs were 500 Hz and 1000 Hz tones presented through a ten-inch speaker located above and to the front, three inches from S's head. CS duration was six seconds. The CS-UCS interval was five seconds, involving a delay procedure, UCS and CS terminated simultaneously. The intertrial interval (ITI) varied randomly among 15, 20, 25 and 30 seconds, to avoid any possibility of temporal conditioning.

Each S appeared at the laboratory accompanied by at least one parent, to whom a description and explanation of the experiment was given, and from whom final permission for S's participation was obtained. Care was taken to assure that permission was granted only after parents clearly understood the exact nature of the experiment. The infant was then placed into an infant crib constructed of 35 x 15 x 15 in. clear 1/4 in plexiglass with a foam rubber pad and changeable covers as a reclining surface. The crib was located inside a sound-attenuated booth (ambient noise level = 30 db). The electrodes were then placed as follows: The active electrode was placed on the arch of the foot half way between the ankle and the first phalange; the referent electrode was placed over the tibia bone, one-eighth of the way up on the shin between the ankle and knee; the ground electrode was placed on the outside of S's upper thigh. The skin surface at each electrode site was prepared with 70 percent ethanol alcohol pads, abrading slightly at the active site. An electrolye paste was used between the electrode and the skin at the placement sites.

The experimental procedure was divided into three parts: habituation, discrimination training, and discrimination reversal. Table 1 illustrates the experimental design. Subjects were divided into two groups. Each Group I S received the 1000 Hz tone as CS+ and the 500 Hz tone as CS-. For discrimination reversal the 500 Hz tone was CS+ and the

TABLE 1

Experimental Design

	Experimental Sessions				
	1	2	3	4	5
	Habituation	Conditioning		Reversal	
Group 1 N = 6	CS+ & CS- (Mixed)	CS+ 1000 Hz CS- 500 Hz		CS+ 500 Hz CS- 1000 Hz	
	20 trials minimum	30 trials daily		30 trials daily	
Group 2 N = 6	CS+ & CS- (mixed)	CS+ 500 Hz CS- 1000 Hz		CS+ 1000 Hz CS- 500 Hz	
	20 trials minimum	30 trials daily		30 trials daily	

1000 Hz tone CS-. The conditions for each Group II S were just the opposite of those for Group I. Subjects in Group II received the 500 Hz tone as CS+ and the 1000 Hz tone as CS-; during reversal, the 500 Hz tone was CS- and the 1000 Hz tone was CS+.

During session 1, all Ss received habituation trials which consisted of mixed presentations of either the CS+ or the CS- on each trial, randomized according to a Gellerman Series. All Ss received at least 20 habituation trials, except those requiring more than 20 trials to meet the habituation criterion of two consecutive non-responses to the same stimulus.

Session 2 was the first session devoted to conditioning. Each S received a minimum of 15 presentations of UCS and CS+ paired, and a minimum of 15 presentations of CS- alone, for a total of 30 trials minimum (30 trials proved to be the minimum possible run before infant state changes caused cessation of the session, however, some Ss allowed more trials under the same state - quiet awake and active awake).

Session 3 was devoted to conditioning with each S receiving the same number of minimum trials as in session 2.

Sessions 4 and 5 differed from sessions 2 and 3 only in that discrimination reversal took place. In session 4, each S received a minimum of 15 paired presentations of the UCS and CS+, and a minimum of 15 presentations of the CS- alone for a minimum total of 30 trials. Session 5 was the same as session 4.

Inside the experimental booth were S and two experimenters. One experimenter recorded minute by minute judgements of infant state on the 6-point scale developed by (Brackbill & Fitzgerald, 1969), (See Appendix A.) The other experimenter attended to the infant's needs. A third experimenter, located in another room, operated the recording apparatus, stimulus programming apparatus and UCS delivery system.

Response Reduction

A distribution of the magnitudes of the SP response evoked by the first tone (always a 1000 Hz tone) presented at the beginning of the habituation session was made, and Ss above the median were designated High Orienters while Ss below the median were designated as Low Orienters. SP was scored according to a method devised by Raskin et al. (1969). SP was calculated in mV change from the negative and positive components. The negative component was calculated in millimeters of pen deflection towards the top of the recording chart. The positive component was calculated using the same units as the negative component, however, pen deflection toward the bottom of the recording chart was considered a positive response. The calculations involved scoring the first wave as the peak change from base level at response onset and the second as a change from the peak of the first. In order to avoid scoring recovery phenomenon as response activity, the second wave was scored only if it reached its peak within 3 sec. of the preceding peak (pl). To be scored as SP, the response must occur within a period of 5 seconds following CS onset. In the case of shifting base levels, Peak level (pl) is to be scored from the point at which the slope changes. A value of 0 is assigned to the point of response onset, and peaks at maximum response levels in either direction of the zero point are measured in mm. (positive or negative).

A difference score was then computed for each S. The difference score consisted of the mathematical difference between the magnitude of response to CS+ and the magnitude of response to CS-.

Results

Habituation. In order to demonstrate conditioned discrimination, it is necessary to demonstrate an increase in response magnitude over trials to the stimulus serving as CS+, while the response magnitude to CS- remains the same or shows a decrement over trials. Prior to the experimental manipulations, the response magnitude to the stimulus later to serve as CS+ was found by the related measures *t*-test not to differ significantly from the response magnitude to the stimulus later to serve as CS- ($t = .05$, df = 11). Since the response magnitudes were initially at the same level, any differences occurring during the subsequent course of conditioning should be due to the experimental manipulations.

Each *S*'s response during the habituation period was analyzed by dividing the habituation trials into two blocks of 10 trials each. The first block of 10 trials consisted of the first 10 habituation trials; the second block consisted of the last 10 trials. Mean response magnitude of the first block of trials was then compared with the mean response magnitude of the last block of trials. The related measures *t*-test indicated a significant decrement in response magnitude ($t = 3.04$, df = 11, $p < .05$), indicating that response habituation occurred (see Figure 1).

Conditioned Discrimination

Over all effects. As indicated in Table 2, 11 of 12 *S*s demonstrated higher response magnitude to CS+ than to CS-.

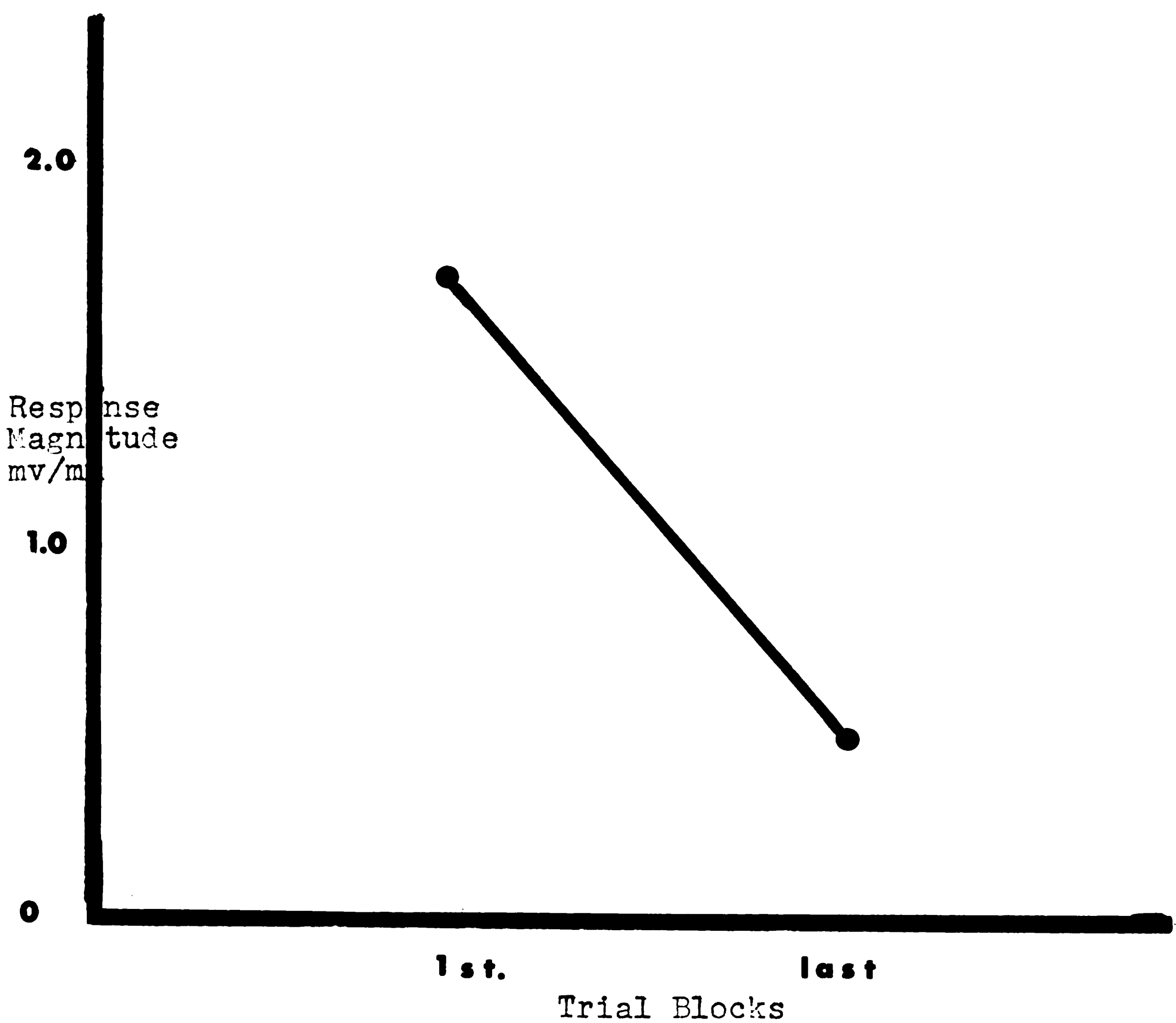

Figure 1

Mean response magnitude to the stimuli to serve as CS+ and CS- for the first and last block of 10 trials during habituation for all Ss.

To test for conditioned discrimination, mean CS+ response magnitude (1.31 mu) was compared to mean CS- response magnitude (.68 mu). This difference was significant ($t=5.73$, $df=11$, $P < .001$) indicating significantly greater response magnitude to CS+ than to CS-.

Individual differences. For each S, all trials from sessions 1 and 2 were combined and then divided into blocks of 10 trials. Each block of 10 trials contained five CS+ trials and five CS- trials. Conditioning was determined by comparing the mean response magnitude of the CS+ trials with the mean response magnitude of the CS- trials. The criterion for conditioning was that the magnitude of the response to the CS+ trials be significantly greater than the magnitude of the response to the CS- trials. As indicated in Table 3, conditioning was demonstrated in six of 12 infants.

Subjects were initially divided into two groups on the basis of the frequency of the tones serving as the CS+ and CS- during discrimination training. The data from these two groups was analyzed, and is summarized in Table 3. The analysis consisted of a comparison between the two groups on response magnitude to CS+ and CS-. As seen in Table 3, no difference of any significance was found between these groups. In view of the lack of significant effects for this initial subject grouping, additional groupings were formed and analyzed.

TABLE 2

Mean response magnitude for each S to the CS+ and CS- during the discrimination phase

Subject	Mean response magnitudes (mu/mm)				
	CS+	CS-	df	t*	P
1	1.03	0.28	5	2.75	$<$.05
2	2.21	1.05	6	3.20	$<$.05
3	1.79	0.73	5	3.66	$<$.05
4	1.08	0.18	5	8.65	$<$.001
5	1.26	0.40	8	5.24	$<$.001
6	1.44	0.56	4	3.07	$<$.05
7	1.32	0.99	7	1.77	NS
8	1.88	1.13	7	1.86	NS
9	0.56	0.58	8	0.13	NS
10	1.00	0.84	10	0.47	NS
11	0.92	0.53	7	1.46	NS
12	1.25	0.89	6	1.35	NS

*Related measures t.

TABLE 3

Analysis of between groups mean response magnitude to CS+ and CS- across all conditioned discrimination sessions

	Mean response magnitudes (mv/mm)				
	Group 1	Group 2	df	t*	P
CS-	0.793	0.566	10	0.911	NS
CS+	1.386	1.236	10	0.551	NS

*Independent groups t.

As seen in Table 2, six of 12 Ss demonstrated conditioning, thus the first comparison made was between those Ss who evidenced conditioning and those who did not show evidence of conditioning. Three comparisons were made: (a) differences in the mean magnitude of the difference score, (b) differences in the mean magnitude of the response to CS+, and (c) differences in mean magnitude of the response to CS-. The results summarized in Table 4 indicate a significant difference in the magnitude of the difference score between the two groups. On the other hand, no significant differences were found between conditioners and nonconditioners for response magnitude differences to either CS+ or to CS-.

Figure 2 shows the discrimination performance of both the conditioned and nonconditioned groups, and compares their performance. Both group curves show a rapid decrease

TABLE 4

Mean response magnitude to the CS+ and CS- and the mean difference score for the conditioned and non-conditioned groups

	Mean response magnitudes (mv/mm)				
	Conditioned	Non-conditioned	df	t*	P
CS+	1.47	1.25	10	1.018	NS
CS-	0.54	0.99	10	2.200	NS
MD	0.94	0.32	10	4.590	.001

*Independent groups t.

near the beginning of discrimination training, however, the conditioned group shows the maximum decrease at the end of the second block of trials, and the non-conditioned group shows the maximum decrease at the end of the third trial block. Immediately after the initial decrease, both curves show an increase, with the conditioned group meeting the criterion for conditioning by the end of the seventh trial block. The non-conditioned group fails to meet this criterion by the end of the seventh trial block, however, the curve shows a trend that indicates that conditioning may have occurred with more trials.

The relationship of OR magnitude to conditionability was examined by ranking all Ss in order on the basis of the OR magnitude from highest and lowest. Subjects were then

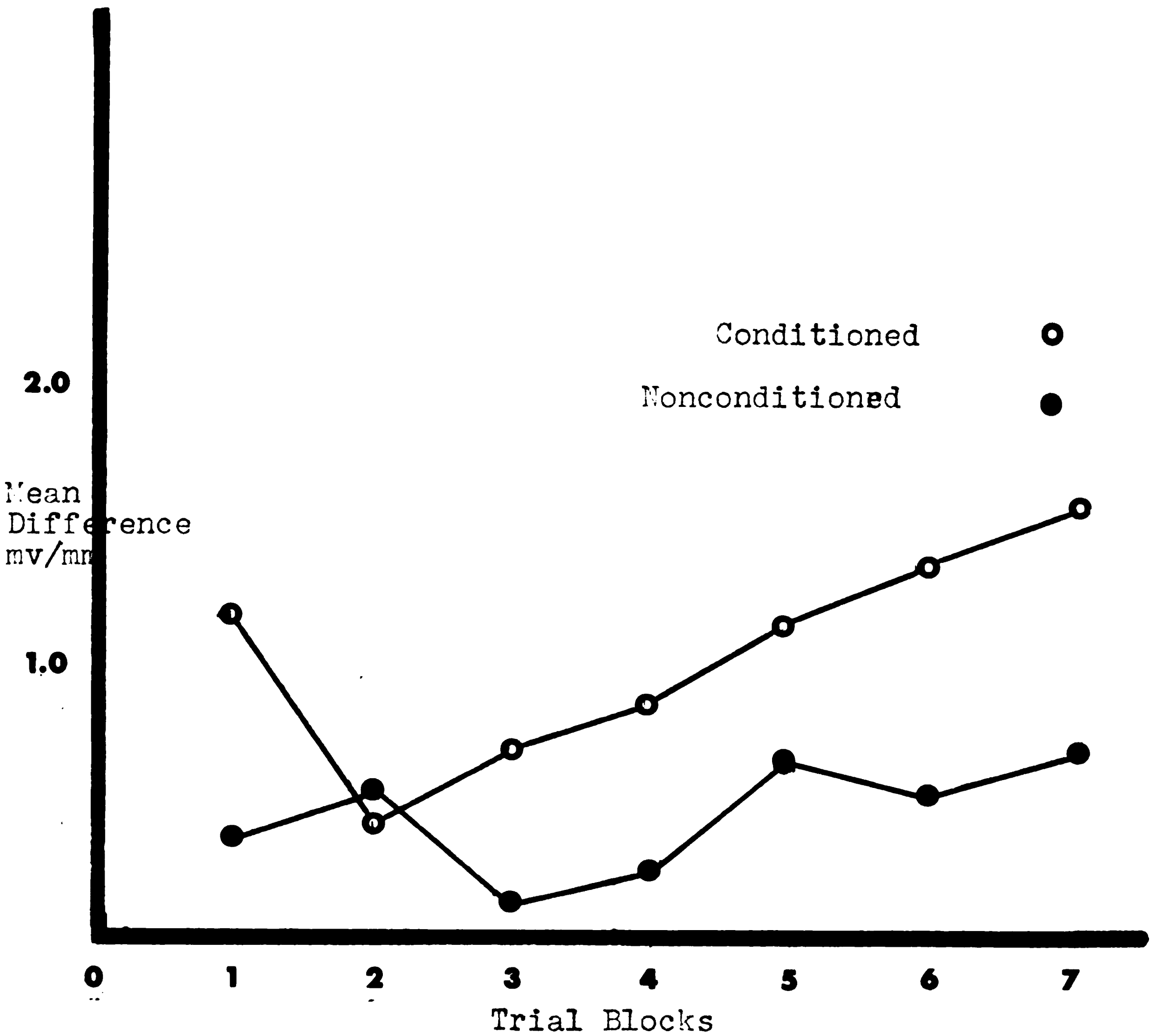

Figure 2

Mean difference score for the conditioned and nonconditioned groups.

divided at the median into two groups, high OR Ss and low OR Ss, with each group containing one half of the total sample. Using the criterion for conditioning set forth previously, it was found that five of six Ss in the high OR group demonstrated conditioning. A Fisher Exact Probability Test indicated that the difference in the number of conditioned Ss over non-conditioned Ss above the median was significant ($p. < .05$). Moreover, Pearson product moment correlations summarized in Table 5 indicated a significant correlation between conditionability and OR magnitude ($t = 2.79$, $r = .66$, $p. < .02$).

Figure 3 shows the discrimination performance of the high and low OR groups. This comparison between the high and low OR groups shows an early difference between the two groups, which at the fourth block of trials decreases to zero. After the fourth trial block the two curves diverge again due to the greater increase in the performance of the high OR group.

The median split of Ss into high and low OR magnitude groups was significantly correlated with the number of trial blocks required for conditioned Ss (discrimination conditioning) to reach the criterion for conditioning ($t = 3.17$, $r = -.71$, $p < .01$). Since the correlation is negative the relationship is inverse, i.e., the higher the OR the fewer blocks of trials required to reach the criterion of conditioning, or the more rapidly conditioning was attained.

TABLE 5

Intercorrelations, Pearson r.

	1	2	3	4	5	6	7	8
1	1.00							
2	0.33	1.00						
3	0.00	0.00	1.00					
4	0.66**	0.33	0.33	1.00				
5	0.16	-0.16	0.16	0.50	1.00			
6	-0.71***	-0.27	-0.40	-0.95****	-0.50	1.00		
7	-0.44	-0.07	-0.41	-0.42	-0.62*	-0.46	1.00	
8	-0.10	-0.40	-0.30	-0.15	-0.16	-0.19	-0.33	1.00

* $P < .05$

** $P < .02$

*** $P < .01$

**** $P < .001$

(1) OR magnitude median split (high or low OR).

(2) Sex.

(3) CS group: 500 Hz versus 1000 Hz.

(4) Conditioned or not conditioned.

(5) Reversal versus non reversal.

(6) Trial blocks to condition.

(7) Trials to habituation.

(8) State score.

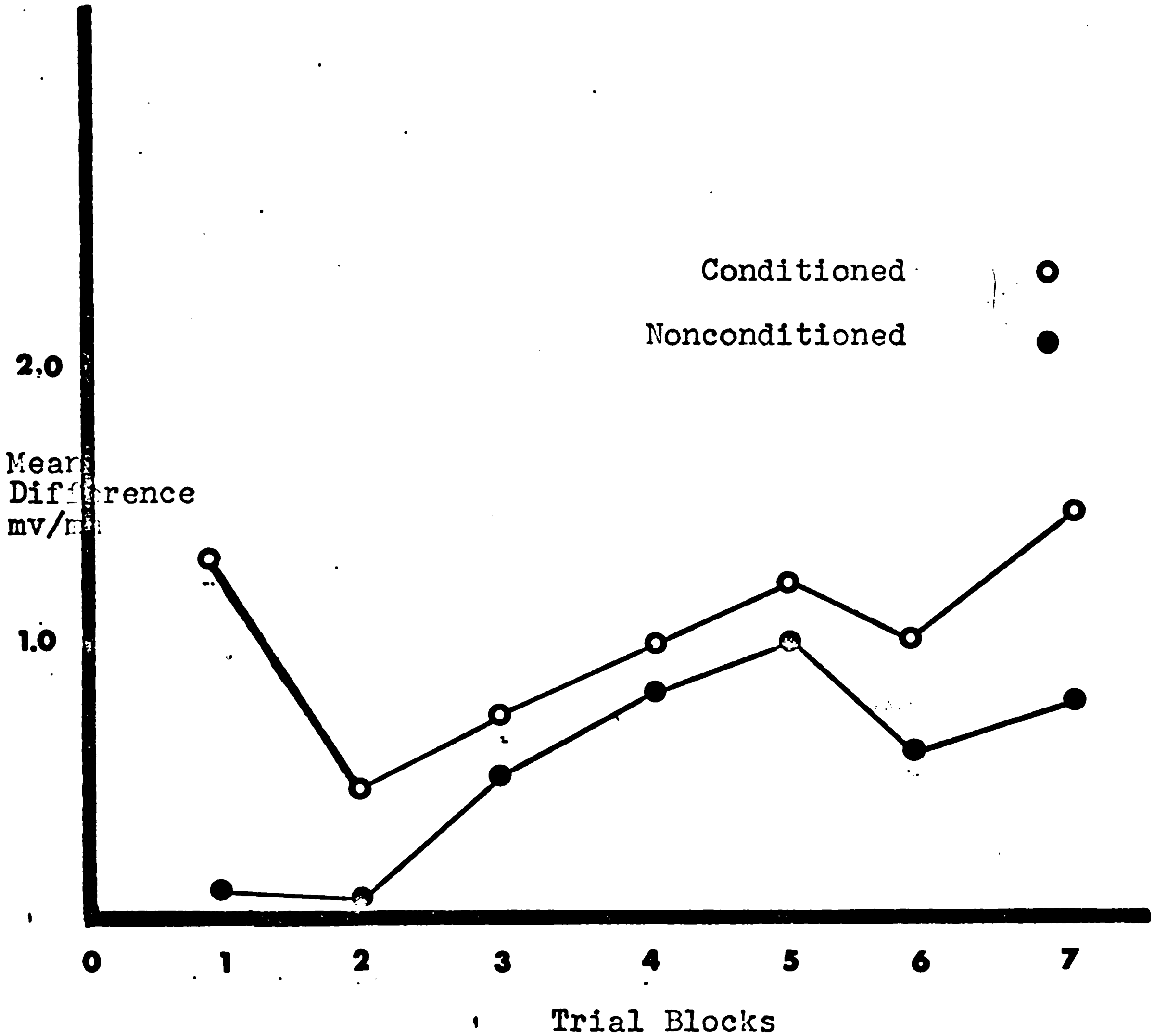

Figure 3

Mean difference score for the high and low OR groups.

Additional analyses were carried out comparing the high and low OR groups. As with the conditioned versus the non-conditioned groups, mean response magnitude to CS+ and CS- stimuli were compared as shown in Table 6; these data yielded similar results to those obtained for conditioned-non-conditioned groups. As for the conditioned and non-conditioned group dimension, the high and low OR groups were not significantly different in mean response magnitude to the CS+ or to the CS-. On the other hand, the high OR group did evidence a significantly greater mean difference score than did the low OR group ($t = 2.52$, df = 10, $p < .05$).

TABLE 6

Mean response magnitude to CS+ and CS- and the mean difference score for the high and low OR groups

	Mean response magnitude (mv/mm)				
	High OR	Low OR	df	t*	P
CS+	1.46	0.99	10	1.59	NS
CS-	0.63	0.90	10	0.95	NS
MD	0.84	0.42	10	2.52	< .05

*Independent groups t.

Conditioned Reversal

Overall effects. As indicated in Table 8 all 12 Ss demonstrated a higher response magnitude to CS+ than to CS- during reversal. Of the 12 Ss, all but one S demonstrated a higher response magnitude to CS+ than to CS- during discrimination conditioning. To test for conditioned reversal, mean CS+ response magnitude (1.04 mv) was compared to mean CS- response magnitude (.59 mv). This difference was significant ($t = 4.18$, $df = 11$), $P < .01$) indicating significantly greater response magnitude to CS+ than to CS-.

Individual differences. The period during which reversal of the auditory discrimination was undertaken was analyzed to determine whether or not conditioned reversal occurred. The analysis was similar to that employed for conditioned discrimination. Five of the 12 Ss demonstrated a conditioned discrimination reversal by meeting the criterion of a significant difference in the mean response magnitude between the CS+ and CS-. These data are summarized in Table 7.

Another criterion for conditionability would refer to the number of Ss who demonstrate an absolute change in direction of responding from the discrimination condition to the reversal condition.

The correlational analysis reproduced in Table 6 indicates no significant correlation between learning the reversal and whether or not S achieved the criterion for conditioning during the discrimination phase.

Wave Form of the SP Response

Habituation. Since the wave form of the SP response is biphasic and one or both components may demonstrate conditioning, an analysis comparing the magnitudes of the

TABLE 7

Mean response magnitude to the CS+ and CS- for each subject during the reversal phase

Subject	Mean response magnitudes (mv/mm)				
	CS+	CS-	df	t*	P
1 SB	0.714	0.360	6	2.901	< .05
2 CG	2.405	0.995	11	3.279	< .01
3 MP	1.712	1.150	7	0.731	NS
4 TG	0.660	0.340	4	3.200	< .05
5 sb	0.525	0.331	6	0.983	NS
6 KS	1.525	0.775	3	1.798	NS
7 BS	0.735	0.451	8	1.044	NS
8 WN	0.811	0.723	8	0.225	NS
9 EW	0.827	0.422	7	2.201	NS
10 FT	1.162	0.450	8	2.028	NS
11 tg	0.886	0.850	5	0.104	NS
12 DZ	0.595	0.260	7	1.820	NS

*Related measures t.

positive and negative waves to the stimulus to be used as CS+ with the response magnitudes to CS- was done. As indicated in Table 8 there were no significant differences. The mean response magnitude of the positive wave to CS+ was not significantly different from the positive wave response magnitude to CS-, (t = .02, df = 11); the mean response magnitude negative wave to CS+ was not significantly different from the response magnitude of the negative wave to CS-, (t = .41, df = 11). Moreover, the positive and negative wave responses were not significantly different in mean magnitude (t = .54, df = 11).

TABLE 8

Mean response magnitude of the positive and negative wave responses during habituation to the CSs.

	Mean response magnitude (mv/mm)				
	Positive wave		Negative wave		
	CS+	CS-	CS+	CS-	df
	0.110	0.080	0.123	0.110	11
	t = .015*		t = 0.406*		
	P = NS		P = NS		

*Related measures t.

<u>Discrimination conditioning</u>. Analyses were made of the response magnitudes of both the positive and negative waves to the CS+ and CS- to determine whether or not conditioning occurred separately for each wave form. The criterion for conditioning was the same as before, that the response magnitude to CS+ be significantly greater than the response magnitude to CS-. For each S the mean magnitude of

the positive wave form to CS+ was compared with the mean response magnitude of the positive wave form to CS-. The results of this comparison are summarized in Table 9 and indicate that only two Ss demonstrated conditioning of the positive wave form. Also the mean response magnitudes to the CS+ and CS- of the negative wave form were compared, and the results as summarized in Table 10 indicate all but three infants failed to condition.

TABLE 9

The mean response magnitudes of the positive and negative wave response to CS+ and CS- for each subject during discrimination conditioning

Subject	Mean response magnitude (mv/mm)				
	CS+	CS-	t	df	P
1 SB	0.425	0.225	1.298	3	NS
2 CG	1.066	0.500	2.460	5	NS
3 MP	-	-	-	-	-
4 TG	4.400	0.050	4.216	3	$<.05$
5 sb	-	-	-	-	-
6 KS	0.425	0.175	1.655	3	NS
7 BS	-	-	-	-	-
8 WN	0.260	0.120	0.721	4	NS
9 EW	0.333	0.333	0.000	8	NS
10 FT	0.500	0.390	0.714	9	NS
11 tg	0.314	0.214	0.917	6	NS
12 DZ	-	-	-	-	-

*Related measures t.

TABLE 10

Mean magnitude of the negative wave response to the CS+ and CS- for each subject during the discrimination phase

	Mean response magnitude (mv/mm)				
Subject	CS+	CS-	t*	df	P
1 SB	0.100	0.050	0.46	1	NS
2 CG	0.500	0.333	0.38	5	NS
3 MP	0.883	0.366	3.09	5	<.05
4 TG	0.400	0.100	3.90	2	NS
5 sb	0.555	0.200	6.57	8	< .001
6 KS	0.666	0.233	2.74	2	NS
7 BS	0.633	0.444	1.10	8	NS
8 WN	0.757	0.600	0.85	6	NS
9 EW	-	-	-	-	-
10 FT	-	-	-	-	-
11 tg	0.275	0.200	0.35	3	NS
12 DZ	0.614	0.385	1.75	6	NS

*Related measures t.

Table 11 summarizes the results of the analysis comparing the overall frequency of positive wave responses to the overall frequency of negative wave responses for each S during discrimination conditioning. Additional analysis compared the magnitude of the positive wave response to the CS+ with the magnitude of the negative wave response to the CS+, yielded no significant differences (t = 1.24, df = 11). Moreover, the magnitude of the positive wave response to the CS- was found not to differ from the magnitude of the negative response to the CS- (t = 1.03, df = 11).

TABLE 11

The mean number of positive and negative wave responses for each subject responding with both the positive and negative waves during the discrimination phase

	Number of responses				
Subject	Mean number of positive waves	Mean number of negative waves	t*	df	P
1 SB	5.25	0.50	14.66	3	<.001
2 CG	5.16	0.33	7.06	5	<.001
3 MP	-	-	-	-	-
4 TG	2.00	1.83	0.172	5	NS
5 sb	-	-	-	-	-
6 KS	2.20	2.40	0.192	5	NS
7 BS	-	-	-	-	-
8 WN	0.87	4.00	4.02	7	<.01
9 EW	-	-	-	-	-
10 FT	-	-	-	-	-
11 tg	4.00	1.28	3.64	6	<.02
12 DZ	-	-	-	-	-

*Related measures t

The frequency of positive wave responses to CS+ and the CS- were compared with the number of negative wave responses to the CS+ and CS-. No significant differences were found (_t_ = .87, df = 11), nor to CS- (_t_ = .92, df = 11).

Conditioned reversal. An analysis of the positive and negative wave responses during the reversal period was similar to that done for the discrimination conditioning period. Conditioning was assessed by comparing the magnitudes of the positive and negative wave responses to CS+ and CS- for each _S_. The analysis of the positive wave response revealed that only one _S_ demonstrated conditioning. Of the 11 remaining _S_s, four did not produce positive wave responses, while six responded with both positive and negative wave responses. Analysis of the negative wave response indicated that two _S_s achieved the criterion of conditioning. However, subsequent analysis revealed that these two _S_s responded more frequently with positive wave responses! Three _S_s failed to respond with any negative wave responses, while the remaining _S_s responded with both wave forms.

Also indicated in Table 12 are the results of an analysis comparing the overall frequency of positive waves with the overall frequency of negative wave forms occurring for each _S_ during conditioned reversal.

The mean magnitude of all positive waves to the CS+ was found to not differ significantly from the mean magnitude of all negative waves (_t_ = .81, df = 11). Similar analysis

TABLE 12

The mean number of positive and negative wave responses for each subject responding with both positive and negative wave responses during the reversal phase

	Numbers of responses				
Subject	Mean number of positive wave responses	Mean number of negative wave responses	t*	df	P
1 SB					
2 CG	5.16	0.66	7.92	11	<.001
3 MP					
4 TG	2.16	3.00	0.92	5	NS
5 sb					
6 KS	1.25	3.28	2.06	3	NS
7 BS					
8 WN	0.77	3.00	2.63	8	<.05
9 EW					
10 FT	2.11	1.55	6.511	9	<.001
11 tg					
12 DZ					

*Related measures t.

revealed like results for the magnitudes of all positive wave responses to CS- (t = .16, df = 11). However, an analysis of the frequency of all wave forms revealed a significant

difference in the frequency of positive and negative wave form responses to CS+, where the frequency of negative wave responses was greater ($t = 2.47$, $df = 11$, $p < .05$). On the other hand, there was no difference in frequency of positive and negative wave responses to CS- ($t = 1.14$, $df = 11$).

Discussion

The results of the present study may be summarized as follows. First, 3 month old infants are capable of learning a conditioned discrimination and a reversal of that discrimination, as indicated by the autonomically mediated SP response. This finding strengthens previous contentions that autonomic conditioning in infants is possible (Brackbill & Fitzgerald, 1969). Second, there are individual differences in OR magnitude found among infants. Third, the individual differences in OR magnitude are related to conditionability; where conditionability in this study refers to the rapidity with which conditioning occurs as well as to the attainment of set criteria concerning response magnitude.

The question arises as to whether or not any difference between the response magnitudes to CS+ and CS- can be considered sufficient to denote a conditioned discrimination. The answer to this question is apparently yes, particularly when, as a control procedure, a reversal of the discrimination is used, and the appropriate shift in response magnitude is made (i.e., the response magnitude to the new CS+ becomes greater than the response magnitude to the new CS-). The occurrence of a significant overall effect during discrimination conditioning indicates a trend toward conditioning for all but one subject. However, of particular importance is the shift in response magnitudes during the conditioned reversal. This shift to greater magnitude responding to the new CS+ over the new CS- indicates that the significance of the pairing of reinforcement with CS+ is learned. However, the failure of some Ss to reach the criterion set for conditioning indicates differences in the degree of conditioning or condition ability among Ss.

The range of the OR magnitude (7.0 mv to 1.0 mv, Md = 2.1 mV) demonstrates that human infants do differ in certain physiological characteristics, and that these particular physiological differences are related to behavior differences at this early age. Individual differences in other systems have been described by a number of authors; cardiac rate (Bridger & Reiser, 1959), homeostatic capacity (Richmond, Lipton & Steinschneider, 1962). However, the most extensive relating of the individual's physiological activity to his behavior has been the positing of relationships between autonomic function and later personality characteristics. The data presented in this study indicates that individually unique levels of autonomic responding are related to individual differences in conditionability.

Strongest confirmation of such individual differences was reflected in the occurrence of a significant number of high OR Ss demonstrating conditioning, with only 1 low OR S showing a conditioned response. The difference between the high and low OR groups (also conditioners and non-conditioners) is evident in other data analyses, for instance, in the difference score data. Also the difference in the degree of conditioning is reflected by the attainment significantly larger response magnitudes to CS+ by the high OR Ss while the low OR Ss did manage only to approach a significant difference in response magnitude between CS+ and CS-. This evidence demonstrates the difference in relative stability of the CR between the two groups, with the high OR subjects showing a tendency toward a more stable CR. Also the finding of a relationship between conditionability and individual differences in OR magnitude is analogous to the findings with adults such as in the research of Maltzman and Raskin and Maltzman and Mandell. If the phenomenon cannot be demonstrated consistently there is then some probability associated with its occurrence. Thus OR magnitude may reflect the probability of an individual's ability to produce and inhibit responses at given instances of stimulation. This is reflected in the existence of a significant difference between the high and low OR groups on the difference score.

The significant difference score data indicates that a higher proportion of the low OR Ss responses to CS- were equal or greater in magnitude than those for the higher OR group. This difference reflects a separation of the two groups on the probability of the unpaired (CS- or incorrect stimulus) stimulus eliciting a response of equal strength as the paired stimulus (CS+ or correct stimulus). This response occurrence probability differs from general responsivity or the activity level of a response system, in that it refers to the likelihood of a response to a specific stimulus in a given class of stimuli rather than the likelihood of a response to any stimulus of that particular class of stimuli, or of a large magnitude response to any of a given class of stimuli. In addition, the data also indicated that the majority of those Ss initially learning the discrimination appear to reach a point of optimum discrimination, or a peak in response magnitude to the CS+ over response magnitude to the CS-. This peak of performance tends to drop off after a few trials with the discrimination showing a tendency to deteriorate. The shape of this function suggests a change of response occurrence probability within Ss. However, this is probably not the case because the magnitude of the responses to CS- decrease, indicating a change in the level of responsiveness. Therefore, the OR reflects the many possible components of an Ss internal system of response occurrence probability, and since these probabilities may be expected to differ among individuals, the indicators of this system may also differ among individuals.

The present results and interpretations conflict with the findings of Morgenson and Martin (1968) using human adults. These investigators found no differences between "aware" and "unaware" Ss on OR magnitude in a verbal conditioning study. Their study also demonstrated that Ss having initially large magnitude responses continued to respond with large magnitude CRs. From the above data Morgenson argues that a correlation between OR magnitude as indexed by a single measure, and CR magnitude indexed by the same measure, does not give evidence of a relationship of the OR with conditioning, but rather demonstrates within system responsiveness. The problem of within system responsiveness is best approached by looking at the discrimination paradigm and its requirement that the response to CS- remain the same while the response to CS+ increase in magnitude. Therefore, if a particular group of Ss are high magnitude responders (high OR) and the level of the CR is higher than for low magnitude responders, then within system responsiveness has possibly been demonstrated. One must evaluate these particular Ss on criterion other than response magnitude when compared on the basis of conditionability. If a group of Ss produces an initially high OR level but a CR level not significantly different from the CR level of the Ss producing an initially low OR level, the designation of within system responsiveness remains important for both groups and not for one to the exclusion of the other. Moreover, any changes produced in the CR level for both groups must then be due to some other factor in addition to within system responsiveness, or to some factor(s) operating alone. The present study indicates that the high and low OR groups failed to differ in response magnitude to the CS+ (CR level). In addition, the conditioned and non-conditioned Ss did not differ significantly in response magnitude to CS+. These results do not fulfill the requirement of greater responsiveness attributable to one group (high magnitude responders) if within system responsiveness were the sole variable involved.

The results of the comparison of the response magnitude to CS- indicates that in one group (the non-conditioned one) the responses to CS- were greater than the conditioned group, demonstrating that Ss in the conditioned group inhibited responding to CS- to a greater degree than did Ss in the non-conditioned group. This explains the greater difference scores for the conditioned group. One might also add that the decrement of the response to CS- over time is a contradiction of the CR being an augmented response due to "sensitization" or pseudoconditioning.

The question of sensitization brings up the position of Dykman (1967) that conditioning is an equivalent process to sensitization, meaning that the process of response facilitation underlying CS augmentation is the same neural process as involved in the conditioning process, and refers to the particular neural pathways sensitized. The reversal process indicates the changing of particular pathways to involve transfer of sensitization to a new stimulus.

Here again one can assert that for the high OR Ss the likelihood of the appropriate response during reversal is governed by the rapidity with which particular pathways are changed to involve transfer of sensitization to a new stimulus. At this point an adequate description of the internal processes involved during conditioning await further clarification. Yet, the individual differences that allow one infant to manifest a certain phenomenon while disallowing another under similar conditions of measurement, may be described as the difference in the likelihood of the operation of certain internal systems producing the appropriate responses. The likelihood of these particular systems operating "properly" may be manifested by differences in the levels of the OR.

An additional factor that may operate to produce an effect on the response system is the S's state or level of arousal. Although state or level of arousal has been found to be related to responsivity in infants (e.g. Brackbill & Fitzgerald, 1969), there was no relationship between state and conditioning found in the present study. Because of the many systems involved in a gross behavioral measure of state, a response like SP may vary little between each of a number of different levels of arousal. These independent fluctuations of one variable may be submerged within the complexity of the interaction of the many variables. For example, the influence of respiration rate on heart rate may be substantial, yet an observed change in respiration rate is not sufficient evidence to conclude that there was a significant change in heart rate.

A behavioral measure of state, as was used in the present study, may be insufficiently sensitive to very subtile internal physiological indices of arousal level. Therefore, studies analyzing the effects of arousal an infant responsivity should include examinations of both physiological and behavioral measures of arousal. Nevertheless, the fact remains that in the present study, the predominate transition from quiet awake to active awake showed no relationship to conditionability.

In addition to the need for further in-depth research into the nature of state, implications for further research arise from the analysis of the separate components of the SP response. The occurrence of more than one particular component of the SP response within the group of infants indicates that infants do not necessarily respond with any particular form of the SP response. Rather, infants respond with all forms of the response without there being a tendency toward one wave form as opposed to another. However, there is a predominately greater occurrence of the uniphasic type of SP response over the biphasic or triphasic (in fact, the triphasic wave was not obtained in the present study). According to data reported by Raskin _et al_. (1969) the predominating occurrence of the positive wave form can be attributed to intensity effects. In the present study, intensity was held constant, thus the intensity explanation contributes little unless there are within S differences in perception of stimulus intensity, or actual intensity as received at the receptor. Therefore, further study is needed to ascertain the extent to which factors like intensity have an effect on the nature of the response.

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APPENDIX A

A Scale for Rating State (Brackbill and Fitzgerald, 1969)

State number	State name	Description
1.	Quiet sleep	The infant's whole body gives the appearance of general muscular relaxation. This is interrupted periodically, however, by brief startles of an apparently spontaneous nature, the infant's eyes are usually closed. Respiration is regular and is somewhat slower than in active sleep.
2.	Active sleep	Characteristics of this stage are diffuse movements of relatively frequent occurrence. These movements may involve the whole body but are most typically seen in the extemities and in the muscles of the face in the form of grimaces, smiling, sucking, and the like. In addition, one can sometimes see conjugate movements of the eyeballs. (As in state 1, the eyelids are usually closed.) Respiration is considerably more irregular and is somewhat faster than in quiet sleep.
3.	Drowsiness	During this stage the infant's motor behavior is often much like that of sleepy people riding subway trains: he relaxes more and more as he gradually falls asleep, then suddenly jerks awake. His eyelids flutter, and his eyes, when visible, have a glassy appearance. Respiration is more apt to be marked by regularity than irregularity.
4.	Quiet Awake	There is little gross motor activity, i.e., movements involving the whole body, although there may be some movements of the extremities and face.

State number	State name	Description
		The baby's eyes are open and in Wolff's terms (1966) are characterized by a bright, shiny appearance, the major difference between this state and the other two waking states is that this is a <u>peaceful</u> state. Accordingly, the vocalizations that occur during this state are not of an "unhappy" variety. Respiration is relatively regular, though less regular than in quiet sleep.
5.	Active awake	This state is marked by a considerable amount of gross motor activity. For example, as an infant becomes unhappy he may begin to writhe. Respiration is often quite irregular. Within the spectrum of vocalizations occurring during this period are those of the cranky, fussy variety.
6.	Crying awake	The criteria for this state are the same as those for the preceding state except that in addition the infant is crying. (He may or may not be producing tears; most very young infants do not). The lower limit of crying is defined as protesting of a definite, sustained nature.