CUED UCS REHEARSAL AND THE IMPACT OF PAINFUL CONDITIONED STIMULI: UCS REHEARSAL INCREASES SCRS BUT REDUCES EXPERIENCED PAIN

ARNOUDE ARNTZ,1* SANNE SPIT1 and HARALD MERCKELBACH2

1Department of Medical Psychology, Maastricht University, P.O. Box 616, NL-6200 MD Maastricht, The Netherlands and 2Department of Psychology, Maastricht University, P.O. Box 616, NL-6200 MD Maastricht, The Netherlands

(Received 20 December 1996)

Summary—The effects of cued UCS rehearsal on responses to a mildly painful CS previously paired with a highly painful UCS were investigated. Following CS pretest and CS-UCS pairings, subjects either mentally rehearsed the UCS (condition 1), received the real UCS (condition 2), mentally rehearsed an unrelated painful experience (condition 3), or waited (condition 4). In a fifth condition, subjects received CS and UCS unpaired before engaging in UCS rehearsal. During a posttest, subjects received CS-alone presentations and rated experienced pain and anxiety, while electrodermal responses were assessed. These responses were compared to pretest and acquisition responses. UCS rehearsal led to pain reduction of the CS comparable to the habituation effects of real UCS confrontation. In line with an associative basis for this effect, UCS rehearsal did not influence the pain experience of an unpaired CS. Yet, rehearsal of a memory of an unrelated painful experience also reduced the pain experience of the CS. Electrodermal responses showed delayed extinction and incubation after UCS rehearsal, but there were no significant effects on subjective anxiety. Incubation of electrodermal responses was related to low self-consciousness and the combination of low self-consciousness and high trait anxiety. Trait anxiety and worry proneness per se did not relate to incubation. The findings suggest that worry-like processes can have functional values like reducing pain impact, and cast doubt upon the contention that UCS rehearsal leads to an overall incubation of fear. © 1997 Elsevier Science Ltd

INTRODUCTION

In an attempt to explain the paradoxical increase of fear responses in the absence of an identifiable UCS, a phenomenon sometimes observed in clinical cases and termed incubation (Eysenck, 1979), Jones and Davey (1990) have proposed that rehearsal of UCS memories may account for this phenomenon. Indeed, three experiments have demonstrated that cued UCS rehearsal after CS-UCS pairings, leads to temporarily increased autonomic responses to subsequent CS-alone presentations (Jones & Davey, 1990; Davey & Matchett, 1994). On the basis of these findings, Davey and co-workers have argued that UCS rehearsal might be an experimental analogue of the worry or rumination processes frequently observed in anxiety disorders. They argue that UCS rehearsal may play an important role in the maintenance or exacerbation of pathological anxiety.

Davey and co-workers have proposed that the post-UCS rehearsal effects are restricted to stimuli that have been associated with the UCS. Several explanations for the effects of cued UCS rehearsal have been put forward (Jones & Davey, 1990; Davey & Matchett, 1994). For example, UCS rehearsal might strengthen the UCS representation, and consequently the CS would elicit a stronger UCS representation which, in its turn, would produce increased CRs (Davey, 1989). Alternatively, UCS rehearsal might inflate the aversive evaluation of the UCS.

The purpose of the present study was twofold. First, it aimed at replicating the findings by Davey and co-workers on the role of UCS rehearsal in the incubation of fear responses. Second, it investigated the influence of UCS rehearsal on pain reactivity, in an attempt to explore possible mechanisms that may play a role in chronic pain problems. As to the first objective, there are several reasons for a replication and extension of the studies by Davey and co-workers. In

*Author for correspondence.
the Jones and Davey (1990) study, for instance, one of the control conditions intended to control for the effects of rehearsing an aversive experience per se. Subjects in this condition were instructed to think of someone trying to stick a pin in their eye and to imagine their reactions to this as vividly as possible. Though this is obviously a very aversive thought, it is conceivable that none of the Ss had ever experienced this, in contrast to the Ss in the experimental condition who all had experienced the aversive UCS (a loud noise) during acquisition. Thus, it is unclear whether effects of rehearsal of aversive scenes are indeed restricted to associated stimuli, or that the aversive stimulus should have been personally experienced. Moreover, though Jones and Davey found that cued UCS rehearsal affected the CR in the post-UCS rehearsal stage, compared to responses to a CS−, the increase of the CR from acquisition to post-test failed to reach significance, so that incubation was not demonstrated. In a later experiment Davey and Matchett (1994) demonstrated that high trait-anxious Ss exhibited incubation of electrodermal responding to a CS+ on the first trial of the post-UCS rehearsal phase, in contrast to those low in trait anxiety, but in this experiment an aversive rehearsal control group was lacking. Davey and Matchett (1994) also reported evidence that incubation was related to higher aversiveness ratings of the UCS rehearsal task, suggesting that the experienced aversiveness of UCS rehearsal might mediate its effects. An important feature of the studies by Davey and co-workers is that only electrodermal responses were investigated. The researchers suggested that findings obtained with this response system could be generalized to all aspects of anxiety. Needless to say, the electrodermal response is only one of the possible indices of fear, and it can also be evoked by other processes than conditioned fear (e.g., orienting, non-aversive arousal; Lang, Bradley & Cuthbert, 1990; Sokolov, 1963). Thus, it would be interesting to examine the effects of cued UCS rehearsal on other fear responses, notably the subjectively experienced level of anxiety.

The second objective of the present study was to test whether cued UCS rehearsal would influence the evaluation of and physiological responses to a slightly painful stimulus that has been paired with a strongly painful stimulus. In this way, an attempt was made to mimic a possible natural process occurring in pain patients, in which slightly painful stimuli (CS) are paired with very strong painful experiences (UCS) during the acute phase of the pain problem. As an example, slight muscle contractions in the back might precede strong and very painful spasms, and might therefore become signals of an intensely aversive UCS. If the patient engages in ruminations about the painful spasms of the acute phase, it is conceivable that responding to slight muscle contractions evokes stronger emotional reactions, and perhaps inflates pain experiences (Arntz, 1991). By using a slightly painful CS and a very strong pain stimulus as UCS in the cued UCS rehearsal paradigm, this hypothesis was put to the test.

It has also been suggested that phenomena like UCS rehearsal and worry might have functional values (Borkovec & Hu, 1990). One possible functional aspect of worry, which at least anxiety patients seem to believe, might be that it prepares the S for the impact of the aversive event (Wells, 1995). Indeed, several studies have demonstrated that correctly or overpredicted painful experiences evoke less emotional, autonomic, and sometimes experienced pain responses than underestimated experiences (Arntz, van den Hout, van den Berg & Meijboom, 1991; Crombez, Baeyens & Eelen, 1994). Thus, one could make an argument for UCS rehearsal leading to reduced pain responses to the CS, a prediction opposite to the ideas described above.

Taken together, the present study investigated the effects of cued UCS rehearsal on a painful CS. In this way, not only conditioned responses to the CS, but also responses evoked by the CS itself (pain responses) could be investigated. Furthermore, the present study assessed subjective fear evoked by the CS, to find out whether these ratings would follow the same pattern as electrodermal responses. Lastly, the study investigated whether worry proneness, trait anxiety, and state anxiety (as suggested by Davey and co-workers), or self-consciousness would relate to possible incubation effects. Self-consciousness might be of interest because it measures people’s dispositional tendency to engage in self-attention, i.e. to attend to one’s inner feelings and thoughts (Fenigstein, Scheier & Buss, 1975; Vleeming & Engelse, 1981), activities that are obviously engaged in during UCS rehearsal. Thus, it might be that UCS rehearsal has differential effects in those that have a dispositional tendency to engage in processes needed for UCS rehearsal compared to those who do not possess this tendency.
METHOD

Subjects

Seventy-two female students volunteered to participate in the experiment. Only female students were selected to reduce within condition variance due to sex-related differences in pain and anxiety reactivity. Mean age was 21.2 yr (SD = 2.8). Subjects received a small remuneration for participating.

Materials

Visual analogue scales (VASs) of 100 mm were used for measurement of experienced pain (anchors: no pain at all and the worst pain I can imagine) and anxiety (anchors: not anxious at all and very anxious). The two VASs were printed on one page with the instruction to turn the page after ratings were made printed underneath. The pages were collected in a ring binder. Ratings were measured in millimetres from the left anchor. Personality factors were assessed by means of the Dutch versions of the Spielberger State-Trait Anxiety Inventory (STAI: van der Ploeg, Defares & Spielberger, 1980), with Cronbach α > 0.90 for both trait anxiety and state anxiety; the Penn State Worry Questionnaire (PSWQ: Meyer, Miller, Metzger & Borkovec, 1990), Cronbach α = 0.94 (Davey, 1993); and the Private Self-Consciousness Scale (PSCS: Fenigstein et al., 1975; Vleeming & Engelse, 1981), with good internal consistency (Cronbach α = 0.83 in a separate sample of 195 students of Limburg University). Six VASs were used for post-experimental questions:

1. experienced aversiveness of rehearsing the painful stimulus;
2. experienced vividness of the imagined UCS during rehearsal;
3. experienced success of rehearsing the UCS (i.e. not disengaging from the UCS rehearsal);
4. experienced difficulty of imagining the UCS;
5. percentage of time actually rehearsing the UCS during the cue;
6. frequency of worries during the experiment.

Apparatus

Two types of painful stimulation were applied to the paraspinal muscles of the Ss. As CS a stimulation (train of rectangular pulses of 25 Hz) of 2 mA (just above pain-threshold level for most Ss as was determined in pilot studies) was delivered by a Siemens Neuroton 627 via two Beckman Ag-AgCl electrodes (8 mm dia., distance 2.5 cm), filled with HP Redux Creme on the left low back region. Duration of the CS was 4 sec. As UCS a 1 sec painful contraction of the right paraspinal muscles (mid-region) was electrically produced via two synthetic electrodes (10 cm dia.) by an Electron D Enraf Nonius physiotherapy apparatus (train of 8.5 mA rectangular pulses of 50 Hz). This stimulation had proven to be very painful, but still tolerable for Ss in a pilot study. The UCS was chosen because of its high validity with respect to clinical pain (painful contraction of back muscles). CS and UCS were both applied to the back muscles to ensure a high level of belongingness between the two.

Skin conductance (SC) was measured via two Beckman Ag-AgCl electrodes (8 mm dia.), placed on the medial phalanges of the second and the third finger of the non-dominant hand. The electrodes were filled with an isotonic paste and were connected with a Beckman Skin Conductance Coupler (type 9844), using the method of constant voltage (0.5 V). The skin was cleansed with distilled water.

Written instructions and the cue indicating that the S should engage in UCS rehearsal (a large exclamation mark) were projected on a screen approximately 3 m before the S by means of a Kodak slide projector.

Design

Table I summarizes the design. There were five conditions. The first condition was the experimental condition, the other four were control conditions. There were four phases in each condition. In phase I, the pretest, four presentations of the CS were given. In phase II, Ss received
Table I. Overview of the design

<table>
<thead>
<tr>
<th>Condition</th>
<th>Phase I Present</th>
<th>Phase II Acquisition</th>
<th>Phase III Rehearsal</th>
<th>Phase IV Extinction (posttest)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Experimental</td>
<td>CS 4x</td>
<td>CS-UCS 6x paired</td>
<td>UCS rehearsal 6x</td>
<td>CS 6x</td>
</tr>
<tr>
<td>2. Reality control</td>
<td>CS 4x</td>
<td>CS-UCS 6x paired</td>
<td>UCS 6x</td>
<td>CS 6x</td>
</tr>
<tr>
<td>3. Pain rehearsal control</td>
<td>CS 4x</td>
<td>CS-UCS 6x paired</td>
<td>unrelated pain rehearsal 6x</td>
<td>CS 6x</td>
</tr>
<tr>
<td>4. Extinction control</td>
<td>CS 4x</td>
<td>CS-UCS 6x paired</td>
<td>wait</td>
<td>CS 6x</td>
</tr>
<tr>
<td>5. Random control</td>
<td>CS 4x</td>
<td>CS 6x UCS 6x unpaired</td>
<td>UCS rehearsal 6x</td>
<td>CS 6x</td>
</tr>
</tbody>
</table>

6 CS and 6 UCS presentations, paired in conditions 1–4, unpaired in condition 5. Phase III was the rehearsal phase, during which Ss of conditions 1, 3 and 5 had to engage in six cued rehearsals, whereas Ss in condition 2 received six real UCSs and Ss in condition 4 had to wait. In phase IV, six CS-only presentations were given (extinction, posttest). In the experimental condition, Ss had to rehearse the UCS during the presentation of a cue. In the second condition ('reality control'), the real UCS was presented after the cue. In condition 3 ('aversive rehearsal control'), Ss had to rehearse the (physically) most painful experience ever experienced. In condition 4, Ss had to just wait during this period. This condition controlled for the effects of time and extinction ('extinction control'). Whereas conditions 1–4 received paired CS-UCS presentations during the second ('acquisition') phase, in condition 5 unpaired CS-UCS presentations were given ('random control') and because Ss engaged in UCS rehearsal during phase III, this condition was used to test for the associative basis of possible UCS rehearsal effects.

Procedure

The Ss were seated at a table 3 m before a screen in a lab room. Subjects were given limited information, including that more information about the hypotheses would be given after the experiment. After giving informed consent, Ss got the following written instructions.

In the experiment, activity of sweat glands will be measured. You will receive a number of electrical stimulations. Each time after each stimulation you have to rate the amount of pain and anxiety you experienced during the stimulation. You have 20 seconds for this. Therefore, please read the list with questions before the experiment starts, so that you can make your ratings quickly after each stimulation. During the experiment, you will see instructions projected on the screen. So watch the screen during the experiment. After the experiment, you will be asked to fill out three questionnaires. Following this, you will get your remuneration. Try to relax now, so that the experiment can start.

The S first filled out the PSWQ and the STAI. Then electrodes were attached. Subjects were told that the electrodes on the back would produce stimulations differing in intensity and quality. Subjects were reassured that the stimulations were safe, and that the S had the right to stop the experiment at any time. The S was subsequently asked whether she had ever experienced a very intense physical pain which she could remember and imagine vividly. It was explained that there was a possibility that instructions on the slide would return to this issue. After this, the VAS's ratings were explained and the experiment proper started.

Pretest. This phase was identical for all Ss. It started with the following instructions, projected on the screen for 20 sec.

In a few moments you will receive several mild stimulations on your back. Fill out the questions after each stimulation.

Following this, four CSs were given (2 mA 4 sec stimulations; intertrial interval 20 sec).

Acquisition. During 20 sec the following instructions were projected:

You will receive several mild stimulations on your back, every time followed by a strong stimulation. Please fill out the questions each time after these two stimulations (conditions 1–4).

You will get now in an arbitrary order mild and strong stimulations on your back. Please fill out the questions after each stimulation (condition 5).

After disappearance of the slide, Ss received the stimulations. In conditions 1–4, Ss got six paired CS-UCS presentations (the CS was immediately followed by the UCS) with an intertrial interval of 20 sec. In condition 5, Ss got six CS and six UCS presentations with an intertrial interval of 10 sec (order: CS-CS-UCS-CS-UCS-UCS-CS-CS-CS-UCS-UCS).

Rehearsal. This phase began with an instruction projected for 45 sec on the screen. Condition 1 had the following instruction:
Next you will see a number of times a large exclamation mark projected on the screen. Every time when this mark is on the screen, you have to think of the stimulations you have just experienced and of how painful they were. Try to imagine these stimulations, the pain, and your reactions to these stimulations as accurately and vividly as possible. When the mark disappears, you may forget the image and think about something else. But every time the exclamation mark appears on the screen, you should think of the stimulations, the pain and your reactions to them, and imagine them as accurately and vividly as possible. In a moment the exclamation marks will follow a number of times.

Condition 2 had the following instruction:

Next you will see a number of times a large exclamation mark on the screen. Every time when this mark is on the screen, you will receive the strong stimulation. Fill out the questions after each stimulation. In a moment the exclamation marks will follow a number of times.

Subjects of condition 3 were given the following instructions:

Before you have been asked about the most terrible pain you ever experienced that you can remember well...

(the instructions that followed were identical to those of conditions 1 and 5, with ‘this pain’ instead of ‘the stimulations’). After the instructions disappeared, the exclamation mark was presented 6 times for 6 sec with an interval of 10 sec.

Condition 4 had the following instructions:

Next you will see a number of times a large exclamation mark on the screen. These marks have no meaning. In a moment the exclamation marks will follow a number of times.

Condition 5 had the same instruction as condition 1. After the instructions disappeared, the exclamation mark was presented six times for 6 sec with an interval of 10 sec. In condition 2, the UCS stimulation was given for 1 sec at the third second of each cue.

Extinction. This phase was identical for all conditions. The following instructions were projected for 20 sec:

You will now receive a number of times a stimulation on your back. Fill out the questions after each stimulation.

After this, the CS (4 sec, 2 mA) was given six times with an intertrial interval of 20 sec.

Following the experiment proper, electrodes were removed and the Ss filled out the post-experimental VASs and the PSCS. Finally, Ss were debriefed, paid and thanked for participating.

Data definition, reduction and analysis

A skin conductance response (SCR) was considered to be an upward curve of the SC within 3 sec after stimulus onset. SCRs were measured as the distance between the trough and the apex of the curve in microSiemens. Non-negative changes were given zero value. SCLs for phases 1, 2 and 4 were derived by averaging the SCLs measured just before each pain stimulation.

To reduce error variance due to individual differences dependent variables were range corrected (Lykken, 1972). As recommended by Lykken (1972), SCRs were divided by the maximum SCR observed during the pretest and acquisition phase. The other variables (SCL, VAS pain and anxiety ratings) were divided by the difference between the maximum and minimum responses during pretest and acquisition. Because Lykken transformations can be invalid in between-S designs (because manipulations might affect the correction factors), it should be stressed that minimum and maximum responses were derived from the phases that were identical for the conditions: pretest and acquisition. There was one exception: in contrast to the other conditions, condition 5 (CS-UCS random control group) received unpaired CS and UCS trials during acquisition. However, there were no significant differences between this condition and the other four conditions (that received paired CS-UCS trials) in maximum responses during acquisition. As a further test, the correction factors were subjected to a MANOVA with the five conditions as between factor variables. Multivariate and univariate tests, as well as planned contrasts comparing the experimental condition with each of the 4 control conditions, were all non-significant. Inspection of the raw data and the range-corrected data showed that the between-condition patterns were identical, while within group-error variance was substantially reduced. It seems therefore justified to use the range-corrected data.
For the final analyses, range-corrected dependent variables were averaged in four blocks: pretest, acquisition, the first 3 trials of extinction, and the last 3 trials of extinction. The hypotheses under investigation were tested by ANOVAs with range-corrected pretest-extinction change scores as dependent variables and planned contrasts comparing the experimental condition with each of the other four conditions. Due to the exploratory character of the study, Bonferroni corrections were not employed.

**RESULTS**

**Pretest differences**

Differences between the conditions in pain and anxiety ratings, SCR, and SCL during pretest were examined with MANOVAs on the responses averaged over the four pretest trials, with planned contrasts comparing the experimental condition with each of the control conditions. No significant differences emerged \([F(4,67) < 1; Ps > 0.42; contrasts: Ps > 0.10]\). Neither did the five conditions differ significantly with respect to any of the questionnaires (PSWQ, STA1 and PSSC) or age \([F(4,67) < 1.49; Ps > 0.21]\).

**Manipulation check**

To check whether the UCS had indeed been more aversive than the CS, differences between mean responses to the UCS (in conditions 1–4, pain and anxiety ratings were made for the CS-UCS combination) and mean pretest responses to the CS were analyzed by means of an ANOVA with planned contrasts. Strong main effects indicated larger responses to the UCS than to the CS on all variables: experienced pain VAS [mean increase 62%, \(F(1,67) = 575.29, P < 0.001]\]; anxiety VAS [mean increase 40%, \(F(1,67) = 68.64, P < 0.001]\]; SCR [mean increase 9.6%, \(F(1,67) = 20.77, P < 0.001]\]; and SCL [mean increase 42%, \(F(1,67) = 45.52, P < 0.001]\]. There was only one significant between-condition effect \([F(4,67) = 6.56, P < 0.001]\): during acquisition mean SCR to the UCS appeared to be much higher in condition 5 (random CS-UCS) than in the other conditions. The effect of increased SC responding to unsigned UCSs is well known (Arntz et al., 1991; Baltissen & Boucsein, 1986). On all other dependent variables the five conditions showed comparable increases from pretest to acquisition phase. More specifically, the manipulation succeeded in inducing increased responses to the UCS, compared to the CS before conditioning.

**Experimental effect on pain ratings**

Mean range-corrected pain rating change scores from pretest to the two extinction blocks are depicted in Fig. 1. Inspection of the figure suggests larger reductions of pain from pretest to extinction in condition 1 than in conditions 4 and 5. Planned contrasts, summarized in Table 2.

![Fig. 1. Reduction of experienced pain of the CS in the 5 conditions during two 3-trial extinction blocks (posttest) compared to the pretest. Difference scores of range-corrected averaged pain ratings (expressed in %) are depicted. The experimental condition differed from the extinction and random control conditions, but not from the real UCS and unrelated pain rehearsal control conditions. (1 = condition 1 (experimental condition); 2 = condition 2 (reality control); 3 = condition 3 (pain rehearsal control); 4 = condition 4 (extinction control); 5 = condition 5 (random control); *P < 0.05 for contrast with condition 1).](image-url)
Table 2. Planned contrasts comparing the experimental condition with the control conditions: test statistics and significance levels.

<table>
<thead>
<tr>
<th>Contrast</th>
<th>Pretest-extinction</th>
<th>Pretest-extinction (other dependent variables partialed out)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Block 1</td>
<td>p</td>
</tr>
<tr>
<td>Jan ratings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>l vs 2</td>
<td>-0.59</td>
<td>0.55</td>
</tr>
<tr>
<td>l vs 3</td>
<td>-0.99</td>
<td>0.33</td>
</tr>
<tr>
<td>l vs 4</td>
<td>-2.31</td>
<td>0.004*</td>
</tr>
<tr>
<td>l vs 5</td>
<td>-2.10</td>
<td>0.039*</td>
</tr>
<tr>
<td>Sociability ratings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>l vs 2</td>
<td>1.89</td>
<td>0.06*</td>
</tr>
<tr>
<td>l vs 3</td>
<td>0.64</td>
<td>0.52</td>
</tr>
<tr>
<td>l vs 4</td>
<td>0.81</td>
<td>0.42</td>
</tr>
<tr>
<td>l vs 5</td>
<td>0.21</td>
<td>0.83</td>
</tr>
<tr>
<td>SCR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>l vs 2</td>
<td>3.05</td>
<td>0.003**</td>
</tr>
<tr>
<td>l vs 3</td>
<td>0.84</td>
<td>0.40</td>
</tr>
<tr>
<td>l vs 4</td>
<td>1.63</td>
<td>0.10*</td>
</tr>
<tr>
<td>l vs 5</td>
<td>-0.02</td>
<td>0.98</td>
</tr>
<tr>
<td>SCL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>l vs 2</td>
<td>2.35</td>
<td>0.021*</td>
</tr>
<tr>
<td>l vs 3</td>
<td>0.57</td>
<td>0.57</td>
</tr>
<tr>
<td>l vs 4</td>
<td>2.47</td>
<td>0.016*</td>
</tr>
<tr>
<td>l vs 5</td>
<td>1.86</td>
<td>0.07</td>
</tr>
</tbody>
</table>

* p < 0.10; ** p < 0.05; *** p < 0.01 (all tests are two-tailed).

For each dependent variable, the influence of the three other dependent variables was partialed out by means of ANCOVA. This means that, for example, influences of pretest-extinction changes in anxiety, SCR, and SCL on changes in pain ratings were covaried out before experimental effects on changes in pain ratings were examined.

Only averaged SCLs of the whole extinction phase are available.

confirmed this observation: decreases in pain ratings were non-significant between experimental condition and conditions 2 and 3, but differed significantly between experimental condition and conditions 4 and 5 in the first extinction block (Table 2). These effects appeared to be weaker in the second extinction block (Table 2).

The analyses were repeated with the three other dependent variables as covariates. This procedure intended to extract any influence of other responses on the pain ratings before analyzing the experimental effects, so that the influence of the experimental manipulation on the ‘true’ pain experience could be better estimated. Even clearer experimental effects were now found (Table 2), suggesting that effects of cued pain UCS rehearsal on pain ratings are not attributable to changes in other dependent variables.

To summarize, cued pain UCS rehearsal appeared to have a pain reducing effect on the CS, an effect comparable to the real experience of the UCS. There was mixed evidence for the hypothesized associative basis of this influence: a pain reducing effect of cued UCS rehearsal was not observed in the CS-UCS random control condition. But, unexpectedly, the experimental condition did not differ significantly from the unrelated painful experience rehearsal group (condition 3), which also showed some pain reducing effect of cued rehearsal.

Experimental effects on anxiety ratings

Mean range-corrected anxiety rating change scores from pretest to the two extinction blocks are depicted in Fig. 2. Inspection suggests increases in anxiety from pretest to the first extinction block in conditions 1 and 5, a reduction in anxiety experienced during the CS in condition 2, and no change in conditions 3 and 4. During the second block, anxiety in condition 1 seems to be reduced. Statistical tests of the planned contrasts did however not yield significant effects (Table 2). There was only one borderline significant effect: the contrast between the first (experimental) and the second (reality control) condition had a significance level of 0.062. Entering the other dependent variables as covariates resulted in even weaker experimental effects (Table 2). In sum, no robust evidence was found for the hypothesis that cued pain UCS rehearsal...
Experimental effects on SCR

Mean range-corrected SCR change scores from pretest to the two extinction blocks are depicted in Fig. 3. The figure shows that SCRs decreased less from pretest to both extinction blocks in conditions 1 and 5 than in the other conditions. Planned contrasts yielded a significant difference between the experimental and the reality control condition in the first extinction block. Trends towards significance were found between the experimental condition on the one hand, and the extinction control condition (condition 4) during the first block, and the reality control group (condition 2) during the second block (Table 2), on the other hand. Entering the other dependent variables as covariates resulted in stronger experimental effects for the first block, but not for the second block (Table 2).

To summarize, there was evidence for the hypothesis that cued pain UCS rehearsal causes temporarily high SCRs. However, contrary to the hypothesis, SCRs were not significantly higher in the experimental condition than in the unrelated pain rehearsal group (condition 3) and the random CS-UCS control group (condition 5). The slower reduction of SCRs in condition 5 is probably caused by the anxiety or arousal increasing effects of unpredictable UCSs that this condition received during the acquisition phase.

Fig. 3. Change in SCRs to the CS in the 5 conditions during two 3-trial extinction blocks (posttest) compared to the pretest. Difference scores of range-corrected averaged SCRs (expressed in %) are depicted. The experimental condition showed significantly less reduction in SCR than the real UCS and the extinction control conditions (1 = condition 1 (experimental condition); 2 = condition 2 (reality control); 3 = condition 3 (pain rehearsal control); 4 = condition 4 (extinction control); 5 = condition 5 (random control); **P < 0.01; +P < 0.10 for contrast with condition 1).
Experimental effects on SCL

Mean range-corrected SCL change scores from pretest to the extinction phase are depicted in Fig. 4. The figure shows that SCLs increased from pretest to extinction in conditions 1 and 3, decreased in conditions 2 and 4, and did not change substantially in condition 5. Planned contrasts yielded significant differences between the experimental condition and both the reality control and the extinction control conditions (conditions 2 and 4). Also, a trend towards significance between the experimental group and the random CS-UCS control condition (condition 5) was found (Table 2). Entering the other dependent variables as covariates did not substantially change these effects (Table 2), indicating that they were independent from changes in other experimental variables.

Further analyses showed that the experimental effects on SCL were not simple posteffects of differentially affected SCLs during the experimental manipulation. An ANOVA on range-corrected change (with respect to pretest) scores measured at the start of the extinction phase yielded non-significant differences between conditions (all planned contrasts is < 0.82; $p > 0.41$).

To summarize, there was evidence for the hypothesis that cued pain UCS rehearsal causes heightened SCL. However, contrary to the hypothesis, SCLs were not significantly higher in the experimental condition than in the unrelated pain rehearsal control group (condition 3). The lack of SCL reduction in condition 5 is probably related to the anxiety increasing effects of unpredictable UCSs.

Post-experimental questions

Following the experiment, the three conditions that engaged in UCS rehearsal (conditions 1, 3 and 5) completed six VASs. There was a significant effect of condition on the first VAS (experienced aversiveness of rehearsing the painful UCS), $F(2,41) = 4.47$, $p = 0.018$. Means of the three conditions were 32.7 (condition 1), 53.9 (condition 3), and 33.6 (condition 5). The experimental condition rated rehearsal of the laboratory pain UCS as significantly less aversive than control condition 3, which rehearsed unrelated pain ($r = -2.65$, $p = 0.011$). There was no difference between the aversiveness ratings of conditions 1 and 5 ($p = 0.92$). Thus, unrelated pain rehearsal appeared to be experienced as more aversive than rehearsal of the experimental pain UCS. The aversiveness ratings suggest that effects of the experimental condition cannot be attributed to weaker aversiveness of UCS rehearsal in control conditions 3 and 5. With respect to the other post-experimental VASs, no significant differences between conditions were found, indicating that UCS rehearsal processes were comparable between the conditions that underwent this procedure.
Test of the incubation hypothesis

According to Davey and Matchett (1994), UCS rehearsal causes incubation of CRs, especially in vulnerable people, like those with a high level of trait anxiety. To test this hypothesis, differences between the mean SCRs of the first and the second block of the extinction phase on the one hand, and the mean SCR of the acquisition phase on the other hand, were subjected to a MANOVA. This revealed a significant multivariate effect of condition \( F(8, 130) = 2.61, P = 0.01 \) and significant univariate effects of condition [first block: \( F(4, 67) = 4.30, P < 0.01 \); second block: \( F(4, 67) = 3.15, P = 0.02 \)]. Changes in mean SCRs from acquisition to extinction are depicted in Fig. 5. As is shown in Fig. 5, SCRs increased during the first extinction block in conditions 1 and 3 (both pain rehearsal conditions), decreased in conditions 2 and 4, and did not substantially change in condition 5. Preplanned contrasts revealed significant differences between the experimental condition and condition 2 (reality control: \( t = 3.55, P < 0.001 \)) and condition 4 (extinction control: \( t = 2.07, P = 0.04 \)), but no significant differences between the experimental condition and condition 3 (unrelated pain rehearsal: \( t = 0.15, P = 0.89 \)) and condition 5 (random control: \( t = 1.14, P = 0.26 \)). During the second extinction block, there were no longer increased SCRs in any of the conditions, but conditions 1 and 3 still displayed stronger SCRs than the other conditions (Fig. 5). Planned contrasts again showed significant differences between the experimental condition and condition 2 (reality control: \( t = 2.66, P < 0.001 \)) and condition 4 (extinction control: \( t = 2.42, P < 0.02 \)), whereas differences between the experimental condition and both of the other two control conditions were still non-significant (\( ts < 1, Ps > 0.37 \)).

Thus, there was at least partial support for the hypothesis that UCS rehearsal leads to CR incubation. Differences between the experimental condition and the random control condition were probably less strong because the unpredictable nature of the UCS in this condition caused increased SCRs to the CS. Again, no differences were found between rehearsal of the experimental UCS (condition 1) and rehearsal of an unrelated painful UCS (condition 3). It was not possible to investigate incubation of the subjective responses to the CS, because no pain and fear ratings of the isolated CS were obtained during the acquisition phase in conditions 1–4.

The influence of personality on incubation

Next, the influence of personality factors on incubation of SCRs to the CS after UCS rehearsal was investigated. According to Davey and Matchett (1994), only high trait anxious people show incubation of the SCR to the CS after UCS rehearsal. Four (personality) factors were assessed: trait and state anxiety (STAI), worry proneness (PSWQ) and self-consciousness (PSCS). In order to reduce the number of predictive variables a factor analysis was executed on the scores of these four variables in the total sample. Two factors were derived: PSWQ, STA trait and state anxiety loaded on the first factor, the PSCS on the second factor. Therefore
scores on the PSWQ and on both STAI scales were summed, and the PSSC was examined separately. Next, median split based groups were formed in both conditions that showed incubation of the SCR (i.e. conditions 1 and 3). Finally, SCR changes from acquisition to extinction were subjected to a 2 x 2 MANOVA with condition (conditions 1 and 3) and group (below and above the median) as between-S factors. Though there seemed to be a trend towards larger incubation effects in above median Ss on the summed STAI/PSWQ factor compared to the below median group, no significant effects of the summed STAI/PSWQ scores were found on SCRs' changes from acquisition to the first or the second extinction block [F(1,26) = 1.12, P = 0.30; F(1,26) = 0.04, P = 0.85]. Interaction effects between this factor and the condition effect (condition 1 vs 3) were also non-significant (P > 0.24). To further test Davey and Matchett’s (1994) hypothesis, the effects of trait anxiety were investigated separately, but, though the effects were in the expected direction, they failed to reach significance.

In contrast, the PSSC had a significant effect on incubation of the SCR. A 2 x 2 MANOVA revealed a multivariate effect of the PSSC (median split defined groups), F(2,25) = 4.01, P = 0.03. In both extinction blocks, those with a low PSSC score had significantly stronger SCRs than those with a high PSSC score [first block: F(1,26) = 5.46, P = 0.027; second block: F(1,26) = 5.76, P = 0.024]. There was no significant interaction with condition, Ps > 0.29. 

Inspection of the means showed that only low PSSC Ss showed incubation [block 1: low PSSC M = 14.8 (condition 1), M = 15.6 (condition 3); high PSSC M = 1.6 (condition 1), M = 0.1 (condition 3); block 2: low PSSC M = 5.4 (condition 1), M = 0.4 (condition 3); high PSSC M = 12.8 (condition 1), M = 6.5 (condition 3)].

Though trait anxiety per se had no relationship to SCR incubation, the hypothesized association emerged when trait anxiety and self-consciousness were analyzed in combination (see Fig. 6). A 2 (high vs low trait anxiety) x 2 (high vs low self-consciousness) ANOVA on the changes in SCR from acquisition to extinction in conditions 1 and 3 combined revealed the following. During block 1 there were main effects of PSSC [F(1,26) = 10.27, P < 0.01] and trait anxiety [F(1,26) = 4.62, P < 0.05], and an interaction between these two personality factors [F(1,26) = 4.17, P = 0.05]. During block 2 there was a main effect of PSSC [F(1,26) = 8.32, P < 0.01], but no longer of trait anxiety, though the trend was in the expected direction [F(1,26) = 3.30, P = 0.08], whereas the interaction between these two personality factors was no longer significant [F(1,26) < 1]. As is shown in Fig. 6, low levels of private self-consciousness

---

*Entering condition as a separate factor was impossible because of the small sample size; this was considered a minor problem given the lack of effect of condition in the separate analyses of trait anxiety and self-consciousness.
(PSCS) and high levels of trait anxiety were both associated with stronger incubation effects, but the incubation was particularly strong in Ss with both low levels of self-consciousness and high trait anxiety. According to Davey and Matchett (1994), incubation of the SCR is related to the degree that Ss experience the UCS rehearsal as aversive. Davey and Matchett (1994) report evidence that high trait anxious Ss experience UCS rehearsal as more aversive than those with low trait anxiety scores. In the present experiment, Ss rated degree of experienced aversiveness of UCS rehearsal after the extinction trials on a VAS. No effect of trait anxiety (median split defined groups) on these ratings was observed in conditions 1 and 3 [F(1,26) = 0.41, P = 0.53]. The interaction between trait anxiety and condition (1 vs 3) also failed to reach significance [F(1,26) = 0.15]. In addition, none of the other post-experimental questions was there any evidence for an effect of trait anxiety [F(1,26) < 0.84, P > 0.37]. The same holds for the relationship of the summed STAI/PSWQ factor with the rehearsal-aversiveness rating, and with the other post-experimental ratings: none reached significance [F(1,26) < 1.02, P > 0.32]. The relationship of the PSCS with UCS rehearsal aversiveness ratings also failed to reach significance [F(1,26) = 0.28, P = 0.66], as did the PSCS (high vs low) x condition (1 vs 3) interaction [F(1,26) = 0.04, P = 0.84]. In conditions 1 and 3 all the other effects of the PSCS and the PSCS x condition interactions on the post-experimental ratings were non-significant [F(1,26) < 2.22, P > 0.15].

To assess whether the PSCS influenced other responses in the two conditions manifesting incubation of the SCR, change scores (extinction blocks 1 and 2 minus pretest, Lykken-transformed) of the other variables were subjected to 2 (high vs low PSCS) x 2 (condition 1 vs 3) ANOVAs. None of the effects involving the PSCS was significant, however. It should be noted that these tests did not test incubation in a strict sense, since pretest-extinction change were analyzed, instead of acquisition-extinction changes (with the exception of SCR, the responses to the CS during acquisition were not separated separately from those to the UCS).

**Summary of findings on incubation**

Clear evidence was found for incubation of the SCR after cued UCS rehearsal in conditions 1 and 3. Incubation appeared to be related to the PSCS (only those with low PSCS scores exhibited incubation) and to trait anxiety (high trait anxiety was related to incubation, but only when considered in combination with self-consciousness). The combination of low private self-consciousness and high trait anxiety was in particular related to SCR incubation. Lastly, there was no evidence that this effect was mediated by increased aversiveness of rehearsing the UCS in low PSCS Ss or high trait-anxious Ss, or to any other process as assessed by post-experimental VASs.

**DISCUSSION**

The most striking finding of the present study was that cued UCS rehearsal was as effective as experiencing the real UCS in reducing the painfulness of the CS associated with the UCS. The present findings also provide a partial replication of the results of Davey and co-workers after UCS rehearsal SCRs to the CS displayed retarded extinction, compared to critical control conditions. This pattern was even more clear with SCL, which clearly increased from pretest to extinction (posttest) after UCS rehearsal. Compared to acquisition, SCRs to the CS were at the beginning of extinction even slightly increased after UCS rehearsal, replicating previous findings by Davey and co-workers on incubation of electrodermal responses after UCS rehearsal. However, the present experiment failed to demonstrate a parallel effect on reports of subjective anxiety. Clearly, this casts doubts on Davey's claim that UCS rehearsal leads to an overall incubation (or delayed extinction) of conditioned fear. It may be that incubation effects are limited to electrodermal responses, perhaps to sympathetic arousal in general. Another interesting finding in this context was that incubation of SCRs to the CS was related to private self-consciousness and, to a lesser extent, to trait anxiety. Though the last relationship supports previous findings (Davey & Matchett, 1994), the relationship between self-consciousness and incubation
of the SCR was clearly stronger. The relationship with trait anxiety only emerged in combination with low self-consciousness.

Cued UCS rehearsal reduced the experience of pain of the CS as much as real experience with the UCS. This finding is difficult to reconcile with the idea that UCS rehearsal could lead to an increased pain experience elicited by a CS. Thus, it is unlikely that UCS rehearsal like processes can explain chronic pain problems. On the contrary, if anything, UCS rehearsal seems effective in helping to reduce the pain experience. In general, it has been difficult to demonstrate that learning processes can increase the experience of pain. For example, in our lab, several attempts were made without much success to condition the experience of pain through classical, evaluative and operant learning conditioning procedures (Arntz, 1991; Lousberg, Groenman, Schmidt & Gielen, 1996). Perhaps subjective pain has erroneously been viewed as a response. Since most responses can be conditioned, it may have been assumed that this would also hold for pain. However, if the experience of pain is conceptualized as an input phenomenon (largely a perceptual experience), it becomes clear that it is highly unlikely that the experience of pain can be produced (or increased) by conditioning procedures.

The finding that UCS rehearsal reduces pain is in line with the idea that there may be functional properties of UCS rehearsal and other worrying-like processes: they may help people to better prepare for pain and reduce the impact of a painful UCS. Further research is needed to replicate this finding and to test whether UCS rehearsal also reduces the pain experience of the UCS itself. It would also be interesting to investigate in more detail various forms of rehearsing the UCS (e.g. verbal vs experiential modes).

Is there an associative basis for the observed effects of UCS rehearsal on pain experience of the CS? The evidence for this was mixed. On the one hand, there was a significant difference between the experimental condition and condition 5 ('random control'), suggesting that pairing of CS and UCS is necessary. On the other hand, rehearsal of an unrelated UCS (personal experience with severe pain) also caused pain reduction of the CS. Although the reduction found with the latter procedure was smaller, it did not differ significantly from the pain reduction that occurred in the experimental condition. Clearly, more research is needed to elucidate whether imagining any painful experience can lead to reduction of the pain experience (or the pain report), and what the contribution is of associative processes. On the basis of the present data, it is difficult to determine what underlying process causes the observed effect. Because anxiety and arousal indices tended to increase after UCS rehearsal in the experimental condition, it is tempting to speculate that increased anxiety, perhaps via endogenous opioid release, led to the observed reduction of pain. However, such a reduction was not observed in condition 5 ('random control'), despite the increases in anxiety and electrodermal responsiveness in this condition. Moreover, since endogenous opioid release due to stress, pain or arousal is a relatively slow process (Willer & Ernst, 1986; Janssen & Arntz, 1996), it is (i) unlikely that it disappeared in condition 5, and (ii) unlikely that it was quickly (say within several milliseconds) triggered by the CS in condition 1. In addition, there is evidence that only highly uncontrollable stress leads to endogenous opioid release (Janssen & Arntz, 1996, 1997a,b). In most pain/fear experiments with humans, no evidence has been found for such an opioid release. An endogenous opioid base for the pain reducing effects of UCS rehearsal seems therefore highly unlikely.

Turning to the effects of UCS rehearsal on fear indices, we largely replicated Davey and co-workers' findings on electrodermal responding, including the temporariness of the incubation and extinction-delaying effects. The lack of significant effects on subjective anxiety may have been a power problem, since the effects were in the expected direction. Alternatively, the effects are restricted to electrodermal or physiological arousal. It remains to be demonstrated that the effects of UCS rehearsal affect fear, and not only a physiological subsystem. Interestingly, as with the experience of pain, rehearsal of a painful experience unrelated to the CS (condition 3) also resulted in incubation of the SCR to the CS. Animal and human studies that have sought to elicit incubation-like phenomena with manipulations such as short CS presentations or high intensity UCSs have largely produced disappointing results (e.g. Malloy & Levis, 1990; Richards & Martin, 1990; Kimmel, Kearns & Anderson, 1992). As far as autonomic arousal is concerned, the results of the present study suggest that UCS rehearsal may provide a more reliable procedure to induce incubation effects.
Unfortunately, condition 5 ('random control') failed as a proper control for the associative basis of effects of UCS rehearsal on fear indices. There were slight increases in subjective anxiety and SCL, and only a slight decrease in SCR during extinction, compared to pretest in this condition. The most probable explanation for this is that the unpredictable nature of the UCS during acquisition made Ss more aroused and anxious (Baltissen & Boucsein, 1986). In retrospect, another CS paired with the UCS might have prevented the effects of unpredictability.

Subjects low in the tendency to engage in self-attention (to attend to inner feelings and thoughts) were more prone to show incubation of the conditioned SCR after UCS rehearsal, especially when they also were high on trait anxiety. Perhaps forced UCS rehearsal is more aversive for people who habitually do not engage in such activity than for people who habitually attend to inner experiences. High trait anxiety (or neuroticism/negative affectivity) seems to further increase the sensitivity for incubation of conditioned electrodermal responses. There was no relationship between private self-consciousness and aversiveness ratings of the UCS rehearsal task. Therefore, it is unlikely that aversiveness mediated the relationship between low self-consciousness and incubation of the SCR. An alternative explanation is that the rehearsal procedure forces Ss to attend more to memories of UCS, UCRs, CSs and CRs, and that increased attention to these memories strengthens UCS-UCR-CS-CR representations/associations, which, in turn, increases electrodermal responding, especially in those who previously paid little attention to these stimuli.

To summarize, it was demonstrated that cued UCS rehearsal reduces pain experienced from a CS previously associated with a very painful UCS. Pain reduction by rehearsal appeared to be as strong as confrontation with the real UCS and this suggests that habituation to pain can take place in imagination. This finding also suggests that UCS rehearsal (and possibly other worry-like activities) might be instrumental in reducing impact of noxious (UCSs. It was also demonstrated that UCS rehearsal leads to (temporary) incubation of the conditioned SCRs. This effect was related to low levels of self-consciousness and to high levels of trait anxiety. Since no incubation effects or delayed extinction effects on subjective anxiety were demonstrated, the results cast doubts on the claim that UCS rehearsal uniformly increases (or reduces extinction of) conditioned fear. Though some evidence was found for the associative basis of the effects, there were also findings contradicting an associative basis. Whereas the UCS rehearsal paradigm offers a fruitful approach, further research with different forms of UCS rehearsal (e.g., verbal vs experiential forms) is necessary.

Acknowledgements—Thanks are due to Graham Davey for his help in designing the present study.

REFERENCES