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THE EFFECTS OF EXTRANEOUS STIMULATION ON
HABITUATION AND RETENTION OF HABITUATION
IN INFANTS AND ADULTS

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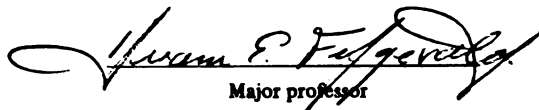
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ABSTRACT

THE EFFECTS OF EXTRANEIOUS STIMULATION ON HABITUATION AND RETENTION OF HABITUATION IN INFANTS AND ADULTS

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The purpose of this study was to investigate whether extraneous stimulation permanently disrupts the retention of habituation or only temporarily elevates responsivity through sensitization. In the first of three consecutive experimental phases, skin conductance responses of human infants and adults were habituated to an auditory stimulus. In Phase II, experimental Ss received one of three conditions: novel auditory stimulation in the first half, second half, or throughout a six-minute retention interval. During Phase II Ss in one control condition continued to receive the habituation stimulus while those in a second control condition received no stimulation. In Phase III all Ss were rehabituated to the same stimulus presented in Phase I.

The results indicated that adults habituated and rehabituated more rapidly than infants but that both infants and adults required fewer rehabituation trials than habituation trials. In addition, while novel stimulation tended to disrupt rehabituation it operated differently on retention in infants compared to adults.

For infants novel stimulation had its greatest disruptive effect on rehabituation when presented in the last half of the retention interval

only. The impact of novel stimulation on habituation was attenuated when presented throughout the retention interval and was more-or-less eliminated when presented only in the first half of the retention interval. For adults, novel stimulation disrupted habituation only when presented in the first half of the retention interval.

Infant habituation performance was interpreted in terms of a dual-process theory of habituation suggesting that novel stimulation temporarily elevates responsivity but does not interfere with retention. Since no clear pattern was found in the habituation performance of adults it was impossible to determine whether novel stimulation directly interfered with retention or operated through some sensitization process to disrupt habituation.

The implications of the present findings for the use of dishabituation phenomena in habituation research was discussed. It was suggested that dishabituation, at least for infants, may be an epiphenomenon.

THE EFFECTS OF EXTRANEOUS STIMULATION ON HABITUATION
AND RETENTION OF HABITUATION IN INFANTS AND ADULTS

By

Bradley Brian Glanville

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INTRODUCTION

Over the last decade developmental psychologists have shown considerable interest in habituation. Habituation refers to the gradual waning of a response to repetitive stimulation. Habituation research was stimulated primarily by renewed interest in "attention" as an investigable construct, and by the possibility that response decrements may reveal important information regarding early behavioral plasticity (Berlyne, 1960; Kagan and Lewis, 1965; Kessen, Haith and Salapatek, 1970; Jeffrey and Cohen, 1971). For example, a rather large literature has accumulated suggesting that habituation is an integral component of arousal, exploratory behavior, and selective attention.

Another reason why habituation research has proliferated in developmental psychology concerns its applicability to a wide range of topics. For example, the habituation procedure has been used to study sensory and perceptual-cognitive processes and to assess the functional maturity of neural systems including both central (CNS) and autonomic (ANS) nervous systems (e.g., Bridger, 1961; Engen and Lipsitt, 1965; Brackbill, 1971; Horowitz, 1972; Friedman, 1972).

Nearly all of the developmental research utilizing habituation methodology owes its origin to the theory of the Soviet physiologist Sokolov (1960, 1963). Briefly, Sokolov's theory was designed to explain habituation of the orienting reaction (OR), which is one of three

reflexively based responses that may occur when an organism detects a change in one or more parameters of stimulation. The OR has both physiological and behavioral components including phasic changes in electrodermal activity, cardiac deceleration, increase in receptor sensitivity, cessation of motor behavior and various electroencephalographic wave forms. The OR is elicited when stimulus change (onset or offset) is mild or moderately intense. The functional significance of the OR is to increase arousal so that the organism is prepared to deal with the novel stimulus event. Thus, theoretically, the OR is integrally related to the maintenance of attention.

According to Sokolov cessation of the orienting reflex is as important for survival as is its elicitation. Clearly, the initiation or consummation of other behavioral sequences depends upon the organism's ability to inhibit orienting when the eliciting stimulus proves to be of little or no biological importance. Sokolov maintains that the progressive diminution of the OR (habituation) to repetitious, nonsignal stimuli is brought about by the gradual construction of an internal replica or "neuronal model" that preserves and refines all dimensions of the external event (i.e. frequency, intensity, duration) somewhere in the CNS (presumably, the cortex). In theory, the neuronal model matches the external event more precisely with each presentation of the novel stimulus. A more-or-less well refined model may then operate as a selective filter: signals to OR arousal centers generated by stimulus parameters matched in the model are blocked; while signals from features not yet established may pass through to trigger an OR. Thus, the gradual diminution of the OR is the behavioral product of the inhibitory control

progressively exerted by the neuronal model over the lower brainstem OR center, particularly the reticular activation system.

If one presents an alteration of the habituated stimulus or a new stimulus altogether, Sokolov's theory predicts a re-elicitation of the OR since the "novel" stimulus would not match the existing neural model. Sokolov suggests the magnitude of OR recovery is a direct function of the amount of discrepancy between the current neuronal model (habituation stimulus) and the new external stimulus.

The OR also will recover to an already habituated stimulus following presentation of a novel event. This phenomenon is referred to as dishabituation. According to Sokolov the occurrence of a new stimulus not only arrests the ongoing habituation process, but also interferes with and diminishes the retention of habituation. In theory the neuronal model established during habituation also preserves and refines dimensions of the new external stimulus. By incorporating features of the novel event the existing neuronal model is altered which, in effect, renders the original habituation stimulus a discrepant event. Sokolov proposes dishabituation of the OR following novel stimulation results from the mismatch between an altered neuronal model and a now discrepant habituation stimulus. Since Sokolov did not endow an altered neuronal model with any mechanisms enabling it to reform or restructure in the absence of the habituation stimulus the disruptive effects of novel stimulation on retention (dishabituation) are assumed to be more-or-less permanent.

Although dishabituation has commanded relatively little empirical interest from developmental psychologists (see Allen and Fitzgerald, 1974) it has been advocated as a control procedure for assessing the

effects of arousal level in infant habituation research (Kessen, 1970; Jeffrey and Cohen, 1971). Moreover, investigators using the habituation technique to study early cognitive development suggest that dishabituation may reveal important information concerning what specific characteristics of the stimulus are incorporated into the neuronal model and how long they are held in memory. In either case it is argued that dishabituation confirms the central mediation of the habituation process. The key assumption is that dishabituation results from the novel stimulus event interfering with habituation or its retention and that response recovery would not occur if systematic changes in arousal, effector fatigue, or sensory adaptation were responsible for habituation.

This assumption has been challenged by Thompson and his associates (Thompson and Spencer, 1966; Groves and Thompson, 1970). Thompson et al. contend that novel stimuli do not interfere with habituation but instead have a sensitizing effect, temporarily elevating responsivity of the organism to stimulation in general. Moreover, dishabituation is held to be an epiphenomenon observable only when a response is elicited by the habituation stimulus while the organism is more aroused.

Thompson et al., have offered an alternative theory which proposes that the response observed on any particular stimulus presentation during habituation is the behavioral product of two independent processes, habituation and sensitization. In this dual-process theory habituation is an inferred decremental process and is confined to the direct S-R pathways intervening between a stimulus and a response. In theory, it is in these neural pathways that inhibition, which eventually produces response decrement, gradually accumulates with stimulus repetition.

On the other hand, sensitization is incremental in nature and is the process by which external stimuli influence the diffuse, central state systems which govern an organism's overall level of arousal or responsivity. Sensitization is produced in amounts corresponding principally with stimulus intensity and/or stimulus repetition. While the sensitization generated by novel stimuli tends to contribute incrementally to the organism's overall level of arousal, the elevation in responsivity is temporary, as sensitization is evanescent in nature and after reaching asymptote begins to spontaneously decay even while external stimulus presentations continue.

Thompson et al. contend that the change in responding observed over trials reflects the relative contributions of these two processes at different points during the course of habituation. Early in habituation (after only a few trials) the to-be-habituated stimulus generates both sensitization and habituation. Sensitization accrues very rapidly, and its net effect on responding may outweigh that of habituation at this point. Thus, Thompson et al. suggest that sensitization can account for the occasional reports of a transient increase in responding early in habituation. Over trials, however, habituation progressively dominates responsivity as sensitization gradually dissipates.

In the dual-process theory framework response recovery phenomena in general, and dishabituation in particular, are considered to be special cases of response sensitization. Dishabituation is considered an epiphenomenon observed only when experimental procedures require elicitation of the response to the habituation stimulus while the organism is more responsive from the sensitization effects of the

extraneous stimulus. Dishabituation should not occur if presentation of the habituation stimulus is delayed thereby allowing the effects of sensitization to dissipate.

It should be noted that there are few, if any, real differences between the inferred decremental process of habituation proposed by Thompson et al, and Sokolov's construct of a neuronal model (Graham, 1973). Instead the major conflict between these two theories centers on the effects of extraneous stimulation on habituation and its retention. An extraneous event may be operationally defined as any stimulus, usually novel, introduced during the course of habituation or presented after habituation but before some test for retention is administered. At issue is whether extraneous stimulation directly interferes with habituation and retention of habituation or whether extraneous stimulation only temporarily elevates responsivity (sensitization) without disturbing habituation itself.

Interestingly enough, no studies directly confronting this issue have been published despite its recognized theoretical and practical significance for habituation research (Jeffrey and Cohen, 1971). Although several investigators have studied the effects of extraneous stimuli on habituation and retention of habituation they did not address the issues raised by Thompson et al. (e.g. Bartoshuk, 1962, Zimny and Schwabe, 1966; Pancratz and Cohen, 1971). Moreover, the results of these studies are inconclusive, at least with regard to the central issues raised by Thompson and his associates.

For example, Zimny and Schwabe (1966) demonstrated galvanic skin response (GSR) recovery upon presentation of a novel auditory

stimulus during GSR habituation in human adults. In this study single presentation of either a novel 4000 Hz or 1000 Hz tone were interpolated among habituation trials to a 500 Hz tone. While the fact that both novel tones dishabituated the GSR tends to support the notion that extraneous events disrupt the habituation process; it was also found that this dishabituation was confined to the first trial in the series of habituation stimuli which followed a novel stimulus. Thus it can be argued that the novel stimuli only temporarily elevated responsivity (sensitization) and did not interfere with habituation itself.

Using a similar experimental procedure Bartoshuk (1962) introduced changes in the intensity and frequency of an auditory stimulus during auditory habituation of cardiac responses in human neonates. In this study groups of infants received 17 trials with a continuous square wave 500 pulse/sec. tone at 80 db with an intertrial interval (ITI) of 60 sec. On trial 18 the tone was increased to 91 db in both groups and then returned to 80 db for trials 19, 20, and 21. On trial 22 the tone frequency was changed to 5 clicks/sec. and then returned to 500 square wave pulses/ sec. on trials 23, 24, and 25. (A similar procedure was used with a 6-sec. ITI group.)

While there was a recovery of cardiac accelerations of the trials following the change in stimulus intensity there was no evidence of a similar recovery on the trials following the change in tone frequency. The response recovery following the intensity change may be interpreted as indicating the novel stimulus interfered with the habituation process. However, since no recovery was observed after the change in frequency it seems unlikely that the novel stimulus had any dishabituating effect. Indeed, even Bartoshuk suggested that the recovery

following the first change in the stimulus might be attributable to a general rise in arousal level. The notion that this increased responsiveness was due to the change in intensity is consistent with the assumption of the dual-process theory that novel events generate sensitization in amounts corresponding to stimulus intensity. On the other hand, the fact that the order of the two stimulus changes was not counterbalanced immediately raises the possibility that any interfering effects of the change in frequency were masked by the dishabituation effects of the earlier change in intensity.

Pancratz and Cohen (1971) investigated the effects of novel visual stimulation on the retention of habituation in four-month-old infants. In this study groups of male and female infants were given ten 15 second exposures to one of four simple colored patterns and the length of visual fixation was the dependent variable. Following the habituation trials one-half of the male and female infants were randomly assigned to a No-interval Condition and one-half were assigned to an Interval Condition. In the No-interval Condition infants were given a retention test immediately following the last habituation trial. For infants in the Interval Condition the retention test was delayed for five minutes by introducing 20 consecutive 15-second exposures to a new visual stimulus; presentation of the new visual stimulus beginning immediately after the last habituation trial.

The retention test consisted of six 15 second test trials on which the familiar (habituation) stimulus and a different one of three novel stimuli were alternately presented. For one-half the infants in

each interval condition the order of the novel (N) and familiar (F) test stimuli was F, N, F, N, F, N and for the other one-half the order was N, F, N, F, N, F.

Pancratz and Cohen assumed that any retention of habituation would be expressed by differential visual fixation to the consecutively presented test stimuli. Only male infants in the No-interval Condition fixated reliably longer to the novel than to the familiar test stimuli. There was no evidence of retention by male infants in the Interval Condition or by female infants in either Interval Condition.

While the authors suggested that, at least in males, the five minutes of novel stimulation completely disrupted retention, the fact remains that males in the Interval Condition showed significantly shorter fixation times to both test stimuli than infants in all other conditions suggests that effector fatigue, and not interference, may have accumulated during the retention interval. The possibility that fatigue may have obscured any retention of habituation is further supported by the fact the 15 seconds of novel stimulation which occurred on the first test trial for one-half the male infants in the No-interval Condition was not followed by any recovery of fixation time on the subsequent familiar stimulus test trial. The lack of any evidence of retention in the female infants was not surprising since only male infants showed a reliable decrement in fixation time over the habituation trials. Thus, while there is some evidence suggesting that the five minutes of novel stimulus presentation disrupted retention, there is no evidence that 15 seconds of novel stimulation had any comparable effect on retention. In the absence of any evidence of some response recovery following 15 seconds

of novel stimulation it is possible to interpret the lack of retention following five minutes of novel stimulation as support for either dual-process theory or OR theory. That is, it can be argued that the non-differential fixation times to novel and familiar test stimuli by male infants in the Interval Condition indicate the interfering or dishabituating effects of extraneous stimulation on retention. Nevertheless, it is possible to offer an alternative explanation based on dual-process theory. It can be argued that sensitization, and not interference, accumulated during the five minutes of novel stimulation. In turn, this sensitization, by elevating responsivity to stimulation in general, may have produced the nondifferential fixation times to the test stimuli. Thus it is entirely possible that any retention by the male infants in the Interval Condition may have been masked by sensitization.

To summarize, there is ample evidence in the studies reviewed here that extraneous stimulation disrupts habituation and/or the retention of habituation. However, it is not clear whether extraneous stimulation directly interferes with the habituation process to produce this disruption (dishabituation) or whether extraneous stimulation only temporarily elevates responsivity through some sensitization-like process.

In view of the important issues raised by this controversy and the potential impact of its resolution the utility of dishabituation phenomena in habituation research, the effects of extraneous stimulation on the retention of habituation were explored in the present study. To investigate effects of extraneous stimulation on retention experimental

procedures require the introduction of extraneous stimulation only after habituation to another stimulus. In the present study a three-phase experiment was employed and presentations of a novel stimulus introduced in a retention interval which temporally separated habituation and re-habituation to another stimulus. In order to attribute differences in retention to the occurrence of novel stimulation equal amounts or degrees of habituation must be established prior to any presentations of novel stimulation. In this study a habituation criterion of no skin conductance responses (SCRs) on two consecutive trials was employed to establish equivalent levels of habituation in the first phase. The third phase, rehabituation trials to the same stimulus presented in Phase I, immediately followed the retention interval. In order to assess the impact of the novel stimulation on retention the same habituation criterion as in the first phase also was used in the rehabituation phase.

Since a major purpose of the present study was to determine whether extraneous stimulation more-or-less permanently disrupts retention or only temporarily elevates responsivity, several different methods were used to introduce the novel stimulation during the retention interval. In condition Extraneous Stimulation - No Stimulation (EN) the novel stimulus presentations occurred only in the first half of the retention interval and no stimulation was presented in the second half. Conversely, in condition No Stimulation - Extraneous Stimulation (NE) the order was reversed so that no stimulation occurred in the first half of the retention interval and novel stimulation only in the second half. These two conditions generated several different hypotheses.

First, on the basis of OR theory, it was assumed that novel stimulation would interfere with habituation and, as long as equal numbers of novel stimulus presentations occur in both conditions, interference need not differ for Conditions EN and NE. Second, since interference should more-or-less permanently disrupt retention, it was also assumed that the order of the Novel Stimulation - No Stimulation periods would not influence the amount of dishabituation on subsequent rehabilitation trials. It was predicted that retention in both conditions would be equally diminished by the novel stimulation.

Alternatively, extrapolations from the dual-process theory position that novel stimulation temporarily elevates responsivity suggest that sensitization would accumulate during the novel stimulus presentations. It was hypothesized that equal amounts of sensitization would accumulate in Conditions EN and NE regardless of whether the novel stimulation occurred in the first or second half of the retention interval. However, Thompson et al. also maintain that sensitization is evanescent in nature and only temporarily elevates responsivity before it begins to spontaneously decay. This immediately suggested that the amount of sensitization remaining at the end of the retention interval in Conditions EN and NE would be a function of the sequence of the Novel Stimulation - No Stimulation periods in Phase II. Unfortunately, Groves and Thompson did not present any specific values when describing the time parameters governing the decay of sensitization (Groves and Thompson, 1970, pp. 424-426). Nevertheless it seemed reasonable to hypothesize that little or no sensitization would dissipate in Condition NE since rehabilitation trials began immediately after the novel stimulation period

in Phase II. In contrast, since there is theoretically a greater opportunity for some sensitization to dissipate before habituation when the no stimulation period followed the novel stimulation, it was further hypothesized that less sensitization would effectively remain at the end of Phase II in Condition EN than in Condition NE. It was predicted then, if sensitization accumulated and differentially decayed during the retention interval, habituation would proceed more rapidly in Condition EN than in Condition NE.

In a third condition, Extraneous Stimulation - Extraneous Stimulation (EE), novel stimulus presentations occurred throughout the retention interval. This condition was designed to test hypotheses concerning the number (amount) of novel stimulus presentations on the retention of habituation. According to OR theory novel events interfere with habituation and the greater the number of novel stimulus presentations the greater the interference. Therefore, it was predicted that novel stimulation throughout the retention interval would result in less retention in condition EE than in either conditions NE or EN.

Alternatively, the dual-process theory suggests that greater sensitization should accumulate when a novel stimulus is presented throughout the retention interval than when presented only in one half of the interval. However, this theory also proposes that sensitization accumulates and reaches asymptote rapidly. Moreover, sensitization may then begin to decay even while novel stimulus presentations continue. However, not only is it impossible to determine when in the retention interval sensitization should reach asymptote, Thompson *et al.* have not addressed the issue of whether continued novel stimulus presentations

influence the rate at which sensitization dissipates once asymptote has been reached. In view of these considerations it was impossible to advance any specific a priori predictions concerning the relative rehabilitation performances for conditions EN and NE vis-à-vis condition EE.

Nonetheless, it is possible to speculate about one set of outcomes which would bear on these crucial issues. Specifically, if rehabilitation proceeds more rapidly in condition EE than in condition NE, it could be argued that less sensitization remained at the end of Phase II in condition EE than in condition EN. This would indicate that sensitization reached asymptote and then began to dissipate in condition EE. Furthermore, if rehabilitation is less rapid in condition EE than in condition EN it could be argued that less sensitization remained at the end of Phase II in condition EN than in condition EE. However, it would be impossible to determine, on the basis of rehabilitation performances, whether less sensitization accumulated in condition EN than EE, or whether sensitization dissipated more rapidly during no stimulation than during continued novel stimulus presentations.

The above predictions were generated on the assumption that extraneous stimulation disrupts rehabilitation. However, according to Ratner (1970) extraneous stimulation may have a facilitative as well as disruptive effect on rehabilitation. In Ratner's response interference theory of habituation whether a particular extraneous stimulus will facilitate or disrupt retention depends upon the compatibility - incompatibility of the responses elicited by the extraneous and habituation stimuli. When the two responses are incompatible (compete) then

presentations of the extraneous stimulus will accelerate habituation and facilitate its retention. Alternatively, when the two responses are more-or-less compatible, habituation will be retarded and its retention diminished by presentations of the extraneous event.

Therefore, two additional conditions were employed to determine whether novel stimulus presentations have a facilitatory or disruptive effect on retention. In one of these conditions, Habituation Control (HC), the habituation stimulus presentations continued throughout the retention interval. In the other condition, Spontaneous Recovery Control (SC), no stimuli were presented in the retention interval. Condition HC was viewed as a baseline control for retention. Condition SC was designed to detect potential decrements in retention due to spontaneous recovery from the absence of habituation stimulus presentations during the retention interval. If retention was greater in conditions HC and SC than in conditions EE, EN, and NE, it would indicate that novel stimulation, either through sensitization or interference, disrupted rehabituation. On the other hand, less retention in HC and SC than in conditions EE, EN and NE would suggest that novel stimulation facilitated rehabituation. Moreover, greater retention in condition EE than in conditions EN and NE would further indicate a facilitatory effect for novel stimulation.

Although little has been said about developmental changes in the effects of extraneous stimulation the present study investigated retention of habituation in human infants and adults. A major reason for not discussing potential developmental changes earlier is the fact that both the OR and dual-process theories are believed to explain the

habituation process at all developmental stages. While there are no a priori reasons from these two theories to anticipate anything other than quantitative changes as a function of age, in the absence of data it is not impossible that qualitative differences may be found. Indeed, there are several reasons for expecting developmental trends in the effects of extraneous stimulation on retention of habituation. For example, there are tremendous developmental changes in learning, memory and other allied perceptual-cognitive processes as well as in ANS functions. Two extreme ages were sampled to enable the present experiment to detect any such important developmental trends in the habituation process.

A second reason for employing infant and adult subjects lies in the fact that research on the dual-process theory has chiefly involved non-human organisms. Nevertheless, Thompson et al. have attempted to explain habituation phenomena in human adults within the framework of dual-process theory. In view of the vast literature devoted to habituation and the implications of dual-process theory for this body of research, it seemed important to examine predictions from the dual-process theory on retention in human infants and adults.

Finally, the present experiment was designed to investigate the utility of dishabituation phenomena in habituation research. Although it would appear that exploring the effects of extraneous stimulation on the retention of habituation in adult humans would be sufficient to resolve this issue the fact remains that dishabituation is more frequently used as a control procedure in infant research (Kessen, et al. 1970). In the absence of data it would be hazardous to generalize from adults to infants (or vice-versa) along any parameters of the habituation process.

METHOD

Subjects

Forty adult subjects were obtained from introductory psychology classes at Michigan State University. Each of the 20 male and 20 female subjects received extra course credit for their participation.

Infants were recruited from birth notices published in local newspapers. Parents were contacted and gave their permission for their infant's only after full details of the experiment were explained. Each of the infants was home reared at the time of testing and was screened for (a) normal gestation length; (b) prenatal abnormality; (c) perinatal or postnatal complications.

Thirty-eight of the 78 infants brought to the laboratory failed to satisfactorily complete the experiment. The data from 28 babies, 15 males and 13 females, were discarded due to excessive crying. Ten of these infants began crying before the experiment commenced, 14 began crying early in Phase I, three in Phase II, and one in Phase III. Four infants fell asleep during the experiment and were excluded as were four infants who were unable to complete the experimental session due to mechanical difficulties with the recording instrumentation. The participation of two other babies was terminated when their mothers began socially interacting with them during the experimental session.

In all, 20 male and 20 female infants completed the experiment. The age of the female infants at the time of testing ranged from 89-98

days ($M = 91.7$ days; $S_D = 4.17$). The male infants ranged from 86 to 103 days old at the time of testing ($M = 91.75$ days; $S_D = 4.24$).

Apparatus

The auditory stimuli were two tape recorded pure tones, one of 1500 Hz and one of 800 Hz. The tones were of five seconds duration and were presented at 90 db (re $0.0002 \text{ dynes/cm}^2$) through a speaker located near Ss' head. For both tones the rise time (period from onset to peak intensity) was 100 msec. This is in keeping with Graham and Jackson's (1970) finding that auditory stimuli with fast rise times (5 msec. or less) are likely to elicit startle or defensive reactions in young infants. Stimulus durations and ITIs were electronically timed.

The subjects were tested individually in a sound attenuated chamber (ambient noise level of 50 db). Adult Ss were seated in a comfortable chair located within the chamber. Infant Ss were placed supine in an infant seat contained within a 90 cm x 37.5 cm x 22.5 cm rectangular plexiglass structure secured to a table within the chamber. A full view of the infants was afforded by a one-way mirror located in the chamber wall.

Skin conductance responses were recorded by two $.78 \text{ cm}^2$ silver-silver chloride electrodes filled with Lykken paste (a Unibase preparation) as a medium and were connected to a constant voltage (.5V) conductance coupler attached to a Grass model 7 polygraph located in an adjacent room. Output from the coupler (1.0 mV output per 1.0 micromho input) was channeled into a model 7p Grass preamplifier. Skin conductance responses were then read out directly in conductance units.

For adults the electrodes were taped on the palmar surface of the left hand. The recording sites for infants were the skin surface over the abductor hallucis muscle on the medial side of the left foot and the skin surface at a point midway between the first phlange and a point directly caudal to the ankle. All contact sites were cleaned with a 70% ethanol solution and allowed to dry before attaching the electrodes.

Design and Procedure

On arrival the adult Ss and the parent(s) accompanying the infant Ss were informed that the experiment was designed to study some simple physiological reactions to auditory stimuli and were advised of their rights as subjects. The parents were then requested to read a document which provided additional instructions and further detailed information about the study. [See Appendix A.] This document informed the parents of the general purpose of the experiment and briefly described the experimental procedure.

The parents were informed that they could sit quietly in the booth and observe the entire experimental session from a chair located behind the infant seat. All questions were then fully answered and informed consent obtained.

Adult Ss were told that they would be seated in a sound attenuated chamber and that their only task was to sit quietly and listen to some tones. Each S was further instructed that the experiment would last about 30 minutes and that by speaking into an open intercom the experiment could be terminated at any time. [See Appendix B.]

The experimental session consisted of three phases; habituation, retention interval, and rehabituation. To investigate the effects of

extraneous stimulation on the retention of habituation five experimental conditions were employed. The habituation and rehabituation phases were identical for all Ss. Experimental procedures differed only in the manipulations introduced during the retention interval. The five conditions were: Habituation Control (HC); Spontaneous Recovery Control (SC); Extraneous Stimulation - No Stimulation (EN); No Stimulation - Extraneous Stimulation (NE); and Extraneous Stimulation - Extraneous Stimulation (EE). /See Table 1./

On arrival S was haphazardly assigned to one of the five conditions with the stipulations that (1) an equal number of males and females were in each condition; and (2) all conditions had N Ss before any had $N + 1$. Then each S was given instructions, the electrodes were attached and a five min. rest period allowed to elapse before the experimental session began.

Phase I

In Phase I all Ss received habituation trials to one of the two auditory stimuli. For half the Ss in each condition a 1500 Hz pure tone was the habituation stimulus and for the remaining half an 800 Hz pure tone was the habituation stimulus. The ITI varied randomly from 20 to 30 sec. with a mean ITI of 25 sec. In order to establish equal levels of habituation among the various conditions all Ss continued to receive habituation trials until a criterion of no skin conductance responses (SCR) on two consecutive trials was achieved.

Phase II

Phase II consisted of a six minute retention interval which began

immediately after the habituation criterion was met in Phase I. In this phase the various treatments associated with the conditions were introduced.

The first two conditions, HC and SC, were control conditions. Condition HC was designed to serve as a baseline control for retention in Phase III. Consequently, Ss in this condition continued to receive presentations of the habituation stimulus throughout the retention interval on the same ITI as in Phase I. Condition SC was designed to detect any decrement in retention due to the absence of habituation stimulus presentations in Phase II. Subjects in this condition received no stimulation during the retention interval.

In the three remaining experimental conditions the retention interval was divided into two 3-minute periods and presentations of an extraneous stimulus introduced in one or both periods. The extraneous stimulus was either the novel 1500 Hz tone or 800 Hz tone, which ever was not the habituation stimulus presented in Phase I.

In condition EN the novel stimulation was introduced in the first three minutes of the retention interval. During the last three minutes of the retention interval no stimulation was presented. In condition NE the order of the novel stimulation and no stimulation was reversed. The no stimulation was presented during the first three minutes of the retention interval. The novel stimulus presentations occurred in the last three minutes of the interval. For condition EE, the novel stimulus was presented throughout Phase II. The novel stimuli were presented on the same ITI as in Phase I.

Phase III

To assess the impact of Phase II on retention all Ss were given rehabilitation trials to the same stimulus presented in Phase I. The same ITI was employed in Phase III as was the same habituation criterion used in Phase I.

In all phases the behavioral state of infants was continuously monitored and rated on a six point scale of infant state (Brackbill and Fitzgerald, 1969). This scale employs motor activity, eye appearance and movements, vocalizations and topography of respiration (e.g., regularity of breathing) to behaviorally index six states ranging from passive sleep to active awake and crying. There are two sleep categories passive sleep (1), active sleep (2), a transitional category drowsy (3), and three awake states quiet awake (4), active awake (5), and crying awake (6). Brackbill and Fitzgerald reported interrater reliability coefficients of .98 for both sophisticated and unsophisticated observers.

An observer was stationed outside the chamber such that the observer was provided a full frontal view of the infants through the one-way mirror. The observer was equipped with a remote control device on which behavioral state and changes in state were recorded. These ratings were recorded continuously on the polygram.

Scoring

An SCR was defined as any transient increase in skin conductivity with an amplitude (peak minus base conductance) greater than .1 micromho. Only those SCRs occurring within one to four seconds of stimulus onset were scored as responses. In order to discriminate stimulus elicited responses from ambient electrodermal activity the .1 micromho response

criterion was supplemented by a second criterion applied whenever a spontaneous SCR greater than .1 micromho was observed within a five second control period immediately preceding stimulus onset. In this event a nonresponse was recorded only if the amplitude of any SCR during the trial was equal to or less than the amplitude of the largest SCR during the control period.

Two dependent measures of state were obtained. The first dependent variable was the mean rated behavioral state of each infant for Phases I, III and each half of Phase II. Mean rated state was calculated by multiplying the cumulative number of seconds the infant remained in each state by the value associated with that state on the scale. These products were then summed and divided by the total number of seconds in the particular phase the states were recorded. This measure was employed to detect any systematic changes in state over the experimental session.

The second dependent measure of state was the number of changes in state in Phases I, III, and each half of Phase II for each infant. This last measure was viewed as potentially more sensitive than the first measure to any effects of the novel stimulation on state.

RESULTS

For each S the number of trials to criterion in the habituation and rehabilitation phases was determined and means computed. Table 2 summarizes the mean numbers of trials to criterion in Phase I and Phase III for infants and adults in each experimental condition.

A 2 x 2 x 2 x 5 x 2 analysis of variance (anova) was performed on these data. The four between-groups factors in this analysis were Age, Sex, Stimulus Frequency (Hz) and Experimental Condition. Since equal numbers of male and female infants and adults served as subjects in each condition it was decided to employ Sex as a between-groups variable in this and subsequent analyses, when appropriate. The within-S factor, Phase, was computed by treating the trials to criterion in Phase I and Phase III as repeated measures. The results of the anova are presented in Table 3.

Summarizing Table 3, Age was the only significant factor between-groups, indicating more rapid habituation in adult Ss. Apparently, neither Sex nor Stimulus Frequency influenced the rate of habituation.

The main effect for Phase was highly significant. Both infants and adults required more trials to habituate in Phase I than to rehabilitate in Phase III, indicating substantial retention in both age groups.

Of all possible between and within interactions only the Age by Phase, Age by Sex by Phase, and Condition by Phase interactions were

TABLE 2. -- Mean Number of Trials to Criterion in Phase I and Phase III Including Criterion Trials for Infants and Adults in Each of the Five Experimental Conditions.

Condition	Group	Phase One	Phase Three
HC	Infant	12.88	3.13
	Adult	9.25	2.0
SC	Infant	13.0	4.25
	Adult	9.63	3.25
EN	Infant	12.63	5.0
	Adult	10.13	5.38
NE	Infant	11.75	8.5
	Adult	7.25	3.13
EE	Infant	12.25	6.75
	Adult	9.38	3.63

HC Habituation Control
 SC Spontaneous Recovery Control
 EN Extraneous Stimulation No Stimulation
 NE No Stimulation Extraneous Stimulation
 EE Extraneous Stimulation Extraneous Stimulation

TABLE 3. -- A Summary of the Analysis of Variance of Mean Number of Trials to Criterion for Adults and Infants by Sex by Tone Frequency by Experimental Condition and by Phases.

Source	SS	DF	MS	F	P
Total	2874.09	159	--	--	--
Between	843.59	79	--	--	--
Age	294.30	1	294.30	40.26	.001
Sex	1.40	1	1.40	.19	NS
Frequency	6.80	1	6.80	.93	NS
Conditions	39.56	4	9.89	1.35	NS
Age x Sex	.32	1	.32	.04	NS
Age x Frequency	1.42	1	1.42	.19	NS
Age x Conditions	65.17	4	16.29	2.23	.1
Sex x Frequency	2.77	1	2.77	.38	NS
Sex x Conditions	30.32	4	7.58	1.04	NS
Frequency x Conditions	21.92	4	5.48	.75	NS
Age x Sex x Frequency	.73	1	.73	.10	NS
Age x Frequency x Condition	44.79	4	11.20	1.53	NS
Sex x Frequency x Condition	18.20	4	4.55	.62	NS
Age x Sex x Condition	11.65	4	2.29	.40	NS
Age x Sex x Frequency x Condition	11.99	4	3.00	.41	NS
Sub Total	551.34	39	--	--	--
Error Between	292.25	40	7.31	--	--
Within-S	2030.50	80	--	--	--
Phases	1593.90	1	1593.90	441.52	.001
Age x Phases	17.57	1	17.57	4.88	.05
Sex x Phases	1.07	1	1.07	.30	NS
Frequency x Phases	3.32	1	3.32	.92	NS
Condition x Phases	109.82	4	27.46	7.60	.001

TABLE 3 (cont'd.)

Source	SS	DF	MS	F	P
Age x Sex x Phase	10.48	1	10.48	2.90	.05
Age x Frequency x Phase	.03	1	.03	.01	NS
Age x Condition x Phase	24.40	4	6.10	1.69	NS
Sex x Frequency x Phase	.48	1	.48	.13	NS
Sex x Condition x Phase	16.40	4	4.10	1.34	NS
Frequency x Condition x Phase	30.14	4	7.54	2.09	.1
Age Sex x Frequency x Phase	.20	1	.20	.06	NS
Age x Frequency x Condition					
Age x Frequency x Condition x Phase	29.70	4	7.43	2.06	NS
Sex x Frequency x Condition					
Sex x Frequency x Condition x Phase	20.74	4	5.18	1.43	NS
Age x Sex x Condition x Phase	14.98	4	3.77	1.04	NS
Age x Sex x Frequency x Condition					
Age x Sex x Frequency x Condition x Phase	13.02	4	3.26	.90	NS
Total Within- <u>S</u>	1886.25	40	--	--	--
Error Within- <u>S</u>	144.25	40	3.61	--	--
Total	2874.09	159	--	--	--

significant. The Age by Phase interaction indicates that the difference between the infant and adult mean numbers of trials to criterion declined from Phase I to Phase III. The overall mean for infants in Phase I was 12.5 trials and for adults the mean was 9.13 trials. In Phase III, the mean number of trials for infants was 5.53 trials while the mean number of trials for adults was 3.48 trials. This significant interaction, coupled with the significant age effect, also indicates that the infant and adult means in both phases are significantly different.

The significant Age by Sex by Phase interaction, in the absence of a significant main effect for Sex, indicates that male adults required fewer trials to criterion than female adults in Phase I while the reverse was true in Phase III. In contrast, female infants required fewer trials in Phase I than male infants, while male infants required fewer trials in Phase III.

Finally, the Condition by Phase interaction indicates that the experimental treatments introduced in Phase II differentially influenced the number of trials to criterion in Phase III as opposed to Phase I. Phase I: Before the effects of Phase II on retention were examined in detail further analyses were required to determine the equivalence of infants and adults at the end of the habituation phase. Since the first anova indicated faster habituation in adults and infants, separate Duncan's Multiple Range Tests (Brunner and Kintz, 1968; p. 115) were performed on these data.

The results of the Duncan's Test on the number of trials to criterion in Phase I for infants is presented in Table 4. It can be seen in Table 4 that there were no significant differences among the

TABLE 4. -- A Summary of the Duncan's Multiple Range Test on the Mean Number of Trials to Criterion in Phase One for the Infant Subjects in each Experimental Condition.

Mean		NE 11.75	EE 12.25	EN 12.63	HC 12.88	SC 13.00
NE	11.75		.5	.88	1.13	1.25
EE	12.25			.38	.63	.75
EN	12.63				.25	.37
HC	12.88					.12

NE No Stimulation Extraneous Stimulation
 EE Extraneous Stimulation Extraneous Stimulation
 EN Extraneous Stimulation No Stimulation
 HC Habituation Control
 SC Spontaneous Recovery Control

means of infants in the experimental conditions. On the basis of these results it appears reasonable to assume that equal levels of habituation were established among infant Ss and that there were no substantial differences among infants in the various conditions prior to the experimental treatments in Phase II.

The results of the Duncan's Test performed on the Phase I trials to criterion for adults are shown in Table 5. As indicated in Table 5, adults in condition NE required significantly fewer trials to criterion in Phase I than adults in any other condition. None of the other differences among the adult means were significant. The fact that adults in one condition habituated more rapidly than adults in the other conditions suggests some systematic sampling error despite the haphazard assignment of Ss to conditions. Thus it cannot be assumed that equivalent levels of habituation were established among adult Ss prior to introduction of the experimental treatments in Phase II.

Phase II: Of interest in the phase were: a) the mean numbers of spontaneous SCRs during each period of no stimulation; and b) the mean number of responses elicited by the habituation and extraneous stimulus presentations. These data may be examined in Table 6.

Briefly, it can be seen in Table 6 that infants in Conditions EN, NE and SC showed slightly greater spontaneous electrodermal activity during each period of no stimulation than adults in the same conditions. It is also evident that infants in condition HC were somewhat more responsive to the habituation stimulus in Phase II than adults. Nonetheless, means can be taken as evidence that both infants and adults were more-or-less habituated at the end of Phase I.

TABLE 5. -- A Summary of the Duncan's Multiple Range Test on the Mean Number of Trials to Criterion in Phase One for the Adult Subjects in Each of the Five Conditions.

	NE	HC	EE	SC	EN
Mean	7.25	9.25	9.38	9.63	10.13
NE	7.25	2.0*	2.13*	2.38*	2.88*
HC	9.25		.13	.38	.88
EE	9.38			.25	.75
SC	9.63				.5

*P .05

NE No Stimulation Extraneous Stimulation
 HC Habituation Control
 EE Extraneous Stimulation Extraneous Stimulation
 SC Spontaneous Recovery Control
 EN Extraneous Stimulation No Stimulation

TABLE 6. -- Mean Number of Spontaneous Responses During No Stimulation and Mean Number of Responses to the Habituation and Extraneous Stimuli in Phase II for Infants and Adults in Each of the Five Experimental Conditions.

Condition	Group	Phase II First	Periods Second
HC	Infant	1.88	1.50
	Adult	1.12	.55
SC	Infant	1.75	1.0
	Adult	1.25	.56
EN	Infant	5.33	1.35
	Adult	5.13	.88
NE	Infant	2.0	5.48
	Adult	1.63	5.25
EE	Infant	5.63	3.68
	Adult	5.50	1.88

HC Habituation Control
 SC Spontaneous Recovery Control
 EN Extraneous Stimulation No Stimulation
 NE No Stimulation Extraneous Stimulation
 EE Extraneous Stimulation Extraneous Stimulation

The fact that infants and adults in Conditions EN and EE were substantially more responsive to stimulation in the first half of Phase II than their counterparts in Condition HC provides strong support for the contention that there was appreciable response recovery to the extraneous auditory stimulation. Moreover, the mean numbers of responses to the extraneous stimulation for infants and adults in Condition NE are remarkably similar to those of infants and adults in Conditions EN and EE. This suggests that three minutes of no stimulation immediately following Phase I in Condition NE did not appreciably influence response recovery to the extraneous stimulation. Finally, it can be seen in Table 6 that the mean number of responses to extraneous stimulation for infants and adults in Condition EE are somewhat lower in the second half of Phase II than in the first half. This immediately suggests that there was some habituation to extraneous stimulation over Phase II.

Phase III: Figure 1 shows the mean number of trials to criterion in Phase III for infant and adult Ss in each of the five experimental conditions. In Figure 1 it appears that adult Ss in each condition required fewer rehabilitation trials to achieve habituation criterion than the corresponding infant Ss. T-tests for independent means were performed on each condition, the results of which are summarized in Table 7. These tests revealed that the differences between the mean numbers of trials to criterion for infant Ss and adult Ss in conditions HC, NE, and EE were significant. The means for infant Ss and adult Ss in conditions SC and EN were not significantly different. This last finding was surprising since it was expected that the usual finding of greater retention in adults would be most pronounced in the SC condition.

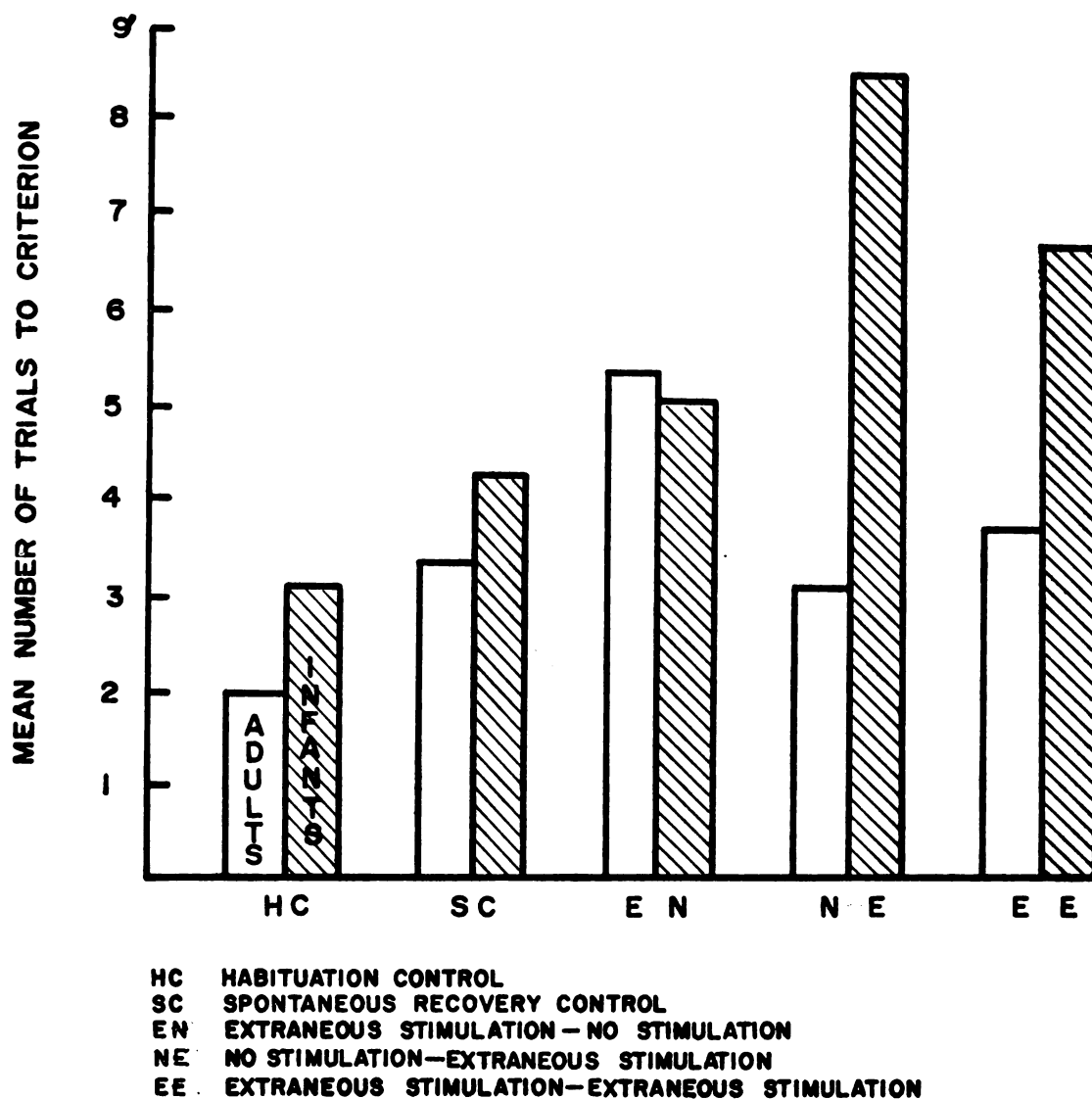


Figure 1. -- Mean Number of Trials to Criterion Including Criterion Trials in Phase III (Rehabilitation) for the Infants and Adults in the Five Experimental Conditions.

TABLE 7. -- A Summary of the Results of the T-tests Performed on the Mean Numbers of Trials to Criterion in Phase III for Infant and Adult Subjects in Each of the Five Experimental Conditions.

Condition	Infant Mean	Adult Mean	Difference	T	DF	P
HC	3.13	2.00	1.13	3.21	14	.01
SC	4.25	3.25	1.00	1.81	14	.10
EN	5.00	5.38	.38	.42	14	NS
NE	8.50	3.13	5.27	9.79	14	.001
EE	6.75	3.63	3.12	2.20	14	.05

HC Habituation Control
 SC Spontaneous Recovery Control
 EN Extraneous Stimulation No Stimulation
 NE No Stimulation Extraneous Stimulation
 EE Extraneous Stimulation Extraneous Stimulation

Figure 1 also shows the effects of Phase II on retention of infants and adults. Overall, it appears that the extraneous stimulation in the retention interval disrupted rather than facilitated habituation in Phase III. Figure 1 also suggests that the experimental treatments in Phase II had different effects on habituation in infants and adults.

First, it can be seen in Figure 1 that infants in the control conditions required fewer habituation trials than infants receiving extraneous stimulation in Phase II. Moreover, among infants it appears that the extraneous stimulation had its greatest impact on retention when presented only in the last three minutes of Phase II. Infants in conditions EN and EE required fewer habituation trials than those in condition NE. Of infants in the three conditions receiving extraneous stimulation in Phase II the fewest trials to criterion in Phase III were required by those in condition EN.

For the adult Ss Figure 1 indicates that the extraneous stimulation had a disruptive effect on habituation when presented only in the first three minutes of Phase II.

To determine which of the infant means and adult means were reliably different separate Duncan's Multiple Range Tests were performed. The results of the Duncan's Test on the mean numbers of trials to criterion for the infant Ss in each condition are shown in Table 8. To summarize Table 8, the analysis revealed that infants in condition NE required significantly more habituation trials to reach criterion than infants in all other conditions. Infants in condition EE required significantly fewer habituation trials than infants in condition NE

TABLE 8. -- A Summary of the Duncan's Multiple Range Test on the Mean Number of Trials to Criterion in Phase Three for the Infant Subjects in Each of the Five Experimental Conditions.

	HC	SC	EN	EE	NE
Means	3.13	4.25	5.0	6.75	8.5
HC	3.13	1.12	1.87*	3.62**	5.37**
SC	4.25		.75	2.5**	4.25**
EN	5.0			1.75*	3.5**
EE	6.75				1.75*

* P .05

** P .001

HC Habituation Control
 SC Spontaneous Recovery Control
 EN Extraneous Stimulation No Stimulation
 EE Extraneous Stimulation Extraneous Stimulation
 NE No Stimulation Extraneous Stimulation

but significantly more trials to criterion than infants in conditions EN, SC, and HC. Infants in condition EN required significantly more trials in Phase III than infants in condition HC. The difference in the numbers of trials to criterion between conditions EN and SC was not significant nor was the difference between conditions SC and HC.

The results of the Duncan's Test performed on the Phase III mean numbers of trials to criterion for adult Ss in the five conditions are exhibited in Table 9. The results of this analysis indicated that adult Ss in condition EN required significantly more rehabilitation trials than adult Ss in conditions HC, SC, NE, and EE. None of the differences between the remaining pairs of adult means were significant.

Behavioral State

Table 10 shows the mean rated state of male and female infants for Phase I, the two three minute portions of Phase II, and Phase III. An inspection of this table reveals that, on the average, male and female infants maintained a quiet awake state throughout the experimental session.

A 2 x 5 x 4 analysis of variance was performed on the mean rated states of the infants. The two between-groups factors in this analysis were Sex and Condition and the within-S factor was Phase, computed by treating the mean rated state in Phase I, each of the two 3-minute portions of Phase II, and Phase III as repeated measures. The results of this analysis are presented in Table 11, where it can be seen that there were no reliable differences in rated state as a function of sex or experimental condition. The absence of a significant main effect for Phase indicates there were no systematic changes in state over the course of the experimental session.

TABLE 9. -- A Summary of the Duncan's Multiple Range Test on the Mean Number of Trials to Criterion in Phase Three for the Adult Subjects in Each Experimental Condition.

	HC	NE	SC	EE	EN
Means	2.0	3.13	3.25	3.63	5.38
HC	2.0	1.13	1.25	1.63	3.38**
NE	3.13		.12	.5	2.25*
SC	3.25			.38	2.13*
EE	3.63				1.75*

* $\underline{P}$.05

** $\underline{P}$.001

HC Habituation Control
 NE No Stimulation Extraneous Stimulation
 SC Spontaneous Recovery Control
 EE Extraneous Stimulation Extraneous Stimulation
 EN Extraneous Stimulation No Stimulation

TABLE 10. -- Mean Rated State of Arousal for the Male and Female Infants in Phase I, Each of the Two Three Minute Periods in Phase II, and in Phase III.

Sex	Phase I	Phase II A	Phase II B	Phase III
Female	4.02	4.05	4.06	4.26
Male	4.28	4.30	4.26	4.17

TABLE 11. -- A Summary of the Analysis of Variance on the Mean Rated State of Arousal for Infants by Sex by Experimental Condition and by Phase.

Source	SS	DF	MS	F	p
Total	25.87	159	--	--	--
Between Groups	12.70	39	--	--	--
Sex	.97	1	.97	3.13	.1
Conditions	1.24	4	.31	1.00	NS
Sex x Conditions	1.08	4	.27	.87	NS
Error Between	9.41	30	.31	--	--
Within- <u>S</u>	13.17	120	--	--	--
Phase	.10	3	.03	.23	NS
Sex x Phase	.83	3	.28	2.15	NS
Condition x Phase	1.43	12	.12	.92	NS
Sex x Condition x Phase	.25	12	.02	.15	NS
Error Within- <u>S</u>	10.81	84	.13	--	--
Total	25.87	159	--	--	--

A 2 x 5 x 4 analysis of variance also was performed on the second dependent measure of state, the number of changes in state. The two between groups and one within-S factors were the same as in the analysis of mean rated state. The results of the second analysis are shown in Table 12. As in the previous analysis, no significant main effects for Sex, Condition, or Phase emerged in the results of this analysis.

The Sex by Conditions interaction was significant, indicating that female infants in condition EN and male infants in condition HC showed the greatest numbers of changes in state (13 and 14, respectively). The absence of significant Condition by Phase and Sex by Condition by Phase interactions suggests that the Sex by Conditions interaction resulted from some sampling error rather than from the experimental treatments or from systematic changes in state during the experimental session.

To summarize, there is no evidence in the results of either analysis that the Phase II treatments or more specifically, the extraneous stimulation, had a significant impact on behavioral state. Nonetheless, the combined results of the analyses performed on the behavioral state measures do provide substantial support for the contention that neither the habituation nor rehabilitation performances of infants was influenced by differences in state or by systematic changes in state over the experimental session.

TABLE 12. -- A Summary of the Analysis of Variance on the Number of Changes in State for Infants by Sex by Experimental Condition and by Phase.

Source	SS	DF	MS	F	p
Total	101.78	159	--	--	--
Between Groups	43.27	39	--	--	--
Sex	.03	1	.03	.05	NS
Conditions	2.46	4	.615	1.13	NS
Sex x Conditions	26.89	4	6.72	12.31	.001
Error Between	16.39	30	.546	--	--
Within-S	58.51	120	--	--	--
Phase	1.12	3	.37	.70	NS
Sex x Phase	.72	3	.24	.45	NS
Conditions x Phase	6.69	12	.56	1.06	NS
Sex x Condition x Phase	5.09	12	.42	.79	NS
Error Within Phase	44.89	84	.53	--	--
Total	101.78	159	--	--	--

DISCUSSION

The purpose of the present study was to determine the effects of extraneous stimulation on the retention of habituation in infants and adults. Table 13, which shows the mean number of trials to criterion in Phase I and Phase III for infants and adults in each of the five conditions, summarizes the major findings of this study. It can be seen in this table that both adults and infants showed substantial retention when a six minute interval intervened between habituation and rehabituation to the same auditory stimulus. In general, rehabituation proceeded more rapidly than habituation for both infants and adults.

The results indicate that extraneous novel auditory stimulation presented during a retention interval tends to disrupt rehabituation in both infants and adults. The infants in all three experimental conditions required more rehabituation trials to criterion than infants in the two control conditions not receiving novel stimulation. Although only the adults in Condition EN required significantly more rehabituation trials than adults in the control conditions, the pattern among the adult means is similar to that of the infants. Only adults in Condition NE required fewer (though not significantly fewer) rehabituation trials to reach criterion than adults in Condition SC. However, the analyses showed that these adults required significantly fewer trials to achieve criterion in the habituation phase than adults in any other

TABLE 13. -- Mean Number of Trials to Criterion Including Criterion Trials During Habituation and Rehabilitation for the Infant and Adult Subjects.

Conditions	Habituation		Retention		Interval	Rehabilitation	
	Infants	Adults	Stimulation	Stimulation		Infants	Adults
Habituation Control	12.88	9.25	Same	Same		3.13	2.00
Spontaneous Recovery Control	13.00	9.63	No Stimulation	No Stimulation		4.25	3.25
No Stimulation Extraneous Stimulation	11.75	7.25	No Stimulation	No Stimulation	Novel Stimulation	8.50	3.13
Extraneous Stimulation No Stimulation	11.66	10.13	Novel Stimulation	Novel Stimulation	No Stimulation	5.00	5.38
Extraneous Stimulation Extraneous Stimulation	12.25	9.38	Novel Stimulation	Novel Stimulation	Novel Stimulation	6.75	3.62

condition. This immediately suggests that the rehabilitation performances of adults in Condition NE may have been confounded by sampling error. In sum, there is no evidence in the present study which indicates extraneous stimulation may facilitate the retention of habituation.

If it is assumed on the basis of the analyses that, except for adults in Condition NE, equal levels of habituation were established in Phase I among the infants and adults, then the results of this study also suggest that extraneous auditory stimulation operated differently on retention in infants and adults.

For infants the results clearly show that extraneous stimulation had its greatest disruptive effect on rehabilitation when presented in the last half of the retention interval. Significantly more rehabilitation trials were required by infants in Condition NE than by those in any other condition. Moreover, the impact of the extraneous stimulation on retention was markedly attenuated in Condition EE, and nearly completely eliminated in Condition EN. That the disruptive effect of extraneous stimulation depended on whether it was preceded or followed by a brief period of no stimulation before rehabilitation, is incompatible with the position that such stimulation interferes with habituation and relatively permanently disrupts its retention.

Instead, these outcomes are entirely consistent with the dual-process theory that extraneous stimulation influences central state systems through some sensitization process. According to this theory sensitization accumulated during novel stimulation which temporarily elevated the responsivity of infants to stimuli in general. Since neither the habituation process nor the retention of habituation is

believed to be directly influenced by extraneous stimulation it was the differential decay of sensitization in Phase II that was responsible for differences in habituation performances among the groups of infants.

The pattern which emerges for the Phase III performances of infants is entirely compatible with this explanation. On the average, the greatest number of habituation trials was required by infants in Condition NE. This suggests little or no sensitization dissipated before habituation trials when novel stimulus presentations occurred in the last half of the retention interval. The fact that fewer habituation trials were required by infants in Condition EE than infants in Condition NE also suggest that sensitization reached asymptote in Phase II and thereafter dissipated even while novel stimulation continued in Condition EE.

The hypothesis that greater sensitization would dissipate before habituation when a period of no stimulation followed the novel stimulation in the retention interval was also confirmed. Fewer habituation trials were required by infants in Condition EN than infants in both Conditions EE and NE. Indeed, it could be argued that the three minutes of no stimulation was sufficient to enable all detectable sensitization to decay since the habituation performances of infants in Conditions EN and SC did not reliably differ. This supports the Thompson et al. view that dishabituation is an epiphenomenon observed only when the response is elicited by the habituation stimulus while the organism is briefly more responsive.

The contention that the novel stimulation temporarily increased the responsivity of infants by operating on central state systems would

have been strengthened if the results of the state measures had indicated systematic changes in state due to extraneous stimulation. One possible explanation for the failure of these measures to indicate any changes in state as a function of novel stimulation is afforded by several informal observations. First, it was noted early in the study that infants showing a change in state early in Phase I almost invariably showed a second change in the same direction. Since all infants were awake and alert at the start of the experimental session, in most cases two consecutive changes in state would be to active awake and then crying awake. In the event of crying the experiment was terminated and the data discarded, as noted earlier, 14 infants were eliminated in Phase I for crying. This raises the possibility that infants most likely to show changes in state during the extraneous stimulation were systematically eliminated in the habituation phase and replaced by infants less responsive to the auditory stimuli.

A second factor which also may have operated to reduce variability on the state measures was the length of the experimental session. Although the six minute retention interval was selected to maintain the duration of the session within acceptable limits (15 to 20 minutes), the fact that the habituation criterion was based on response amplitude allowed the duration of Phase I to vary considerably. That is, with this criterion the more responsive the infant to the habituation stimulus the longer Phase I. In turn, the longer Phase I the more likely the duration of the experimental session would exceed the ability of the infant to remain in a quiet, alert state. It is a real possibility then, that the experimental design favored infants who showed few changes in state.

The results of the analyses of Phase III performances indicated that in adult Ss, novel stimulation had a disruptive effect of rehabituation when it was presented in the first half of the retention interval only. Of the adults in the conditions receiving novel stimulation in the retention interval only adults in Condition EN required reliably more rehabituation trials to reach criterion than the adults in the two control conditions.

The pattern among adult Ss' performances is not consistent with either OR theory or dual-process theory. Even if the data of adults in Condition NE are disregarded because of potential sampling error, neither theory adequately explains the finding of greater retention in Condition EE than in Condition EN.

Clearly if novel stimulation had generated sensitization in adult Ss then fewer rehabituation trials should have been required when a period of no stimulation rather than more novel stimulus presentations occurred in the second half of the retention interval. On the other hand, if novel stimulation interfered with the retention of habituation it would be expected that more interference (and therefore less retention) should have occurred when the novel stimulus was presented throughout the retention interval rather than in one half of the interval.

There are at least two possible explanations for the fact that the results did not support either of these predictions. First, the fact that the time parameters of two crucial processes, sensitization and spontaneous recovery, are not precisely specified in either OR or dual-process theory renders it difficult to determine the exact experimental manipulations required to test these differential predictions.

Secondly, in view of the finding that for adults the mean numbers of trials to criterion in Phase III, including criterion trials, ranged from a low of 2.0 trials (Condition HC) to a high of 5.38 trials (Condition EN), it is entirely possible that any effects of extraneous stimulation on habituation were masked by the overall superior retention shown by adult Ss (floor effect).

To briefly summarize, the results of the present study indicate that, at least in infants, extraneous novel stimulation does not interfere with or disrupt the retention of habituation. Instead it appears that such stimulation temporarily heightens responsivity to stimulation in general through some sensitization process. This immediately suggests that the response recovery observed on rehabilitation trials following the presentation of novel stimulation is not a case of response dishabituation but a result of eliciting the response while the organism is briefly more responsive. The infant data clearly support the position that the impact of extraneous stimulation on later rehabilitation, while disruptive, is only temporary. These results indicate that the number of rehabilitation trials required following the occurrence of novel stimulation is a direct function of the amount of transient sensitization effectively remaining when the habituation stimulus presentations resume.

Since it is widely assumed that dishabituation is the result of the novel stimulation directly and more-or-less permanently disrupting the retention of habituation, the results of the present study have several important implications for infant research utilizing habituation procedures. First, the present findings do not support the

contention that dishabituation phenomena can be used to infer that response decrements are brought about by some central habituation process rather than by systematic changes in state during the experimental session. Indeed, the current study indicates that novel stimulation may have dramatic incremental effects on responsivity without influencing the retention of habituation.

Second, the suggestion that dishabituation may be employed to determine what stimulus factors influence retention of habituation also is not supported by the present study. The retention of habituation, at least when measured by rehabituation, does not appear to be directly influenced by presentations of novel events. Instead it appears that the mechanisms governing the retention of habituation are not affected by extraneous stimulation and that presentations of novel stimuli may neither accelerate nor retard spontaneous recovery in infants.

Finally, the results of the present study suggest that extraneous stimulation has different effects on retention of habituation in infants and adults. While no clear pattern emerged in the adult data it seems possible that novel events may directly interfere with and disrupt retention in adults. Further research is required to further explore and detail the effects of extraneous stimulation on habituation in adults as well as to clarify any potential developmental changes in these effects.

LIST OF REFERENCES

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- Allen, T. W., and Fitzgerald, H.E. Habituation as an index of intra-sensory integration of form. Journal of Genetic Psychology, 1974, 124, 131-144.
- Bartoshuk, A. K. Human neonatal cardiac acceleration to sound: habituation and dishabituation. Perceptual and Motor Skills, 1962, 15, 15-27.
- Berlyne, D. E. Conflict, Arousal, and Curiosity. New York: McGraw-Hill, 1960.
- Brackbill, Y. The role of the cortex in orienting: orienting reflex in an anencephalic human infant. Developmental Psychology, 1971, 5, 195-201.
- Brackbill, Y., and Fitzgerald, H.E. Development of the sensory analyzers during infancy. In L. P. Lipsitt and H. E. Reese (Eds.), Advances in Child Development and Behavior. Vol. 4. New York: Academic Press, 1969.
- Bridger, W. H. Sensory habituation and discrimination in the human neonate. American Journal of Psychiatry, 1961, 117, 991-996.
- Bruning, J. L. and Kintz, B. L. Computational Handbook of Statistics, Glenview, Illinois: Scott, Foresman and Company, 1968.
- Friedman, S. Habituation and recovery of visual responses in the alert human newborn. Journal of Experimental Child Psychology, 1972 13, 339-349.
- Graham, F. K. Habituation and dishabituation of responses innervated by the autonomic nervous system. In H. Peeke, and M. Herz (Eds.), Habituation: Behavioral Studies, Vol. 1. New York: Academic Press, 1973.
- Graham, F. K., and Jackson, J. C. Arousal systems and infant heart rate responses. In H. W. Reese and L. P. Lipsitt (Eds.), Advances in Child Development and Behavior, Vol. 5. New York: Academic Press, 1970.
- Groves, P. M., and Thompson, R. F. Habituation: a dual-process theory. Psychological Review, 1970, 77, 419-450.

- Horowitz, A. B. Habituation and Memory: infant cardiac responses to familiar and discrepant auditory stimuli. Child Development, 1972, 43, 43-53.
- Jeffrey, W. E., and Cohen, L. B. Habituation in the human infant. Advances in Child Development and Behavior, Vol. 6. New York: Academic Press, 1971.
- Kagan, J., and Lewis, M. Studies of attention in the human infant. Merrill-Palmer Quarterly, 1965, 11, 95-127.
- Kessen, W., Haith, M. M., and Salapetek, P.H. Infancy. In P. H. Mussen (Ed.), Carmichael's Manual of Child Psychology. New York: John Wiley and Sons, 1970.
- Pancratz, C. N., and Cohen, L. B. Recovery of habituation in infants. Journal of Experimental Child Psychology, 1970, 9, 208-216.
- Ratner, S. C. Habituation: research and theory. In J. Reynierse (Ed.), Current Issues in Animal Learning. Lincoln, Nebraska: University of Nebraska Press, 1970.
- Sokolov, E. N. Neuronal models and the orienting reflex. In M. A. Brazier (Ed.), The Central Nervous System and Behavior. Madison, New Jersey: Madison Printing Company, 1960.
- Sokolov, E. N. Perception and the Conditioned Reflex. New York: Pergamon, Press, 1963.
- Thompson, R. F., and Spencer, W. A. Habituation: a model phenomenon for the study of neuronal substrates of behavior. Psychological Review, 1966, 73(1), 16-43.
- Zimny, G. H., and Schwabe, L. W. Stimulus change and habituation of the orienting response. Psychophysiology, 1966, 2 (2), 103-115.

APPENDICES

APPENDIX A

A Sample Copy of the Instructions for the Parents of Infant Subjects

Parents: (Please read carefully)

The experiment your child is about to participate in was designed to study some simple physiological responses that occur when certain kinds of events capture babies' attention.

The physiological responses we are interested in are: 1) the rate at which the heart is beating; and 2) changes in the activity of the sweat glands of the skin. To study these responses two sets of recording sensors will be taped to the surface of your baby's skin after the contact site has been wiped with an alcohol pad. To record heart-rate a sensor will be taped on each side of the baby's chest. These sensors will pick-up the minute electrical signals the heart muscles generate with each beat. These signals will then be sent to a machine in the next room where they will be recorded. Sweat gland activity will be monitored by taping a second set of sensors to the bottom of the baby's left foot. These sensors will pick-up minute changes in the electrical properties of the skin associated with sweating. These signals will also be sent to the adjoining room where they will be amplified and converted to lines drawn on moving paper records.

The apparatus for recording both responses was carefully constructed and has been thoroughly tested. All potential hazards have

been removed. There is no danger involved whatsoever, and your baby will not even feel the sensors. In fact, one of our major concerns is that your child may fall asleep before we have concluded our tests.

The stimuli we have selected to present are some simple, pure tones. These tones are of 800 and 1500 cycles per second; which means that the pitch of each tone is well within the range of human hearing. The tones will be presented at 80 decibels. This means that the tones are slightly louder than people's voices when they are engaged in everyday conversations.

The Experimental Session

Briefly, your baby will be placed in a comfortable bassinette located in a sound controlled booth and the sensors will be attached. Then, after your infant has adjusted to the new surroundings, the session will begin and it will last about 20 to 30 minutes.

The objective of the session is to study what influences the length of time infants pay attention to particular events. And, once an event becomes boring (that is, he stops attending to it), how long will it be before that event will again be interesting to baby? The session is designed to help us answer these and other questions and has been divided into three phases.

Phase I: In this phase your baby will hear the same tone repeatedly until he stops responding to it. This tone is five seconds long and will occur once every 20 to 30 seconds. When baby stops attending to this tone, Phase I will end and the next phase will start.

Phase II: In this phase one of four things can happen, depending on the group to which your infant is assigned. These four events are:

- 1) a new tone will replace the first tone;
- 2) the tone stops and a period (six minutes) of silence follows;
- 3) both a period of silence (three minutes) and new tones will follow the first tone;
- 4) the same tone as in the first phase will be presented in this phase.

Phase III: This phase concludes the study. Here we will examine the effects of the events of the second phase on baby's attention to the first tone. Thus in this phase, the first tone will again occur just as before.

State: A student will view your infant at all times through a one-way mirror located at the foot of the bassinette. Should baby fall asleep or become excessively agitated, this student will inform me and we will immediately stop the session.

If you have any questions so far please ask them now.

Parent: A comfortable chair has been placed in the booth so that you may sit quietly and watch your baby throughout the study. While you are watching, we would like you to complete an informal questionnaire designed to gather background information on the infants who participate in our research. The information you supply will be kept strictly confidential, and, as in all our researches, the individuals who participate will remain anonymous.

Do you have any additional questions?

Parent's Rights: Of course, you and your infant's participation in this research is voluntary. Therefore we want to stress the fact that you may terminate the session any time you desire. In the event that you

wish to exercise this option, an intercom has been placed in the chamber. All you need to do is speak into the intercom.

Finally, University regulation and ethical standards established by the Psychology Department require that we obtain your informed consent before your infant participates in this study. If you are willing to allow your infant to participate in this study and if you understand what we are asking of you please sign this document in the space provided below.

Signature: _____ Date: _____

APPENDIX B

A Sample Copy of the Instructions for the College Student Subjects.

The experiment you are about to participate in is designed to study some simple physiological responses that occur while you attend to certain kinds of events. The responses we are interested in are: 1) the rate at which the heart is beating; and 2) changes in the activity of your sweat glands.

Both of these responses occur reflexively and, in order to study them, recording sensors must be attached to the surface of your skin. To record heart rate one sensor will be taped to your ankle and another to your arm. These sensors will pick up the minute electrical signals generated by the heart muscles on each beat.

To study sweat gland activity, which, incidentally reflects your overall level of arousal, two sensors will be taped to your left palm and forearm. These sensors will monitor minute changes in the electrical properties of your skin. You will not feel any of the changes picked up by the sensors. These responses are so small that they will be amplified many times before they are recorded on moving paper in the adjacent room.

The stimuli we are interested in studying are some simple tones. These tones will be presented over a speaker located in a sound controlled booth. You will be seated in that booth during the experiment session.

Do you have any questions so far?

In a few minutes you will be seated in that booth and the sensors will be attached. A few minutes of silence will then follow so that you may adapt to the surroundings. You will be told when the experimental session is to begin. It will last about 30 minutes.

At various times during the session you will hear some tones, and sometimes you will not hear anything. The experiment is fully automated and therefore, there is no reason to become excited if it seems as if nothing is occurring. Your only task during the experiment will be to sit quietly, relax and listen. Please try to avoid unnecessary movements as the sensors are easily biased.

Do you have any questions?

Do you understand what you are to do?

("O.K.," now let us go into the booth.)

Attach Contacts

- 1) Prep pads. This is to prepare sensor site and the solution is alcohol.
- 2) Cream. This is to insure a good contact between sensor and skin.
- 3) Sensors. These are for heart rate. These are for skin activity.
- 4) Do you have any questions?
- 5) "O.K.," the experiment will begin shortly. Remember you can be in contact with us at all times through the intercom. If you have no problems during the experiment please do not talk. However, if at anytime you begin to feel particularly uncomfortable, please speak up and we will immediately terminate the study and you will still receive your extra credits.

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