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OF THE GALVANIC SKIN RESPONSE.**

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STIMULUS GENERALIZATION OF HABITUATION
OF THE GALVANIC SKIN RESPONSE

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
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By

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* * * * *

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INTRODUCTION

When a response is repeatedly elicited through the presentation of a particular stimulus, a decrement in the magnitude of the response is usually observed. This decrement can come about through several organismic changes. First, there is the process of sensory adaptation, which refers to some temporary peripheral condition modifying sensory input. Secondly, there is fatigue, which is a temporary condition limiting effector output. Finally, there is habituation, a more permanent, apparently centrally mediated, process which some theorists consider to be the most primitive form of learning. Sensory adaptation and fatigue are identifiable through the rapid and spontaneous (if you are looking at the outside of the organism) recovery of function that occurs following a brief rest period. These temporary processes are rarely encountered by the molar behaviorist.

Habituation, as distinct from fatigue or sensory adaptation, has been recognized and studied for many years. Excellent reviews of previous research can be found in Harris (1943), Thorpe (1963), and Thompson and Spencer (1966). However, some disagreement persists in regard to the operations required for establishing habituation, as well as in regard to some defining characteristics of the phenomenon.

Pavlov (1927) and most adherents of Pavlovian theory (e.g., Konorski, 1948; Sokolov, 1963) have considered habituation to be a

manifestation of internal inhibition. Internal inhibition is seen as a process whereby a previously positive conditioned stimulus gradually becomes an active inhibitory stimulus. In his early thinking, Pavlov thought that nonreinforcement was a necessary condition for the establishment of internal inhibition. However, his view changed in that he came to regard the repeated presentation of a stimulus as the necessary operation for establishing internal inhibition, whether or not it was followed by reinforcement. Thorpe (1963) presents a theory of habituation that is very similar to Pavlov's *original* conception of internal inhibition. He (Thorpe) defines habituation as "*the relatively persistent waning of a response as a result of repeated stimulation which is not followed by any kind of reinforcement.*" (Thorpe, 1963, p. 74, italics his). Thorpe's view of the operations required to establish habituation coincides with the operations used to define experimental extinction. Thompson and Spencer (1966) present a view of habituation that is similar to Pavlov's final conception of internal inhibition. They also disagree with Thorpe in that they believe that spontaneous recovery from habituation occurs. The composite view of habituation is that it is a relatively permanent (or temporary) waning of a response arising from repeated nonreinforced (or merely repeated) stimulus presentations.

Habituation has been studied by the Pavlovian school primarily as habituation of orienting responses. That is, certain responses are observed to occur whenever a novel stimulus is presented. With repeated stimulus presentations, these responses cease to occur. Among these orienting responses are changes in vasoconstriction, galvanic

responses of the skin, and changes in the electroencephalogram (Sokolov, 1963).

Thus, habituation of the galvanic skin response (GSR) has been demonstrated as a function of repeated stimulus presentations and a recurrence of the response to a change in the stimulus by a number of investigators. Coombs (1938) repeatedly presented an auditory stimulus, such as a horn honking or bell ringing, while observing the GSRs of the subject. After habituation the nature of the auditory stimulus was changed. A generalization of habituation to the new auditory stimulus was observed. The stimuli used were too complex to permit observation of a gradient of habituation across any dimension of similarity. Porter (1938) investigated cross-modality habituation by repeatedly presenting subjects with either a visual stimulus or an auditory stimulus until the subjects failed to give a GSR, and then presenting a stimulus of the other modality. The results were not statistically significant according to the techniques of the day (critical ratios less than 3.00), possibly due to the small number of subjects (eight). Mundy-Castle and McKiever (1953) studied GSR adaptation (habituation) rate and its relationship to EEG rhythms, age, and sex. Grings (1960) and Kimmel (1960) investigated changes in GSR magnitude accompanying changes in the consequences of the stimulus. An increased magnitude of responding was found when the consequences of the stimulus were altered. Grings refers to this phenomenon as a perceptual disparity reaction. Allen, Hill, and Wickens (1963) repeatedly presented a three-stimulus complex and then presented one of the first two stimuli alone. A significant increase in GSR magnitude

was found to the element alone. Williams (1963) repeatedly presented a tone (380 cps) and then on four consecutive trials presented four test tones (470, 1000, 1400, and 1850 cps), then repeated the procedure for each subject. A gradient of generalization based on the similarity in pitch of the test stimuli to the habituated stimulus was found on the second test. Maltzman and Raskin (1965) used the magnitude of a subject's GSR to a change in a sequence of stimuli to classify the subject as either a high or low orienter. This designation was then related to the subject's performance in a learning situation.

At the same time, a number of investigators (e.g., Hull, Hovland, Wickens, Grant, Kimmel) have used the GSR as a response measure in the study of classical conditioning. In this procedure, a supposedly neutral stimulus, such as a light or tone, is paired with a mildly painful stimulus, usually an electric shock. These investigators were aware that the "neutral" stimulus would elicit a GSR prior to association with the UCS. Because of this, some investigators (notably Hovland) presented the CS alone for several trials prior to its pairing with the UCS. However, the phenomenon of the GSR as an orienting response or a perceptual disparity reaction has caused doubts concerning the utility of the GSR as an index of conditioning.

In particular, studies utilizing the GSR as the response measure have experienced difficulty in demonstrating stimulus generalization gradients on initial test trials (or cycles). Hovland (1937), Littman (1949), and Wickens, Schroder, and Snide (1954) obtained complete generalization on initial tests, with a gradient emerging

only after repeated tests. This emerging gradient phenomenon has been cited by Mednick (Mednick and Freedman, 1960) as evidence that a gradient of association is not established until the subject experiences the test stimuli. It is difficult to imagine how a stimulus generalization gradient could be established during testing in a between-groups design such as that employed by Wickens, et al., where each subject experiences only the original CS and one test stimulus. The Mednick hypothesis would predict a flat gradient on all test trials. At the conclusion of their article, Allen, Hill, and Wickens (1963) suggest that GSRs related to procedural changes, such as those observed in their study and by Grings (1960) and by Kimmel (1960), might contribute to the flat gradient of stimulus generalization which is typically found on the first test trial in GSR conditioning. It is not clear how the perceptual disparity reaction as described by Grings could mask the gradient of association. However, if some process arose that resulted in greater GSR magnitudes the more dissimilar the test stimuli to the training stimulus, it could interact with the stimulus generalization of association effect and produce a flat gradient of GSR magnitude. There are other required characteristics of such a process. The gradient of GSR magnitude resulting from the process must disappear quickly in order to explain the gradient that emerges in the conditioning studies. It would have to be established by procedures similar to the procedure for conditioning. Finally, it would have to be established in the presence of a reinforcing stimulus. The author believes that a generalization of habituation phenomena could mask the gradient of association in stimulus generalization studies.

The Williams study (1963) gives evidence that a generalization of habituation gradient exists. However, her study was not designed in such a way as to give information regarding the durability of the gradient. This can be most easily investigated using a between-groups design. Also, positive results obtained with the between-groups design could not be given the theoretical interpretations of Mednick. Two procedural limitations exist in the Williams study. First, only test stimuli of higher pitch than the habituated stimulus were employed, and it is possible that the magnitude of the GSR might depend on absolute qualities of the stimulus such as pitch. Second, the Williams study used a fixed intertrial (or interstimulus) interval of only seven seconds. Intertrial intervals in GSR conditioning studies typically are at least 40 sec. in order to permit a recovery in baselevel resistance before eliciting another response.

The present study is designed to determine whether habituation occurs when a procedure similar to classical conditioning studies is used, whether this habituation is generalized along a dimension of similarity so as to mask an association gradient, and whether the gradient of habituation changes in such a fashion as to permit the emergence of a stimulus generalization of association gradient after a few test trials.

METHOD

Subjects

The Ss were 120 college students, both male and female, who chose to participate in the experiment as partial fulfillment of a laboratory requirement for an introductory psychology course.

Apparatus

Stimulus duration was controlled by Tektronix equipment consisting of a wave-form generator and a power supply. Stimulus duration was measured by a Hunter Klock-kounter. The stimuli employed were four tones, 670, 1000, 1400, and 1850 cps, all at approximately 60 db (re. .0002 dyne/cm²). The tones had been judged by several Os to be equal in loudness. Each stimulus was generated by a Jackson audio frequency oscillator and delivered through Willson sound barrier earmuff earphones. The GSR was measured by means of a Fels Dermohmeter and recorded from electrodes clamped to the palm and back of the left hand. The 3/4 in. diameter zinc electrodes were contained in plastic cups and they were freshly filled for each S with an electrode jelly consisting of zinc sulphate, bacto-agar, and distilled water. The E recorded the response visually to the nearest 200 ohms from a meter on the face of the instrument. A reading was taken of the resistance at the time the stimulus was administered and its minimal value during any response initiated within two sec. after stimulation.

The S's room was adjacent to the room containing the oscillators, timing equipment, dermohmeter, and E. The room was sound-shielded and contained a small ventilating fan, which prevented S from hearing the operating noises produced in E's room. During the experiment, S's room was dimly illuminated.

Procedure

The Ss were seated in the sound-shielded room. They were given instructions that the experiment concerned the reaction of Ss to supposedly neutral stimuli, and that they would hear a number of tones presented at irregular intervals. E then attached the electrodes to the palm and back of the S's left hand and placed the earphones on S. The E then left the room. Approximately two min. later, the first stimulus was presented. Each S received ten presentations of the habituation tone. Half of the Ss received a tone of 670 cps and half a tone of 1850 cps. Each S then received five presentations of a new tone (670, 1000, 1400, or 1850 cps). These frequencies were chosen as representing subjectively equal steps on the Mel scale of pitch (Stevens and Volkman, 1940), and were four of the tones used by Williams (1963). This results in test trials to S_1 , S_2 , or S_3 , with half the Ss receiving higher tones than the habituation tone, half receiving lower tones. All tones had a duration of 2000 msec. The intertrial intervals varied between 40 and 65 sec., with a mean of 55 sec. Base level resistance and GSRs were recorded.

RESULTS

Analysis of the magnitude of the GSRs elicited by the tones was based on the square root of the magnitude (in 200 ohm units). This transformation was used to minimize the effects of a limited number of extreme scores.

GSRs to the first tone (Trials 1-10) are presented in Fig. 1. An ANOV of these responses indicates a significant trials effect (habituation) ($F = 76.4$, $df = 9/1052$, $p < .01$), and no significant difference based on the pitch of the tone.

GSRs to the test tone (Trials 11-15) are also shown in Fig. 1. An ANOV on these responses indicates a significant trials effect ($F = 50.71$, $df = 4/468$, $p < .01$), and a significant difference between groups ($F = 5.90$, $df = 2/117$, $p < .01$).

The GSR magnitudes to the test stimuli (S_1 , S_2 , and S_3) on the first, third, and fifth test trials (Trials 11, 13, and 15) are shown in Fig. 2. This is part of the same data presented in Fig. 1, but is plotted across groups to illustrate the generalization effect.

Spearman rank order correlation coefficients between magnitudes of GSRs on Trial 1 and Trial 11 were computed and are as follows:

$S_0 \rightarrow S_1$ $r = +0.09$, n.s.; $S_0 \rightarrow S_2$, $r = +0.24$, n.s.; $S_0 \rightarrow S_3$, $r = +0.64$, $p < .01$.

Figure 3 shows the relationship between failures to respond on the terminal trials to the first stimulus and the magnitude of the

Fig. 1.--Magnitude of GSRs Following Stimulation

Fig. 2.--Stimulus Generalization of Habituation

Fig. 3.--The "Overlearning" Phenomenon

GSR on the first test trial (Trial 11). For all groups, as the number of "no responses" immediately prior to the change in tones increases, the magnitude of the GSR to the new tone decreases.

Base level resistance is shown in Fig. 4. An ANOV indicates a significant trials effect ($F = 27.99$, $df = 9/1052$, $p < .01$) during presentation of the first stimulus (Trials 1-10), but no significant differences based on the pitch of the tone. An ANOV of base level resistances during presentations of the test stimuli (Trials 11-15) reveals a significant trials effect ($F = 12.60$, $df = 4/468$, $p < .01$) and a significant groups by trials interaction ($F = 2.82$, $df = 8/468$, $p < .05$) but no significant differences between the base levels of the groups.

Fig. 4.--Baselevel Resistance Preceding Stimulation

DISCUSSION

In regard to GSR magnitude to the first tone (S_0), Fig. 1 illustrates that there is a marked initial response to S_0 . The determinants of the magnitude of this initial response are not known. However, it is of interest that the pitch of the tone (670 or 1850 cps) was not a relevant factor. One might guess that intensity would be a stimulus variable related to the magnitude of this initial response, but the verification of this will require additional research. With repeated presentations of S_0 , a significant decrement in the GSR magnitude occurred. It should be noted that 46% of the Ss failed to give an observable response on Trial 10. When the new tone was presented (Trial 11) a GSR occurred, the magnitude of which was a function of the similarity in pitch of that new tone to the previously experienced tone (S_0) (Figs. 1 and 2). As the new tone was repeatedly presented (Trials 11-15), there was a decrement in response to the new tone. The rapidity of the response decrement to both the first tone and the second tone should be noted. This is one of the requirements of the phenomenon if it is to explain the failure of most investigators to find a generalization gradient on the first few test trials (or cycles, if it is a within-subjects design). This indicates that habituation to the initial tone will occur within the number of trials typically used in GSR conditioning. Further, during testing, it is the incomplete

generalization of this habituation to the test tone that produces the flat gradient of GSR magnitude. The rapid completion of inhibition of this orienting response during the initial test trials permits the emergence of a gradient of GSR magnitude based on the generalization of association.

The "overlearning" phenomenon (Fig. 3) indicates that continued stimulus presentations, even after S has ceased to give an observable response, increase the generalized habituation. Such an effect would not be predicted from a non-inhibition theory, such as those based on the "expectancy" of S. According to expectancy theory, S ceases to respond to the first stimulus because he comes to expect its occurrence, and his response when the stimulus is changed is due to "surprise." If the failure of S to respond to S_0 is an index of expectancy, the more "non-response" trials, the greater should be his expectancy and the greater his surprise when a different stimulus occurs. Just the opposite effect occurs with regard to GSR magnitude. The Ss were questioned at the end of the experimental session, and on no occasion was a S unaware that the stimulus had changed during the experiment.

Maltzman has observed consistent individual differences in the magnitude of the GSR to stimulus changes. In the present study, there was a significant correlation between the Ss' initial response to S (Trial 1) and to the test stimulus (Trial 11) only when the greatest change in pitch occurred ($S_0 \rightarrow S_3$). That is, only when the stimuli were relatively independent in terms of the inhibition was a significant correlation found. This suggests that when inhibition is accrued, the amount of inhibition is not necessarily proportional to the initial

magnitude of the response. The absence of a significant correlation between Trials 1 and 11 in two of the three groups gives added support to the validity of the "overlearning" effect, since it also occurred in these groups.

In regard to base level resistances (Fig. 4), during the presentation of S_0 the only significant effect was a gradual increase in resistance over trials. This effect is usually observed in GSR conditioning studies, and the reason for the increase is unclear. During presentations of the test stimuli, there was again a significant increase over trials. In addition, there was a significant groups-by-trials interaction, probably due to the initial decrease in resistance for the $S_0 \rightarrow S_3$ group. This was the group that gave the largest response on Trial 11. All groups showed a similar drop in base level resistance on Trial 2 following the large response on Trial 1. It is possible that this temporary decline is of psychological significance in that it reflects an alerting of the S or it may be due to incomplete recovery from the preceeding response. The author favors the latter interpretation. There was no significant difference in base levels between groups, therefore differences in response magnitude during testing could not be attributed to base level differences.

When a novel stimulus is presented, a GSR is elicited. This response has been labeled an orienting response (OR) by many investigators. This experiment illustrates that as a stimulus is repeatedly presented, an inhibitory phenomenon occurs which is manifested in a decrement of the elicited GSR (GSR-OR). This inhibitory process

generalizes to other stimuli subsequently presented along a dimension of similarity.

The repeated presentation of a stimulus and a subsequent shift to one or more similar stimuli is inherent in the procedure for investigating stimulus generalization of association. The failure of many studies of stimulus generalization to find a gradient on the first few test trials (or cycles) which employ the GSR as the response measure (Hovland, 1937; Littman, 1949; and Wickens, Schroder, and Snide, 1954) could be attributable to an interaction between the gradient of association and the gradient of partial OR inhibition. The rapid completion of the OR inhibition to the test stimulus would explain the rapidly emerging gradient of association.

In the generalization of association procedure, an added operation, the presentation of the reinforcing stimulus, occurs. For example, the present study is quite similar to the first experiment of Wickens, Schroder, and Snide except for the omission of reinforcement. The interpretation of the failure to find a stimulus generalization gradient that has been offered here assumes that the inhibition of the orienting response occurs in the presence of a reinforcing stimulus. This is in accord with Pavlov's final conception of internal inhibition. Of course, if the reinforcing stimulus itself produces GSR changes which are not orienting responses, the inhibition of the OR may be masked. In many GSR studies, unless a number of adaptation trials are given prior to conditioning, the magnitude of the GSR to both the CS and the UCS declines during conditioning, and unless the magnitudes are compared to a control group having experienced unpaired stimuli,

the associative effect is not evident. The author believes this decrement can be attributed to OR habituation during conditioning.

It is not evident to the author that this phenomenon (OR inhibition) accounts for the failure of Brown (1942) to find an initial SG gradient in a runway situation. Nor is it evident that all reactions to novel stimuli (such as exploratory reactions, Berlyne, 1960) can be directly related to the OR. Indeed, the general relevance of the OR to molar behavior is unclear. The work of Maltzman and his associates relating general OR tendencies of the S and his performance in learning situations is a promising beginning, but research is required to relate the specific occurrence of the OR, or its inhibition, to the S's molar behavior in relation to the stimulus.

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AUTOBIOGRAPHY

I, Charles Dean Corman, was born in Charleston, West Virginia on July 13, 1936. I attended public schools in South Charleston, West Virginia, and graduated from South Charleston High School in 1954. I attended West Virginia University as an undergraduate from 1954 to 1956, and from 1959 to 1961, receiving my A. B. degree in 1961. I attended the graduate school of West Virginia University in 1961, and received my M. A. degree in 1962. I enrolled in the graduate school of The Ohio State University in 1962. I have served as a Teaching Assistant, Research Assistant, Assistant Instructor, and as a Pre-doctoral Fellow on a grant from the National Institute of Mental Health.