AN INVESTIGATION OF STIMULUS-SPECIFICITY IN LONG-TERM HABITUATION

by

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ABSTRACT

It has been established that, with stimulus change, the degree of orienting-response recovery from short-term habituation (i.e., habituation within a single stimulus series) is positively correlated with degree of stimulus-change. The present study represents an attempt to explicate the stimulus-specific nature of long-term habituation (i.e., habituation retained across stimulus series). To this end, four groups of twenty subjects were provided with two experimental "sessions", separated by ten minutes. Across three groups, the degree of intersessional stimulus-similarity was varied, being either identical (Group 4), intramodally different (Group 3), or intermodally different (Group 2). To determine to what extent the presentation of any stimulus series in Part A is necessary for a lowering of responding in Part B, Group 1 was given a stimulus series only in Part B. Occurrence of the orienting response was measured via changes in skin conductance, and two measures of long-term habituation were employed: the magnitude of response to the initial stimulus of Part B and the number of trials responded to before reaching an habituation criterion of three consecutive nonresponses.

Three measures of tonic arousal were employed: frequency of spontaneous fluctuations in skin conductance, skin conductance level, and heart rate level. Neither evidence for non-stimulus-specific influences nor for intermodal generalization of long-term habituation obtained, though these results were somewhat equivocal since the measures of long-term habituation may have been confounded by the differing response-eliciting properties of the various stimuli employed in Part A. Evidence for intramodal generalization was found with initial response magnitude but not with trials-to-criterion, suggesting that initial response magnitude is the more sensitive measure of LTH. Both measures of LTH showed a decrement across sessions with repetition of an identical stimulus.

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DEDICATION

This work is humbly dedicated to my parents, Charles and Julia Van Doren, and to my brother, Gary Van Doren. Each of them has contributed more to the richness of my life than words can express...

INTRODUCTION

In the course of his studies of classical conditioning in dogs, Pavlov (1927) made note of an unconditioned response elicited by the first few presentations of conditioned stimuli: The dogs moved their heads and pricked their ears in such a way as to direct their sensory apparatus toward the stimulus-source. After repeated presentations, this response would fade and the conditioned response would replace it. Pavlov termed the unconditioned response the "investigatory" or "orienting" reflex (OR), and expended considerable effort trying to eliminate extraneous stimuli which might elicit an OR and disrupt the conditioning process.

Over the years, the OR has come to be the focus of considerable investigation in its own right. The source of much of this interest was eloquently summed up by Pavlov:

> It is this reflex which brings about the immediate response in man and animals to the slightest changes in the world around them, so that they immediately orientate their appropriate receptor organ in accordance with the perceptible quality in the agent bringing about the change, making full investigation of it. The biological significance of this reflex is obvious. If the animal were not provided with such a reflex its life would hang at every moment by a thread. In man this reflex has been greatly developed with far-reaching results, being represented in its

> highest form by inquisitiveness-- the parent of that scientific method through which we may hope one day to come to a true orientation in knowledge of the world around us. (Pavlov, 1927, p. 12)

Additional interest undoubtedly stemmed from an observation mentioned above: With repeated presentation of a stimulus, the OR gradually diminishes and finally disappears. This process, termed <u>habituation</u>, may be considered a form of learning in the sense that it represents a change in behavior with experience. The OR thus seems to tie into the learning process in two ways, consisting of behaviors to maximize information uptake and demonstrating behavioral plasticity with such uptake.

Habituation, merely considered as a waning of a given response with repeated stimulation, is not restricted to the OR. Responses in organisms throughout the phylogenetic tree, even including the contraction of protozoans following mechanical stimulation, demonstrate reductions in responsiveness with repeated elicitation (Eisenstein and Peretz, 1973). As such, habituation must be considered a primitive form of learning indeed. However, Thompson and Spencer (1966) have developed a more stringent definition of habituation with perhaps more relevance to human learning and the OR. They have operationalized habituation in terms of nine parameters:

1. Repeated stimulation produces decreased responding.

2. With cessation of stimulation, spontaneous recovery occurs.
3. Repeated habituation series produce greater habituation.
4. Greater rates of stimulation produce more rapid habituation.
5. Greater stimulus intensities produce slower habituation.
6. Greater numbers of trials beyond habituation produce slower response recovery.
7. Habituation to a given stimulus will generalize to other stimuli.
8. Presentation of a different stimulus produces response recovery.
9. Repeated presentation of the different stimulus produces decreased response recovery.

Applying this definition, habituation is restricted to a more circumscribed portion of the phylogenetic hierarchy, to date observed only in intact and spinalized (a spinal cat preparation) mammals (Eisenstein and Peretz, 1973).

Measurement of the OR has moved from the somatic aspects reported by Pavlov to more quantifiable measures such as the EEG and various covert and autonomic response systems (e.g., vasomotor, heart-rate, skin-conductance, and respiratory changes). The use of these measures as components of the OR became prevalent as studies of autonomic conditioning began to reveal that these systems, too, show an unconditioned response to the first few presentations of the conditioned stimulus (Robinson and Gantt, 1947). Also, studies of the "arousal reaction", itself composed of EEG and autonomic activity, led to its identification with the OR (Vinogradova, 1969). Presumably, the autonomic indices represent a phasic increase in sympathetic tone concomitant with an increase in "arousal" or alertness. Thus, a full picture of the OR arose as a complex of central (electroencephalographic and striate-muscular) and autonomic responses, all of which presumably are aspects of mechanisms which are related, directly or indirectly, to the enhancement of information uptake or to the results of such enhancement. Studies of the OR have predominantly relied on autonomic measures, probably due to their ease of measurement.

Establishing himself as a prominent investigator of the OR, E. N. Sokolov (1963, p. 546) formalized three parameters by which physiological response systems could be characterized as components of the OR:

1. "nonspecificity with regard to the quality of the stimulus";

(The response occurs to a diversity of stimuli, regardless of modality.)

2. "nonspecificity with regard to the intensity of the stimulus";

(The response occurs to either onset or offset of the stimulus.)

3. specificity-of-habituation with regard to the characteristics of the stimulus.

(The response occurs to, or is increased by, any superthreshold change in the stimulus.)

More importantly, he presented what has come to be known as the "comparator" theory of habituation, which served as a stepping-stone for much of the research to follow and to this day continues to influence the thinking of researchers in the field. Sokolov (1963) basically considered stimulus input to be followed by a process in which the new stimulus is compared to a "neuronal model" of the previous stimulus and habituation to result from inhibition generated by the matching of the model with the input. The more nearly the two match, thought Sokolov, the less robust is the resultant OR. With each additional presentation of the stimulus the neuronal model is improved, until a complete match produces maximal inhibition. Habituation was thus considered to be a direct consequence of the formation and elaboration of a neuronal model of the repeated stimulus. The crucial factor determining OR-elicitation was therefore stimulus novelty; the less novel a stimulus becomes, the less vigorous is the response to it. Sokolov (1963, b) also noted the effect of imparting a stimulus with signal value, finding significant stimuli (those that serve to indicate that a behavioral contingency is in effect or that an unconditioned stimulus is impending) to lead to slower habituation. Nonetheless, the primary factor in Sokolov's model, and the major factor considered by most of the research to follow, was stimulus novelty.

A sizeable body of studies evaluating Sokolov's comparator theory (see Graham, 1973, for a review) have been carried out on humans. Many of these have employed a simple stimulus-change paradigm in which an iterated stimulus is followed by a stimulus that is in some way different than the iterated stimulus. A recovery of the habituated OR to the changed stimulus-- most commonly assessed in terms of electrodermal responses-- is consistent with Sokolov's theory and demonstrates the stimulus specificity of the habituation process. As Graham (1973) has documented, not only has recovery of the OR with a change in stimulus been frequently demonstrated, but there are also numerous studies which have shown a positive relation between degree of stimulus change and amount of recovery of the OR. Evidence has in some cases led investigators (e.g., Bernstein (1979); O'Gorman (1979)) to question whether stimulus novelty is sufficient for the recovery of the OR. However, the issue raised by these authors is not whether stimulus novelty is an important factor influencing OR-elicitation. Rather, they are asking what additional variables are necessary for stimulus novelty to affect the OR.

Although most of the work on the OR has focused on habituation in the short term, studying stimulus change within a single experimental session, the recent influence of two-stage information-processing models is beginning to interest psychophysiologists and is leading to the study of habituation as a more long-term phenomenon. Information-processing models of memory posit two structural components: Long Term Memory (LTM) and Short Term Memory (STM). LTM is conceptualized as the information processing system's relatively permanent, passively maintained repository of knowledge. By contrast, the contents of STM, or "working memory" as it is sometimes called, require an expenditure of finite processing resources in order to be maintained. The finite nature of these resources imposes a severe capacity restraint on STM.

The expenditure of processing resources, known as "rehearsal", serves not only to prevent the otherwise rapid decay of STM-elements but also to encode them into LTM for long-term storage. The elements of LTM are thought to be organized in a hierarchically designed network of associations. Thus, in a simple case, two elements entering the System for the first time may be retained in STM through rehearsal and may therefore be transferred, along with their relation to one another, to LTM; the more prolonged is this rehearsal, the more complete is the ensuing LTM-representation. With the cessation of rehearsal, the elements will fade from STM but a later presentation of one of the elements may lead not only to the retrieval of that element from LTM into STM, but also to the retrieval of the associated element.

Sokolov (1969) has himself elaborated two types of theoretical memory mechanisms not unlike those of the two-stage information-processing memory model. If one considers habituation to reflect a learning process, the application of information-processing models of memory would seem entirely reasonable. Such a framework is completely consistent with the Sokolovian model and brings with it an abundance of data from the study of human memory, data engendering a wealth of specifically testable hypotheses.

The applicability of two-stage memory models has recently been formally reviewed by Ohman (1979), who described the OR as denoting "a call initiating processing [p. 444]." Thus, an incoming stimulus is first evaluated at a preattentive level. Following this, an OR is elicited in one of two ways: The incoming stimulus matches an STM-element that has been "primed" as significant (as previously noted by

Sokolov), in which case processing is engaged and associations are retrieved from LTM whereby the System's further activity may be guided; or the incoming stimulus does not match the contents of STM, in which case an OR is produced by a LTM-search for associated elements and by the encoding of the incoming stimulus into LTM.

Although Ohman's article signals a growing importance of information-processing models in psychophysiological theory, the systematic experimental investigation of long-term habituation from this perspective is just beginning to appear. The first studies of this kind involved the use of animals as subjects. Investigating the habituation of the startle response in intact rats, Davis (1970) noted that, consistent with Thompson and Spencer's (1966) fourth habituation parameter, stimuli presented every two seconds produced lower responding than those presented every sixteen seconds. However, testing both groups after a one-minute or one-day retention interval, the effect was reversed: The animals that had previously been more rapidly stimulated showed greater responding than the sixteen-second animals. As a possible explanation for this effect, Davis invoked the two-stage information-processing model, contending that the 2-second group may have shown a greater response decrement during training than the 16-second group because the faster rate of presentation more effectively thwarted the decay of the STM-elements. A match between stimulus input and the STM "neuronal model" was quickly achieved thanks to the rapid stimulus presentation. On the other hand, since the 16-second group was allowed more time to process the habituation stimuli, its members should have had more time to process each presentation of the habituation stimulus, thus should have developed LTM-elements more thorough than those of the 2-second group. Thus it was that, following the retention interval in which the STM-element faded from both groups, the 16-second group showed a greater response decrement than the 2-second group. A match between stimulus input and the LTM-based neuronal model was quickly achieved thanks to the previous thorough processing of the habituation stimulus.

A formal model of the interaction between STM and LTM in habituation was elaborated by Wagner (1976), who distinguished two means by which a STM-element may come to be: A "self-generated" STM representation is a direct result of an immediately prior stimulus presentation, whereas "retrieval-generated" STM-elements are those that have been transferred from LTM. He posited that both of these processes produce the same net result: an STM-element that may match a presented stimulus and thereby lead to an attenuated response. He also pointed out that, due to the associative nature of LTM organization, the presentation of one stimulus may lead to the retrieval of an associated stimulus. For example, a conditioned stimulus would be associated with the LTM-element representing the unconditioned stimulus, in which case presentation of the conditioned stimulus would serve to retrieve the representation of the unconditioned stimulus from LTM, producing less responding when the unconditioned stimulus itself is presented.

Wagner's work focused on the effect of retrieval-generated STM elements on long-term habituation (LTH). Following the abovementioned line of reasoning, Wagner stated that, just as in Pavlovian conditioning, contextual cues may come to be associated with the unconditioned stimulus. A subject returning to a situation in which previous habituation training has been provided may therefore have a retrieval-generated STM representation of the stimulus before the first presentation following the retention interval. However, if during the retention interval the subject has been exposed to the experimental situation without presentation of the habituation stimulus, the strength of the association might be lessened and the response decrement would accordingly be lessened. In Pavlovian-conditioning terminology, if the response decrement were thought of as resulting from an inhibitory response, this would be referred to as extinction of the conditioned (inhibitory) response.

Wagner (1976) tested this hypothesis on the vasomotor response of the rabbit (Whitlow, 1975). His procedure involved providing two groups with habituation training, followed two days later by a test stimulus identical to the habituation stimulus. On the first day following training the experimental group was exposed to the stimulus-delivery environment, though without actual stimulus delivery. This group was thereby given the equivalent of Pavlovian extinction training and, reasoned Wagner, would have a weakened LTM-association of the habituation stimulus with its context. In harmony with his expectations, the experimental group showed a greater recovery of the OR to the test stimulus. Confirming that this was not due to a general sensitizing effect in the "extinguished" group, no difference between groups in magnitude of response to a stimulus differing from the original habituation stimulus was observed. It would therefore seem that contextual cueing is effective in "priming" STM, producing a decrease in response to the first presentation of a stimulus that had been previously habituated in that context.

Wagner (1976) also reasoned that a dishabituating stimulus interspersed with presentations of an habituation stimulus would serve to prematurely terminate the rehearsal of the habituation stimulus and would thereby impede the formation of the LTM-element and its associations with contextual stimuli. Once again using the rabbit's vasomotor response, Wagner (1976) found support for his hypothesis. In a single group, two stimuli were presented during habituation training. One of these stimuli was always followed by a dishabituating two-second sequential-compound visuotactile stimulus; the other was never followed by such a stimulus. After a 15-minute retention interval, presentation of the habituation stimuli showed greater responding to the stimulus that had been followed by the displacement stimulus.

Thus, work by Davis (1970) and Wagner (1976) has systematically explored the implications of two-stage information-processing in the context of studies of LTH in animals. The human OR literature, in comparison, has paid relatively little attention to LTH and has only recently begun to consider the implications of two-stage models of information processing.

Several authors (Galbrecht, Dykman, Reese, and Suzuki, 1965; Kimmel and Goldstein, 1967; Harding and Rundle, 1969; Bishop and Kimmel, 1969) have shown LTH to occur in humans, generally by repeating stimulus series across sessions. The sessions of Galbrecht et al (1965) were separated by "two to three days", while those of Kimmel and Goldstein (1967) and Harding and Rundle (1969) were weekly. Bishop and Kimmel (1969) showed that retention intervals of as little as 20 minutes produce a cross-sessional decrement in initial response magnitude and in the number of trials needed to reach habituation, but with retention intervals of one week or more such a decrement was not reliably obtained.

However, it is not clear from these studies to what extent LTH is in fact due to the retention of a specific model of the repeated stimulus, or whether it is due more to the operation of non-stimulus-specific factors producing decrements in responding regardless of the similarity of discrete stimuli repeated across sessions. It has been found, for example, that level of arousal as measured by tonic skin conductance or frequency of spontaneous skin conductance fluctuations (SSF) is positively correlated with the magnitude of the electrodermal OR and negatively correlated with its rate of habituation (Bohlin, 1973 (a), 1973 (b), 1976; Carroll and Pokora, 1976; Siddle and Heron, 1976; Goldwater and Lewis, 1978; Siddle, O'Gorman, and Wood, 1979). Coupled with the observation that these arousal measures decrease across sessions (Corah and Stern, 1963; Maltzman, Smith, Kantor, and Mandell, 1971), this implies that LTH may be an effect of a reduction in arousal with increased exposure to the experimental setting, rather than of the comparison of an improving LTM neuronal model with stimulus input. Unfortunately, Galbrecht et al (1965), Kimmel and Goldstein (1967), and Bishop and Kimmel (1969) failed to report any measures of arousal level. Harding and Rundle (1969), however, did report drops in arousal (see Figure 1) across weekly sessions.

A study of the human OR equivalent to that of Davis' (1970) study has suggested that the direct relationship of LTH and interstimulus interval (ISI) length may in fact be mediated by arousal level (Gatchel, 1975). Although Gatchel successfully replicated Davis' findings, he also showed that the short-ISI group maintained a skin conductance level (SCL) greater than that of the long-ISI group. Following this, Gatchel and Gaas (1976) provided further evidence that arousal level can affect LTH. Manipulating arousal with a threat of shock rather than with ISI, they showed that subjects so threatened maintain a higher SCL and show less LTH than a nonthreatened group.

Thus, it is clear that factors other than a process of stimulus-comparison may influence LTH. This does not, however, answer the question of whether stimulus comparison does in fact exert its own influence. Such a question might be addressed by applying the stimulus-change paradigm so popular in human short-term habituation studies within a LTH design. To the extent that magnitude of response to a change in stimulus is greater than that to the same stimulus, it indicates that habituation is at least partially stimulus-specific, and a stimulus-comparison

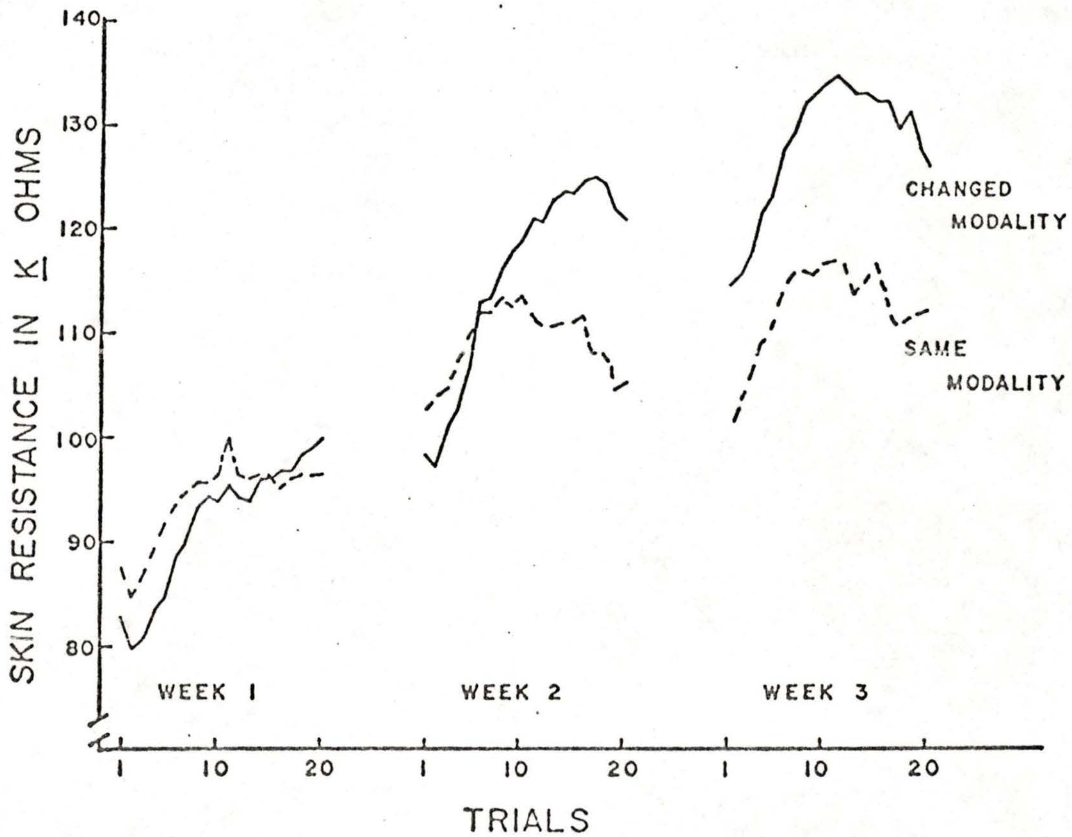

Figure 1: SRI CVEF TRIALS-- (HAFCING ANC RUNCLE, 1969)

process may be inferred to be responsible. The equivalent investigation of LTH would employ stimulus change across sessions rather than within sessions. A greater drop in responding across sessions shown by the group receiving the same stimulus (relative to a group receiving different stimuli) might be attributable to a process of stimulus comparison.

Only one study has been directed toward determining the importance of stimulus-specific factors in LTH (Harding and Rundle, 1969). These experimenters exposed two groups of subjects ("CHANGED" and "SAME") to series of 20 stimuli in each of three weekly sessions. All subjects wore headphones, had a potential light source placed in front of them, and wore a vibrator strapped to one leg. The SAME group received the same stimulus in each session (tactile, visual, or auditory) and the CHANGED group received a different stimulus in each session. Stimuli remained unchanged within sessions.

Both groups (see Figure 2), not surprisingly, showed an effect of TRIAL on mean response amplitude-- both showed short-term habituation. Both groups were also found to show an effect of WEEK on mean response amplitude-- the average response for both groups dropped across sessions. This finding was interpreted as demonstrating "long-term retention of habituation despite a change in the stimulus modality." [p.392] In fact, the group that had the same stimulus across sessions showed an average response magnitude no lower than that of the group receiving different stimuli across sessions. Given the absence of a GROUP x WEEK effect on this measure, one might be tempted to infer that long-term habituation is entirely due to non-stimulus-specific factors.

Unfortunately, this measure may have been seriously confounded by an arousal effect generated by the authors' research design, resulting in the absence of a GROUP x WEEK effect. Although subjects were never informed of the type of stimulation they would be receiving, they may have been implicitly led to certain expectations that were differentially met across groups. All subjects were exposed to all three stimulus-delivery apparatuses in all three sessions. For subjects in the SAME group, this meant that two of the apparatuses went unused throughout the study. In contrast, all three apparatuses were used in the CHANGED group. It seems likely that exposing a subject to an apparatus implicitly induces the expectation that it will be used. Subjects exposed to three apparatus and told that they will be participating in three weekly sessions are likely to have the experiment "figured out" after the first session. Coming back the second time, they might understandably be expecting the activation of a different

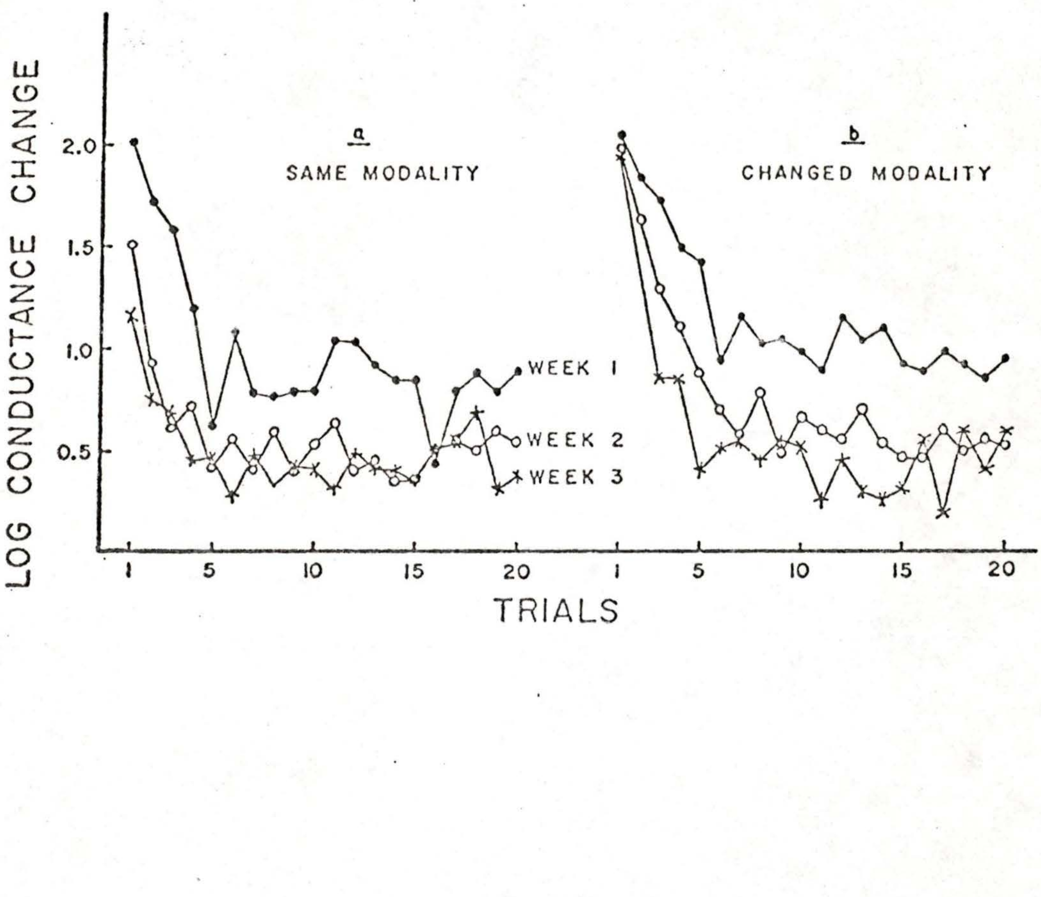

Figure 2: RESPONSE MAGNITUDE OVER TRIALS-- (HARDING AND RUNDLE, 1969)

apparatus. A divergence from their expectations, as may have occurred in the SAME group, might lead to increases in arousal, producing less LTH. Since the session-2 and session-3 experiences of the CHANGED group most likely matched the subjects' expectations, this group would not show such an arousal effect.

This contention is supported by Harding and Rundle's tonic skin resistance level (SRL) measure. (Being the inverse of skin conductance, SRL is negatively correlated with arousal.) On week 1, there was no TRIAL x GROUP interaction effect upon SRL (see, again, Figure 1). On week 2, the first few trials also show equivalent SRL's across groups. Beyond this point, the SRL of the CHANGED group continued its trend, increasing both within sessions and between sessions. The SRL of the SAME group reversed its trend, maintaining a lower level than the CHANGED group throughout the rest of the experiment.

By differentially affecting arousal in their groups, Harding and Rundle may have induced greater responding in their SAME group from about trial 3, session 2 through the remainder of their study. Such an effect could have easily washed out the lower responding of this group predicted by a stimulus-specific hypothesis. It is notable that this is the very point at which they observed the absence of stimulus-specific influence on the long-term retention of habituation.

Also, it is by no means apparent that response magnitude averaged over an entire session is a reasonable measure of LTH. It is clear from Wagner (1976) that an effect of LTH on the response magnitude to the first stimulus following a retention interval would be expected. Additionally, the findings of Kimmel and Goldstein (1967) and Bishop and Kimmel (1969) suggest that LTH may be expressed by increases in rate of habituation (as indicated by decreases in the number of trials to reach an habituation criterion). Since conceptually there is no reason that the retention of a neuronal model from a previous session would necessarily influence the ultimate level of responding attained, differences between groups early in a given session might easily be obscured by averaging over the entire session.

When Harding and Rundle restricted their analysis to the initial response magnitude of each session, a GROUP x WEEK effect became apparent. The SAME group showed large drops in trial-one response magnitude across weeks, whereas the DIFFERENT group showed no drop at all. This result has implications opposite to their abovementioned finding, seeming to indicate that a response decrement across sessions is very dependent on the intersessional similarity of the stimuli.

It is noteworthy that the differential-arousal effect does not compromise their observations concerning the stimulus-specific nature of initial response magnitude, since the intergroup difference in SRL was not evident in the first few trials of the second week. Called into question is their finding of no stimulus-specific influence upon the later portions of the habituation curve. Their results might spuriously lead to a drastic overrating of the effect of non-stimulus-specific factors upon LTH.

Thus, the findings of Harding and Rundle are somewhat contradictory: The WEEK effect with overall response magnitude in the CHANGED group implies intermodal generalization of habituation, while the absence of such an effect upon initial response magnitude implies no such generalization. There is therefore clearly reason to examine the issue of whether LTH does show cross-modal generalization. In fact, the literature leaves open the question of whether intermodal generalization of short-term habituation has been clearly established.

At any rate, it is apparent that the factors involved in LTH remain somewhat obscure. The evidence provided by Harding and Rundle suggests that LTH is at least partially a result of stimulus-specific factors. The salience of non-stimulus-specific factors, however, remains uncertain. It is not clear to what degree LTH is a result of matching a specific control element retrieved from LTM with the current stimulus or whether it is more a result of less-specific factors such as decreased responsiveness following adaptation to the experimental setting.

The present study was designed to elucidate the relative influence of stimulus-specific and non-stimulus-specific factors in long-term habituation. To the extent that non-stimulus-specific factors influence LTH, it was thought that a group, having successfully completed an experimental session without exposure to discrete presentations of habituation stimuli, might show greater habituation than a group exposed to the stimuli when in the experimental setting for the first time.

In order to be able to examine the degree of stimulus-specificity operating in LTH, the degree of similarity of stimuli across sessions was varied. Groups were provided with intermodal stimulus change (as in Harding and Rundle) or intramodal change (to see if greater similarity produces greater LTH-generalization), as well as with no stimulus change at all (i.e., the same stimulus series repeated across sessions).

A tertiary motive for the current investigation was to assess the viability of studying long-term habituation employing relatively brief retention intervals; only Bishop and Kimmel (1969) have used such a short interval in studying LTH, but since some inconsistent results have been generated from this lab (i.e., Kimmel and Goldstein [1967] found no LTH effect with initial response magnitude, whereas Bishop and Kimmel did), it was thought that such reconfirmation was in order. Since the duration of STM-representations is taken to be very brief, it would certainly seem that a retention interval of one week is unnecesarily long. Of course, a retention interval on the order of minutes rather than days or weeks offers obvious practical advantages. Thus, any gross disparities between the present result and that of previous LTH studies might raise questions about the suitability of the use of brief retention intervals or of other aspects of the paradigm employed here.

METHOD

Design

Four groups of subjects were employed, provided with experiences in two experimental "sessions" ("Part A" and "Part B"; see Table 1). The similarity of the two "sessions" provided to each group varied from not very similar to identical. These "sessions" actually took place within a single experimental sitting, and might therefore be more appropriately labelled "parts." The interpart interval was designed to provide a maximum of distractions for the subject, enhancing the distinction between the parts and making the interpart interval analagous in quality, if not degree, to the intersession interval employed in more traditional designs.

TABLE 1

EXPERIMENTAL DESIGN

Part A		Part B
Group 1: Visual memory task +	+ ten-minute	+ All groups:
Group 2: 12 light offsets +	+ retention	+ 12 2000-cps
Group 3: 12 500-cps tones +	+ interval	+ tones
Group 4: 12 2000-cps tones +		

The four groups received identical treatment in Part B--repeated presentations of a 2000-cps tone. However, the groups differed according to the nature of their treatment in Part A. For Group 1, Part A consisted of the performance of a simple visual memory task; Group 2 was exposed to repeated offsets of the overhead illumination; Group 3 was exposed to a series of 500-cps tones; and Group 4 was exposed to repeated presentations of the 2000-cps tone.

By Part B, Group 1 had undergone previous exposure to the experimental context, though without receiving presentations of repetitive, discrete stimuli. This condition was intended to provide subjects with the opportunity to learn of the nonthreatening, nondemanding nature of the experimental setting. It was thought that this would engender a feeling of having successfully completed an experimental session without providing a memory of discrete stimuli to influence behavior in Part B. To the extent that LTH is a product of such non-stimulus-specific factors, Group 1 should show habituation in Part B greater than that of Group 4's habituation to an identical stimulus series in Part A.

Group 2 was exposed to two stimulus series (one in each Part) with the same temporal characteristics but differing in modality; Group 3 was exposed to two stimulus series (one in each Part) with the same temporal qualities and in the same modality, though differing along a dimension within that modality. Finally, Group 4 was exposed to two Parts identical in every way.

While Group 1 was intended to provide an idea of the extent of non-stimulus-specific factors in single-session studies of long-term habituation, Groups 2, 3, and 4 were intended to provide an estimate of the degree of stimulus-spcificity operating in such a design. An hypothesis accounting for LTH exclusively in terms of stimulus-specificity would predict only the "identical" group (Group 4) to show LTH. An hypothesis to the other extreme, attributing LTH entirely to non-stimulus-specific adaptation to the experimental context, would predict no differences in LTH among the four groups. In view of the evidence reviewed above, in particular the STH stimulus-change literature, the hypothesis entertained herein was that varying degrees of LTH would be demonstrated by all four groups in Part B. It was thought that 4B would show the greatest retention of habituation, followed in turn by 3B,2B, and 1B.

In this study, the subjects were uninformed about the precise nature of the stimuli to be presented for two reasons: Uninformed subjects would be less likely to have an a priori representation (however vague) of the stimulus in STM, producing a minimal rate of habituation that would provide a maximally sensitive measure of variations in LTH.

Also, it was thought that the likelihood that differential expectancies between groups would contribute to differential rates of habituation would be diminished. To this end, the Harding and Rundle design was improved upon in that stimulus-delivery apparatus were as unobtrusive as possible, hopefully avoiding the confounding of subject expectations with stimulus-memory.

In order to verify that the subjects' a priori expectations of the nature of the stimuli did not vary from group to group, a questionnaire was administered at the end of the experimental session (see appendix B).

Finally, in order to minimize error variance, all groups were matched with respect to pre-experimental level of spontaneous fluctuations in skin conductance (SSF), since, as stated above, this measure has been shown to correlate positively with both trials-to-criterion and with amplitude of response.

Subjects

Female undergraduate volunteers from the subject pool of the University of Victoria Department of Psychology were solicited via telephone and were informed that this experiment would involve the recording of their physiologic responses to series of innocuous stimuli. A total of 83 women participated in the study, three of whom were discarded from analysis-- two due to equipment failure and one for health reasons. Twenty subjects were randomly assigned to each of four groups, with the constraint that the groups would be matched with respect to frequency of spontaneous fluctuations in skin conductance during a two-minute period preceding treatment.

Apparatus

Each subject was seated in a comfortable easychair in an electrically shielded chamber. Illumination in the chamber was provided by two 40-watt bulbs in each of two ceiling fixtures and one 60-watt bulb in a reading lamp shining over the subject's left shoulder. The visual stimulus presented to Group 2 in Part A was a one-second offset of the ceiling lights, leaving only the reading lamp on. The offsetting of the ceiling lights was controlled by a tape programmer (controlling the intervals between offsets) coupled with a digital timer (controlling the duration of the offsets).

All tones (80 dB, one second long) were presented over headphones and superimposed over white noise (55 dB, contiuously emitted); intensities were measured with a sound-pressure level meter at the headphones. Each tone triggered a pen deflection of a particular polygraph channel (constituting an event marker), as did each light offset.

The tones were prerecorded, from a Wavetek model 134 signal generator, onto three cassette tapes: one for Part A Group 3 (12 500-cps tones), one for Part A Group 4 (12 2000-cps tones), and one for Part B all groups (12 2000-cps tones). The interstimulus intervals (ISI's) varied among durations of 25, 30, 35, and 40 seconds, in pseudorandomized fashion (i.e., in each block of four trials, each ISI was represented once; within each block the ordering of ISI's was randomly computer-generated). The ordering of intervals in Part A was identical for Groups 2, 3 and 4. (This of course did not apply to Group 1.) In Part B a second permutation of interval orders, identical for all groups, was provided.

Also in Part B, a thirteenth tone (500 cps) was provided to all groups. It was thought that such a tone, identical to that presented to 3A, might provide information concerning the long-term effects of stimulus similarity with an intervening repeated stimulus.

The items of the memory task (Part A, Group 1) were innocuous photographs. The memory set consisted of five photos; the second set consisted of the same five plus ten additional (distracter) photos.

Clipped to the subject's collar was a microphone to detect unusual respiration or movements in the chamber. Polygraph pen deflections accompanied by the sounds of subject movement (especially noticeable in a vinyl easychair) or heavy sighing, coughing or sneezing were discounted as artifactual. The experimenter wore stereo headphones over which he monitored both chamber sounds and the subject's headphone output. Two Ag-AgCl electrodes with a K-Y Jelly electrolyte were attached to the palmar surface of the middle segment of the middle- and forefinger of the nonpreferred hand. Skin-conductance was transmitted, via a constant-voltage skin conductance unit (MacPherson, MacNeil, Marble, and Reeves, 1976), to two channels (one high- the other low-gain) of the polygraph for recording. The function of the high-gain channel was to detect phasic fluctuations in skin conductance, while the low-gain channel recorded tonic skin conductance level.

Finally, a photoplethysmograph was attached to the third finger of the nonpreferred hand, transmitting peripheral pulse volume to a third channel of the polygraph.

Procedure

Each group was exposed to two six-minute experimental parts, separated by an interval of ten minutes. Prior to entering the experimental chamber, the subject was told that there would be breaks during the experiment while the equipment was calibrated. Furthermore, she was informed that, since the recordings being taken required the maintenance of alertness, she would be asked to read a magazine during the breaks to ward off drowsiness. The experimenter and subject then entered the shielded chamber, the subject was seated, fully upright, in the easychair and informed that she could abort the experiment at any time by simply voicing a desire to do so. The electrodes and microphone were then attached; the subject was told of their purpose, asked to move as little as possible, provided with the magazine, and asked if the reading lamp provided suitable light for reading.

The experimenter then left the chamber to calibrate the polygraph, asking the subject to read during his absence. After calibration, he returned to remove the magazine, to tell the subject that a two-minute period of baseline measurement would follow, and to place the white-noise-emitting headphones on her, explaining that they were necessary to mask extraneous noise. The experimenter again left the chamber. During the following two-minute interval the subject's number of spontaneous fluctuations was counted and she was assigned to one of two SSF levels: low (0 - 3 SSF's) or high (4 or more SSF's). On this basis the subject was then assigned to one of the four experimental groups such that they would be matched with respect to basal SSF. The experimenter reentered the chamber, removed the headphones, read the appropriate instructions (see Appendix A), replaced the headphones, left the chamber, and presented the appropriate Part-A stimuli to the subject.

After Part A, the experimenter returned the subject's magazine, removed the headphones, left the chamber, and allowed five minutes of reading time. He then again reentered the chamber and conversed with the subject for about five minutes, asking minor demographic details and generally trying to keep the subject alert and at ease. Finally, he again took the magazine, read aloud the instructions for Part B (see Appendix A), reapplied the headphones, left the chamber, and presented the Part B stimuli.

Following Part B a brief questionnaire was presented to each subject (see Appendix B), the rationale of the experiment was explained, the subject was asked not to discuss the experiment with anyone for a period of two months, and she was dismissed with thanks.

Scoring

Stimulus-linked responses were defined as the largest change in skin conductance of at least 0.02 micromhos beginning one to four seconds following stimulus onset. The same amplitude criterion was applied to spontaneous fluctuations.

A single deflection was considered to have ended when the slope of the curve reached zero. Thus, two upward deflections separated only by a horizontal segment were considered as two distinct changes in skin conductance. In the absence of a stimulus, these would have been two spontaneous fluctuations. Had they both begun one to four seconds following a stimulus onset, the larger deflection would have been considered a response and its amplitude scored from its onset to its peak.

Trials-to-criterion for a given subject was defined as the number of stimuli presented before that subject reached an habituation criterion of three consecutive nonresponses. A subject showing no response on any of the first three trials would have been considered to have shown zero trials-to-criterion, while a subject who had not reached criterion before trial 12 yet showed no response to trial 12 would have been considered to have shown eleven trials-to-criterion.

In addition to SSF, two other measures of tonic arousal were scored: heart rate level (HRL) and skin conductance level (SCL). SSF and HRL were assessed during a two-minute period preceding the assignment of subjects to groups (and divided by four to give rate per 30 seconds), during the first and last 30 seconds of Part A, and during the first 30 seconds of Part B. SCL was assessed just prior to assignment, at the end of Part A for Group 1, and two seconds before the presentation of each stimulus for all groups.

Analysis of Effects

First, Cochran's test of homogeneity of variance and the Kolmogorov-Smirnov test for goodness-of-fit to a normal curve were used to determine whether each measure conformed to the assumptions of parametric analysis.

Initial response magnitude and trials-to-criterion of 4A was then compared to that of 4B. If any group was to show LTH it would be this one, since Group 4 was essentially serving to replicate the already well-established phenomenon of LTH with cross-sessional presentations of identical stimuli.

To assess the effects of the Part-A experiences upon Part-B responding, 4A (the no-treatment control condition) was compared to 1B, 2B, and 3B. Assuming that there would be some non-stimulus-specific influence upon 1B, 2B, and 3B, and a "generalization of habituation" affecting 2 and 3B, these conditions were expected to produce lower initial responding and more rapid habituation (lower trials-to-criterion) than 4A.

From the STH literature, it was expected that, relative to 4A, 4B would show the greatest drop in initial response magnitude and trials-to-criterion followed in turn by 3B,2B, and 1B. To determine this, multiple comparisons of the four Part-B conditions were conducted.

Thus, the primary analyses were: a 4A-4B comparison, a 4A-1B,2B,3B comparison, a 1B-2B-3B-4B comparison. Further comparisons were purely of a post-hoc nature and were intended to elaborate fully on the nature of the results obtained. Also, a caveat is in order: An alpha-level of .05 was adopted throughout these analyses, despite the highly repetitive nature of the comparisons performed. Thus, the cautious reader should bear in mind that the experimentwise error rate has been severely inflated. Significant results corroborating earlier findings would seem safe to accept; others might best be accepted tentatively rather than conclusively.

RESULTS

Mean response magnitude over trials for each group is represented in Figure 3 (for Part A) and Figure 4 (for Part B). These graphs show the greatest separation between groups to exist in the frist trials of each part.

Since initial response magnitude showed heterogeneous variance across groups in Part B (see Table 2), and since SSF was not consistently normally distributed (see Table 3), these measures were analyzed nonparametrically.

The first comparative analyses sought to confirm that LTH had occurred in Group 4-- the condition that was thought to maximize the liklihood of LTH. Matched-pairs tests (see Table 4) indicated that both initial response magnitude (p = .001, Wilcoxon) and trials-to-criterion (p = .002, t-test) dropped significantly across parts within Group 4.

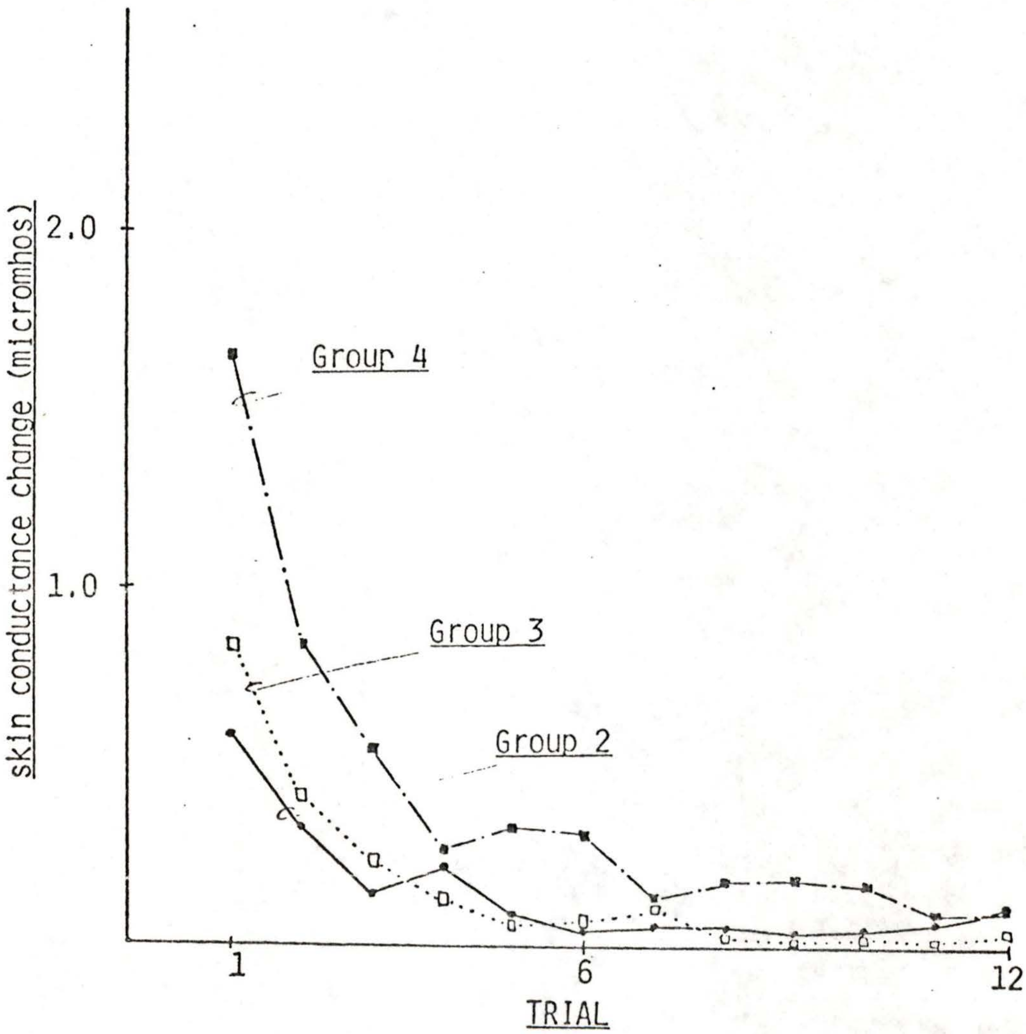

Figure 3: Mean response magnitude over trials-- Part A

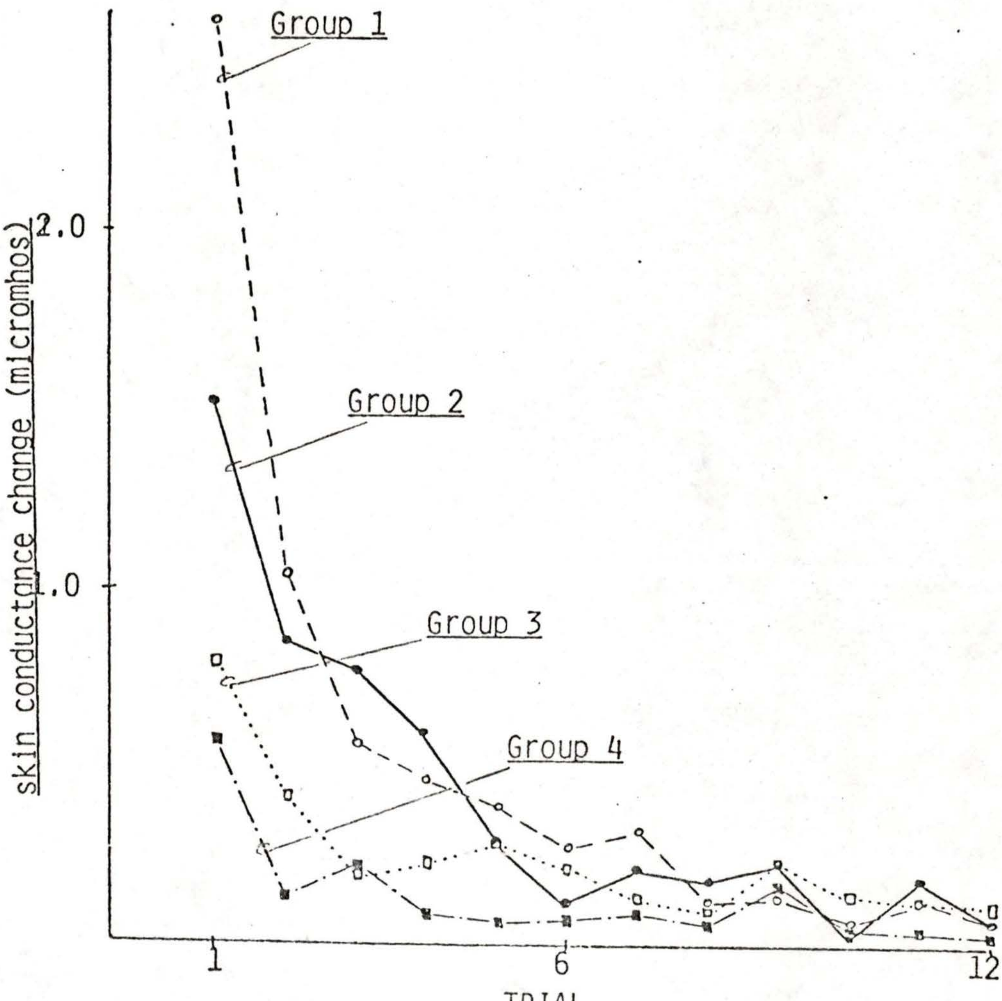

Figure 4: MEAN RESPONSE MAGNITUDE OVER TRIALS-- PART B

TABLE 2

DETERMINATION OF HOMOGENEITY OF VARIANCE

COCHRAN TEST FOR HOMOGENEITY OF VARIANCE

	I.R.M.	T.T.C.
Part A---	p=.080	p=.399
Part B---	p=.000	p=.578

	S.S.F.	S.C.L.	H.R.L.
Preceding treatment---	p=.716	p=.383	p=.844
Beginning of Part A---	p=.411	p=.390	p=.765
End of Part A---------	p=.020	p=.142	p=.048
Beginning of Part B---	p=.243	p=.253	p=.253

TABLE 3

APPROXIMATION OF THE DATA TO A NORMAL DISTRIBUTION

KOLMOGOROV-SMIRNOV GOODNESS OF FIT

(Group 4)

	I.R.M.	T.T.C.
Part A---	p=.545	p=.412
Part B---	p=.272	p=.155

	S.S.F.	S.C.L.	H.R.L.
Preceding treatment---	p=.393	p=.270	p=.844
Beginning of Part A---	p=.321	p=.295	p=.566
End of Part A---------	p=.000	p=.419	p=.958
Beginning of Part B---	p=.084	p=.608	p=.954

TABLE 4

DETERMINATION OF LTH WITHIN GROUP 4

MATCHED-PAIRS TESTS (4A vs 4B)

initial response magnitude---ties = 0, Z = -3.285, p = .001
trials to criterion----------d.f. = 19, t = 4.20, p = .000

Initial Response Magnitude

Mean initial response magnitudes, with their associated 95% confidence intervals, are reported in Figure 5 . Performing an overall Kruskal-Wallis ANOVA on conditions 4A, 3B, 2B, and 1B (see Table 5), a significant GROUP effect was evident (p = .000). Repeated Mann-Whitney U-tests (also in table 5) comparing 4A with, in turn, 3B, 2B, and 1B showed 3B to be significantly lower than, and 2B and 1B to not significantly differ from, 4A (p's = .0006, .3505, and .2132, respectively). Despite the apparently greater variability of 1B and 2B compared to that of 4A, Kolmogorov-Smirnov tests proved nonsignificant (see table 6).

Kruskal-Wallis analysis restricted to the four groups of Part B (conditions 1B, 2B, 3B, and 4B) also indicated a significant GROUP effect (p = .000; see table 7). The ensuing multiple Mann-Whitney comparisons showed 1B to be significantly greater than 2B (p = .0498), 3B (p = .0001), and 4B (p = .0000); 2B showed only a tendency for greater responding than 3B (p = .0677) and significantly greater responding than 4B (p = .0090); 3B did not significantly differ from 4B (p = .5241).

A Kruskal-Wallis ANOVA performed on the three groups of Part A (conditions 2A, 3A, and 4A) also discerned a significant GROUP effect (p = .000; see table 8). Multiple Mann-Whitney comparisons showed this effect to be entirely

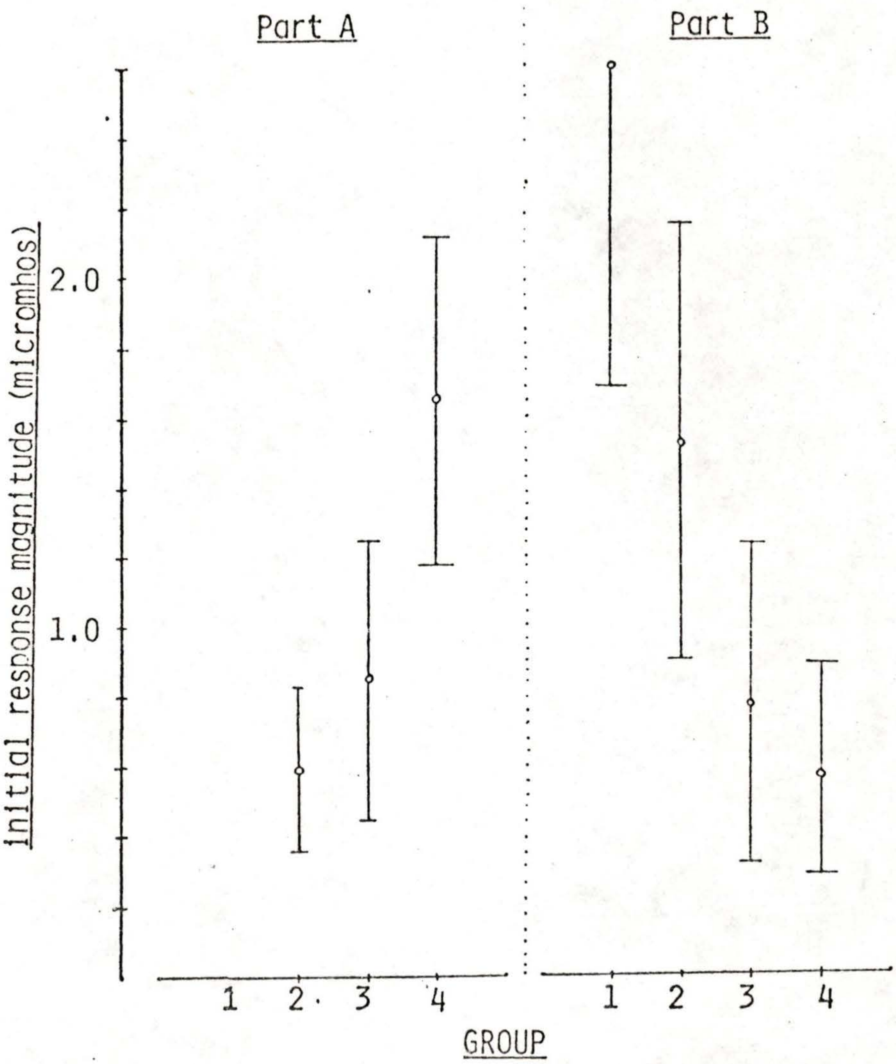

Figure 5: MEAN INITIAL RESPONSE MAGNITUDES

TABLE 5

DETERMINATION OF LTH OF GROUPS 1,2, AND 3

KRUSKAL-WALLIS ANOVA (1B,2B,3B,4A)

(corrected for ties)

chi-square	significance
17.907	0.000

MANN-WHITNEY U TESTS	Z	2-TAILED P
1B vs 4A-------------	-1.2447	0.2132
2B vs 4A-------------	-0.9336	0.3505
3B vs 4A-------------	-3.4102	0.0006

TABLE 6

COMPARISON OF DISTRIBUTIONS OF 1B AND 2B TO 4A.

KOLMOGOROV-SMIRNOV 2-SAMPLE TEST(initial response magnitude)

	max(abs diff)	2-tailed p
1B vs 4A-------	-0.3500	0.1
2B vs 4A-------	0.4000	0.1

TABLE 7

'COMPARISON

KRUSKAL-WALLIS ANOVA (1B,2B,3B,4B)

(corrected for ties)

chi-square	significance
23.130	0.000

MANN-WHITNEY U TESTS		
1B vs 4B-------------	-4.1149	0.0000
2B vs 4B-------------	-2.6118	0.0090
3B vs 4B-------------	-0.6370	0.5241
1B vs 3B-------------	-3.8020	0.0001
2B vs 3B-------------	-1.8267	0.0677
1B vs 2B-------------	-1.9617	0.0498

due to 4A's greater responding than 3A (p = .0016) and 2A (p = .0001); no significant difference between 2A and 3A was detected (p = .4090).

TABLE 8

COMPARISON OF INITIAL RESPONSE MAGNITUDE OF 2A, 3A, & 4A

KRUSKAL-WALLIS ANCVA (2A,3A,4A)

(corrected for ties)

chi-square	significance
17.270	0.000

MANN-WHITNEY U TESTS	Z	2-TAILED P
2A vs 4A-------------	-3.8841	0.0001
3A vs 4A-------------	-3.1521	0.0016
2A vs 3A-------------	-0.8256	0.4090

Trials-to-criterion

Figure 6 displays the mean trials-to-criterion and associated 95% confidence intervals for each condition. Paralleling the nonparametric analysis of initial response magnitude, a parametric ANOVA for conditions 4A, 3B, 2B, and 1B was performed. For trials-to-criterion, however, no significant GROUP effect obtained ($F(3,76) = 0.459$, $p = .712$).

The same analysis, restricted to the four groups of Part B, also proved nonsignificant ($F(3,76) = 1.957$, $p = .128$). However, the fact that the trials-to-criterion of 4B (mean = 3.5) showed a tendency to be lower than the trials-to-

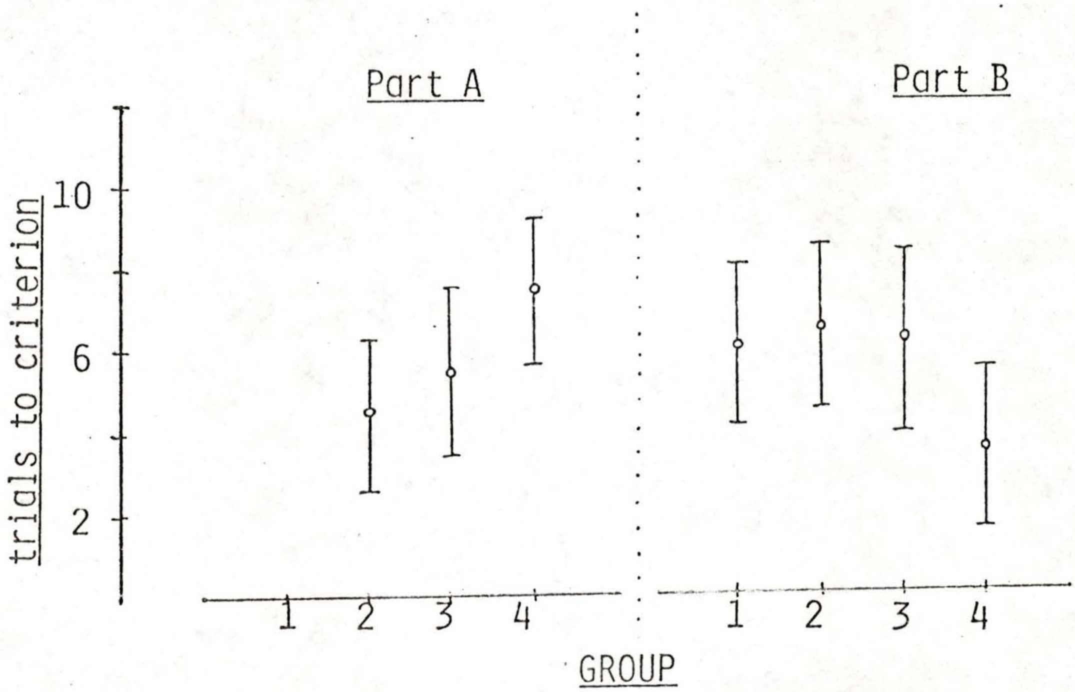

Figure 6: MEAN TRIALS TO CRITERION

criterion of 1B, 2B, and 3B (means = 6.0, 6.4, and 6.1, respectively) should not be overlocked. Also, the overall ANOVA on trials-to-criterion in Part A was not significant ($F(2,57) = 2.784$, $p = .070$).

Tonic Measures

Mean skin conductance level (SCL) for each group, measured two seconds prior to the presentation of each stimulus, is portrayed in Figures 7 and 8 . Measurement throughout Part A was not feasible for Group 1, since performance of the visual memory task resulted in enough movement to obscure the recordings. A matched-pairs t-test comparing SCL (see Figure 9) just prior to trial 1 to that just prior to trial 12 (see Table 9) indicated a significant overall net drop in SCL in both Part A ($p = .000$) and Part B ($p = .000$). The rise in SCL from the end of Part A to the beginning of Part B was also significant ($p = .000$), as was the increase from the beginning of Part A to the beginning of Part B ($p = .002$). For groups 2-4, HRL (see Figure 10) significantly dropped from the beginning of Part A to the beginning of Part B (d.f. = 57, $T = 3.39$, $p = .001$). For SSF (see Figure 11), this drop was also significant ($Z = 2.372$, $p = .018$).

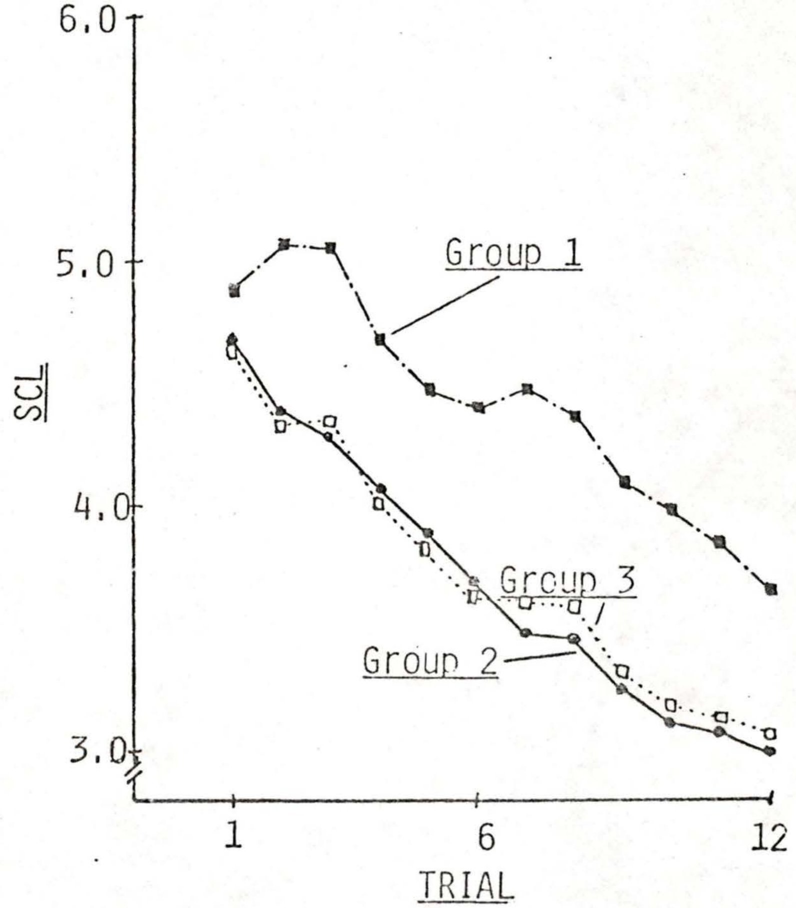

Figure 7: MEAN SKIN CONDUCTANCE LEVEL OVER TRIALS-- PART A

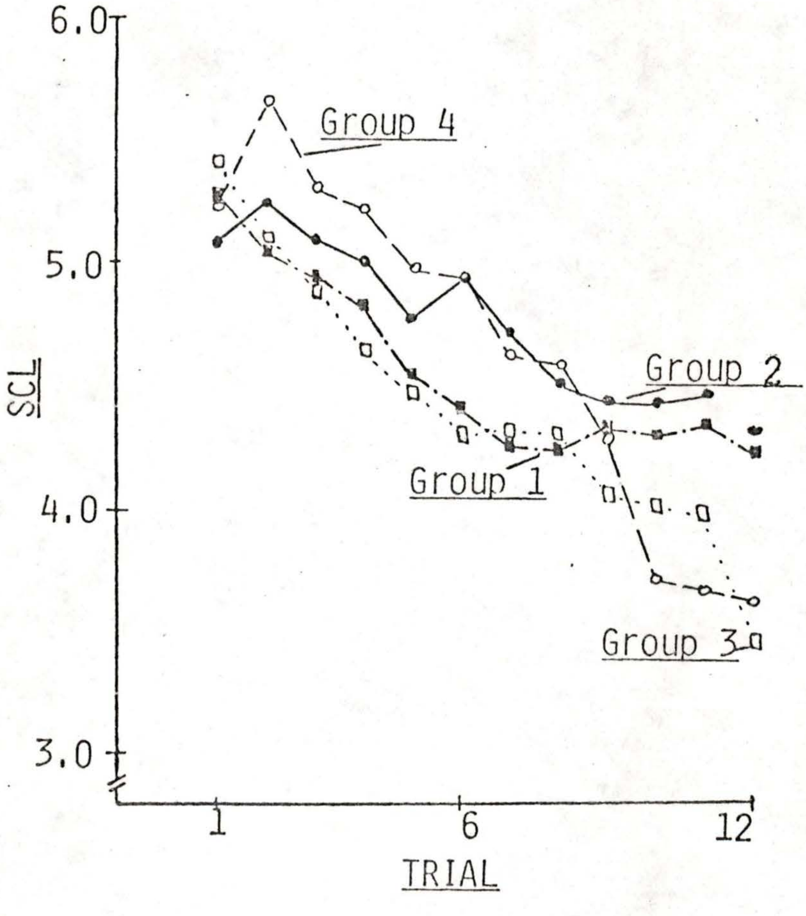

Figure 8: MEAN SKIN CONDUCTANCE LEVEL OVER TRIALS-- PART B

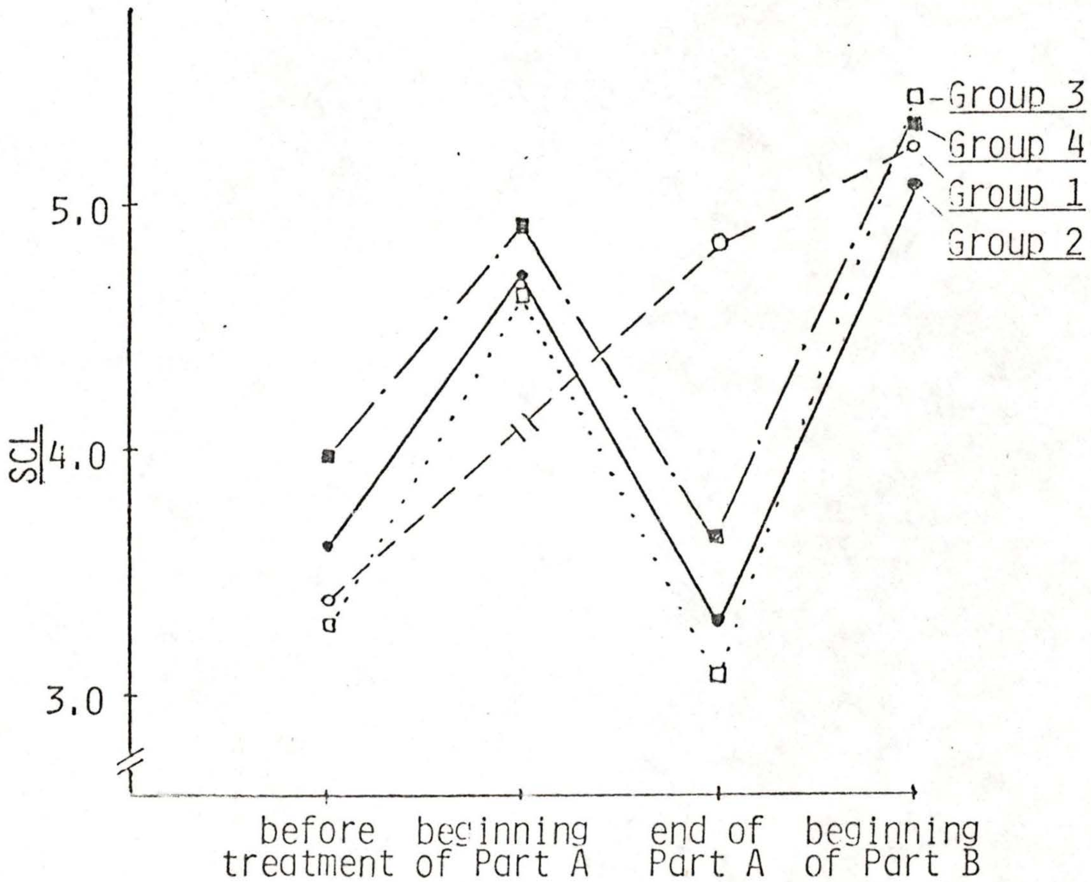

Figure 9: MEAN SKIN CONDUCTANCE LEVELS

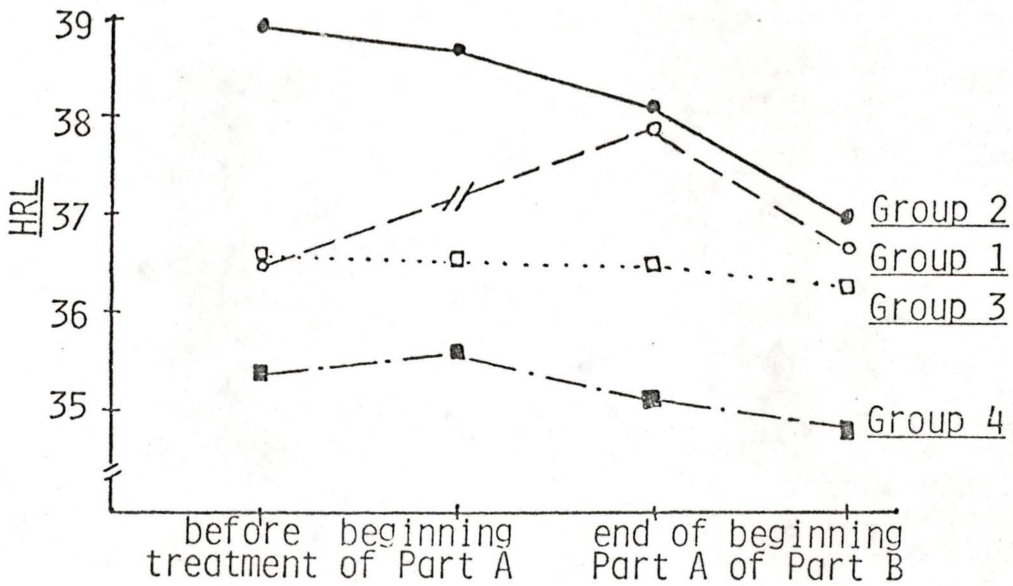

Figure 10: MEAN HEART BEATS PER 30 SECONDS

By the end of Part A, movement due to the task had subsided sufficiently to once again enable the measurement of tonic levels. Thus, it was possible to compare the tonic levels of all four groups at each of the points displayed in Figures 9 - 11 A oneway ANOVA performed at each of these points for each of these measures (see Table 10) showed the only intergroup differences to exist at the end of Part A, for SCL and SSF (p's = .0197 and .0002, respectively). Multiple comparisons revealed these differences to have entirely resulted from the higher levels displayed by Group 1.

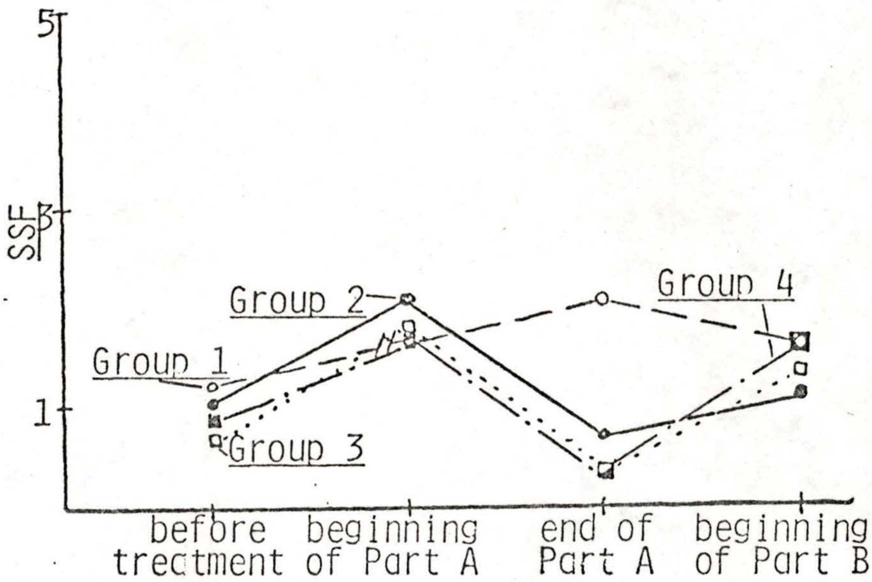

Figure 11: MEAN SPONTANEOUS FLUCTUATIONS PER 30 SECONDS

TABLE 9

DID SCL VARY THROUGHOUT THE SESSION?

MATCHED-PAIRS T-TESTS ON SCL

	T	DF	P
Decrease in Part A-------------------------------	8.98	59	.000
Decrease in Part B-------------------------------	8.88	77	.000
Increase from end of A to beginning of B---------	-9.84	78	.000
Increase from beginning of A to beginning of B---	-3.31	59	.002

TABLE 10

INTERGROUP COMPARISONS OF TONIC MEASURES

<u>ONEWAY ANOVAS OF TONIC MEASURES</u>

SCL (parametric)

Preceding treatment---	F (3,76) = 0.459, p = .718
Beginning of Part A---	F (2,57) = 0.065, p = .937
End of Part A---------	F (3,75) = 3.493, p = .020
Beginning of Part B---	F (3,76) = 0.054, p = .983

HRL (parametric)

Preceding treatment---	F (3,74) = 1.112, p = .350
Beginning of Part A---	F (2,55) = 1.785, p = .177
End of Part A---------	F (3,73) = 1.080, p = .363
Beginning of Part B---	F (3,72) = 0.524, p = .667

SSF (nonparametric)	CHI-SQUARE	SIGNIFICANCE
Preceding treatment---	0.139	.987
Beginning of Part A---	0.237	.888
End of Part A---------	19.066	.000
Beginning of Part B---	0.865	.834

DISCUSSION

Multiple- vs. single-session designs

To first ascertain that the single-session design employed is a viable method by which to study LTH, some findings of previous studies were compared with the current results. The most fundamental finding in cross-session studies of habituation is that the degree of habituation increases with repetition of the same stimulus series. As mentioned above, this finding-- the basic LTH phenomenon-- is so well established that Thompson and Spencer (1966) have incorporated it as one of the defining characteristics of habituation. The within-group comparison of 4A with 4B revealed a cross-Part drop in both initial response magnitude and trials-to-criterion, matching the intersessional decrement found in the multiple-session studies mentioned above. This replication of LTH therefore implies that it is appropriate to use the single-session design to investigate LTH.

Also mentioned above, a secondary finding characteristic of multiple-session habituation studies is that of an arousal decrement both within and between sessions.

Although there seems no reason to demand such an effect of all LTH studies, it may be noted that, for the most part, comparable results were obtained with the currently employed design. The only discrepancy appeared with the comparison of SCL at the beginning of Part A to SCL at the beginning of Part B: A significant <u>increase</u> in SCL occurred across Parts. Such a finding is not only at odds with what would be expected of a multiple-session study, but also contradicts the current results showing an interpart decrement in two other arousal measures (SSF and HRL).

This apparently incongruous interpart SCL activity may, however, make sense in light of a finding by Bundy and Mangan (1979). These researchers made note of a hydration effect leading to increases in SCL as a function of the time the electrodes have been attached. Since in the current study the electrodes had been attached about 16 minutes longer at the beginning of Part B than at the beginning of Part A, the apparent increase in SCL may be attributable to hydration of the electrolyte. It would therefore seem reasonable to accept the other two measures, SSF and HRL, as more accurately indicative of true interpart changes in arousal.

Thus, considering the apparent comparability of multiple-session and single-session studies of LTH, it would seem that no evidence contraindicating the use of relatively brief retention intervals was obtained. The use of multiple-session designs appears to constitute an unnecessarily unwieldy method of studying LTH.

Stimulus-specific and non-specific effects

Initial response magnitude

The absence of a significant difference between 1B and 4A provides no evidence, with the current design, for the contribution of non-stimulus-specific factors to LTH. The implication, then, is that exposure to the experimental setting per se does not necessarily produce a decrement in responding to stimuli later presented in that setting.

Of course it also bears mentioning that the 1A condition, a visual memory task, is not completely analogous to an habituation "task." The intent of 1A was to impart an impression of having successfully completed an experimental session without providing discrete habituatory stimuli. Although the memory task was active in nature whereas habituation "tasks" are quite passive, it was thought that such a mildly active task would only exaggerate a feeling of successful accomplishment. Unfortunately the active nature of the task also prohibited the recording of tonic levels, eliminating any verification that the 1A condition was successful in instilling arousal effects like those of sessions consisting of habituatory stimuli. On the other hand, the fact that SCL, SSF, and HRL at the beginning of Part B were virtually the same in Group 1 as in the other groups suggests that these subjects also sustained a decrement in arousal.

Group 2B also showed no significant difference from 4A. Since Group 2 showed an interpart decrement in arousal (excluding SCL, for reasons stated above), yet demonstrated no LTH, it provides further evidence for the absence of non-stimulus-specific influence on LTH.

The absence of a difference between 2B and 4A also implies that there was no generalization of habituation in Group 2, despite their exposure to a temporally-similar but modality-different stimulus in Part A. This absence of a 2B-4A difference, implying an absence of intermodal generalization of LTH, is also consistent with Harding and Rundle (1969) who, as mentioned above, found no decrement in initial response magnitude across weeks in a group receiving intermodal stimulus change.

Initial responding of 3B, lower than that of 4A, implies that intramodal generalization of LTH did occur. Despite the fact that the 500-cps tone of 3A was very different than the 2000-cps tone of 3B, prior habituation to the 500-cps tone led to initial responding lower than would have been expected (as indicated by initial responding of 4A) had no prior habituation been provided. Thus, some effect of degree of stimulus similarity upon LTH was evidenced.

In general, then, the comparison of 4A with 1B, 2B, and 3B provided no evidence for non-stimulus-specific influences on LTH and no evidence for intermodal LTH generalization, but did provide evidence for intramodal LTH generalization.

Returning to the comparison of 1B with 4A, a finding with potentially important implications for the interpretation of the current results came to light. Although nonsignificant, 1B appears to show at least a tendency for greater variability and greater responding than 4A. Such a finding was quite surprising since it was supposed that 1B would, if anything, show a tendency for lower responding resulting from greater experience with the experimental setting.

Graham (1973) pointed out that there have been STH studies showing responding to a test stimulus, following habituation to another stimulus, to be greater than responding to the initial presentation of the habituation stimulus. She suggested that such a finding may be understood in terms of expectancy, with repeated presentations of the habituation stimulus generating a decreasing subjective probability of occurrence of a changed stimulus. That is, as the neuronal model of the habituation stimulus becomes more sharply defined, the perceived likelihood of the occurrence of a different stimulus diminishes. A subject first entering the experimental setting might, for example, have no reason to expect a tone rather than a light; at this point, the light would elicit responses no greater than those to the tone. After habituating to a series of tones, however, the subject's expectations may be more sharply defined. Presentation of a light at this point might produce a greater input/model discrepancy than at the beginning of the session, hence a greater response.

Although this explanation might account for the absence of generalization of LTH in Group 2, it is unclear why 1B should have shown even a slight tendency for facilitated responding. Group 1 received no habituation stimuli in Part A, and their instructions for Part B clearly indicated that the second phase of the experiment was to be quite different from the first. Why, then, should this group have a more fully defined set of expectancies prior to Part B than Group 4 had prior to Part A? (In fact, subject responses to the questionnaire indicated no differences in expectancies: 10 subjects in 1B and 11 subjects in 4A reported expecting an auditory stimulus.)

Perhaps a factor other than expectancy per se should be considered. Jackson (1974) has shown that the intensity of an habituation stimulus can affect responding to a later test stimulus. She provided an habituation series of tones to five different groups, each group receiving the tones at a different intensity. Following habituation, each group was given a test stimulus at each of the five intensities. Jackson found that subjects who had habituated to the less-intense stimuli showed greater responding to the more-intense test stimuli than a control group that simply received the test stimuli without prior habituation. The implication, then, is that responding to a test stimulus may actually be facilitated by prior habituation to a stimulus of lower intensity.

Although the present design did not involve variations in the physical intensity of the stimuli, Jackson's study may be analogous on a more abstract level. One might argue that the "subjective intensity" of the Part A stimuli did vary across groups, producing an effect similar to that resulting from Jackson's manipulation of "physical" intensity. Support for such a contention would come from the response magnitude data of Part A, showing the 2000-cps tone to be a greater response elicitor than either the 500-cps tone or the light-offset. This finding in itself was somewhat surprising since Corman (1966) had previously shown that the magnitude of responses to 670- and 1850-cps tones do not significantly differ. However, as pointed out by Graham (1973), Corman's statistics compared responses to the two tones averaged over ten trials. His analysis may have therefore been insensitive to differences in the earlier trials. The current finding of greater initial responding to a 2000-cps tone than to a 500-cps tone suggests that Graham's criticism may have been well founded.

At any rate, if one is willing to accept a 2000-cps tone as more "intense" than a 500-cps tone, a light offset, or the memory-task condition, then one might well consider the possibility that initial response magnitudes of 1B, 2B, and 3B may have been heightened as a result of the general "Jackson effect" elaborated above. In such a case, evidence for non-stimulus-specific influences and/or for cross-modal generalization may have been obscured. If the absence of a Jackson effect had been assured by matching the eliciting qualities of all stimuli, such evidence might have obtained.

Turning to the comparison of 1B, 2B, 3B, and 4B, we see that, in spite of the possibility of a Jackson effect influencing the obtained results, 3B was not statistically greater than 4B. Such a result is consistent with the conclusion of intramodal generalization of LTH, though it had been expected, based on STH studies, that initial response magnitude would be greater in 3B than in 4B (i.e., that generalization of LTH would not be complete). Only the relative ordering of these two means was consistent with such an expectation. The fact that the ordering of all four group means was as predicted might imply that the Jackson effect heightened response levels but did not eliminate intergroup differences resulting from LTH generalization.

Thus, the predicted ordering obtained but at higher levels than groups 1B, 2B, and 3B might have shown without a Jackson effect. Since 2A and 3A had not significantly differed, it can be argued that a Jackson effect should not have differentially affected these two groups. Given an equal influence of the Jackson effect in groups 2 and 3, it is clear that stimulus similarity is indeed a factor contributing to LTH.

In fact, the extent of the intramodal generalization found, so great as to lead to no difference between 3B and 4B, might encourage the mollification of our concerns over a putative Jackson effect. If the Jackson effect is so completely overcome by the effects of stimulus similarity in the case of Group 3, then perhaps the absence of an interpart decrement in groups 1 and 2 may be accepted with greater confidence.

Trials to criterion

As mentioned above, Group 4 showed a highly significant drop in trials-to-criterion from Part A to Part B, replicating the basic LTH phenomenon and matching the result obtained with initial response magnitude. However, the results of the other comparisons were less straightfoward. Conditions 1B, 2B, and 3B did not statistically differ from each other, from 4A, nor from 4B. Given that 4A and 4B did differ, the implication may be that groups 1B, 2B, and 3B fell somewhere between 4A and 4B, but trials-to-criterion was not as sensitive as initial response magnitude in discriminating between groups. In part, the greater insensitivity of trials-to-criterion could be a result of the addition of STH effects, which should be identical across groups, to the effects of LTH. Initial response magnitude, being closer in time to Part A and not influenced by STH in Part B, might therefore be regarded as a "cleaner" measure of LTH.

Trials-to-criterion, then, does not permit definitive conclusions concerning possible effects of Part A on Part-B responding in groups 1, 2, and 3. In terms of means, however, it does seem that cross-Part repetition of an identical stimulus produces more rapid habituation than any other previous experience. Since groups 1-3 provided no trials-to-criterion-evidence for any effects of Part A upon Part-B responding, an evaluation of the effects of degree of stimulus similarity was not possible with this measure.

Conclusion

Thus, although Group 1 provided no evidence for the influence of non-stimulus-specific effects on LTH (Neither initial response magnitude nor trials-to-criterion of 1B differed from that of 4A.), and Group 2 provided no evidence for intermodal generalization of LTH (showing no difference between 2B and 4A for either of our measures), the possibility of a Jackson effect attenuating these results cannot be entirely ruled out.

Group 3 provided evidence for intramodal LTH generalization with respect to initial response magnitude but not for trials-to-criterion, perhaps suggesting that initial response magnitude is more sensitive to the effects of stimulus-similarity across Parts. Visual inspection of the habituation curves presented in Figures 3 and 4 convey an impression of agreement with the initial response magnitude findings: The curves of 1B, 2B, and 4A appear similar, as do the curves of 3B and 4B. Group 4 showed a drop in both trials-to-criterion and initial response magnitude across parts. The particularly robust findings with this group are at least partially attributable to the fact that 4A-4B was a within-group comparison.

Comparisons within Part B revealed that, in general, the ordering of mean initial response magnitude was consistent with the expected effect of LTH-generalization, though response levels may have been elevated by the Jackson effect, perhaps obscuring evidence for intermodal generalization and non-stimulus-specific effects. No such ordering was obtained with trials-to-criterion, perhaps due to the equal influence upon all groups of STH in Part B, or perhaps due to a ceiling effect in conjunction with elevated measures resulting from the Jackson effect. In any event, these results indicate initial response magnitude to be the more sensitive measure of LTH.

A discrepancy arises when one considers that Harding and Rundle (1969) found an effect of WEEK in their CHANGED group, implying that generalization does occur across modalities. Of course, no such finding was obtained in the current study. Harding and Rundle may have been successful in showing intermodal generalization by matching all of their stimuli for subjective intensity, thereby avoiding a Jackson effect. On the other hand, the fact that these authors' WEEK effect seems to reflect a difference in the asymptotic level of responding reached with successive sessions is disturbing; why should a historical difference between groups produce a difference in the ultimate level of responding attained?

In addition, Harding and Rundle (1969) showed no difference in the degrees of LTH (as measured by asymptote) between CHANGED and SAME conditions. This is particularly anomalous, since in the present study only intramodal generalization of LTH was evidenced, and only with initial response magnitude. Either the degree of similarity between Harding and Rundle's SAME and CHANGED groups was mitigated by the SRL differences, as discussed in the introduction, or the difference between "same" (4) and "changed" (2 and 3) groups in the present study was exaggerated by the Jackson efect.

The results of the present study are concordant with a stimulus-comparator/information-processing model of LTH: The use of brief retention intervals within a single experimental session was justified, and the notion that degree of stimulus-similarity does influence LTH was at least partially supported.

A somewhat surprising finding was that tonal pitch exhibits a dynamogenic effect similar to that of stimulus intensity. This effect may have mitigated the results which might otherwise have unequivocally implied that non-stimulus-specific factors are significant with respect to LTH and that intermodal generalization of LTH does occur.

It is clear that further research is mandated. Not only does the repeated nature of the statistical analyses employed imply the need for further empirical verification, but it is also quite evident that improvements in the current design are needed: The various stimuli employed in Part A should be matched with respect to their eliciting properties, and 1A should consist of a more passive condition, enabling the recording of tonic measures throughout the experimental session. On the other hand, the possibility that "subjective stimulus-intensity" effects can influence LTH might bear more direct exploration as a phenomenon of interest in its own right.

GLOSSARY

CPS: cycles per second

EEG: electroencephalographic

HRL: heart rate level

ISI: interstimulus interval

LTH: long-term habituation

LTM: long-term memory

OR: orienting reflex

SCL: skin-conductance level

SRL: skin-resistance level

SSF: spontaneous skin-conductance fluctuations

STM: short-term memory

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Appendix A

INSTRUCTIONS

The following represents the verbatim instructions read to each group prior to the beginning of each part.

<u>Instructions for 1A</u>. "To the left of your chair you will find a box containing a set of items. After I leave the chamber, please open the container and study these items, trying to commit them to memory. After some time I will come in and take the set away. After another period of time I will give you a larger set of items, some of which will have been in the original set. Try to pick out the items in the second set that had been in the first set, sorting them into a separate pile. After some time has elapsed I will come in to see how you have done. Please maintain an alert posture with the chair fully upright and your eyes open. The maintenance of alertness is essential. You will not be informed of the exact nature of the items beforehand, but they are not emotional or threatening in any way."

<u>Instructions for 1B, 2A, 3A, and 4A</u>. "This portion of the experiment will involve the presentation of a series of innocuous stimuli. You are required to do nothing but to

stay alert. We will just be measuring your physiologic functions during the series. Please maintain an alert posture with the chair fully upright and your eyes open. The maintenance of alertness is essential. The type of stimuli you will be getting will be randomly determined, and you will not be informed of the exact nature of the stimuli prior to experiencing them, but they are not emotional or threatening in any way."

Instructions for 2B, 3B, and 4B. "This portion of the experiment will involve another series of innocuous stimuli. You are required to do nothing but stay alert. We will just be measuring your physiologic functions during the series. Please maintain an alert posture with the chair fully upright and your eyes open. The maintenance of alertness is essential. Once again, the type of stimuli you will be getting will be randomly determined and you will not be informed of the exact nature of the stimuli prior to experiencing them, but they are not emotional or threatening in any way. The type of stimuli you will be receiving will be randomly determined and bears no relation to the type of stimulus you had in Part A."

Appendix B

POST-EXPERIMENTAL QUESTIONNAIRE

ALL GROUPS

Were all of the tones in part 2 alike?

If you think so, I'll tell you that in fact the last one was different in pitch from the others. If you had to guess, would you say it was higher or lower in pitch?

If not, which one (or ones) were unusual and how was it (or were they) different?

How certain are you of your responses, on a scale from one to ten with "one" representing "not at all certain" and "ten" representing "absolutely certain"? (Experimenter provides visual portrayal of scale.)

GROUPS III AND IV

If you think all of the tones in part 2 were not alike, would you say any were more like the tones of part 1?

If so, which one (or ones)?

How certain are you, on our 1 - 10 certainty scale?

GROUPS II, III, AND IV

Just before beginning part 1, did you have an idea about the kind of stimulus you were likely to be getting?

If so, what kind of stimulus were you expecting?

How sure were you, on our 1 - 10 certainty scale, that you would be getting the expected stimulus?

If not, what would you have said if you had been required to predict the kind of stimulus you would be getting?

How sure of your prediction would you have been, on our 1 - 10 certainty scale?

ALL GROUPS

Just before beginning part 2, did you have an idea about the kind of stimulus you were likely to be getting?

If so, what kind of stimulus were you expecting?

If it was a tone, were you expecting a particular pitch?

How sure were you, on our 1 - 10 certainty scale, that you would be getting the expedted stimulus?

If not, what would you have said if you had been required to predict the kind of stimulus you would be getting?

How sure of your prediction would you have been, on our 1 - 10 certainty scale?

When you heard the first tone in part 2, to what degree did you feel surprised by it, on a scale from one to ten with "one" representing "not at all surprised-- as if I'd delivered it myself" and "ten" representing "very surprised."

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