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Differential effects of expectancy and associative mechanisms on diminution of unconditioned response in electrodermal classical conditioning

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The purpose of this experiment was to study whether conditioned diminution of the unconditioned response (UR) is a phenomenon with an associative basis. Twenty-five subjects received discrimination training with an interval between conditioned stimulus (CS) and unconditioned stimulus (US) of 5 s (differential conditioning group). The same stimuli were presented to another twenty-five subjects, but in an explicitly uncorrelated manner (non-conditioning group). After the acquisition phase, participants of each group were tested with seven presentations of CS+/US and CS-/US. The results of the acquisition phase showed that the UR amplitude was lower in the differential conditioning group than in the non-conditioning group. In the testing phase, CS+/US presentations elicited URs of lower amplitude than CS-/US in the differential conditioning group, but not in the non-conditioning-group. These findings are discussed as a result of expectancy and associative effects of conditioning processes.

Efectos diferenciales de los mecanismos asociativos y de expectación sobre la disminución de la respuesta incondicionada en el condicionamiento clásico electrodérmico. El objetivo de este experimento era estudiar si la disminución de la respuesta incondicionada (RI) es un fenómeno de base asociativa. Para ello, veinticinco sujetos recibieron entrenamiento discriminativo, con un intervalo de 5 segundos entre el estímulo condicionado (EC) y el estímulo incondicionado (EI) (grupo de condicionamiento diferencial). Los mismos estímulos fueron presentados a otros veinticinco sujetos, pero de un modo explícitamente descorrelacionado (grupo de no-condicionamiento). Tras la fase de adquisición, los sujetos de cada grupo recibieron siete presentaciones de EC+/EI y de EC-/EI. Los resultados de la fase de adquisición mostraron que la amplitud de la RI era más baja en el grupo de condicionamiento diferencial que en el grupo de no-condicionamiento. En la fase de prueba, las presentaciones EC+/EI suscitaron RIs de menor amplitud que las presentaciones EC-/EI, pero sólo en el grupo de condicionamiento diferencial. Estos hallazgos son discutidos como un resultado de los efectos asociativos y de expectación de los procesos de condicionamiento.

In the study of classical conditioning of electrodermal and eyeblink reactions, reduced response to the unconditioned stimulus (US) after repeated pairing of a conditioned stimulus (CS) with the US has been frequently observed (Baxter, 1966; Kimmel, 1967; Kimmel & Pennypacker as described in Kimmel, 1966). This phenomenon has been called «conditioned diminution of the unconditioned response (UR)» (Kimble & Ost, 1961), and a range of explanations have been offered.

An important issue is whether the conditioned diminution of the UR has an associative basis (Kimble & Ost, 1961). Much research on human subjects in electrodermal conditioning has supported the interpretation that diminished UR, seen in the presence versus the absence of a training CS, depends upon the associative integrity of the CS (Donegan & Wagner, 1987, p. 340). Experiments carried out by Baxter (1966), Kimmel (1967) and Kimmel and Pennypacker (described in Kimmel, 1966) seem to confirm a deteriorative effect of conditioning on the amplitude of the UR. However, other parallel research has not been able to reproduce these findings (Grings & Schell, 1969, 1971).

Morrow (1966) conducted a particularly convincing test of the associative basis of the conditioned diminution. If the conditioned diminution of the UR depends on the association CS-US, then it should be attenuated by extinguishing the conditioned response (CR). Using this procedure, Morrow found that extinguishing the CR led to a recovery of US effectiveness on postextinction CS-US test trials. However, these results should be considered as tentative since the extent of the recovery was the same for groups receiving different numbers of extinction trials.

More recently, Donegan and Wagner (1987, Experiment 2), working on the rabbit conditioned eyeblink preparation, demonstrated the presence of discriminative control over the con-

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ditioned diminution of the UR. These researchers found that the mean amplitude of the eyeblink response was lower when the US was preceded by the CS+ than when it was preceded by the CS- or when it was not preceded by any CS. These findings suggest that the conditioned diminution phenomenon depends on the association of the CS with the US. This diminution is therefore likely to be a regular concomitant of classical conditioning (Kimmel & Bevill, 1996; Marcos, 1998; Marcos & Redondo, 1999).

Demonstration of the associative basis of the conditioned diminution of the UR has made it clear that the phenomenon cannot be attributed solely to a perceptual-cognitive process which enables preparation for the impending US (expectancy). Neither can it be attributed to unlearned modulating influences in responding to the US, such as a response interference mechanism.

The purpose of the present study was to demonstrate in human subjects that the conditioned diminution of the UR has an associative basis. To achieve this, SCR amplitude was measured within a differential classical conditioning paradigm, with the aim of assessing the presence of discriminative control by the CS. With this procedure, subjects learn an association between the CS+ and US. As a result of this association, presentation of the CS+ activates processes related to the US which are responsible for the CR to the CS+. This way, the CS+ acquires excitatory properties for the CR. On the other hand, the CS-, which is always presented without US association, will become an inhibitory stimulus. This inhibitory CS- comes to suppress processes related to the US, and one might expect that this CS- would elicit the opposite of the excitatory response tendencies. If the UR conditioned diminution depends (as suggested by previously cited studies) on the association of an excitatory CS+ with the US, one might expect that the presentation of an inhibitory CS- immediately before the US would produce an opposite effect on the amplitude of the UR. Therefore, differential conditioning could be an adequate method for studying the possible associative basis of the UR diminution phenomenon.

If then, a truly random control group in which CS and US are presented in an explicitly uncorrelated manner is also included, the excitatory and inhibitory effects of the CS on the UR can be compared with a neutral condition in which CS does not exhibit any excitatory or inhibitory effect on UR amplitude, since the probability of presentation of the US will be the same in the presence or absence of the CS (Rescorla, 1967).

More specifically, the purpose of this study was to test this hypothesis for the acquisition phase: that preceding the US by a CS with which it has been previously paired (CS+) produces a more diminished UR than when US is presented alone or preceded by a CS explicitly uncorrelated with the US (CSunc).

For the testing phase, the following hypotheses are formulated: 1) that preceding the US by a CS+ produces a more diminished UR compared to a CS explicitly unpaired with the US (CS-), 2) that preceding the US by a CS with which it has been previously uncorrelated (CSunc) produces a more diminished UR compared to a CS-, and 3) that the CS+ produces a more diminished UR than the CSunc. The assumption underlying these predictions is that the CSunc does not possess associative properties, either excitatory or inhibitory, since it has been presented during the conditioning trials explicitly uncorrelated with the US.

Methods

Subjects

Subjects were 50 undergraduate volunteers, ages 20-30. All received class credit for their participation in the experiment. An additional 9 subjects were rejected, 5 of these for presenting an extreme habituation of the UR after the 10th acquisition trial, and 4, among those originally assigned to the experimental group for not manifesting differential conditioning. Another 7 subjects had also been rejected for giving SCRs outside the limits of 0.2 to 0.8 micro-Siemens (μS) in response to aversive white noise US in the initial phase of the experiment. The inclusion of this criterion was aimed at obtaining a homogeneous sample with regard to initial reactivity to the US.

Stimuli, Materials and Apparatus

The CS+ consisted of the image on a computer screen of a red square, measuring 7.5 x 4 cm, on a dark blue background. The same stimulus was presented to the control group in an explicitly uncorrelated manner along with the US. To avoid confusion, this stimulus will be called CSunc in the control group, thus indicating that it is the same stimulus, however now being presented in an uncorrelated fashion. The CS- was also an image on a computer screen of a red circle of approximately the same size and displayed against the same color background as the CS+ square.

A white noise generator was used to produce the aversive US, which had an intensity of 90 dB and was delivered through headphones. This white noise, at the same time, served as an imperative stimulus for a reaction time task (RTT). This task involved a keypress on a respose box with the index finger of the dominant hand. Previous work by Maltzman and Pendery (1988) had already demonstrated the possibility of utilizing these types of tasks as USs elicitors of electrodermal responses. Later, another study by Lipp and Vaitl (1990) showed that this task accompanied by positive feedback when there was an improvement with respect to the previous trials, was more effective for the acquisition of electrodermal CRs than when electric shocks or aversive white noise were used. Therefore, the US consisted of a combination of the burst of white noise with the RTT accompanied by positive feedback.

Since the time of Wundt (1880, cited in James, 1890), researchers have known that a warning stimulus facilitates voluntary reaction time (RT). For blocked foreperiods the latency of RT increases directly with the duration of the foreperiod (e.g. Putnam, 1990; Sollers & Hackley, 1997). Posner (1978) theorized that these effects are due to a phasic enhancement of alerting, which reduced the time needed for some central mechanism to respond to the build-up of sensory information. This way, it can be assumed that the voluntary RT to the US reflects the warning-signal quality of the CS when this stimulus is consistently paired with the US. Hence, the RT to the US could be used to determine the expectancy degree in conditions in which the CS is presented followed by the US.

Skin conductance was recorded on a Biopac MP100WS through a constant .5 V bridge (Lykken & Venables, 1971). SCRs were recorded using bipolar placement of 0.25 cm^2 area Ag/AgCl electrodes filled with isotonic electrode paste (Grass EC33) and attached with adhesive collars to the medial phalanges of the second and third fingers of the subject's non-dominant hand.

Stimulus onset and offset, interstimulus and intertrial intervals were controlled by a PC computer.

Variables and Design

The twenty-five subjects exhibiting discriminative control during the acquisition phase were assigned to the differential conditioning group (experimental group). Another twenty-five subjects made up the non-conditioning group (control group), in which CS and US were presented in an explicitly uncorrelated manner. To determine whether differential conditioning had occurred, two criteria were used: 1) at least 7 CRs should occur to the CS+ in the last 10 trials and, 2) there should be a significant difference between the CR amplitude elicited by the CS+ and the CS-. The application of such restrictive criteria was to conform to the need for selecting a group of subjects that unequivocally showed differential conditioning, in order to clearly evaluate the effects of conditioning on the amplitude of UR.

SCRs were scored as CRs when they occurred between 1 and 4 s from CS onset. A minimum response amplitude of 0.01 μS was required for both CR and UR measures.

The acquisition phase of the experiment was thus designed according to a 2 (conditioning) x 20 (trials) factorial model with repeated measures on the last factor. In the testing phase, for all subjects of the differential conditioning group, each CS (CS+ and CS-) was presented 7 times and always followed by the US. In the same manner, subjects of the non-conditioning group also went through 7 trials in which each CS (CSunc and CS-) was presented followed by the US. The same designs were employed for the analysis of RT data.

Procedure

The experiment consisted of four parts.

Adaptation phase

Once the apparatus was connected and the electrodes had been attached, two demonstration trials with only the burst of white noise were presented. This was done in order to select only subjects giving SCRs within the limits of 0.2 to 0.8 μS in response to the aversive white noise US. Subjects were told to relax so that their level of activation would decrease and therefore not affect the subsequent electrodermal recording. Adaptation continued for 3 or 4 minutes to allow electrodermal activity to stabilize.

Habituation of the OR elicited by the CSs

The aim was to eliminate the possible OR produced by these stimuli before starting the conditioning trials. Each subject was informed that only geometric shapes would be presented during this phase. Each stimulus (square or circle) was presented twice in random order, starting with the CS+.

Acquisition phase

This phase was begun with the presentation of the instructions on the computer screen, informing the subjects about the objective of the experiment. Specifically, subjects were told that the purpose of the experiment was to measure consistency over time in response patterns to different stimuli (i.e., geometric shapes and bursts of white noise) and that their job was to pay attention to the computer screen and to press a key on the response box as quickly as possible and immediately at the onset of the burst of white noise.

The conditioning trials followed thereafter. In the differential conditioning group 20 presentations of CS+/US and CS- were made, presented randomly with the restriction that no more than two consecutive CSs could be the same. The US was presented immediately following the termination of each CS+. Throughout the experiment, CS duration was 5 s, and US duration was 0.4 s. The inter-trial interval was 25 s (offset of US to onset of next CS).

In the non-conditioning group each of the stimuli (CSunc, CS- and US) were also presented 20 times, following a similar sequence to that of the differential conditioning group, but with the exception that the US was presented following the termination of CSunc only on 10 trials, such that on another ten occasions these stimuli were presented unpaired.

Testing phase

Each subject was instructed via the computer screen that from then on the burst of white noise (US) would follow all the geometric shapes presented (square or circle), 5 seconds after stimulus onset. This way, awareness of the CS/US relationship and predictability of the US were controlled. The subject was also told to press the key upon hearing the burst of white noise and that the quicker this was done, the better.

This phase consisted of 7 random presentations each of CS+ and CS- followed by US, with the restriction that the US was never preceded by the same CS+ or CS- two or more times consecutively. In a similar way, subjects of the non-conditioning group also received 7 CSunc/US and 7 CS-/US presentations. The duration of these stimuli was the same as in the acquisition trials.

Scoring and analysis

CR and UR were scored during acquisition and testing phases. CR is defined as a SCR which began 1-4 s following CS onset. The SCR which began 1-4 s following US onset was recorded as a UR. The RTs to the burst of noise US were also recorded.

For reasons discussed by Venables and Christie (1980), the SCR was logarithmically transformed to normalize the distributions prior to analysis. To avoid a value of 0 log, as well as the log of amplitudes lower than 1 μS (which would be negative), 1 is conventionally added to all SCRs amplitude scores. Thus, the data are expressed in terms of log (1 + SCR amp.). These data were then range corrected by dividing each response by the maximum response for each subject (Lykken, 1972). The obtained values ranged between 0 and 1. In order to avoid operating with such small values, the resulting values were multiplied by 1000.

To evaluate the reliability of effects on the amplitude of the SCRs, ANOVAs were calculated. Greenhouse-Geisser epsilon corrections were used to adjust probabilities for repeated measures effects (Jennings, 1987). A rejection region of $p < 0.05$ was used for all main effects and interactions.

Results

To evaluate the potential effect of the initial electrodermal reactivity to US on the amplitude of the CR and UR, a 2 x 2 ANOVA (conditioning x trials) with SCR data from the responses elicited by the two presentations of US in the adaptation phase was carried out. Results of this ANOVA showed that the main effect of conditioning was not statistically significant, $F(1/48)= 2.95$, $p>0.05$, and that a significant conditioning x trials interaction did not exist either, $F(1/48)= 0.35$, $p>0.05$.

Results of acquisition phase

Since the main purpose of this paper was to demonstrate the effect of conditioning on the UR diminution, it is important to first determine if the SCR elicited by the CS+ in the differential conditioning group was significantly greater than the SCR elicited by this same stimulus in the non-conditioning group (CSunc).

SCR data for the CR from acquisition phase were subject to a 2 x 20 ANOVA (conditioning x trials). This ANOVA yielded a highly significant main effect of conditioning, $F(1/48)= 14.77$, $p<0.05$, with the differential conditioning group (M= 224) responding more than the non-conditioning group (M= 117). The main effect of trials was not significant, $F(19/912)= 1.40$, $p>0.05$. A significant interaction between conditioning and trials was not observed either, although it approaches significance, $F(19/912)= 1.83$, $p= 0.06$.

The 2 x 20 ANOVA (conditioning x trials) with SCR data for the UR showed that the main effect of conditioning was not statistically significant, $F(1/48)= 0.73$, $p>0.05$. A significant trials factor effect was observed, $F(19/912)= 3.66$, $p<0.05$, which was caused by an increase in responding with trials. The follow-up trend analysis revealed a significant linear trend, $F(19/912)= 19.91$, $p<0.05$. There was also a significant interaction between conditioning and trials, $F(19/912)= 2.68$, $p<0.05$. As seen in Figure 2, the UR amplitude remains more or less stable in the differential conditioning group over trials, whereas the UR amplitude increases almost systematically in the non-conditioning group over trials.

To further examine this effect, separate post-hoc t-test were carried out for each trial. These tests reached significant differences in trials 1, 2, 3, 11 and 13. The differences approached significance in trials 8, 15 and 17.

Given that the RTT can contribute additional information about the expectancy effect, RT data to the burst of white noise (US) were subject to a 2 x 20 ANOVA (conditioning x trials). Results of this ANOVA showed that the main effect of conditioning was statistically significant, $F(1/39)= 14.58$, $p<0.05$, subjects of the differential conditioning group (M= 202) responding more quickly than those of the non-conditioning group (M= 270). Only 39 subjects are depicted here, given that in some trials it was not possible to correctly record the RT because the subject would strike the key before the noise was produced. There was a general reduction in RT latency over trials, as indicated by the significant trials effect, $F(19/741)= 17.22$, $p<0.05$. The conditioning x trials interaction was not significant, $F(19/741)= 0.71$, $p>0.05$.

Results of testing phase

The goal of the testing phase consisted in determining the differential effect of CS+, CSunc and CS- on UR amplitude and RT when US is preceded by these stimuli.

The evaluation of the effect of the preceding stimulus (CS+ and CS-) in the differential conditioning group was carried out by means of a within-subjects design of 2 (preceding stimulus) x 7 (trials) with repeated measures on the two factors. The corresponding ANOVA with SCR data for the UR amplitude indicated that the main effect of preceding stimulus was significant, $F(1/24)= 5.43$, $p<0.05$, indicating a greater UR amplitude with CS- (M= 519) than with CS+ (M= 486). The main effect of trials was not statistically significant, $F(6/144)= 1.01$, $p>0.05$. The preceding stimulus x trials interaction was not significant either, $F(6/144)= 0.19$, $p>0.05$.

The ANOVA for RTT data revealed that only the effect of trials was significant, $F(6/126)= 5.82$, $p<0.05$, showing a faster response to the burst of white noise over trials.

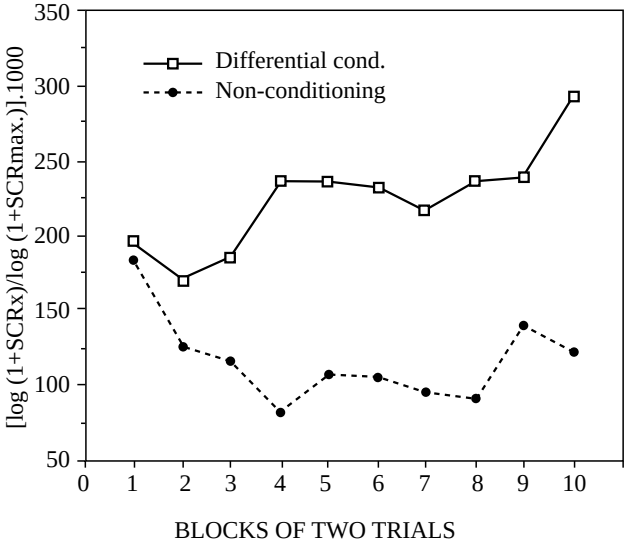

Figure 1. *Evolution over acquisition trials of mean CR amplitude in the differential conditioning and non-conditioning groups*

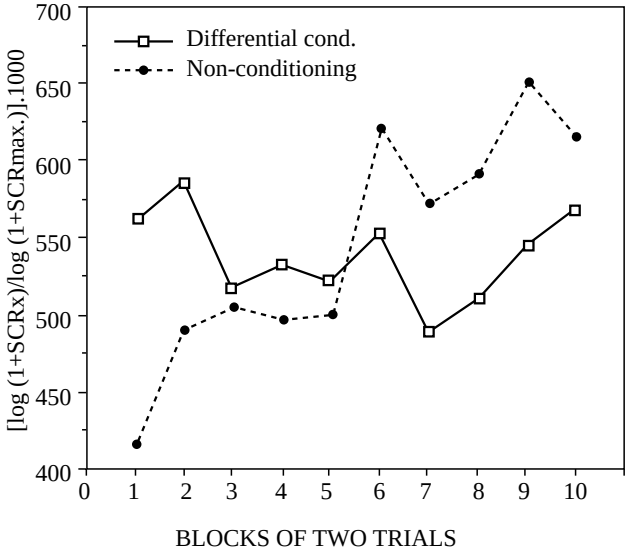

Figure 2. *Evolution over acquisition trials of mean UR amplitude in the differential conditioning and non-conditioning groups*

Since the main purpose of this paper was to demonstrate the associative basis of the UR diminution, it is important to know the course of the CRs over trials in relation to the different preceding stimuli. Hence, SCR data for the CR of the differential conditioning group were subject to a 2 (preceding stimulus) x 7 (trials) ANOVA. Results of this ANOVA indicated that the subjects exhibited CRs that were significantly greater to CS+ (M= 238) than to CS- (M= 211), [F (1/24)= 5.17, p<0.05]. The amplitude of CR showed a general decline over the course of the trials, F (6/144)= 4.67, p<0.05. A significant interaction between preceding stimulus and trials was not observed.

The same design was utilized to evaluate the effect of preceding stimulus (CSunc and CS-) on UR amplitude in the non-conditioning group. Results of the ANOVA showed that the main effect of preceding stimulus was not significant, F (1/24)= 0.11, p>0.05. There was a general decline in UR amplitude over trials, F (6/144)= 6.86, p<0.05, but the preceding stimulus x trials interaction did not reach significance, F (6/144)= 0.40, p>0.05.

The ANOVA for RT data showed that only the trials affected the quickness of the response to the burst of noise, F (6/144)= 5.43, p<0.05. Neither the preceding stimulus, F (1/24)= 1.75, p>0.05, nor its interaction with the trials affected the RT latency, F (6/144)= 0.28, p>0.05.

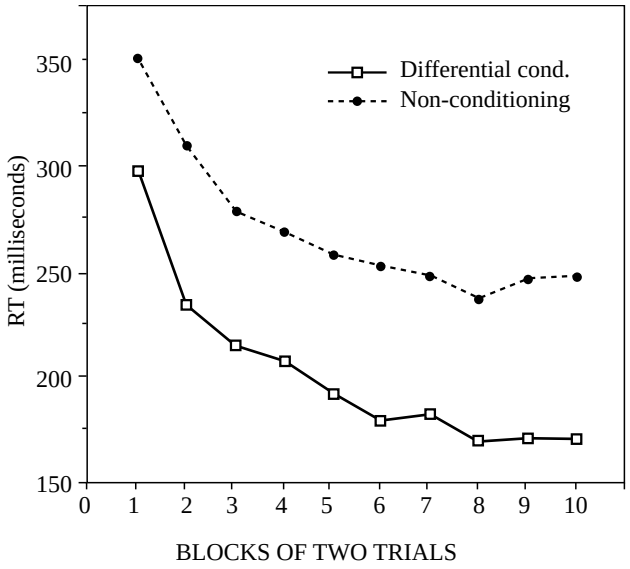

Figure 3. *Mean RT latency (in milliseconds) to US over the acquisition trials in the differential conditioning and non-conditioning groups*

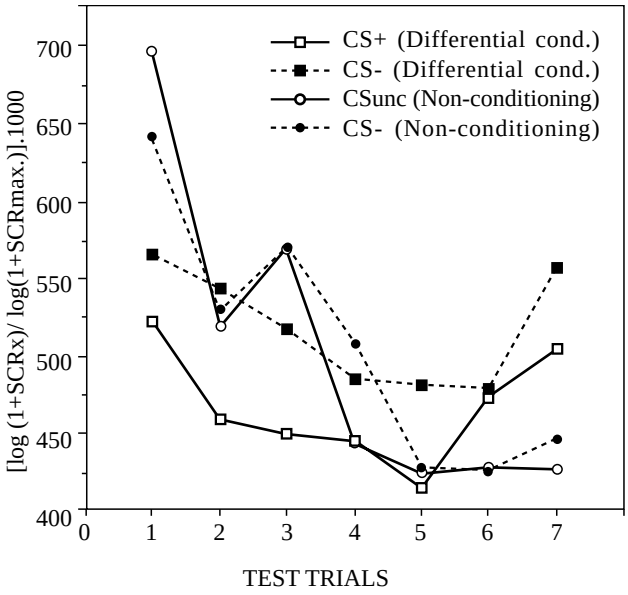

Figure 4. *Mean UR amplitude as a function of the CS that precedes the US presentation in the differential conditioning group (CS+ or CS-) and non-conditioning group (CSunc or CS-)*

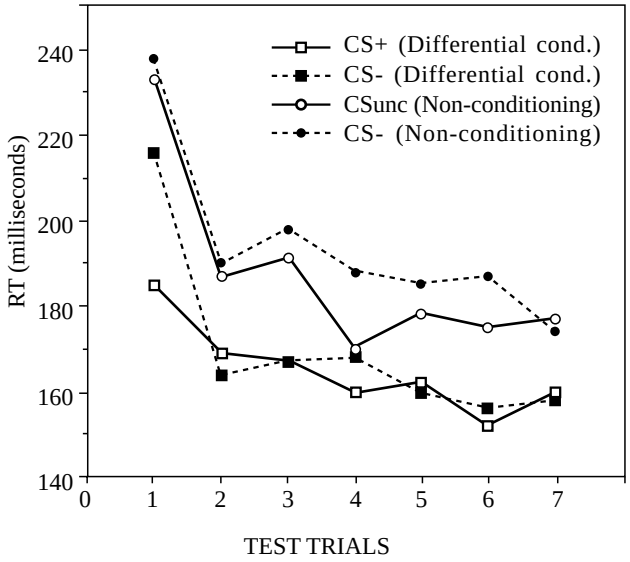

Figure 5. *Mean RT latency (in milliseconds) to US when preceded by CS+ or CS- in the differential conditioning group, and CSunc or CS- in the non-conditioning group*

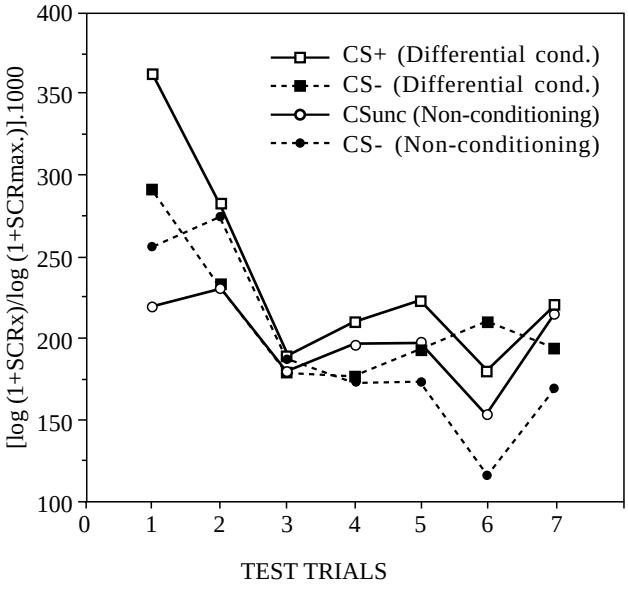

Figure 6. *Mean amplitude of the SCRs elicited by the CS+ and CS- in the differential conditioning group, and CSunc and CS- in the non-conditioning group*

Results of the ANOVA for the CR data revealed that only the main effect of trials was significant, $F(6/144)= 2.75$, $p<0.05$.

Lastly, the effect of the CS+ and of CSunc on UR amplitude when these stimuli were presented preceding US was compared. Given that CS+ was presented in the differential conditioning group and the CSunc in the non-conditioning group, SCR data for the UR of both groups were subject to a mixed-model ANOVA. The factors included in the analysis were preceding stimulus (CS+ and CSunc) x trials (seven trials). This ANOVA yielded a significant main effect of trials, $F(6/288)= 4.15$, $p<0.05$, that showed a general diminution of UR amplitude over trials, whereas the main effect of preceding stimulus was not statistically significant, $F(1/48)= 0.52$, $p>0.05$. The preceding stimulus x trials interaction was not significant either, $F(6/288)= 2.10$, $p= 0.07$, although it approaches significance.

The mixed-model ANOVA of 2 (preceding stimulus) x 7 (trials) revealed that the preceding stimulus, $F(1/48)= 4.96$, $p<0.05$, as well as the trials, $F(6/270)= 5.74$, $p<0.05$, significantly affected the RT. A significant interaction between the preceding stimulus and trials, $F(6/270)= 0.91$, $p>0.05$, was not found.

The same ANOVA for CR data showed once again that only the trials had a significant effect on CR amplitude, $F(6/288)= 3.86$, $p<0.05$.

Discussion

Acquisition phase

In general, the results of the acquisition phase show the effect of conditioning on UR conditioned diminution. When the US, preceded by CS+, is presented, the amplitude of the UR remains more or less stable over trials. However, UR amplitude tends to increase over trials if the US is presented by itself or when it is preceded by CSunc. Although the UR amplitude hardly decreases in the differential conditioning group, it suggests an effect of UR conditioned diminution, since the presentation of the CS and US in an explicitly uncorrelated manner increases the UR amplitude, as observed in the non-conditioning group.

The CS+ warning-signal quality for US could explain the elicitation of the CR, as well as the diminution of the UR amplitude in the differential conditioning group. In the non-conditioning group the expectancy mechanism does not intervene because there is no stimulus to warn the presentation of the US and, therefore, an UR conditioned diminution does not occur.

The signaling effect of CS+ is more evident in the results of the secondary RTT in the two groups. The RTs are significantly faster in the differential conditioning group simply because the CS+ warns the imminent presentation of the US, whereas in the non-conditioning group no warning stimulus for the US exists.

Furthermore, in both groups a diminution in the RTs over trials due to training can be observed. The diminution of RTs in the non-conditioning group is accompanied by an increase in SCR amplitude, possibly as a consequence of an increasing amount of information processing resources, which have to be allocated in processing the US to optimize the keypress response. However, the diminution of RTs is not associated with an increase in SCR amplitude in the differential conditioning group. This could be due to the fact that, in addition to stimulus anticipation, an associative mechanism is also involved. This mechanism reduces the response amplitude to the US when this stimulus is presented repeatedly paired with the CS+.

Testing phase

The results obtained in the differential conditioning group show the existence of a discriminative control of the CS on UR amplitude. The compound CS+/US elicits URs of lower amplitude than the compound CS-/US. This result is particularly important given that the subjects were previously informed that the presentation of the CS+ and of CS- would be followed by US. For this reason, one cannot attribute its differential effect on UR amplitude solely to a expectancy effect, given that both CSs signal the US in a similar fashion.

The quality of this signal, which is similar for both stimuli, is reflected in the results obtained in the secondary RTT. The RTs to US are nearly the same in both conditions. On the other hand, the results showed that CS+ elicited CRs of greater amplitude than CS-. Therefore, the difference in UR amplitude between the two conditions for US presentation could be attributed to the excitatory effect of CS+, or to the inhibitory effect of CS-, or to the sum of both effects, which would confirm our general hypothesis that the UR conditioned diminution has an associative basis.

The results in the non-conditioning group indicate that there is no difference in the SCR amplitude, nor in the RT, when US is presented preceded by CSunc or by CS-. The fact that the responses to both stimuli follow a similar pattern over the seven trials of the testing phase would indicate the absence of associate properties specific for each of the CSs or, in other words, that the CS- does not produce an associative inhibitory effect. According to Furedy, Riley and Fredrikson (1983), a possible explanation for this result could be that the autonomic nervous system does not react differentially in CSunc/US and CS-/US conditions because contiguity does not exist between the stimuli in any of the two conditions, despite the contingency relation CS/US being different.

The absence of significant difference in UR amplitude between the condition CS+/US of the differential conditioning group and the CSunc/US condition of the non-conditioning group could be explained because the CSunc acquires associative (excitatory) properties over testing trials, such that when approaching the fourth trial, it would produce an effect on UR amplitude similar to that of CS+. As seen in figure 4, during the first three trials the CS+ produces a greater diminution of UR than CSunc, although this difference is later reduced very quickly. The time course of the CR amplitude in both conditions over trials is also consistent with this interpretation. The occurrence of longer RTs to CSunc/US condition can be adequately explained simply because during the acquisition phase the subjects of the non-conditioning group had not been trained to respond to the US previously indicated by a CS, whereas in the differential conditioning group the CS+ consistently signaled the US presentation immediately after.

General discussion

In conclusion, the results of the two phases of the experiment can be adequately explained by means of the expectancy mechanism and another mechanism of associative basis generated by classical conditioning. The additive effects of both mechanisms would be responsible for the UR conditioned diminution. On the one hand, the expectancy mechanism produces a considerable reduction in UR amplitude, in condition CS+/US of the acquisition phase as well as in all the conditions of the testing phase. On the other hand, the presence of a moderate level of discriminative con-

trol over the amplitude of unconditioned SCR and the different time course exhibited by amplitude measurements of UR and RT during the acquisition phase suggests that the conditioned diminution of the UR also has an associative basis.

The effect of this associative mechanism is even more evident in the differential conditioning group during the testing phase. Before starting this phase the subjects were informed that the CS+ and the CS- would always be followed by the US, hence the expectancy effect should be the same in the two conditions. Given that the RTs are approximately the same in both CS and US presentation conditions this seems to indicate that the subjects have learned the same contingency relation in the CS+/US and CS-/US presentations. The warning-signal quality of the CS+ and CS- would be the same and, therefore, the expectancy effect should also be the same under both conditions. This way, the greater UR conditioned diminution observed in the CS+/US condition should be attributed to a mechanism of associative basis produced by the conditioning that occurs during the acquisition phase. The elicitation of CRs of greater amplitude with the CS+ than with CS- reinforces this interpretation.

This general discussion of the results is congruent with «the two-process view of Pavlovian conditioning» postulated by Furedy and Riley (1987). These authors consider that human classical conditioning encompassed two learning processes:

a) A cognitive, propositional learning process, based on the processing of the correlation between signs (CSs) and significates (USs). This learning process is sensitive to contingency-based differences. We suggest that this cognitive process is responsible for the expectancy mechanism, that initially reduces UR amplitude when the subject has learned the CS/US contingency relation.

b) A non-cognitive, response learning process that occurs mainly through contiguity between the CS and US. In our view this process would be responsible for the UR amplitude diminution that occurs with the repeated pairing of the CS and US and explains the associative basis that we have postulated for the phenomenon of the conditioned diminution of the UR in the electrodermal conditioning.

Our position is that both cognitive (expectancy) and response (associative) processes play an important role in the diminution of the UR amplitude taking place during electrodermal conditioning.

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