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UNCONDITIONED RESPONSE DIMINUTION IN THE SKIN RESISTANCE RESPONSE*[1,2]

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SUMMARY

An experiment was carried out to investigate unconditioned response diminution in the skin resistance response. By using an alternating series of paired and unpaired stimuli the differential predictions of the hypotheses of response interference, conditioned inhibition and expectancy could be tested. *S*s were 27 young adult male students. The unconditioned stimulus was a tone of 105 db. For the conditioned stimulus the *S*s were divided into two groups, one receiving a tone at 65 db and the other a tone at 85 db. Unconditioned response diminution was found. This diminution showed no significant change over trials and showed no correlation with amplitude of the conditioned response. This result is best explained in terms of expectancy.

A. INTRODUCTION

It has often been found that when the unconditioned stimulus is presented alone, the response is larger than the unconditioned response in the paired conditioning paradigm. This phenomenon is known as unconditioned response diminution. There are three hypotheses which have been put forward to explain the effect. These account for the diminution in terms of conditioned inhibition, response interference, and expectancy, respectively.

The conditioned inhibition (CI) hypothesis suggests that in the conditioning situation, CI develops over trials in addition to the more frequently studied conditioned excitation of the conditioned response (CR). This CI inhibits the amplitude of the unconditioned response (UR). The theory is put forward by Sokolov (12) for the skin resistance response (SRR), and by Kimble

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and Ost (7) for eyeblink conditioning. It has been followed up and developed by Kimmel (8), who reviews the area.

The expectany hypothesis assumes that the UCR is to some extent an orienting response. Diminution in the size of this response would be expected when the *S* was warned by the conditioned stimulus (CS) about the impending onset of the unconditioned stimulus (US). This hypothesis is particularly applicable to the SRR conditioning situation where the orienting response probably accounts for most of the UR. Various versions of the expectany hypothesis have been suggested. Lykken (10) interpreted results as suggesting that the CS acted as a warning signal in the SRR situation and explained this in terms of his Preception Theory. Kimmel (8) has suggested that the expectancy hypothesis is, in many ways, similar to Grings' (3) Stimulus Disparity Theory. Sokolov (11) sees the SRR as an aspect of the orienting reflex, and thus predicts a larger SRR to stimuli which are more novel or occur with less warning.

The response interference hypothesis was put forward by Grings and Schell (5), as an explanation of the results of UCR diminution experiments. It was previously implied as a process in an earlier article by Grings and Lockhart (4). They suggest that much of the diminution found may be due to simple interference between responses. Where the US is preceded by a CS, then the UR is probably preceded by a CR. If the CR had not recovered by the time of onset of the UR, then the amplitude of the UR may be reduced, either by lack of recovery of the response producing system, or by reduction in the range of possible variation.

The three theories mentioned above are not mutually exclusive and indeed all three processes may be operating at once. It is empirically very difficult to separate out the contributions of the individual effects. The experimental design most frequently used to demonstrate UCR diminution involves the presentation of a series of paired CS-US trials, followed by a series of US-alone trials. This design is used by Kimble and Ost (7) for the eyeblink situation, and by Kimmel and Pennypacker (9) for the SRR. However it is apparent that in such a situation all the theories mentioned will make the same prediction. Kimmel and Pennypacker claim that the results they obtain in such a paradigm support the CI Hypothesis. However CI is an Intervening Variable, whereas Response Interference is almost at the level of a measurement artifact. It can thus be argued that Response Interference is a more obvious and parsimonious explanation, and that its possibility should be eliminated before concluding that results support the more abstract concept of conditioned inhibition. With eyeblink conditioning, the impor-

tance of response interference has been recognized by Kimble and Ost (7) who, in the paired series, only considered those UR's occurring in the absence of a CR. However this selection may be far from random with respect to the variable under observation. It may be that the absence of a CR reflects an overall dropping off in the level of responding. If so, then considering only the trials on which no CR occurred would lead us to think that UCR diminution had occurred when in fact it had not. In addition, neither of the above experiments is able to exclude expectany as a possible explanation of the results.

Another class of experiments has compared the effects of the trace and delay conditioning paradigms. Baxter (1), with the SRR found more diminution with delay than with trace conditioning. Following Pavlov, who has shown less CI with the trace than with the delay paradigm, Kimmel has claimed that Baxter's results support CI as an explanation of UCR diminution. However, Grings and Schell (6) failed to replicate this result. Further, Kimmel's conclusions ignore the possibility that multiple responding may be more frequent with delay than with trace stimuli. If so, response interference would differentiate the groups in the same direction as CI. The trace-delay comparison does however control for expectancy.

Of the Baxter experiment, Grings and Schell also point out that the significant difference between the trace and the delay groups is largely accounted for by differences between the control groups. This observation points up a major difficulty with all skin resistance work. The SRR is so sensitive to changes in order and novelty that the effect of randomization itself can have quite a sizable effect on response amplitude and habituation rate. This can bias results in such a way that spurious significant differences may be found between experimental and control groups. Designs using an intrasubject control overcome this problem. However if this intrasubject design takes the form of a set of experimental stimuli followed by a set of control stimuli, then additional difficulties are introduced as effects are confounded with habituation and with dishabituation at the change.

B. Design

In the present experiment another alternative design was used. Here a CS-US stimulus pair was presented in alternation with a US alone, so that each paired UR had an adjacent unpaired control response. With half of the *S*s the stimulus series was initiated with the pair, while with the remainder it began with the US alone. In this way any order effects which existed were counterbalanced.

Consider the predictions of the three theories mentioned above in such a design. With response interference, we would expect diminution to be largest at the beginning of the series where the response to the CS was largest, but as this response habituated the amount of diminution should decrease. This is, of course, only true for the SRR where the orienting response to the CS is much larger initially than any conditioning effects. To the extent that any diminution is due to response interference we should also expect a correlation of both CR amplitude and CR recovery with the amount of diminution. With a more intense CS we would expect a larger CR and thus more response interference.

The effects of expectancy on our design would, to a certain extent, depend on the instructions given to the *S*. If, as in the present experiment, the *S* were completely instructed before the experiment on what to expect and when to expect it, then the amount of diminution due to expectancy should be present right from the start of the experiment and should continue throughout.

Finally, for conditioned inhibition, we would expect the amount of diminution to be zero on the first trial, but to increase progressively throughout the experiment. We thus see that with this design we achieve at least some separation in the predictions of the three hypotheses.

C. Method

In our experiment there were four groups of *S*s, comprising a 2 × 2 factorial design. The first factor was CS intensity which was at two levels, the CS being either at 65 db or at 85 db. The second factor was order of presentation and was also at two levels, depending on whether the stimulus series was initiated by a CS-US pair or by a US alone. Each *S* received eight CS-US stimulus pairs and eight adjacent control US alone. For one level of the second factor however the control US alone was the one prior to the CS-US pair, while for the other it was the one following.

In all cases the US was a tone of 105 db intensity (re .006 dyne/cm^2). All stimuli were of two seconds duration, sinusoidal, and at a frequency of 1000 Hz. The interstimulus interval between CS onset and US onset was seven seconds, while the interval between onset of the pair and onset of the tone alone was 40 seconds.

1. *Subjects*

The 27 *S*s were all male, mean age 20.5 years, *SD* 2.4 years. Two were students in psychology, 11 in art, and the remaining 14 in dentistry. *S*s of the three types were randomly assigned to the four groups.

2. *Apparatus*

Skin resistance was measured by the use of an apparatus built in the department and described elsewhere (13). The electrodes were Ag/AgCl and of an area of 64.2 mm^2. The electrode placement was bipolar, from the first to the second finger of the left hand. Tones were generated by an Audio Oscillator (SG65A Advance), and were presented binaurally through stereophonic headphones. Both stimulus occurrence and skin resistance were recorded on magnetic tape and on paper through a Mingograf EEG polygraph. The stimuli were presented on line from a Linc-8 computer, which was also used to analyze the responses.

3. *Procedure*

The *S* was seated in a comfortable chair in a soundproofed room. While the electrodes were being attached he was instructed completely on what was to follow. Information about the volume of and the time interval between the tones was given. He was asked to relax and do nothing during the experiment. The lights in the subject room were then switched off, and there was a three minute delay before stimulation began.

D. Results

The magnetic tape record of the *S*s' responses was analyzed on a Linc-8 computer. A response to a stimulus was defined as one whose onset occurred between .5 and 5.0 seconds after stimulus onset. The response peak was taken as the first maximum to occur following a response onset. If there was more than one peak within five seconds of stimulus onset, then the largest of these was taken. If no onset was detected, then a response of amplitude zero was recorded. Otherwise the resistance measure was converted into conductance, and response amplitude was recorded as the difference between peak conductance and response onset conductance.

The data were then further reduced on a CDC 6600 Computer using the Nybmul Multivariance Program (2). This program first took the individual measures and applied transformations to them to yield three combined measures for each block (a block being one CS-US pair together with its adjacent control stimulus). Prior to this transformation all scores were transformed into square root of conductance measured in tens of millimhos. This was in order to normalize the distribution of amplitude variables for subsequent analysis of variance. The three combined measures thus generated were as follows:

(*a*) DIM—amount of diminution. This was measured as the difference between the response to the US alone and the response to the US in the pair.

(*b*) CR—the amplitude to the response to the first stimulus in the pair.

(*c*) REC—an amplitude measure of recovery of the first response at the point of onset of the second stimulus of the pair. It was calculated by subtracting the base level at stimulus onset for the CS from the equivalent measure for the US in the pair.

These three measures were obtained for each *S* for all eight blocks. Following this combining of within block parameters, measures were combined across blocks to give means and change scores for each of the three measures, giving six variables in all. Change scores were calculated as the difference between the mean for the first four blocks and the mean for the last four blocks.

Means and standard deviations for all six variables for the two levels of CS intensity are given in Table 1.

TABLE 1
MEANS AND STANDARD DEVIATIONS FOR THE SIX VARIABLES IN EACH OF THE TWO CS INTENSITY GROUPS (UNITS ARE ALL SQUARE ROOT CONDUCTANCE)

Variable	Grand mean (N = 27)	CS of 65 db (N = 13) Mean	*SD*	CS of 85 db (N = 14) Mean	*SD*
Diminution	3.84	1.41	11.49	5.71	6.85
Change in diminution	−1.44	2.65	16.24	−5.83	16.76
CR amplitude	19.69	18.43	16.05	19.81	22.53
Change in CR amplitude	7.08	4.65	11.48	9.03	13.43
CR recovery	1.34	1.59	2.93	1.09	1.75
Change in CR recovery	1.16	0.69	3.06	1.52	2.95

Analysis of variance was carried out by a multivariate technique to adjust for unequal cell frequencies. The overall amount of diminution was significant at the .05 level. However the level of CS intensity did not significantly affect the level of diminution. There was no significant change in the amount of diminution over trials. The two CS intensity groups did not differ in the amplitude of the resultant CR, nor in the amplitude of recovery seven seconds after stimulus onset. Habituation of the response to the CS was significant, as was change in the amount of recovery over trials.

From the within groups correlation matrix it was found that there was no significant correlation between amount of diminution and either CR amplitude or amount of recovery. Change in diminution over trials, as well

as being nonsignificant in the analysis of variance, did not correlate significantly with any other variable.

E. Conclusions

From these results it seems that UCR diminution has been demonstrated. Further, the UCR diminution shown is not due to response interference, as diminution does not correlate with aspects of the CR. It may be that the interstimulus interval of seven seconds is too long to show response interference effects. Grings and Schell (6) found that the response interference they obtained was much smaller with interstimulus intervals greater than six seconds. Also the loudest stimulus in the present experiment was 85 db, compared with a loudest stimulus of 95 db in their experiment.

It was also found that the amount of diminution remained constant over trials. There was no increase over trials as would be predicted by the conditioned inhibition hypothesis. The diminution occurred at full effect on the first block. The hypothesis which best explains these results is the expectancy hypothesis. It can thus be concluded that in the SRR the amplitude of the response to a stimulus is smaller when the *S* has had some warning about the time of onset of that stimulus, and that this effect can sometimes account for the phenomenon of unconditioned response diminution.

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