Fear relevance and diminution of unconditioned skin conductance responses

H. Merckelbach, M.A. van den Hout

Summary: According to Donegan and Wagner’s priming model [1987], a signalled UCS will elicit a smaller UCR than an unsignalled UCS. Assuming that fear-relevant CSs are good predictors of aversive UCs, while fear-irrelevant CSs are relatively bad predictors of aversive UCs, the present study examined the effect of fear relevance on electrodermal UCR diminution during the acquisition phase of a single cue conditioning procedure. Four groups were studied, each of which consisted of 12 subjects. Group 1 had a fear-relevant CS (a slide of an angry face) paired with a UCS (7 mA shock), whereas group 2 had a fear-irrelevant CS (a slide of a happy face) paired with a UCS. Groups 3 and 4 had unpaired presentations of the CS and UCS and served as control groups for 1 and 2. There were 4 habituation, 8 acquisition, 4 recovery (UCS-only), and 6 extinction (CS-only) trials. While overall UCR levels were lower in the paired than in the unpaired control groups, it was also found that the size of UCR decrement and subsequent recovery was greater in the angry face CS-paired group than in the happy face CS-paired group. This finding is in line with the predictions that flow from the Donegan and Wagner model.

Key words: SCR, single cue conditioning, fear relevance, UCR diminution


Schlüsselwörter: Furcht-Relevanz, Konditionierungsuntersuchungen

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Introduction

Several studies have shown that pairing a neutral, conditioned stimulus (CS) with an aversive, unconditioned stimulus (UCS) does not only result in the appearance of a conditioned response (CR) but also in a CS-linked attenuation of the uncondi-

1) An earlier version of this paper was presented at the 3d World Congress of Behaviour Therapy, Edinburgh, September, 1988.
tioned response (UCR) [see reviews by Kimmel, 1966; Dawson und Schell, 1987; Donegan und Wagner, 1987]. This latter effect has been termed "UCR diminution", while "UCR recovery" refers to the increase in UCR magnitude which occurs when, after a number of CS-UCS pairings, the UCS is presented without a preceding CS.

Elektrodermal [Grings and Schell, 1971], cardiovascular [Lykken, Macindoe and Tellegen, 1972; exp. 1], evoked potential [Lykken et al.,1972; exp. 2], and eyelink [Kimble and Ost, 1961] studies have reported reliable UCR diminution and recovery effects. Furthermore, parametric studies have shown that variables that are known to affect the CS in aversive Pavlovian conditioning are also of relevance to UCR diminution and recovery. Thus, the number of reinforced trials correlates positively with the amount of UCR diminution and subsequent recovery [Kimmel and Pennypacker, 1962], the amount of diminution and recovery vary with interstimulus intervals in exactly the same manner as CS conditioning does [Kimble and Ost, 1961]; Grings and Schelle, 1971], and finally, the presentation of CS-only trials leads to an extinction of UCR diminution [Morrow, 1966]. An interpretation of these effects in terms of effector fatigue or CR/UCR interference [Grings and Schell, 1969] is not convincing, as it is a well-established fact that UCR diminution and recovery can also be found in trace conditioning setups, i.e. in conditioning procedures in which there is a time gap between CS offset and UCS onset [Grings and Schell, 1971]. All in all, there can be no doubt that UCR diminution and recovery are genuine conditioning phenomena, with UCR diminution reflecting a conditioned inhibition controlled by the CS and UCR recovery reflecting a release of this inhibition by CS omission [Lykken and Tellegen, 1974].

With regard to the theoretical interpretation of these phenomena, Donegan and Wagner [1987] proposed a "priming" model which is based on an information processing approach to conditioning. The Donegan and Wagner model rests on two basic assumptions. The first assumption is that "primed", i.e. signalled, events are less effectively processed in short-term memory than unsignalled events. The von Restorff effect can be taken as empirical support for this assumption [van den Hout, Zijlstra and Merckelbach, 1988]. A second, more theoretical, assumption is that the magnitude of the UCR indexes the depth of processing of the UCS in short-term memory. The implication of these assumptions is that a CS-signalled UCS will be less effectively processed in short-term memory and, therefore, less successful in eliciting a UCR than an unsignalled UCS.

Using electric shock as the UCS and fear-relevant stimuli (e.g. slides of snakes, fearful or angry faces) or fear-irrelevant/neutral stimuli (e.g. slides of mushrooms or happy faces) as CSs, various studies have found that electrodermal responses, once conditioned, extinguish more slowly to fear-relevant than to fear-irrelevant/neutral CSs [see reviews by Öhman, 1986; Dimberg, 1986; McNally, 1987], thereby confirming a number of predictions that can be derived from Seligman's "preparedness" hypothesis [1971]. However, virtually no attention has been paid to the effect of the fear relevance of the CS on the development of the UCR during aversive conditioning. In what seems to be the only study with data bearing on this topic, Orr and Lanzetta [1980] reported a decrease in electrodermal UCRs for subjects who were shown a slide of a fearful face as the CS and an increase for subjects shown an happy face CS. One explanation for Orr and Lanzetta's finding might be that fear
relevance is associated with an increased degree of UCR diminution. More specifically, following Donegan and Wagnerś model [1987], one would expect an evolutionary "belongingness" between a CS and an aversive UCS to result in the CS being a better predictor of the UCS, which, in turn, would result in less effective UCS processing and greater UCR diminution. Similarly, one would expect a CS that is incompatible with an aversive UCS (e.g. a happy face) to be associated with less UCR diminution. Assuming that such a CS is a bad predictor of aversive UCSs, CS-UCS pairings should result in a high level of UCS processing and, consequently, in a reduced UCR diminution.

The present study was carried out in order to explore the relationship between fear relevance and UCR diminution. Drawing on Donegan and Wagnerś model, the hypothesis tested was that fear-relevant CSs will induce more UCR diminution and recovery than fear-irrelevant CSs. Using a simple conditioning procedure, the electrodermal UCR diminution in subjects given a fear-relevant CS was compared to the UCR diminution in subjects given a fear-irrelevant CS.

Methods

Subjects
The subjects were 48 students (22 males and 26 females), all of whom received some small financial compensation for their participation in the experiment. Their mean age was 21.1 years (range: 18 – 33 years).

Apparatus and Stimulus Materials
Skin conductance level (SCL) and skin conductance response (SCR) were picked up using two Beckman Ag-AgCl electrodes (8 mm diameter) attached to the medial phalanges of the second and third fingers of the subjectś right hand and connected to a Beckman Skin Conductance Coupler (type 9844). SCL and SCR recordings were based on the constant voltage (.5 V) method. The coupler allowed for a maximum sensitivity of 0.05 micromho.

Respiration was recorded using a Beckman Respiration Belt, fastened around the subjectś chest. The respiration belt was connected to a Beckman Pressure/Pulse/Voltage Coupler (type 9884). SCR and respiration were monitored on a Beckman R711 polygraph.

CSs were slides of angry and happy faces, taken from Ekman and Friesen [1975]. A Kodak Carousel was used for presentation of the slides, which were projected onto a white screen. The size of the projected image was approximately 75 × 1.10 cm, and it appeared 2 m in front of the subject.

A capacitor was used for administration of the shock UCSs. The shocks were delivered through two electrodes attached to the first finger of the subjectś left hand. The shock intensity was set at 7 mA (dc).

Slide presentation, shock administration, and intertrial intervals were controlled by a PDP Minc-11 microcomputer.

Design
A 2 × 2 between-subject design was used, with type of CS (angry face CS vs. happy CS) as the first between-subject factor and conditioning (paired vs. unpaired CS-
UCS presentations) as the second between-subject factor. Thus, four groups were studied, each of which consisted of 12 subjects. In group 1, an angry face CS was paired with shock, whereas in group 2, a happy face CS was paired with shock. Groups 3 (angry face) and 4 (happy face) served as control groups in which the CS and shocks were explicitly unpaired. Truly random control groups were not used, as it has been shown that explicitly unpaired CS-UCS presentations provide an appropriate control procedure for simple conditioning [Furedy and Schiffman, 1971].

Procedure
Each subject was seated in a comfortable chair placed in a dimly lit, sound-attenuated chamber. Recording apparatus and the Kodak Carousel were located in an adjacent room. Slides were projected through a hole in the wall. After the subject had filled in the fear questionnaire [FQ; Marks and Mathews, 1979], electrodermal recording sites were cleaned with distilled water and the electrodes and respiration belt were attached. The experiment was described to the subject as a study of physiological reactions to different sensory stimuli. No information about the contingency between CS and UCS was given. Next, the subject received a series of shocks of increasing intensity until the 7 mA level was reached. He or she was then asked to indicate on a 14 cm visual analog scale, with 0 indicating "not painful at all" and 14 indicating "extremely painful", how painful he or she thought the 7 mA shock was.

A single cue conditioning procedure was then carried out with each subject seeing only one CS slide. The subject was first given 4 CS-only (habituation) trials. An acquisition phase followed in which groups 1 and 2 received 8 CS-UCS pairings. Shock UCSs were delivered exactly at CS offset. For groups 3 and 4, CS and UCS were presented unpaired. That is, one stimulus was presented at the beginning of the intertrial interval and the other stimulus was presented at the midpoint of this interval. A recovery phase consisting of 4 UCS-only presentations followed. Finally, 6 extinction (CS-only) trials were given.

CSs had a duration of 5 sec and shocks had a duration of 0.5 sec. Intertrial intervals varied from 20 to 40 sec and had a mean of 30 sec. In order to control for irrelevant aspects of the CSs, different subjects within the same group saw different CSs.

Response Definition and Analysis
SCLs were measured on four occasions: before habituation, between habituation and acquisition, between recovery and extinction, and at the end of the extinction phase. SCRs were defined as the maximal deflections occurring 1 – 5 sec after CS or UCS onset. SCL and SCR were measured in micromho and square-root transformed.

Respiration was used as control variable. Following the criteria of Stern, Ray, and Davis [1980], trials with respiratory irregularities were excluded from statistical analyses. Such irregularities occurred on less than 2 % of the trials. SCR values for these trials were estimated on the basis of the SCRs on adjacent trials. As UCR diminution and recovery are generally seen as phenomena associated with classical
conditioning, it is obligatory to ascertain that conditioning actually occurred in
groups receiving paired CS-UCS presentations. Consequently, not only UCRs, but
also CRs were examined in the present study.

Not only were absolute UCR levels taken into account, but also, and most impor-
tantly, the size of UCR decrement and recovery. Thus, for each subject, a UCR
diminution score and a UCR recovery score were calculated [Kimmel and Penny-
packer, 1962]. The former score consisted of the average SCR to the first two
shocks during acquisition minus the average SCR to the last two shocks acqui-
sition. The latter score consisted of the mean SCR on the recovery trials minus the
mean SCR to the last two shocks during acquisition. Greater diminution values re-
fect a larger UCR decrement, whereas positive recovery values indicate that the
mean UCR on recovery trials is greater than that on the final acquisition trials.

FQ scores, subjective evaluation of the shock, SCLs, SCR to CS and UCS, and
UCR diminution and recovery scores were subjected to 2 (fear relevance: angry
face CS vs. happy face CS) × 2 (conditioning: paired CS–UCS vs. unpaired
CS – UCS presentation) analyses of variance (ANOVARs).

For ANOVARs involving a trial factor as the repeated measure, Greenhouse-Geisser
corrections were used. The trial factor consisted of blocks of two trials.

Results

FQ, Subjective Evaluation of the UCS, and SCLs.

Table 1 shows the mean FQ scores as well as the mean subjective evaluations of
the 7 mA shock UCS of the four groups. The 2 (fear relevance) × 2 (conditioning)
ANOVARs revealed no significant group differences for either FQ scores or evalua-
tion of the UCS.

<table>
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<td>22.5</td>
<td>20.8</td>
<td>22.8</td>
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<td></td>
<td>(11.8)</td>
<td>(14.5)</td>
<td>(9.5)</td>
<td>(14.1)</td>
</tr>
<tr>
<td>UCS evaluation</td>
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<td>4.8</td>
<td>4.6</td>
<td>5.5</td>
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<tr>
<td></td>
<td>(1.9)</td>
<td>(1.6)</td>
<td>(1.6)</td>
<td>(1.2)</td>
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</table>

*1; the angry face CS-paired group, 2; the happy face CS-paired group, 3; the angry face CS-unpaired
group, 4; the happy face CS-unpaired group.

SCL data were subjected to a 2 (fear relevance) × 2 (conditioning) × 4 (occasions)
ANOVA, with the last factor having repeated measures. Again, no significant
group differences emerged. The main effect of occasions was the only source re-
aching significance [F (3,132) = 14.1, p < 0.05], due to a systematic SCL increase
during the experiment in all groups.
**SCRs to CSs**

SCRs during habituation trials (left panel, Figure 1) were evaluated with a 2 (fear relevance) × 2 (conditioning) × trials (blocks of two trials) ANOVA, with the last factor having repeated measures. Except for a significant main effect of trials [F(1,44) = 17.3, p < 0.05], which was caused by a decrease in SCRs over trials, no further significant main or interaction effects were found.

![Graph showing SCR response over trials](image)

**Fig. 1.** Mean SCRs (micromho) to CSs during habituation (H), acquisition (A), and extinction (E) of the four groups

Analysis of the acquisition data (middle panel, Figure 1) revealed a main effect of conditioning [F(1,44) = 4.3, p < 0.05], caused by the overall higher level of responding to the CS in groups with paired CS-UCS presentations than in groups with unpaired presentations. Furthermore, a significant main effect of trials (blocks of two trials) emerged [F(3,132) = 14.6, p < 0.05]. This effect was due to a general decline in responding over acquisition trials. Conditioning effects in the angry face CS-paired group were not stronger than those in the happy face CS-paired group; both the fear relevance × conditioning interaction [F(1,44) < 1.0] and the fear relevance × conditioning × trials interaction [F(3,132) = 1.2, p = 0.31] remained non-significant.

As regards the extinction data (right panel, Figure 1), the overall decrease in responding resulted in a main effect of trials (blocks of two trials) [F(2,88) = 25.4, p < 0.05]. The main effect of conditioning remained non-significant [F(1,44) < 1.0]. This can be attributed to the fact that responding in the happy face CS-paired group did not differ from responding in the unpaired groups. Though not significant, the fear relevance × conditioning × trials interaction [F(2,88) = 1.7, p = 0.20] suggested a resistance to extinction in the angry face CS-paired group. To further
examine this effect, separate post hoc t-tests were carried out for each extinction trial block. Only for the second extinction block, the difference in CRs between the angry face CS-paired group and all other groups approached significance \[ t(44) = 1.6, p = 0.06, \text{one-tailed} \].

**SCRs to UCSs**

A 2 (fear relevance) × 2 (conditionings) × trials (blocks of two trials) ANOVA, performed on the SCRs to shocks during acquisition (Figure 2), revealed a significant main effect of conditioning \[ F(1,44) = 5.3, p < 0.05 \]: overall, UCRs in the paired groups were smaller than those in the unpaired groups. In addition, a borderline significant effect of fear relevance was found \[ F(1,44) = 3.6, p = 0.06 \], due to the larger UCRs in the angry face CS-unpaired and angry face CS-paired groups than in the happy face CS-unpaired and happy face CS-paired groups, respectively. The significant main effect of trials \[ F(3,132) = 44.1, p < 0.05 \] was caused by a general decrease in responding over trials. As a fear relevance × conditioning × trials interaction suggested, UCR diminution tended to be weaker in the angry face CS-unpaired group than in all other groups \[ F(3,132) = 1.9, p = 0.14 \].

![Diagram](image)

**Fig. 2.** Mean SCRs (micromho) to UCRs during acquisition (A) and recovery (R) of the four groups.

Examination of UCRs on the first acquisition trial revealed a main effect of fear relevance \[ F(1,44) = 4.2, p < 0.05 \]: angry face CS groups had significantly larger initial UCRs than the happy face CS groups, the means (sqrt-micromho) being 1.46 (s. d. = 0.50) and 1.18 (s. d. = 0.44), respectively.
An ANOVA of the recovery UCRs (Fig. 2) yielded no significant main or interaction effects. A closer inspection of Figure 2 suggests that apart from group differences in initial UCRs, the slope of the UCR decrement curve in the angry face CS-paired group is steeper than that of the happy face CS-paired group. A 2 (fear relevance) × 2 (conditioning) ANOVA of the diminution scores (mean UCRs on the first two acquisition trials minus mean UCRs on the last two acquisition trials), shown in Table 2, confirms this suggestion. The only effect reaching significance was the interaction of fear relevance with conditioning [F(1, 44) = 4.0, p = 0.05], caused by a stronger UCR decrement in the angry face CS-paired group than in all other groups. To control for initial differences in UCR level, diminution scores were again subjected to a 2 × 2 ANOVA but this time with UCRs on the first acquisition trials as covariate. However, the significant interaction of fear relevance with conditioning did not disappear [F(1, 43) = 4.3, p < 0.05]. Post-hoc t-tests indicated that while the angry face CS-paired group had a significantly greater diminution score than the angry face CS-unpaired group [t(44) = 1.8, p < 0.05, one-tailed], the happy face CS groups did not differ in this respect [t(44) < 1.0].

### Tab. II  Mean diminution and recovery scores (micromho) of the four groups.  (Standard deviations are given in parentheses).

<table>
<thead>
<tr>
<th>Groups*</th>
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<th>2</th>
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<th>4</th>
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<tbody>
<tr>
<td>Diminution</td>
<td>0.51</td>
<td>0.32</td>
<td>0.28</td>
<td>0.44</td>
</tr>
<tr>
<td></td>
<td>(0.37)</td>
<td>(0.27)</td>
<td>(0.24)</td>
<td>(0.30)</td>
</tr>
<tr>
<td>Recovery</td>
<td>+0.22</td>
<td>+0.13</td>
<td>-0.05</td>
<td>+0.09</td>
</tr>
<tr>
<td></td>
<td>(0.32)</td>
<td>(0.26)</td>
<td>(0.20)</td>
<td>(0.29)</td>
</tr>
</tbody>
</table>

* See Table I for list.

A 2 (fear relevance) × 2 (conditioning) ANOVA performed on the recovery scores (mean UCRs on the first two recovery trials minus mean UCR on the last two acquisition trials), shown in Table 2, yielded a significant effect of conditioning [F(1, 44) = 3.9, p < 0.05]; UCS-only trials elicited a stronger UCR increase in paired groups than in unpaired groups. As a marginally significant interaction of fear relevance with conditioning [F(1, 44) = 2.4, p = 0.13] suggested, the UCR increase tended to be stronger in the angry face CS-paired group. Post-hoc t-tests showed, indeed, that the difference in UCR recovery between the angry face CS-paired group and the unpaired groups [t(44) = 2.1, p < 0.05, one-tailed] was greater than that between the happy face CS-paired group and the unpaired groups [t(44) = 1.2, p = 0.14, one-tailed]. Furthermore, whereas the happy face CS groups had comparable recovery scores [t(44) < 1.0], the angry face CS-paired group showed a stronger recovery than the angry face CS-unpaired group [t(44) = 2.5, p < 0.05, onetailed].
Discussion

Two important conclusions can be drawn from the data obtained in this study. First, the finding of lower UCR levels in paired groups than in unpaired groups confirms, of course, the findings of previous studies [e.g., Grings and Schell, 1971]. Recalling that UCS intensities were constant across subjects and across trials, that subjective evaluation of the UCS did not differ among groups, and that for the paired groups reliable conditioning effects (i.e., reliable CRs) were found, it seems plausible to assume that differences in UCR levels have an associative basis, i.e., are the result of a conditioned inhibition operating in the paired groups.

Second, whereas the happy face CS-paired and the happy face CS-unpaired groups did not differ with regard to UCR diminution and recovery scores, these indices were larger in the angry face CS-paired group than in the angry face CS-unpaired group. This finding confirms the predictions that flow from the priming model proposed by Donegan and Wagner [1987]. One has to admit, however, that the present study fails to provide insight into the critical mechanism underlying this finding. That is, it remains unclear whether the results have to be attributed to increased UCR diminution and recovery in the angry face CS-paired group, to reduced UCR diminution and recovery in the happy face CS-paired group, or to both processes. Obviously, to settle this issue, future studies regarding fear relevance and UCRs should employ not only fear-relevant and fear-irrelevant CSs (i.e., CSs which are incompatible with the UCS) but in addition neutral CSs (e.g., slides of flowers).

Interpretation of the UCR diminution and recovery data is also complicated by differences in initial UCRs: Regardless of whether or not the CS and UCS were paired, groups with an angry face CS had higher initial UCRs than groups with a happy face CS. On the one hand, the facts that UCS intensities were kept constant across groups and that subjective estimates of the UCS did not differ among groups seem, at first, to suggest that initial UCR differences were due to chance. On the other hand, it may well be that confrontation with a fear-relevant CS potentiated responding to the UCS. Öhman, Eriksson, Fredrikson, Hugdahl, and Olofsson [1974; exp. 4] reported that the administration of shocks prior to habituation increases differential responding to fear-relevant and neutral CSs during habituation. Yet, there is no a priori reason to exclude the possibility that such a process might also operate the other way around.

Thus far, psychophysiological research “preparedness” has dealt almost exclusively with extinction rates of responses conditioned to either fear-relevant CSs or neutral CSs [see reviews by McNally, 1987; Merckelbach, van den Hout and van der Molen, 1988]. The current results can be taken as an extension of this research in that they emphasize the effect of fear relevance on UCR diminution. Further research along this line might shed light on the numerous failures to replicate the slower extinction of CRs to fear-relevant CSs than that of CRs to neutral CSs found by Öhman and colleagues [e.g., McNally and Foa, 1986; Merckelbach, van der Molen and van den Hout, 1987; Merckelbach and van den Hout, 1988].

Kimmel and Pappaceller [1962] suggested that the function of UCR diminution is to avoid “unnecessary emotional overresponding” (p. 23) to the UCS. Similarly, Lykken [1966] argued that UCR diminution results from “a kind of anticipatory afferent tuning” (p. 451), i.e., from a sensory inhibition of the UCS. There is,
indeed, evidence that changes in the subjective perception of the UCS intensity mirror electrodermal UCR diminution during conditioning [Schell and Grings, 1971]. In this context, a study by Dawson, Schell and Tweddle Banis [1986] is also of relevance. These authors demonstrated that extinction of CRs to fear-relevant CSs parallels subjects' expectations of shock UCS. Taken together, the aforementioned studies might imply that a relatively more efficient UCR diminution in groups with fear-relevant CSs than in groups with neutral or fear-irrelevant CSs results in the former groups attributing less significance to the UCS. In the long run, this would offset any initial differences in CRs and UCRs between fear-relevant CS and fear-irrelevant or neutral CS groups. The net effect of this hypothesized process would be equal CR extinction rates in fear-relevant and fear-irrelevant CS groups. This might especially be true for studies in which high intensity UCSs are employed, since there is reason to assume that high intensity UCSs promote a more efficient UCR diminution [Donegan and Wagner, 1987].

As regards the CRs found in the present study, the absence of a facilitating effect of fear relevance on CR development during acquisition is in line with the earlier research of Dimberg [1986; 1987]. This author concluded that the critical effect of fear relevance on CRs manifests itself during extinction. Although the present study found some evidence for a resistance to extinction of SCR conditioned to angry faces, this effect was not as strong as that reported by Dimberg. Yet, it should be noted that UCS-only (i.e. recovery trials) preceded the extinction phase. It is a well-established fact that such UCS-only trials elicit post-conditioning reevaluation of the UCS and, consequently, undermine the occurrence of CRs during subsequent extinction [Davey, 1987].

References


