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Habituation of the orienting response as a function of

inter- and intramodal transfer of conceptual information

by

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Introduction

The predominant and the most elusive issue that has appeared throughout the history of psychology is the determination of cognitive processes. Very early in man's intellectual history, it was proposed that higher levels of functioning presuppose lower levels. Therefore, one might better understand the operation of the "soul" by discovering its relationship to the body. For instance, Aristotle presumed that the heart was the bodily actualization of the psyche. Thus the functioning of the body and of the psyche were inextricably intertwined. This notion waned from the beginnings of Christianity through the Middle Ages, and sanctions against its espousal were imposed. It wasn't until almost two thousand years after Aristotle's death that Rene Decartes directed psychology again toward the acknowledgment of the reciprocal influences of the mind and body. This notion of mind-body interaction reached its zenith with Gustav Fechner's "identity hypothesis." According to this idea, mind and body are two aspects of a fundamental unity, and the relationship between the two can be found in a statement of the quantitative relationship between bodily stimuli and mental phenomena.

At about the same time that Fechner was attempting to find support for his identity hypothesis, physiologists were making giant strides toward an understanding of the

functioning of the nervous system. Probably the most
significant physiological advance of the nineteenth century,
as far as present day psychophysiology is concerned, was made
by Hermann von Helmholtz. Helmholtz found that the nervous
impulse is not instantaneous but rather takes an appreciable
amount of time to travel along a neuron. The significance of
this discovery is that the "mind" is actually <u>limited</u> by its
corporeal environment.

Helmholtz' discovery is recognized as lending
significant import to a swing from the notion of the ancients
that the mind moves the body to the opposite and emerging
notion that the body determines mind. Ivan Sechenov, one of
Helmholtz' students, attempted to once and for all destroy
the idea that any psychic phenomena come from places other
than the nervous system. His thesis was that <u>psyche</u>, instead
of being independent of the body, is actually a function of
the nervous system, and therefore the investigation of
psychic phenomena is a physiological matter. He explained
all behavior, including thinking, as reflex activity.
However his explanations were only theories, and it fell upon
Ivan Pavlov to put Sechenov's theories to experimental,
laboratory analyses.

In his studies of reflex activity, Pavlov noted a
curious phenomenon that he called the "what-is-it?" reaction.
At first this response was seen as an annoyance and often

even a source of embarrassment--something that should be
controlled or eliminated. It wasn't until decades later that
this response was investigated in its own right. Today this
response is called the orienting response (OR), but the most
concise statement describing it is still that made by Pavlov
in 1910.

> 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 orient
> their appropriate receptor organ in accordance with the
> perceptable quality in the agent bringing about the
> change, making a 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,
> 1960, p. 12].

Serious investigation into the OR didn't begin until
after the Second World War, and almost all of this early
research was carried out in the Soviet Union. It wasn't
until the 1960s that Western researchers began rigorous
investigation of the OR. A major force generating Western
interest in the OR was the translation into English in 1963
of Ye. N. Sokolov's Perception and the Conditioned Reflex.
Sokolov acknowledged that the OR is evoked in an organism
whenever a change in the environment is perceived by that
organism. However he extended the Pavlovian discovery by
noting that with repeated stimulation of the once novel

situation, the OR habituates. These two parameters--evocation by a perceived change in stimulation and habituation upon continued presentation--although certainly not exhaustive, do weigh very heavily in delimiting an OR.

In order to explain the development and habituation of the OR, Sokolov advanced the notion of a "neuronal model of the stimulus." He described the neuronal model as a "polyvalent model of the stimulus in which all or a considerable group of its properties are represented [p. 287]." Upon repeated presentation of a stimulus (be it single or multiple; simple or complex), a neuronal model of the stimulus situation is established in the central nervous system. All subsequent stimuli processed by the senses are compared to the neuronal model. As long as the afferent information matches the model, the OR will be suppressed. But when there is a mismatch between the model and the representation of the input, the OR reappears. The OR then facilitates the reception of the elements responsible for the mismatch by increasing the sensivity of all sensory systems.[1] Moreover, the less the neuronal model and the stimulus

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[1]It should be noted that the contention of Sokolov that the OR is responsible for increased sensitivity in all sensory analyzer systems has found little support outside Sokolov's own laboratory.

differ (except if the model and the stimulus are near threshold), the less likely is an occurrence of OR reappearance, and this relationship is reflected in the magnitude of the consequent OR.

This notion provoked investigators to search for gradients of stimulus generalization in which OR magnitudes reflect the degree of disparity between a stimulus and the neuronal model of the previously presented stimuli. The first assaults on this issue were made by using fairly simple paradigms. Typically, subjects were presented with a series of identical stimuli after which a test stimulus was presented. The test stimulus differed from the previously presented stimuli on a simple sensory (i.e., quantitative) dimension. The magnitude of the subsequent OR was then compared to the amount of disparity of the test stimulus from the previous stimuli.

An independent variable often used within this paradigm is stimulus intensity. Investigations of the effect of change in auditory intensity have, however, not found a simple, functional relationship between stimulus change and consequent OR magnitude. Bernstein (1968) and Kimmel (1960) found that OR magnitude was greater for intensity changes in the upward direction than in the downward direction. O'Gorman, Mangan, and Gowen (1970) noted that only increases in intensity had the effect of evoking an OR to a habituated

tone. James and Hughes (1969), on the other hand, reported a generalization gradient of OR magnitude which increased to changes to higher intensities and decreased to changes to lower intensities of white noise.

In the visual mode, there has been a paucity of studies concerned with the relationship of change in intensity and the function of the consequent OR. Those few studies in this area have yielded results as discordant as investigations of the effect of change in auditory intensity. In two studies (Bernstein, 1968; Maltzman, Harris, Ingram, & Wolff, 1971) OR magnitude was found to be greater for an increase in light intensity than for a decrease. However, in a replication of one of his own studies, Bernstein (1969) found that only about half of the subjects who were aware of the stimulus change gave ORs to that change.

Edwards (1973)[1] showed that after only a few habituation trials, magnitude and direction of an OR to stimulus changes are direct functions of changes in stimulus intensity. However, as the number of habituation trials preceding the changed stimulus increases, direction of intensity change becomes less important in determining the magnitude of an OR. Edwards suggests that the effects of intensity change may be

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[1]Unpublished study entitled "Skin Conductance Response Magnitude to Stimulus Intensity Reductions Following Habituation," 1973.

built into the afferent-efferent system, and only as a neuronal model is developed out of stimulus repetition does the stimulus parameter of intensity become incorporated into the model.

Studies involving changes in tone frequency have yielded findings only slightly more consistent than those involving changes in stimulus intensity. Williams (1963), using a within-subjects design, presented her subjects with a tone for 15 repetitions. On trial 16 she presented a tone of a different frequency and found that OR magnitude was a function of degree of change from standard to test tone. Corman (1967) noted identical results when using a between-subjects design. Zimny and Schwabe (1965) also found generalization for relatively large changes from standard to test tone. But Geer (1969) and O'Gorman et al. (1970) found no such generalization for small changes.

More recently, research of generalized habituation of the OR has been concerned with stimulus changes that not only differ physically but also those which diverge from cognitive expectancies. The neuronal model proposed by Sokolov (1963) is "a system reflecting the most probable sequence of future actions.... The nervous system thus elaborates a forecast of future stimuli as a result of repeated stimulation and compares these forecasts with stimuli actually in operation [Sokolov, p. 289]." Therefore by controlling for physical

parameters of change while varying conceptual correspondence with the forecasted stimulus, conceptual generalization can be investigated.

Unger (1964) initiated studies of the cognitive generalization of the neuronal model. He demonstrated that after OR habituation had taken place to a progression of numbers presented in series, an out-of-sequence number would evoke an OR. In this case, the return of the OR could not have been a function of physical novelty since each stimulus presentation was physically unique. Instead, OR re-evocation must have been a function of conceptual novelty. Zimny, Pawlick, and Saur (1969) described conceptual novelty as being a function of the specificity of a class of previously presented stimuli forming a neuronal model of the stimulus situation. They presented to their subjects either (1) the numbers 21 through 60 in serial order, (2) the same numbers in a random order, or (3) the number 21 repeated 40 times. In all groups the number 600 was occasionally interpolated in the presentations. Results of this study supported the hypothesis that the more a class of repeated stimuli delimits the extent to which a subsequent stimulus may vary and still fit the evolving neuronal model, the greater will be the magnitude of the OR to a stimulus falling outside these limits.

In another test of the hypothesis of Zimny et al.
(1969), Geer (1971) varied the specificity of the evolving
neuronal model by directly varying the probability of
occurrence of a particular stimulus in a stimulus series.
His results revealed that the magnitudes of an OR to a
particular stimulus may be inversely related to the
probability of that stimulus occurrence. In line with this
notion is evidence that OR habituation rate is closely
related to the degree of uncertainty in the stimulus series
(Lovibond, 1969).

More recently, Yaremko and his colleagues (Yaremko,
1971; Yaremko, Blair, & Leckart, 1970; Yaremko & Keleman,
1972) have approached the issue of conceptual generalization
from another direction. Instead of varying habituating
stimuli while holding constant the test stimulus, they held
the habituating stimuli constant and varied the test
stimulus. For example, Yaremko and Keleman presented the
even numbers 10 through 22 sequentially followed by a test
stimulus which was out of sequence by ±3 (21 or 27) or ±15 (9
or 39). Like previous investigators, they found that after
the serial presentation of numeric stimuli, an
out-of-sequence stimulus would cause an OR. What is more
important, however, is that their studies revealed that the
magnitude of the OR to the test stimulus was a function of
conceptual disparity between the expected and the presented

stimulus, irrespective of the direction of that disparity.

From the studies reviewed above, it appears that conceptual information is more obedient to the neuronal model notion of OR habituation than are strictly physical parameters. The problem that this might seem to pose for Sokolov is more apparent than real. Since the neuronal model is formed at a "higher" nervous level, it may be argued that ideational information is what is important in the formation of this model and that the specific physical nature of the input is only of secondary importance.

Statement of the Problem

The presumed function of the OR is necessarily based on inter-analyzer connections since a change in stimulation arriving via any analyzer will evoke an OR, which in turn effects all analyzers by increasing their sensivity. Furthermore, with repeated presentation of a once novel stimulus, the OR will be replaced by the adaptive response; those analyzers which are least sensitive to the novel stimulus habituate first while those analyzers specified for the reception of that change habituate last. Thus, while a stimulus causing an OR may initially be carried by afferents of only one analyzer, OR evocation and subsequent habituation in all analyzer systems implies that there are inter-analyzer connections. And according to Sokolov, these connections are mediated at a higher nervous level--the neuronal model.

If it is the case that a neuronal model is established at a level higher than that of the analyzer systems and if conceptual parameters of the stimulus remain the same, then transfer of stimulation from one modality of input to another should show minimal effects on the restructuring of the neuronal model (as indicated by the magnitude of the consequent OR). On the other hand, if a neuronal model is modality specific, any change in mode will evoke an OR regardless of the similarity of other aspects of the stimulus.

The importance of whether or not habituation is crossmodal bears directly on the implicit generality of Sokolov's neuronal model. According to Sokolov, OR habituation takes place because non-specific pathways leading from the cortex (the site of the neuronal model) to the reticular formation (the OR amplifying system) are activated. The cortico-reticular pathways are activated by concordance between input and the existing neuronal model, and in turn they inhibit the effect of the collaterals arriving in the reticular formation from the sensory analyzer system (Lynn, 1966). Sokolov, however, eludes the question of whether or not a neuronal model built up using one analyzer system is effective in inhibiting (via cortico-reticular pathways) the afferant collaterals leading from each receptor system to the reticular formation. It is to this point that the present studies are directed.

Based on Sokolov's theory, as well as results frequently obtained in previous experiments, it is predicted that (1) presentation of a conceptually related series of stimuli will result in habituation of the OR to that series and (2) a test stimulus carrying identical conceptual information but differing from the habituation stimuli on physical parameters will re-evoke an OR. Finally, as a test of implications drawn from Sokolovian theory, (3) inter- or intramodal change in the presentation of concordant conceptual information

should not be significantly different in the magnitude of the OR evoked to that change.

Experiment I

Two groups were used to test the hypotheses outlined above. A third group was added to determine the effects, if any, of a change in both inter- and intramodal dimensions over and above either change alone. All groups received simultaneous presentations of two sets of ordered stimuli. One set of ordered stimuli consisted of numbers presented in series while the other set was composed of letters presented alphabetically. One set of stimuli was presented auditorily; the other set presented visually. On trial 10 the expected number and letter were presented either in (1) a changed form within the same modalities, (2) the reciprocal modalities, or (3) both. Appropriate controls were established to minimize the effect of modality stimulation per se. The skin conductance response (SCR) was used as a measure of the OR because "the main laws governing the galvanic skin reactions are identical with those described in connexion with the orientation reflex [Sokolov, 1963, p. 56]."

Method

Subjects

The subjects were 69 student volunteers enrolled in various undergraduate psychology courses at Iowa State University. All subjects were naive to this type of experiment. The data from five subjects were rejected because of either gross body movements during a stimulus

presentation, mechanical malfunctions, or experimenter error. The data from four more subjects were rejected for failing to meet the criterion of producing a SCR of at least 0.1 micromho to the first stimulus. The remaining 60 subjects were assigned to one of three groups.

Apparatus

During the experiment the subjects were seated in moderately comfortable armchairs, which were separated by a wooden partition, in an Industrial Acoustic Company, Model 1202-A sound resistant test room. The subjects faced and were approximately 1.5 m from a white projection screen.

The characters of the visual stimuli were typed in elite type on Aquabee acetate paper and mounted, with either red or green cellophane, in slide holders. All visual stimuli were presented via a Kodak Carousel projector (5 in. lens) equipped with a modified Wollensak, Alphax shutter and located outside the window of the test room, 2.25 m from the projection screen. Each character subtended dimensions of approximately 1.5° by 1.5° visual angle. Auditory stimuli were recorded on Scotch recording tape (1.5 mil Tenzar) via a Roberts, model 5000 tape recorder and delivered over an AR-3 speaker located immediately below the projection screen. Simultaneous presentation of visual and auditory stimuli was accomplished by programming a burst of white noise on one channel of the recording tape which coincided with the

auditory stimuli on the other channel. When the tape was
played, the white noise pulse was used to trigger the
projector via a noise activated relay. The illumination of
all visual stimuli was 21.5 lx. The mean peak stimulus
intensity for the auditory stimuli was 78 db. The reflected
light and noise levels of the test room were <0.002 cd/m² and
55±5 db, respectively.

Skin conductance was recorded from Beckman Bipotential
electrodes (10 mm diameter skin contact) injected with
Beckman electrode paste and applied to the volar surfaces of
the base of the metacarpal bones of the index and little
fingers. Skin conductance was amplified by a Beckman Type R
Dynograph via preamplifer couplers made according to the
specifications of Lykken and Venables (1971). A microphone
was located inside the test room so that the experimenter
could detect any talking or gross body movements.

Procedure

Subjects were placed in the test room either alone or
with one other subject. The electrodes were then applied to
each subject's non-preferred hand while the experimenter
explained the function of the electrodes. Without disclosing
the specific nature of the stimuli to be presented, the
subjects were told that after the experimenter had left the
room, there would be a three minute rest period before any
stimuli were presented; all that was required of them was to

watch the screen. The experimenter answered any relevant questions, instructed the subjects not to talk or move during the experiment, then left the room. After a period of at least three minutes, which allowed the subjects' skin conductance levels to stabilize, the stimulus presentation series was initiated.

Subjects were assigned to one of three groups in order of their arrival at the experimental session so that the data for different groups were gathered in a parallel, not a sequential fashion. Half of the subjects in each of the three groups received nine habituation trials of serial presentations of the numbers 1 through 9 auditorily and simultaneous alphabetical presentations of the upper case letters A through I visually. To control for any confounding effects of stimulus material and modality of presentition, the other half of the subjects in each group received the same stimuli but the presentation mode was reversed. For group INTER, all visual stimuli were presented against a green background; all auditory stimuli were presented in a masculine voice. For the groups INTRA and INTRA+INTER, the first nine visual stimuli were presented against a red background; the first nine auditory stimuli were presented in a feminine voice. On trial 10--the test trial--the visual stimulus for all groups was on a green background; the auditory stimulus was in a masculine voice. Furthermore, on

the test trial, groups INTER and INTRA+INTER experienced a

shift in modality of presentation of the expected stimuli.

For example, letters which were formerly presented visually

were now presented auditorily while numbers formerly

presented auditorily were, on the test trial, presented

visually. On trials 11 through 13, each group received the

numbers 11 through 13 and the letters K through M presented

in the same manner for that group as had been the stimuli on

trials one through nine. All stimuli were presented for a

duration of 2 s with a constant 28 s interstimulus interval.

Thus, group INTRA experienced mild intramodal changes in the

physical parameters between habituation and test trials,

group INTER experienced a change in mode of the expected

stimulus, and group INTRA+INTER received both an intra- and

intermodal stimulus change. In all cases, however, the

conceptual dimensions of the stimulus series remained

unchanged. These experimental conditions are displayed in

Table 1.

Results

SCR was computed as the difference between the immediate

prestimulus conductance level and the level of maximum

conductance resulting from a change that was initiated

between 1 and 4 s after the onset of the stimulus. (The

unadjusted data from this experiment are reported in Table 7,

Appendix B.) These responses were then adjusted for

Table 1. Experimental paradigm: Experiment I.

GROUP	MODE	STIMULUS PRESENTATIONS		
		HABITUATION TRIALS	TEST TRIAL	POST – TEST
		1 2 3 4 5 6 7 8 9	10	11 12 13
INTER	AUDITORY	┌──────────MALE VOICE──────────┐ 1 2 3 4 5 6 7 8 9	J	11 12 13
	VISUAL	A B C D E F G H I └──────────────GREEN──────────────┘	10	K L M
	AUDITORY	┌──────────MALE VOICE──────────┐ A B C D E F G H I	10	K L M
	VISUAL	1 2 3 4 5 6 7 8 9 └──────────────GREEN──────────────┘	J	11 12 13
INTRA	AUDITORY	┌───FEMALE VOICE──┐ 1 2 3 4 5 6 7 8 9	┌MALE VOICE┐ 10	┌FEM. VOICE┐ 11 12 13
	VISUAL	A B C D E F G H I └──────RED──────┘	J └──GREEN──┘	K L M └──RED──┘
	AUDITORY	┌───FEMALE VOICE──┐ A B C D E F G H I └──────RED──────┘	J └──GREEN──┘	K L M └──RED──┘
	VISUAL	1 2 3 4 5 6 7 8 9	10	11 12 13
INTRA + INTER	AUDITORY	┌───FEMALE VOICE──┐ 1 2 3 4 5 6 7 8 9	┌MALE VOICE┐ J	┌FEM. VOICE┐ 11 12 13
	VISUAL	A B C D E F G H I └──────RED──────┘	10 └──GREEN──┘	K L M └──RED──┘
	AUDITORY	┌───FEMALE VOICE──┐ A B C D E F G H I └──────RED──────┘	┌MALE VOICE┐ 10 └──GREEN──┘	┌FEM. VOICE┐ K L M └──RED──┘
	VISUAL	1 2 3 4 5 6 7 8 9	J	11 12 13

individual differences in range of SCR "by dividing each SCR
by the largest SCR elicited from that individual in the
session [Lykken & Venables, 1971, p. 668]."

On these data, two analyses were conducted. (Analysis
of variance summary tables for Experiment I are presented in
Tables 2 and 3, Appendix A.) First, a split-plot factorial
analysis of variance tested habituation over the first nine
stimulus presentations (within-block effect) and also
examined differences between groups and between
counterbalanced divisions of a group in the rate of
habituation (between-block effects). This analysis revealed
that only the effect of trials (i.e., habituation) was
statistically significant. There were no differences in the
rate of habituation either between groups or between the
counterbalanced conditions of each group. Moreover, no
interaction reached statistical significance. A Newman-Keuls
multiple comparison test was done to determine at what point
OR habituation appeared (i.e., after how many trials did the
SCR stabilize). When the adjusted SCR means for trials 1
through 9 were collapsed across all groups, this procedure
revealed significant differences between trial 1 and all
other trials, between trial 2 and all remaining trials, and
between trial 3 and both trials 8 and 9 ($p < .05$). All other
differences were non-significant. Apparently the SCR
habituated by about the second or third trial.

A second split-plot factorial analysis of variance
compared the differential effects of changed stimuli on the
rate of OR habituation. OR magnitude on the immediate
pre-test stimulus was compared to the magnitude of the OR to
the test stimulus for each group (within-block effect) as
well as the relative differences between test conditions
(between-block effect). Only the effect of trials (i.e.,
changed stimuli) proved to be statistically significant. No
differences between the INTER, INTRA, or INTRA+INTER groups
in the amount of re-evocation of the OR to the changed
stimulus was apparent. Likewise, the counterbalanced
divisions of each group did not differ. Again, no
interaction reached statistical significance. The results of
Experiment I are displayed in Figure 1.

Discussion

The results of this experiment support the three
hypotheses tested: (1) the presentation of a conceptually
related series of stimuli did result in OR habituation, (2)
an interpolated stimulus carrying compatible conceptual
information but differing from the habituation stimuli on
physical parameters did re-evoke an OR, and (3) differences
in the extent of the re-evoked OR between stimuli changed
inter- or intramodally were trivial. Confirmation of the
first two of these hypotheses comes as little surprise since
similar results have been evidenced throughout the
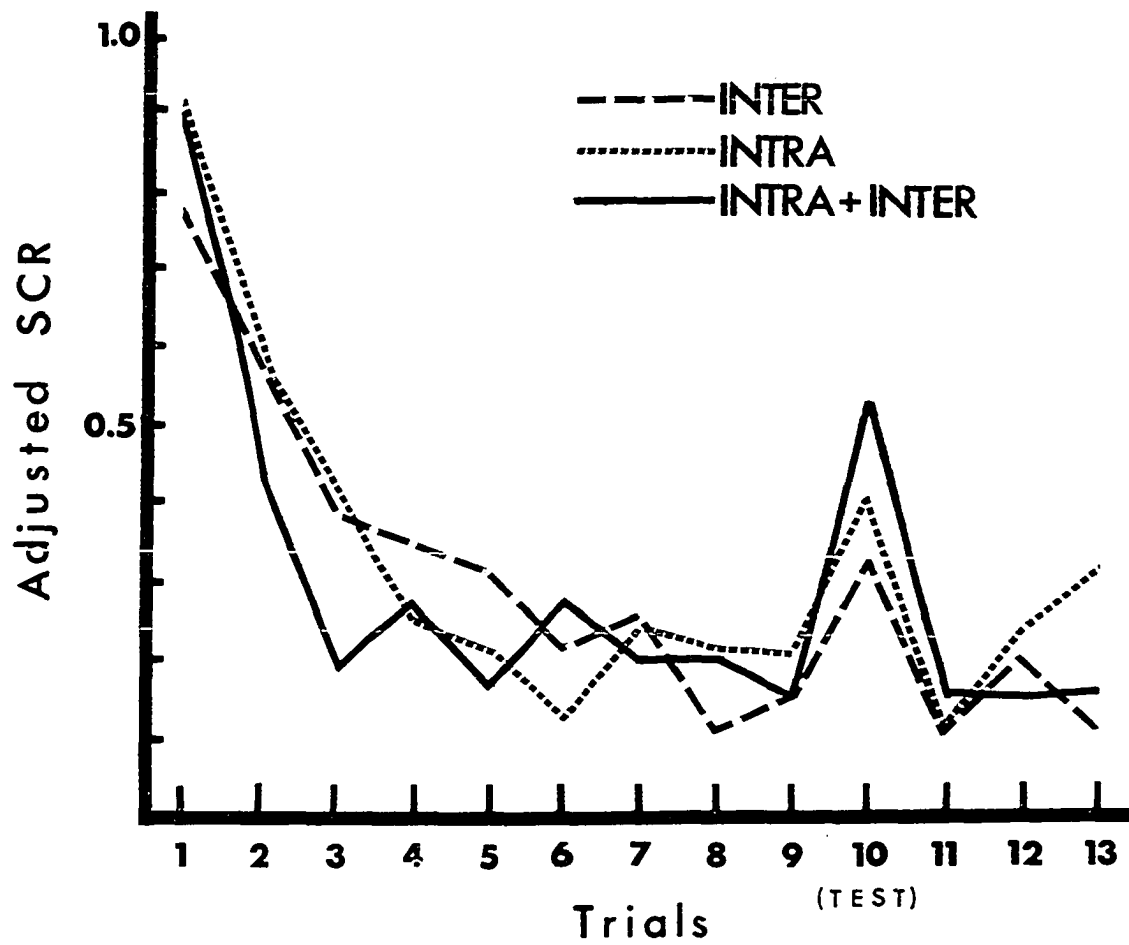
Figure 1. Mean adjusted SCRs depicting habituation and re-evocation of the orienting response: Experiment I.

literature. Instead, it is the finding of only trivial differences between inter- and intramodal changes, as well as the added finding of no significant differences between these two groups and a third in which changes were both inter- and intramodal, that makes these results unique. The fact that no differences between these groups were found suggests that, within the Sokolovian framework, the neuronal model is established at a level higher than the specific analyzer system.

However it may be that the effects of inter- versus intramodal changes show only very subtle differences that were washed out by one or more extraneous variables operating at the time the changes were made. For instance one factor that has a direct effect on OR magnitude is change in stimulus intensity from pre-test to test stimulus presentation. That changes in stimulus intensity had any influence in equalizing the simultaneous effects of inter- or intramodal changes in this experiment can, however, be dismissed in rather short order. For each group, illumination was a constant 21.5 lx for all visual stimuli; auditory stimuli changed from 78 db to 79 db, from 77 db to 78 db, and from 78 db to 76 db mean peak intensity for the INTER, INTRA, and INTRA+INTER groups respectively. These differences are trivial at most (Van olst, 1971).

Another factor which may have caused the INTER, INTRA, and INTRA+INTER groups to be non-differentiated is that the neuronal model is only in its early development when the changed stimulus is presented, and consequently the OR is almost purely a result of "a change" regardless of whether that change is of a physical or of a cognitive nature. Perhaps the physical and cognitive elements of a stimulus series are established at different rates in the development of the neuronal model. Moreover, the cognitive elements may enter the neuronal model only after the model has passed some stage of development based on physical parameters alone. This possibility finds support in evidence reported by Edwards (1973) and Geer (1969) suggesting that early in habituation trials, the OR may not be closely tied to the specific (experimenter defined) stimuli. But as the stimuli salient to the experiment are repeatedly presented, the ORs become more dependent on the content of the stimulus and less dependent on the stimulus presentation per se. As Geer states, "Perhaps the presentation of any stimuli in an experiment reduces ORs to 'stimuli presentations' and to a much lesser part to specific aspects of the stimuli [p. 201]." Therefore, extending the number of habituation trials may be necessary to ferret out the effects of the particular stimulus changes of interest.

A third factor which may have acted to depress possible differences between the three experimental groups is what shall be labled the "decimal effect." In brief, the decimal effect refers to the appearance of an OR to certain _trials_ regardless of the stimulus being presented during those trials. Specifically, trials acquiring the power of the decimal effect are those which the subject is aware occur in intervals of ten, beginning with trial ten. That is, the expectancy of "things happening" in intervals of ten (and fives to a lesser degree) is a function of the culture in which we live. The American number system (and the number system of the world for that matter) is almost exclusively decimal. Because of this, we have made cognitive anchor points of decimal values. We constantly deal with decimal quantities, and we expect controlled events to follow a decimal representation as well.

The notion of the decimal effect can be extended to the present study. Subjects expect things to happen in a psychological experiment (Orne, 1962). And since the investigator controlling the experimental environment is also a member of the same decimal society, there is reason to expect changes to "happen" in intervals of ten.

In order to eliminate the possible effects of these last two extraneous variables (the first one was seen not to be operating), a second experiment was conducted.

Experiment II

Experiment II was a replication of Experiment I with the important exception that the number of pre-test habituation trials was extended from 9 to 16. This allowed the neuronal model to become better developed and consequently better able to discriminate subtle differences between present and previous stimuli. At the same time, it removes the possibility of the decimal effect contributing to the magnitude of the test trial OR. The hypotheses under investigation remained the same as those outlined for Experiment I.

Method

Subjects

The subjects were 62 student volunteers drawn from various undergraduate psychology courses at Iowa State University. All subjects were naive to this type of experiment. The data from five subjects were rejected because of either gross body movements during the presentation of a stimulus, mechanical malfunction, or experimenter error. The data from three more subjects were rejected for failing to meet the criterion of producing a SCR of at least 0.1 micromho to the first stimulus presentation. The remaining 54 subjects were assigned to one of three groups.

Apparatus

The apparatus used was the same as that used in
Experiment I with the minor exception that the mean peak
stimulus intensity for the auditory stimuli was 76 db.

Procedure

There were two differences in procedure between this and
the previous experiment. First, since no differences were
found in Experiment I between counterbalanced divisions of
each experimental group, no such counterbalancing was done in
Experiment II. All pre- and post-test numeric stimuli were
presented auditorily; all pre- and post-test alphabetical
stimuli were presented visually for all subjects in all
groups. A second and important difference was that the total
number of trials was extended to 20, with the test stimuli
being imposed on trial 17. All other facets of the procedure
were the same as those described for Experiment I.

Results

The data, recorded as SCRs adjusted for individual
differences, were entered into two analyses paralleling those
conducted in Experiment I. (Unadjusted data are presented in
Table 8, Appendix B; analysis of variance summary data are
displayed in Tables 4 and 5, Appendix A.) To test for
pre-test habituation of the OR, a split-plot factorial
analysis of variance was computed over trials 1 through 16.
The results obtained in this analysis revealed that, again,

only trials had a significant effect. Neither the effects
due to groups nor the interaction of groups with trials
reached statistical significance. A Newman-Keuls test like
that done in Experiment I was again administered to evaluate
the point of SCR habituation. A similar pattern of
habituation was revealed. Trial 1 differed from all other
trials, trial 2 differed from all remaining trials, and trial
3 differed from trials 10, 11, 12, 13, and 15 ($p<.05$). All
other diferences were non-significant. Habituation again
appears after two or three trials.

A second split-plot factorial analysis of variance
tested for statistical differences of re-evoked ORs between
the INTER, INTRA, and INTRA+INTER groups on trial 17.
Results like those obtained in Experiment I were evidenced
once more: a change in stimulation from trial 16 (pre-test)
to trial 17 (test) resulted in significantly increased SCRs
while there were no differences due to groups. But a
significant groups X trials interaction was found.
Subsequent analyses were done on this interaction to
determine the exact nature of the effect. Using Tukey's HSD
multiple comparison test (see Kirk, 1968), it was found that
while the INTER and the INTRA+INTER groups showed significant
trials effects [$\bar{x}(17 - 16) = 0.34$, $p<.025$, one tailed; $\bar{x}(17 -
16) = 0.48$, $p<.025$, one tailed; respectively],

no such effect was manifested in the INTRA group [$\bar{x}$(17 - 16)
= 0.16, p>.05] The results of Experiment II are represented
in Figure 2.

Discussion

Once again the well documented effect of OR habituation
to ordered stimuli was evidenced. Also an overall effect due
to the interpolation of a novel stimulus was demonstrated.
But an interaction between groups and trials over the
immediate pre-test to test trials revealed that while the
INTER and INTRA+INTER groups both exhibited re-evocation of
the OR, the INTRA group did not. This indicates that a
transfer of conceptual information across modalities elicited
an OR while no such OR reappearance came with a mild change
within a modality.

Experiment II, by better allocating degrees of freedom
to the tests critical to the basic question of this study, as
well as by holding better control over factors which might
have been responsible for minimizing possible differences
between experimental groups during test stimulus
interpolation in Experiment I, may have been able to coax out
the subtle effect of modality specificity of OR habituation.
Of course, not all factors controlled were of consequence.
The decimal effect, given as a possible factor in influencing
the results of Experiment I, was non-existent in Experiment
II. This can be inferred from a non-significant difference

Figure 2. Mean adjusted SCRs depicting habituation and
re-evocation of the orienting response:
Experiment II.
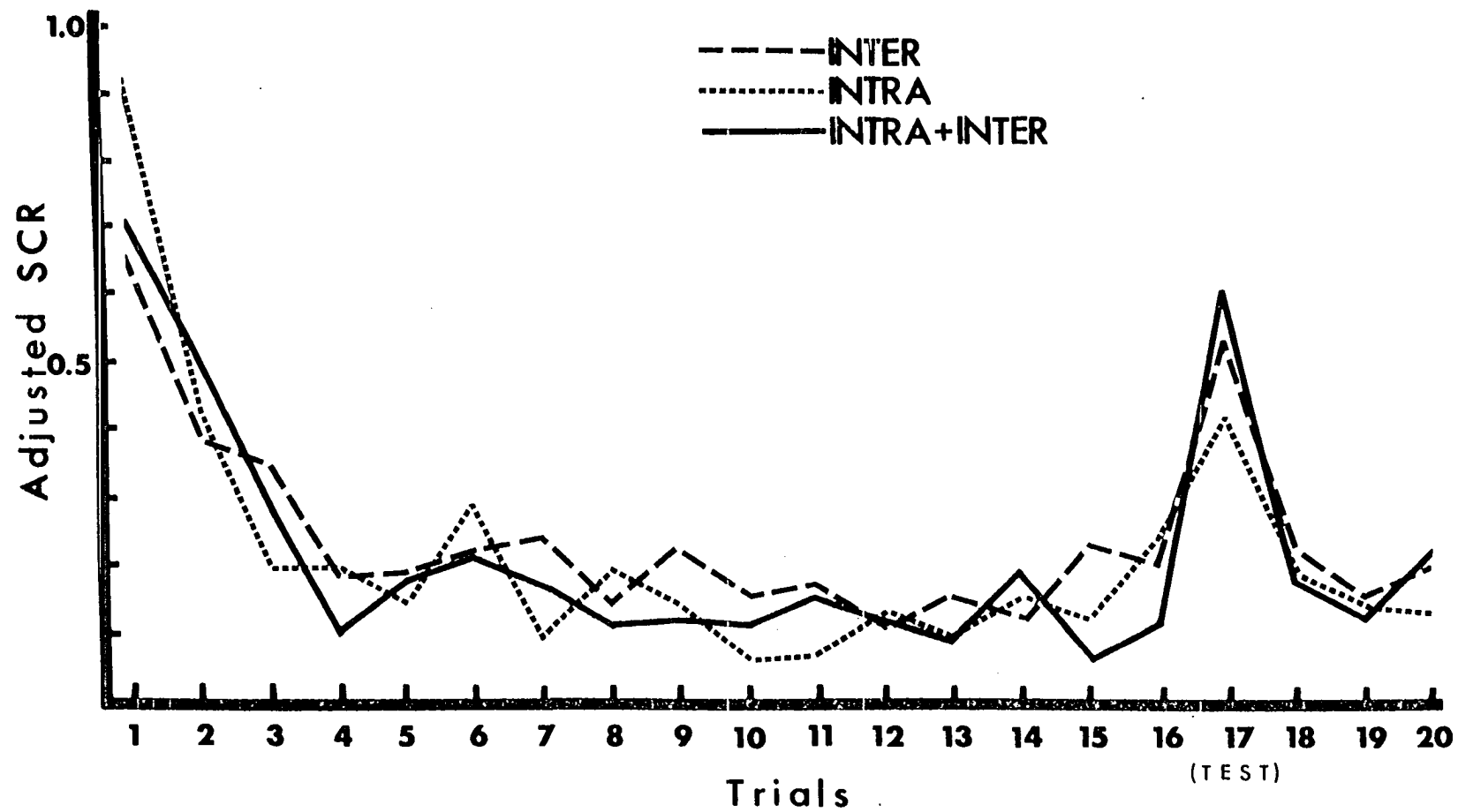
between trials 9 and 10 in the Newman-Keuls procedure outlined above as well as from inspection of Figure 2. (On the other hand, this finding adds some retroactive credence to the results of Experiment I.)

Instead it was the extension of trials in Experiment II that was influential in obtaining the present results. This was demonstrated by a highly significant three-way interaction of a split-plot factorial analysis of variance wherein the experimental groups of Experiment I were compared to those of Experiment II over immediate pre-test and test trials. (The results of this analysis are presented in Table 6, Appendix A.) Apparently by increasing the number of presentations in a stimulus series, a finer and more discriminating neuronal model is formed. So when a novel stimulus is presented, the OR evoked is less in response to novelty as a whole than to only that part of the stimulus which makes it novel. Recalling studies reviewed earlier (e.g., Unger, 1964; Yaremko & Keleman, 1972; Zimny et al., 1969), it was noted that conceptually related stimulus presentations were most obedient to Sokolov's notion of the neuronal model. Combining this fact with the results of Experiment II, showing significant OR re-evocation when an intermodal change is made but not when an intramodal change is made, it is apparent that a neuronal model is formed at a level no higher than the sensory analyzer system.

General Discussion

The experiments presented here yielded different but compatible results having direct bearing on Sokolov's theory of OR evocation and subsequent habituation. Since these results were designed within the theoretical framework established by the nction of the neuronal model, it is not the intent of the author to imply that this theory be abandoned. Instead, the findings reported here suggest a slight but important modification of Sokolovian theory. Modality specificity, involving the formation of as many models as there are modes of presentation (and reception), must be incorporated into the theory. This addition of modality-specific models does not necessarily preclude the complete substitution of _the_ neuronal model of a stimulus situation. A "grand" model which receives as input information from sensory models could be posited. However by endowing each modality-specific model with the ability to become established along both physical and cognitive dimensions (as the results of these experiments suggest), as well as in the interests of parsimony, a grand model becomes a superfluous element. That each modality-specific neuronal model does contain conceptual as well as physical information is demanded by the results of Experiment II in which a change causing the re-appearance of an OR was defined _only_ in terms of a modality change _per se_.

Modified in such a manner, Sokolov's theory would not
lose any descriptive power while it would gain in being
better able to explain the data at hand as well as findings
in areas not ordinarily the concern of psychophysiologists.
For instance, in a review of encoding categories of verbal
material, Wickens (1970) stated that "different dimensions
vary in their effectiveness for proactive inhibition release.
In general, semantic dimensions ... are highly effective,
whereas physical characteristics ... are relatively
ineffective in releasing proactive inhibition [p. 1]." In
terms of Sokolovian theory, one might just as easily explain
an improvement in recall following a cognitive change as a
consequence of increased receptivity of the to-be-recalled
material--i.e., an OR. But by making the modifications in
the theory as indicated here, one could also easily explain,
at a psychophysiological level, other findings like those of
Wittlinger (1967) which demonstrate that modality may be an
effective dimension in bringing about a release from
proactive inhibition.

Release from proactive inhibition is but one area in
which psychophysiology might add insight. With the
popularity of fields of research like attention and
information processing, theoretical models of
psychophysiological phenomena can add much to the developing
knowledge of perceptual and cognitive co-functioning.

Findings from studies of "selective" attention share mutual
support with the modified theory herewith proposed. Treisman
and Davies (1973) required their subjects to respond to
particular target stimuli interpolated in a stimulus series.
The subjects had to divide their attention between two such
tasks; this division of attention being either within or
between the auditory and visual modes. Not surprisingly, the
results showed that when the two inputs were in the same
modality, detection cf the targets was appreciably inferior
to the performance of subjects monitoring only one of the two
inputs. "However," Treisman and Davies state, "the main
finding ... is the considerable increase in the subjects'
ability to divide their attention between two inputs when
these are in different modalities rather than the same
modality.... There is clearly some modality-specific
perceptual capacity that cannot be redeployed to inputs in
another modality when required. This means that there is
effectively more capacity available when two modalities are
monitored than one. These results then conflict with the
suggestion that all processing capacity is interchangeable
between different types of analysis, storage and control [p.
113]." These researchers further admit the possibility "that
each modality actually has its own separate semantic system
[p. 115]."

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If indeed it is the case that conceptual as well as physical information is processed in a modality-specific manner, then one can presently only speculate as to the variety of stimuli to which man is capable of simultaneous attention. Present speculation, however, is a precursor of future research. Investigations of the extent of modality specificity of environmental stimuli will soon be in demand.

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Appendix A: Analysis of Variance Summary Tables

Table 2. Summary of analysis of variance of pre-test
habituation: Experiment I.

Source of variation	Degrees of freedom	Mean squares	F values
Groups	2	805.88	.42
Counterbalancing	1	912.59	.47
Groups X Counterbalancing	2	21.87	.01
Subjects within Groups	54	1937.08	
Trials	8	29,532.47	46.18**
Groups X Trials	16	863.45	1.35
Counterbalancing X Trials	8	578.50	.90
Groups X Counterbalancing X Trials	16	871.55	1.36
Subjects X Trials within Groups	432	639.51	

**$p < .001$

Table 3. Summary of analysis of variance of re-evocation of
the orienting response: Experiment I.

Source of variation	Degrees of freedom	Mean squares	F values
Groups	2	1038.23	.79
Counterbalancing	1	243.67	.18
Groups X Counterbalancing	2	1200.78	.91
Subjects within Groups	54	1319.09	
Trials	1	18,525.67	29.60**
Groups X Trials	2	880.68	1.41
Counterbalancing X Trials	1	195.08	.31
Groups X Counterbalancing X Trials	2	1104.53	1.76
Subjects X Trials within Groups	54	625.80	

**$p < .001$

Table 4. Summary of analysis of variance of pre-test
habituation: Experiment II.

Source of variation	Degrees of freedom	Mean squares	F values
Groups	2	650.11	.31
Subjects within Groups	51	2106.43	
Trials	15	14,096.60	29.10**
Groups X Trials	30	465.71	.96
Subjects X Trials within Groups	765	484.49	

**p<.001

Table 5. Summary of analysis of variance of re-evocation of
          the orienting response: Experiment II.

Source of variation	Degrees of freedom	Mean squares	F values
Groups	2	235.53	.12
Subjects within Groups	51	2023.73	
Trials	1	35,708.23	52.72**
Groups X Trials	2	2352.07	3.47*
Subjects X Trials within Groups	51	677.36	

*p<.05
**p<.001

Table 6. Summary of analysis of variance of re-evocation of
the orienting response: Experiment I and
Experiment II.

Source of variation	Degrees of freedom	Mean squares	F values
Experiment	1	990.17	.65
Group	2	27,989.66	18.41**
Experiment X Group	2	727.56	.48
Subjects within Experiments	112	1520.66	
Trials	1	22,841.08	33.00**
Experiment X Trials	1	176.44	.25
Groups X Trials	2	6852.41	9.90*
Experiment X Trials X Group	2	105,814.56	152.89**
Subjects X Trials within Experiment	112	692.10	

*$p<.05$
**$p<.001$

Appendix B: Raw Data

Table 7.   Raw data gathered in Experiment I.   Values represent SCRs expressed in tenths of micromhos.

Group: INTER, pre- and post-test letters presented visually

| Subject | \-Trials\-\-\-\-\-\-\-\-\-\-\-\-\-\-\-\-\-\-\- | | | | | | | | | | | | |
	1	2	3	4	5	6	7	8	9	10	11	12	13
1	18	10	19	12	0	6	6	1	0	14	3	18	13
2	14	9	15	14	20	10	1	2	3	8	7	2	11
3	5	5	7	4	18	8	1	3	0	11	1	17	21
4	10	3	0	0	0	1	2	4	0	1	0	4	4
5	41	28	27	35	29	27	24	14	22	9	22	31	28
6	3	4	3	10	1	0	0	0	0	1	5	0	30
7	41	22	20	21	20	27	16	12	7	20	0	0	3
8	6	7	0	1	0	0	0	0	0	0	0	2	1
9	14	10	16	13	20	4	0	0	0	0	0	0	1
10	20	8	1	14	0	0	0	0	0	0	0	15	0

Group: INTER, pre- and post-test numbers presented visually

Subject	1	2	3	4	5	6	7	8	9	10	11	12	13
1	28	5	1	0	2	0	1	0	0	8	1	0	0
2	2	0	0	0	0	0	0	0	0	0	0	0	0
3	1	5	1	0	2	0	9	4	0	3	0	0	0
4	11	5	2	1	1	0	0	0	0	0	0	0	0
5	47	31	35	0	0	23	36	8	0	12	1	18	0
6	21	14	16	20	13	17	27	1	13	25	11	1	7
7	5	4	4	5	4	4	0	3	7	9	2	0	0
8	35	17	26	16	31	0	24	6	9	38	15	5	34
9	4	0	0	0	0	0	0	0	0	0	0	0	0
10	8	9	7	5	3	1	0	0	6	0	0	0	2

Table 7 (continued).

Group: INTRA, pre- and post-test letters presented visually

Subject	\<--------------------Trials--------------------\>												
	1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	0	0	3	0	0	0	0	0	0	0	0	0
2	5	7	3	0	1	1	1	1	1	3	2	4	0
3	8	8	0	3	2	0	1	0	1	1	2	10	0
4	20	6	12	2	3	0	1	5	0	10	0	2	0
5	33	17	34	29	21	31	21	31	15	43	10	15	8
6	26	15	17	16	6	0	15	16	0	21	5	2	2
7	9	10	8	6	2	4	5	0	2	8	0	0	1
8	9	1	0	0	0	0	0	1	2	5	0	0	0
9	59	45	41	3	13	26	15	25	5	17	10	12	10
10	34	31	30	30	17	4	25	17	34	52	35	17	10

Group: INTRA, pre- and post-test numbers presented visually

Subject	1	2	3	4	5	6	7	8	9	10	11	12	13
1	9	2	1	0	3	1	0	0	4	7	4	5	5
2	8	4	0	0	0	0	0	0	0	0	0	1	0
3	17	21	14	0	0	1	0	0	0	0	0	0	0
4	10	2	2	2	3	3	6	9	3	7	2	0	0
5	9	11	10	5	9	2	11	5	12	0	0	1	1
6	9	3	5	0	0	0	2	3	5	5	0	1	5
7	14	10	4	0	0	0	0	0	0	13	0	1	1
8	5	3	4	0	0	0	0	0	0	1	0	0	0
9	24	16	8	16	17	2	11	0	0	1	0	0	0
10	7	8	3	0	0	0	1	2	0	0	0	0	0

Table 7 (continued).

Group: INTRA+INTER, pre- and post-test letters presented visually

Subject	Trials												
	1	2	3	4	5	6	7	8	9	10	11	12	13
1	11	7	4	3	6	8	2	3	6	6	4	3	6
2	14	6	0	3	2	4	2	0	1	15	0	0	13
3	16	5	0	0	0	0	0	0	0	0	0	0	0
4	31	6	4	2	0	1	1	16	0	21	0	0	0
5	28	17	14	15	9	5	14	18	1	6	7	5	1
6	5	3	2	0	3	0	3	4	4	7	1	4	0
7	26	10	11	12	11	13	0	0	10	10	20	16	23
8	3	2	0	2	0	0	0	0	0	1	0	0	0
9	14	15	0	2	0	0	0	0	0	1	0	0	0
10	10	19	10	29	2	22	0	1	0	7	0	2	0

Group: INTRA+INTER, pre- and post-test numbers presented visually

Subject	1	2	3	4	5	6	7	8	9	10	11	12	13
1	1	0	0	0	0	0	0	0	0	0	0	0	0
2	6	4	0	2	0	0	0	0	0	4	0	0	0
3	17	8	0	0	2	21	0	12	22	29	1	11	0
4	8	2	2	3	0	9	2	0	0	5	4	1	0
5	5	7	3	0	0	1	5	2	2	6	3	2	5
6	3	0	1	0	0	3	0	0	0	2	0	1	0
7	21	14	17	17	15	1	15	17	4	13	0	1	0
8	21	3	3	2	11	0	0	0	3	5	8	1	0
9	40	14	4	16	4	1	1	21	0	32	14	0	0
10	9	4	0	0	0	0	10	0	0	1	0	0	0

Table 8. Raw data gathered in Experiment II. Values
represent SCRs expressed in tenths of micromhos.

Group: INTER

					Trials					
Subject	1	2	3	4	5	6	7	8	9	10
1	40	15	20	17	4	6	0	12	0	0
2	8	9	9	6	15	0	9	2	15	7
3	7	7	3	0	0	9	5	2	6	0
4	16	11	1	13	12	2	19	15	9	12
5	7	2	4	0	1	2	1	0	0	0
6	6	0	0	1	0	0	0	0	0	0
7	8	1	2	0	15	0	7	0	4	14
8	49	26	28	41	13	61	28	32	36	49
9	2	1	2	1	2	2	4	0	0	0
10	9	10	10	0	2	3	2	5	6	0
11	7	6	10	2	0	0	0	0	0	0
12	22	24	23	25	15	7	4	9	6	5
13	2	13	1	1	0	1	0	0	1	0
14	2	0	0	0	0	0	0	0	0	0
15	17	2	0	3	0	0	1	0	17	6
16	9	3	5	2	1	2	1	2	4	0
17	20	18	5	0	3	7	2	0	0	0
18	32	16	10	0	2	16	29	1	23	39

					Trials					
Subject	11	12	13	14	15	16	17	18	19	20
1	2	12	25	6	23	0	14	3	2	4
2	4	0	0	4	7	12	22	0	16	0
3	5	0	2	0	0	0	10	2	0	8
4	24	28	17	20	24	29	36	24	17	24
5	0	0	0	0	0	0	3	0	1	0
6	0	0	0	0	0	0	1	0	0	0
7	0	0	0	1	28	0	1	0	0	15
8	26	21	41	25	49	66	25	2	43	2
9	0	0	0	0	0	0	0	0	0	0
10	6	1	0	0	0	0	3	0	0	0
11	0	0	0	0	0	0	2	0	0	0
12	6	0	5	0	8	0	39	37	0	0
13	0	0	1	0	0	0	1	0	0	0
14	0	0	0	0	0	0	0	0	0	0
15	17	12	20	27	20	28	44	12	4	5
16	1	0	0	2	0	0	11	0	0	0
17	0	0	0	0	0	18	39	0	1	0
18	6	18	5	10	10	5	40	63	22	7

Table 8 (continued).

Group: INTRA

Subject	1	2	3	4	5	6	7	8	9	10
1	20	5	0	0	2	5	0	0	0	0
2	68	46	40	14	32	10	16	3	21	6
3	37	22	11	3	14	13	8	20	21	3
4	36	18	0	1	0	31	0	0	0	0
5	10	8	0	3	0	10	0	0	0	0
6	105	58	44	50	42	74	38	40	6	60
7	15	13	6	16	17	5	4	17	22	8
8	8	9	1	4	1	10	1	0	0	0
9	9	3	2	4	0	0	0	0	0	0
10	36	7	0	1	0	2	0	0	0	0
11	3	0	1	1	0	0	0	0	0	0
12	2	2	1	0	0	0	0	0	0	0
13	24	1	0	0	0	0	0	0	0	0
14	23	12	9	9	8	6	8	18	18	3
15	59	3	6	0	0	0	0	0	0	0
16	30	23	13	20	4	6	1	28	28	2
17	10	0	3	1	0	3	3	0	0	0
18	32	22	7	8	18	4	1	24	1	6

Subject	11	12	13	14	15	16	17	18	19	20
1	1	3	1	21	2	22	23	1	0	0
2	0	50	0	0	0	14	22	0	4	0
3	15	3	17	10	3	23	13	7	8	15
4	0	1	0	0	0	0	3	0	0	0
5	0	0	0	0	0	0	1	0	0	0
6	24	43	22	77	4	43	83	135	47	131
7	3	12	15	1	3	0	51	26	8	19
8	0	0	0	0	6	1	5	2	4	9
9	0	0	0	0	0	0	0	0	0	1
10	0	1	0	0	1	0	1	0	0	0
11	0	1	0	0	1	0	0	2	1	0
12	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	3	2	0	0
14	7	6	10	9	1	23	41	15	25	23
15	0	0	0	0	0	3	0	0	0	0
16	17	27	14	18	1	32	43	4	0	0
17	0	0	0	0	0	0	0	0	0	2
18	0	3	2	9	27	19	31	26	18	0

Table 8 (continued).

Group: INTRA+INTER

	Trials									
Subject	1	2	3	4	5	6	7	8	9	10
1	2	5	2	0	0	0	0	0	0	0
2	14	11	13	4	7	11	13	14	11	4
3	20	19	18	0	3	2	0	0	0	0
4	28	15	15	4	17	27	49	0	12	52
5	13	12	8	0	8	2	0	0	0	0
6	26	7	5	0	3	0	0	0	0	2
7	13	9	4	4	6	1	3	5	0	1
8	10	11	2	0	0	0	0	0	0	0
9	10	5	0	0	1	2	0	0	0	0
10	11	17	18	7	17	8	16	11	13	30
11	19	12	18	0	0	10	0	5	0	0
12	12	13	1	3	6	5	1	5	1	0
13	6	1	0	0	0	0	0	0	0	0
14	28	26	17	20	9	0	51	0	30	0
15	1	0	0	0	0	0	0	0	0	0
16	29	29	18	0	0	55	0	0	0	0
17	12	13	12	10	13	10	10	15	12	13
18	19	8	9	8	0	9	0	4	6	0

	Trials									
Subject	11	12	13	14	15	16	17	18	19	20
1	0	0	0	0	0	0	0	0	0	0
2	10	6	11	12	13	3	20	9	13	19
3	0	0	0	0	0	0	3	2	0	0
4	0	11	0	0	0	0	59	1	16	0
5	2	1	5	1	0	15	19	9	9	10
6	0	1	0	2	0	2	10	6	6	2
7	0	0	8	1	0	0	25	3	2	5
8	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	1	1	1	0
10	41	25	7	25	20	3	29	16	0	22
11	33	0	0	7	1	0	48	2	10	1
12	0	0	0	4	0	0	7	8	2	11
13	0	0	0	0	0	0	0	0	0	0
14	0	32	0	45	0	20	34	12	5	17
15	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	9	2	0	0
17	16	20	9	25	0	1	32	1	0	16
18	1	0	2	0	4	11	21	12	0	0