Can prepared fear conditioning result from verbal instructions?

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Abstract

Evolutionary fear-relevant stimuli such as snakes or spiders are thought to be prepared to elicit fear reactions. This implies that the acquisition of conditioned fear responses is facilitated when these stimuli serve as conditioned stimuli (CSs). Moreover, extinction of conditioned fear responses is delayed when CSs are prepared stimuli. The research presented in this article addresses the question whether such selective learning effects can be obtained even when participants do not experience pairings of CSs and US but receive only instructions about those pairings. Two experiments were conducted in which participants were verbally informed about the relationship between fear-relevant and fear-irrelevant CSs and the presence of an electrical stimulus (US). However, CSs were never actually paired with the US. US expectancy ratings and skin conductance responses were recorded during multiple CS only trials. In the first experiment, we observed acquisition, extinction and reinstatement of fear on the basis of instructions, but these effects were not modulated by the fear-relevance of the CSs. In the second experiment, we manipulated whether participants actually experienced the CS-US contingencies or were merely instructed. We obtained facilitated acquisition for the merely instructed fear-relevant CS+. We discuss these results in relation to the evolutionary fear learning model of Öhman and Mineka (2001) and the expectancy bias model of Davey (1992).

Keywords: Fear, Conditioning, Preparedness, Instructions, SCR

Prepared fear conditioning via verbal instructions

1. Introduction

Fear conditioning in the lab is commonly established by repeatedly pairing an initial neutral stimulus (the Conditioned Stimulus or CS) with an aversive stimulus (the Unconditioned Stimulus or US), resulting in fearful reactions (or Conditioned Responses, CRs) to the initial neutral CS. However, direct pairings of the CS and US are not necessary to establish fearful CRs. Fearful reactions can also be established by providing participants with verbal information about the contingency between the CS and US, in the absence of any actual CS-US pairings (Field, 2006; Rachman, 1977). Previous research has demonstrated that verbal instructions can be a very powerful tool for inducing fear reactions (e.g., Cameron, Roche, Schlund, & Dymond, 2016; King, Eleonora, & Ollendick, 1998; Merckelbach, de Jong, Muris, & van den Hout, 1996; Muris & Field, 2010). Despite its potency, however, fear conditioning through verbal instructions is still poorly understood (e.g., Olsson & Phelps, 2007).

According to Olsson and Phelps (2007), fear conditioning through verbal instructions can be partly dissociated from learning via direct experience and learning via social observation (see also: Olsson & Phelps, 2004). That is, verbal instructions primarily result in cognitive contingency learning, while learning via direct experience and via social observation result in both contingency learning and affective learning. Affective learning is the acquisition of defensive responses to potentially threatening stimuli. This type of learning is proposed to take place in an automatic way and is assumed to be independent of cognitive contingency learning (Hamm & Weike, 2005; Mineka & Öhman, 2002). Cognitive contingency learning, on the other hand, refers to the purely cognitive learning of contingencies between events.

Alternatively, according to single-process models of associative learning (De Houwer, 2009; Mitchell, De Houwer, & Lovibond, 2009), learning is the result of the non-automatic formation of propositions. According to this view, there should not be any qualitative differences between pathways of learning because learning via all the different pathways is mediated by the same underlying processes. Thus, verbal instructions should be able to result in learning on measures that are believed to capture affective components of learning as well. This is supported by a number of studies that show that verbal instructions can result in the acquisition of defensive responses (Cameron et al., 2016; Costa, Bradley, & Lang, 2015; Grillon, Ameli, Woods, Merikangas, & Davis, 1991) and subjective feelings of fear and distress (Raes, De Houwer, De Schryver, Brass, & Kalisch, 2014; Soeter & Kindt, 2012), which are considered to be affective measures of fear (Hamm & Weike, 2005; Soeter & Kindt, 2012). Such results call into question whether distinctions should be made between the processes underlying learning via verbal instructions and other types of learning.

Nevertheless, it may be that there are certain instances of affective learning that cannot be obtained through verbal instructions, thus requiring a multi-process account for the different pathways of fear acquisition. The most prototypical example of affective learning is perhaps prepared learning (Öhman & Mineka, 2001). Selective or prepared learning refers to the finding that the pairing of a fear-relevant CS (e.g., pictures of snakes or spiders) with an aversive US (e.g., an electric shock) produces a stronger CR that is more easily established or more resistant to extinction than CRs to fear-irrelevant CSs (e.g., a picture of a flower or a bird). The idea for a varying capacity of stimuli to become associated with an aversive event was introduced by Seligman (1971) in his preparedness theory. According to this theory, stimuli that were potentially threatening for survival in our ancestral history are more easily learned to be feared. This auxiliary assumption to learning theory could explain why certain types of phobias, such as these for heights and spiders, are more prevalent than others

(Rachman, 1977). A large set of experiments have provided evidence for this preparedness theory in the lab using fear conditioning (for a review see: Öhman & Mineka, 2001).

It has been argued that prepared learning is due to the operation of a specific fear learning module (Mineka & Öhman, 2002; Öhman & Mineka, 2001). Features of this proposed module include selective activation in the presence of aversive events, automatic activation with a minimal amount of stimulus processing, and encapsulation from higher cognitive influences. Because of the selective and automatic nature of this learning module, we would not expect that prepared learning is a property of fear conditioning via verbal instructions because it seems unlikely that verbal instructions provide the conditions to recruit this module in the learning process (Olsson & Phelps, 2004, 2007).

However, several previous experiments have provided evidence that prepared learning can be obtained via verbal instructions. Öhman, Eriksson, Fredriksson, Hugdahl and Olofsson (1974) and Davey (1992) both reported that threatening participants that a shock will follow the CSs during the experiment, without actually pairing the CSs with the US, potentiated fear reactions more in the group that saw fear-relevant CSs than in the group that saw fear-irrelevant CSs. However, because no non-threatened CSs had been included in these experiments, it is impossible to determine whether threat instructions generated specific potentiation of fearful reactions to the threatened fear-relevant CS+s, or generated a general potentiation of fearful reactions to all fear-relevant stimuli. While the former would be an instance of selective learning, the latter is not. In two other studies by Hugdahl and Öhman (1977) and Hugdahl (1978), participants were given instructions that one CS would be followed by a shock but the other CS would not. These instructions led to stronger acquisition effects (Hugdahl & Öhman, 1977) and to more resistance to instructed extinction (i.e., the combination of verbal CS-no US instructions and removal of the shock electrodes; Hugdahl, 1978) in the group receiving these instructions about fear-relevant CSs compared to the group receiving these instructions about fear-irrelevant CSs, even though participants had never actually experienced the instructed contingencies. These studies clearly show that prepared learning can be obtained when conditioning is established through verbal instructions, and thus further show that learning via verbal instructions and learning through direct experience of contingencies may be very similar. However, the fact that instructed extinction was less strong with fear-relevant than with fear-irrelevant CSs does demonstrates that there are limits to what can be learned through verbal instructions (Hugdahl, 1978), and seems to contradict a single-process account of fear learning (De Houwer, 2009; Mitchell et al., 2009).

Nevertheless, there are several caveats that potentially limit the interpretability of these experiments. First, the resistance to instructed extinction effect (Hugdahl & Öhman, 1977; Hugdahl, 1978; Öhman, Erixon, & Lofberg, 1975) has been difficult to replicate. In subsequent studies, the combination of an extinction phase with explicit instructions that USs would no longer be presented, resulted in a complete reduction of the CR for both fear-relevant and fear-irrelevant CSs (Lovibond, 2004; McNally, 1987). Second, there is a methodological issue that might complicate the interpretation of the results from Hugdahl and Öhman (1977) and Hugdahl (1978). In both experiments, a between-subjects design was used in which one group was verbally conditioned with fear-relevant CSs and the other group was verbally conditioned with fear-irrelevant CSs. Such a design is not optimal because differences between groups, such as elevated state-anxiety due to repeated exposure to fear eliciting stimuli (pictures of snakes and spiders), are not controlled for. Such uncontrolled differences in state-anxiety between groups may lead to alterations in conditioning that do not reflect prepared learning (e.g., Vriends et al., 2011). Recent studies on prepared learning therefore usually make use of a within-subject design (Ho & Lipp, 2014; Olsson, Ebert, Banaji, & Phelps, 2005). Finally, it is possible that the prepared learning in the studies of Hugdahl might reflect expectancy biases, that is, a bias to expect the US in the presence of a fear-relevant CS, and thus do not reflect learning through a specialized module that is independent of higher-order cognitions (Davey, 1992). Demonstrating that prepared learning effects are due to expectancy biases would challenge the need for a separate fear learning system (Öhman & Mineka, 2001). The studies of Hugdahl and Öhman (1977) and Hugdahl (1978) lacked the inclusion of expectancy ratings to determine whether the observed prepared learning effects were due to such expectancy biases.

Hence, so far it remains unclear whether prepared learning can be obtained with verbal instructions, and whether these prepared learning effects are due to expectancy biases. We conducted two new experiments employing a within-subjects design to investigate these issues and to thus shed new light on the important theoretical debate about the need to supplement a cognitive (propositional) learning system with an affective fear learning module. In both experiments, participants received instructions about the contingency between fear-relevant and fear-irrelevant CSs, on the one hand, and an aversive US (an electrical stimulation), on the other hand. Within each fear-relevance category, one CS was instructed to be followed by the US while the other was instructed never to be followed by the US. After the instructions, a short test was given to make sure that participants understood and remembered the instructions correctly. After the instructions and test, participants continued to an unannounced extinction phase. Evidence for selective learning could be established during this phase through stronger CRs to the fear-relevant CS+ (i.e., facilitated acquisition) or through resistance to extinction of CRs for the fear-relevant CS+.

We collected skin conductance responses (SCR) and US expectancy ratings as dependent measures in both experiments. SCRs are traditionally measured in studies that investigated prepared fear learning, and have been shown to be sensitive to prepared learning effects. Inclusion of US expectancy ratings allowed us to evaluate whether obtained preparedness effects were due to expectancy biases (Davey, 1992). Furthermore, these two measures were supplemented with fear ratings in the second experiment. Fear ratings are considered to be a more affective measure of fear learning (Mertens et al., 2015; Soeter & Kindt, 2012) and may therefore be more sensitive to preparedness effects.

Additionally, in the second experiment, we manipulated whether the instructed contingencies were actually experienced or merely instructed. This was accomplished by adopting a procedure introduced by Raes, De Houwer, De Schryver, Brass and Kalisch (2014) that allowed us to manipulate on a within-subjects basis whether verbally threatened CSs are actually paired with the US. On the basis of the fear learning module account of Öhman and Mineka (2001), we expected that actually experiencing the instructed contingencies would strengthen prepared learning effects because effects of actual CS-US pairings are assumed to be mediated in part by the fear learning module (Olsson & Phelps, 2004, 2007).

Finally, we included a reinstatement shock after the extinction phase. So far, preparedness effects on the reinstatement of extinguished fear have not been investigated before, although several interesting predictions can be made with regard to the reinstatement of fear with fear-relevant stimuli as CSs. That is, given that reinstatement is believed to reflect the facilitated retrieval of the excitatory CS-US relationship learned during acquisition instead of the competing inhibitory CS-noUS relationship learned during extinction (Bouton, 2004; Haaker, Golkar, Hermans, & Lonsdorf, 2014), reinstatement should be less pronounced for fear-relevant CSs because less inhibitory learning (extinction) takes place for fear-relevant CSs. Alternatively, more reinstatement could be expected for fear-relevant CSs because acquisition is more pronounced for these CSs (Fredrikson, Hugdahl, & Öhman, 1976; Öhman, Fredrikson, & Hugdahl, 1978) and therefore the excitatory CS-US memory is more easily retrieved after a reinstatement manipulation. Including a reinstatement shock after the extinction phase in our study allowed us to explore these different predictions regarding reinstatement of fear for fear-relevant CSs.

2. Experiment 1

Experiment 1

2.1 Participants

Thirty-seven right-handed psychology students at Ghent University participated in exchange for €8. Of these, the data of eight participants were excluded from analyses because they either did not believe the instructions (N = 5), did not find the US sufficiently unpleasant (N = 1), or both (N = 2) (see below for more details on how this was assessed).

2.2 Material

2.2.1 Psychophysiology.

SCRs were collected using a Coulbourn Lablinc V system (Coulbourn Instruments, Allentown, PA) and standard Ag/AgCl electrodes (0.8 cm diameter) filled with K-Y jelly. The electrodes were attached to the thenar and hypothenar eminences of the non-dominant hand. The signal was measured using a constant voltage coupler (0.5 V) and digitized at 10 Hz. The collected data were analyzed with Psychophysiological Analysis (PSPHA) (De Clercq, Verschuere, De Vlieger, & Crombez, 2006). SCRs were calculated by subtracting the mean value of a baseline period (2 seconds before CS onset) from the highest amplitude within a 1 to 8 s interval after CS onset (Pineles, Orr, & Orr, 2009). In this scoring method, negative values were recoded to zero. Finally, collected SCRs were range corrected with the highest recorded amplitude for that participant to account for individual differences in responsivity (Lykken & Venables, 1971) and square root transformed to normalize the data (Dawson, Schell, Filion, & Berntson, 2007).

2.2.2 US expectancy ratings.

US expectancy ratings were collected on each trial using a 9-point Likert scale presented below the CSs with 5 anchor points: 1 = “not at all”, 3 = “rather not”, 5 = “uncertain”, 7 = “to some extent”, 9 = “certainly”. Above the CSs the question: “To what extent do you expect the shock?” was presented. Participants indicated their answer by clicking one of the response options of the Likert scale with the computer mouse using their dominant hand.

2.2.3 Stimuli.

Four pictures of a snake, spider, bird and butterfly, each 570 by 400 pixels in size (15 by 10.5 cm), were used as CSs in the experiment. These were the same pictures as used in the first experiment from Olsson et al. (2005) in which prepared learning was observed. Assignment of the pictures to the role of CS+ and CS- was orthogonally counterbalanced over participants within each fear-relevance category. For the practice phase, a white and a yellow square were used, also 570 by 400 pixels in size.

The US was an electrical stimulus that consisted of 38 rectangular pulses of 2 ms with and inter pulse interval of 6 ms, creating a stimulus of approximately 300 ms. This stimulus was administered by two lubricated Fukuda standard Ag/AgCl electrodes (1-cm diameter) to the left leg over the retromalleolar course of the sural nerve. The stimulus was generated by a constant current stimulator (DS7A, Digitimer, Hertfordshire, UK). The intensity of this stimulus was determined for each participant individually to be unpleasant but not painful using a stepwise work-up procedure (*mean intensity* = 3.17 mA, *SD* = 1.13).

2.3 Procedure

2.3.1 General information and work-up procedure.

Upon arrival at the laboratory, participants were seated and informed about the general characteristics of the experiment. They were informed that in the experiment an electrical stimulus would be presented to them but that this stimulus was not harmful. Furthermore, they were informed about the presence of a camera and an intercom system that allowed the experimenter to monitor for artifacts that might interfere with the skin conductance measures (such as sneezing, yawning, …). After this information, the electrodes for measuring skin conductance and for administering the US were attached to the left hand and the left leg, respectively. The skin conductance signal was checked by having participants breathing deeply in and out. If the signal was clear, participants went through the work-up procedure. During this work-up, participants were exposed to gradually increasing intensities of the electrical stimulus. Participants could verbally report after each exposure how they had experienced the stimulus. When they indicated the stimulus to be unpleasant but not painful, the procedure was stopped and participants were informed that this was the electrical stimulus intensity level that would be used during the experiment. Finally, the experiment program was started and continued automatically without the presence of the experimenter.

2.3.2 Pre-training instructions and training phase.

Participants were told that they would see four pictures during the experiment and that two of these pictures would sometimes be followed by the shock while the other two pictures would never be followed by the shock. They were instructed that their task was to indicate during the experiment to what extent they expected the shock using a scale presented below the pictures. Furthermore, they were told that before they would see the pictures they had to complete a training phase to become familiar with the setup of the experiment. In this training phase, they would see a white square which would sometimes be followed by the shock and a yellow square which would never be followed by the shock.

During the training phase, participants were shown white and yellow squares, each presented four times (8 trials in total), in the middle of the screen for 8 s. The squares were preceded by a fixation cross presented for 3 s, signaling the onset of the CSs. Three out of four presentations of the white square (CS+) were followed by the US, determined in a random fashion. CSs were presented in a random sequence. On each trial, SCRs were measured and participants provided expectancy ratings (see the Materials section). The inter-trial interval was 10, 12 or 16 s, randomly selected.

2.3.3 Verbal instructions and retention test.

After the training phase, participants were told that they would now see the different stimuli together with information about whether a stimulus can be followed by the shock. Participants were asked to remember this information well and were told that they would have to complete a test afterwards about the instructions. Subsequently, all the CSs were shown one by one in the middle of the screen in a random order. For CS+s the sentence “Will SOMETIMES be followed by the shock” was presented above the picture, while for CS-s the sentence “Will NEVER be followed by the shock” was presented. Participants could navigate through these instructions by pressing the space bar.

After these instructions, the participants completed a short test about the instructions. During this test, each stimulus was presented twice in the middle of the screen in a random sequence. Participants were asked to decide for each stimulus whether it could be followed by a shock by clicking one of two response buttons depicted on the screen below the stimulus. On one button (200 by 100 pixels) “sometimes shock” and on the on the other “never shock” was projected. If participants failed to select the correct answer for each picture, they were told that they had not selected the right option for all the pictures and that they will have to redo the test. After that, they received the contingency instructions again, followed by the test.

This continued until participants passed the test without making errors (average number of tests until pass = 1.28, *SD* = 0.53, range = 1-3).

2.3.4 Extinction phase and reinstatement.

After the retention test, participants continued to an unannounced extinction phase. During this phase, participants saw each stimulus six times (24 trials in total). On no occasion was a stimulus followed by the US. Stimulus order was randomized with the exception that the same CS could not be presented on more than two consecutive trials. Stimulus and ITI duration were identical to those used in the preceding training phase. Similarly, SCRs and US expectancy ratings were collected online throughout the extinction phase.

After the last extinction trial, an unannounced reinstatement US was presented to the participants. The US was administered 15, 17 or 21 s after the last extinction trial ended and was followed by the first post-reinstatement trial after 18, 20 or 24 s, randomly selected. The reinstatement US was administered while participants viewed a black screen. After this unannounced US, each stimulus was presented to the participants two more times using a trial procedure identical to that of the extinction trials.

2.3.5 Manipulation checks.

At the end of the experiment, participants were asked to rate their belief in the instructions by selecting one of four forced-choice options (“not believable”, “somewhat believable”, “very believable” and “fully believable”) and to indicate how unpleasant they found the shock, using a scale with seven forced-choice possibilities (“very pleasant”, “rather pleasant”, “somewhat pleasant”, “neutral”, “somewhat unpleasant”, “rather unpleasant”, “very unpleasant”). In both cases, options were presented using a dropdown list. The two questions were presented in a random order.

2.3.6 Data analysis.

US expectancy ratings and SCRs were analyzed separately with repeated measures ANOVAs. Two ANOVAs were run to assess the effects of our experimental manipulations. First, the extinction phase was analyzed using an ANOVA with CS (CS+ or CS-), Fear-relevance (fear-relevant or fear-irrelevant) and Trial (one to six) as within-subject factors. Second, the effect of the reinstatement US was assessed by comparing the last trial of the test phase with the first trial after the reinstatement US (factor Time) with factors CS and Fear-relevance. The crucial interactions for our research question are those between Fear-relevance and CS (facilitated acquisition), between Fear-relevance, CS and trial (resistance to extinction) and between Fear-relevance, CS and Time (reinstatement for the fear-relevant CS+).

An alpha-level of .05 was applied for statistical significance and Greenhouse-Geisser corrections are reported when the sphericity assumption was violated

2.4 Results

2.4.1 Manipulations checks.

The majority of the participants indicated that they found the instructions to be very believable (20 participants, 54%) or fully believable (10 participants, 27%). Six participants indicated that they found the instructions somewhat believable (16%) and one participant reported not to believe the instructions (3%). These latter seven participants were excluded from analyses.

Furthermore, most of the participants experienced the US as rather unpleasant (24 participants, 65%) or as somewhat unpleasant (10 participants, 27%). Three participants indicated the US to be neutral or pleasant (8%) and were excluded from analyses (see Participants section)[1].

2.4.2 US expectancy ratings.

2.4.2.1 Extinction phase.

We obtained instruction-based fear conditioning as evidenced by higher US expectancy ratings for CS+s than for CS-s (see Figure 1), main effect of CS: $F(1, 28) = 208.31$, $p < .001$, $\eta^2_p = .88$. However, this conditioning effect was not qualified by the nature of the CS, interaction between CS and Fear-relevance: $F(1, 28) = 1.93$, $p = .176$, $\eta^2_p = .06$. Hence, no evidence for facilitated acquisition was obtained for US expectancy ratings. Furthermore, US expectancy ratings tended to decrease over trials, main effect of Trial: $F(1.85, 51.91) = 18.52$, $p < .001$, $\eta^2_p = .40$, and this effect was qualified by a significant interaction between CS and Trial, $F(1.75, 48.90) = 11.29$, $p < .001$, $\eta^2_p = .29$, indicating that US expectancy decreased more strongly for the CS+s (i.e., extinction; see Figure 1). However, this extinction effect was also not reliably modulated by the nature of the CS, three way interaction between CS, Trial and Fear-relevance: $F(3.58, 100.17) = 1.91$, $p = .122$, $\eta^2_p = .06$. Hence, neither facilitated acquisition nor resistance to extinction was obtained for the US expectancy ratings during the extinction phase.

2.4.2.2 Reinstatement effect.

The reinstatement shock led to a general increase in US expectancy, main effect of Time: $F(1, 28) = 21.98$, $p < .001$, $\eta^2_p = .44$. Importantly, the main effect of time was qualified by a significant interaction between Time and CS, $F(1, 28) = 7.83$, $p = .009$, $\eta^2_p = .22$. This interaction was due to larger increases in US expectancy for CS+s after the reinstatement

[1] Exclusion of these participants did not alter our conclusions regarding the data. Similar results were obtained when all participants were included in the statistical analyses.

shocks than for CS-s (see Figure 1). Again, these results were not modulated by the factor Fear-relevance: main effect Relevance, $F < 1$; interaction between Time and Relevance, $F(1, 28) = 1.51$, $p = .229$, $\eta^2_p = .05$; three way interaction between Time, CS and Relevance, $F(1, 28) = 2.03$, $p = .165$, $\eta^2_p = .07$.

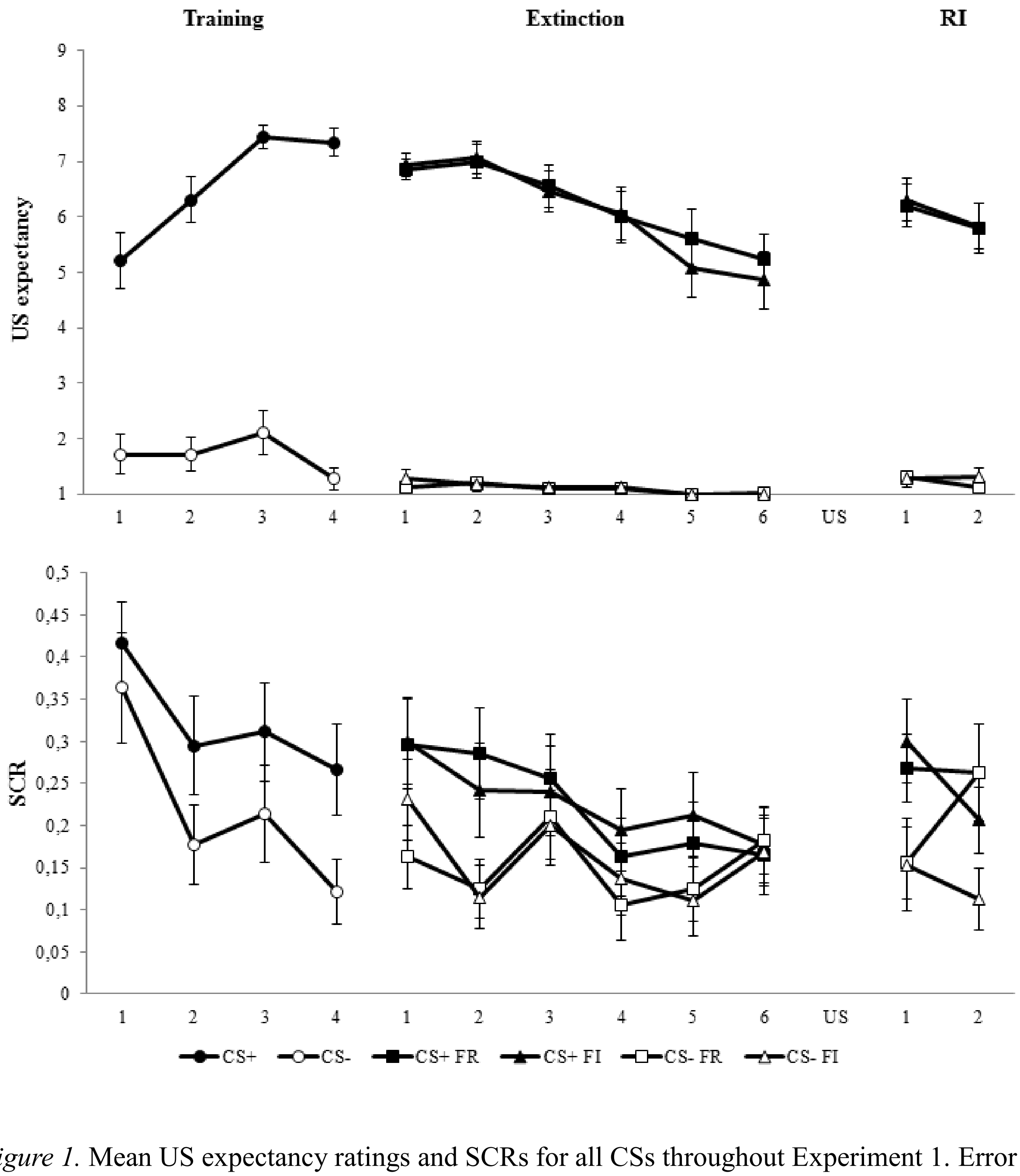

Figure 1. Mean US expectancy ratings and SCRs for all CSs throughout Experiment 1. Error bars represent Standard Error. RI = reinstatement; FR = fear-relevant; FI = fear-irrelevant.

2.4.3 SCRs.

2.4.3.1 Extinction phase.

SCRs to the CS+s were stronger than to the CS-s (see Figure 1), demonstrating acquisition of fearful reactions on an autonomous measure on the basis of verbal instructions, main effects of CS, $F(1, 28) = 9.68$, $p = .004$, $\eta^2_p = 0.26$. Furthermore, SCRs decreased over trials throughout the extinction phase, main effect of Trial: $F(3.16, 88.47) = 3.19$; $p = .026$; $\eta^2_p = 0.10$. This effect tended to be larger for CS+s than for CS-s (i.e., extinction; see Figure 1), interaction between CS and Trial number, $F(5, 140) = 2.16$; $p = .062$; $\eta^2_p = 0.07$.

However, as for the US expectancy ratings, neither the acquisition effect nor the extinction effect on the SCRs were qualified by Fear-relevance, all *F*s < 1.

2.4.3.2 Reinstatement effect.

Unlike the case for the US expectancy ratings, the reinstatement US did not lead to a general increase in SCRs, main effect of Time, $F(1, 28) = 1.90$; $p = .179$; $\eta^2_p = 0.06$. However, it did lead to a specific increase of SCRs for CS+s (see Figure 1), interaction between Time and CS, $F(1, 28) = 5.83$; $p = .023$; $\eta^2_p = 0.17$. The main effect of Fear-relevance and the interaction effects related to this factor were not significant, all *F*s < 1.

2.5 Discussion

In Experiment 1, we observed acquisition, extinction and reinstatement effects on the basis of verbal contingency instructions, both on US expectancy ratings and SCRs. To our knowledge, this is the first study to show reinstatement for US expectancy ratings and SCRs in conditioning through verbal instructions (Haaker et al., 2014).

Regarding our main research question, however, we did not find evidence for stronger acquisition or slower extinction for fear-relevant CSs. One reason for a lack of prepared learning effects in our experiment might be the fact that the CSs and the US were never actually paired. On the basis of the previously outlined evolutionary fear learning module, one could argue that giving mere verbal contingency instructions might not be sufficient to recruit this module into the learning process (Mineka & Öhman, 2002; Olsson & Phelps, 2004, pp. 287). Previous experiments indeed suggest that verbal instructions mainly result in expectancy learning but to a smaller degree in affective learning (Lipp, Mallan, Libera, & Tan, 2010; Olsson & Phelps, 2004; Sevenster, Beckers, & Kindt, 2012). Therefore, direct experience of the CS-US contingency might be necessary for affective learning and consequently to obtain fear-relevance effects.

To test for this hypothesis, we adopted a procedure developed by Raes, De Houwer, De Schryver, Brass, and Kalisch (2014) which allowed a within-subject comparison of instructed fear conditioning with and without actual CS-US pairings. In this procedure, participants are instructed about two CSs that are said to be predictive of an electrical stimulus. Participants are also informed that in a first training phase only one of the CSs (i.e., CS+1) will be actually paired with the US while the other CS (i.e., CS+2) will only be followed by the electrical stimulus in a later test phase of the experiment. Before that test phase, participants are warned that now both CS+1 and CS+2 will be followed by the electrical stimulus, while in fact neither of them is followed by the stimulus during this phase. The crucial comparison in this procedure is the comparison during test between the CS whose relation to the US was both instructed and experienced as the result of actual CS-US pairings (i.e., CS+1) and the CS whose relation with the US was only instructed (i.e., CS+2). Any difference between CS+1 and CS+2 during test can be attributed to the presence of actual CS-US pairings. We extended this procedure by including both a fear-relevant and a fear-irrelevant CS+1 and CS+2 to assess whether actual experience strengthens selective learning effects.

Furthermore, in Experiment 2, we collected fear ratings in addition to US expectancy ratings and SCRs. Even though prepared learning effects have been observed on US expectancy ratings and SCRs (e.g., Davey, 1992; Lovibond, Siddle, & Bond, 1993; Öhman, Erixon, & Löfberg, 1975), fear ratings might be a better measure for capturing the emotional components of preparedness effects, that is, components that are driven by a fear learning module (Mertens et al., 2015; Soeter & Kindt, 2012).

3. Experiment 2

3.1 Participants

A sample of 41 right-handed psychology students at Ghent University completed the experiment in exchange for €12. Of these, five were removed from analyses because they reported not to believe the instructions (N = 2) or because of lost data during recording (N = 3).

3.2 Material

3.2.1 Psychophysiology.

SCRs were collected and pre-processed in the same manner as in Experiment 1. Additionally, SCRs were averaged per two trials to obtain an equal number of data points as for the subjective ratings (as in Raes et al., 2014).

3.2.2 US expectancy and fear ratings.

US expectancy and fear ratings were collected in separate blocks, interspersed throughout the experiment (as in Raes et al., 2014). Right before this block, participants were asked to think back to their most recent encounter with the stimulus and were told that questions regarding the expectancy of the electrical stimulus referred only to the actual electrical stimulus and not the picture of the lightning bolt (which was used as a placeholder for CS+2 during a practice phase; see below). For each CS, fear and US expectancy ratings were collected, resulting in 12 trials in each ratings block. The order of the trials in the rating block was randomized.

During rating trials, a CS was presented in the middle of the screen with either the question “To what extent did you expect an electrical stimulus while viewing this photo?” (US expectancy) or “How much fear did you experience while viewing this photo?” (fear). Participants could provide an answer by clicking one of the response alternatives of a 9-point Likert scale presented below the CSs. For US expectancy, the anchors of the Likert scale were 1 = “certainly not”, 3 = “rather not”, 5 = “uncertain”, 7 = “rather certain”, 9 = “certain”. For fear ratings, the anchors were 1 = “none at all”, 3 = “very little”, 5 = “uncertain”, 7 = “to some extent”, 9 = “very much”. There was no response deadline.

3.2.3 Stimuli.

Six stimuli were selected from the IAPS database. These were pictures of a spider, snake, rat, cow, deer and a rabbit (IAPS pictures 1200, 1080, 1280, 1670, 1620 and 1610, respectively)[2]. All pictures were 300 by 230 pixels in size (8 by 6 cm). Allocation of these pictures within each fear-relevance category to the role of CS+1, CS+2 and CS- was randomized for each participant.

[2] Virtually all fear conditioning studies investigating prepared learning in the laboratory have used pictures of either snakes or spiders as CSs. We considered rats to be a third fear-relevant CS based on a study from Hygge and Öhman (1978) who found preparedness effects with a rat picture as a fear-relevant stimulus and based on correlational studies that have found rats to be a universal fear-relevant animal similar to snakes and spiders (Davey et al., 1998; Ware, Jain, Burgess, & Davey, 1994).

The same electrical stimulus as in Experiment 1 served as the US in this experiment. Again, the intensity of this stimulus was determined for each participants individually via a work-up procedure (*mean intensity* = 5.36 mA, *SD* = 2.86).

Finally, a picture of a lightning bolt (approximately 200 by 200 pixels) presented for 500 ms was used as the placeholder US (as in Raes et al., 2014).

3.2.4 Questionnaires.

Prior to the experiment, participants completed a Dutch translation of the trait version of the State-Trait Anxiety Inventory (STAI-S; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983; van der Ploeg, Defares, & Spielberger, 2000). After the experiment, participants completed a custom-made questionnaire about credibility of the experimental instructions. In this questionnaire, participants indicated the clarity and believability of the instructions on a 10-point scale and could additionally provide general remarks about the experiment (as in Raes et al., 2014).

3.3 Procedure

3.3.1 Pre-practice instructions.

After arrival at the laboratory, participants were informed about the general characteristics of the study and went through a work-up procedure as in Experiment 1.

After all electrodes had been applied and checked, participants received instructions about the contingencies on the computer screen without the presence of the experimenter. Participants could move through the instructions in a self-paced way by pressing the spacebar. First, participants were shown the six CSs simultaneously on the screen for a minimum duration of 5 s. On the following instruction page, participants were informed that four of these photographs could sometimes be followed by an electrical stimulus, while the other two could never be followed by the stimulus. Next, participants saw the four CS+s, two fear-relevant and two fear-irrelevant, presented simultaneously on the screen with the sentence "+electrical stimulus!" beneath them. Thereafter, they saw the two CS-s simultaneously on the screen together with the sentence "NO electrical stimulus!".

After these instructions, participants were warned that they would first go through a practice phase. In this phase, they were told, some of the electrical stimuli would be replaced by a picture of a lightning bolt in order to avoid administering too many electrical stimuli before the actual experiment starts. They were informed that on the next page they would see which photographs would be followed, during the practice phase, by the picture of the lightning bolt. On the following page, participants again saw all four CS+s. Two CS+s (CS+1s), one fear-relevant and one fear-irrelevant, were accompanied by the sentence "+electrical stimulus!" and the other two CSs (CS+2s), one fear-relevant and one fear-irrelevant, were accompanied by a plus sign and the placeholder US.

Finally, participants were warned that they would have to complete a short test about the instructions. In the first half of this test, participants were asked to indicate for each picture whether it could be followed by the electrical stimulus during the test phase. In the second half of the test, they were asked to indicate whether a picture would be followed by either the electrical stimulus, a picture of a lightning bolt or whether it would not be followed by the electrical stimulus during the practice phase. On each trial of this test, participants were shown a CS in the middle of the screen together with the possible response buttons (100 by 100 pixels): "shock", "no shock" and (only for trials related to the practice phase) "lightning bolt" depicted below it. Above the CSs, the sentence "Please select the correct option for the test(/practice) phase." was shown. Participants could select their answer by clicking one of the response buttons. Each CS was presented twice, once for the questions regarding the test phase and once for the questions regarding the practice phase (12 trials in total). Participants were required to select the correct answer on each trial. If they failed to do so, they received the instructions again and had to redo the test (average number of tests until pass = 1.81, *SD* = 0.95, range = 1-5).

3.3.2 Practice phase.

During the practice phase, CSs were presented on the screen for 8 seconds. CS presentation was preceded by fixation cross depicted for 4 s. The ITI was either 12, 14 or 16 s, randomly selected. Each CS was shown six times (36 trials total). Trial order was randomized with the restriction that maximally two consecutive trials could contain the same CS. On the first, third and last occurrence of the fear-relevant and fear-irrelevant CS+1, stimulus offset was followed by the electrical stimulus. Similarly, on the first, second and fifth occurrence of the fear-relevant and fear-irrelevant CS+2, stimulus offset was followed by the placeholder US. The practice phase was interrupted three times, after every twelve trials, for a rating block (see the Materials section).

3.3.3 Pre-test instructions, test phase and reinstatement.

Before the start of the test phase, participants were warned that all CS+s would now be predictive of the electrical stimulus. The trial procedure was identical to that of the practice phase, apart from omitting all US and placeholder US administration. Similarly, the test phase was interrupted three times for a rating block.

After the last rating block of the test phase, an unannounced US was presented. Next, each CS was presented two more times using the same trial procedure as in the test phase. The experiment ended with a final rating block.

3.3.4 Data analysis.

US expectancy ratings, fear ratings and SCRs were analyzed separately with repeated measures ANOVAs. Both the practice and the test phase were analyzed using an ANOVA with the within-subject factors CS (CS+1, CS+2, CS-), Fear-relevance (relevant or irrelevant) and Block (1 to 3). Additionally, an extra ANOVA was run to examine the reinstatement effect. Responses from the last block of the test phase and the reinstatement phase (factor Phase) were subjected to a repeated measures ANOVA with CS, Fear-relevance and Time (before or after reinstatement US) as within-subjects variables. As in Experiment 1, evidence for prepared learning can be provided by significant interactions between Fear-relevance and CS (facilitated acquisition), between Fear-relevance, CS and Block (resistance to extinction), or between Fear-relevance, CS and Phase (facilitated or inhibited reinstatement). Such interactions were followed up with specific *t*-tests. Greenhouse-Geisser corrections are reported when the sphericity assumption was violated and an alpha-level of .05 was applied.

3.4 Results

3.4.1 Questionnaires.

Trait STAI scores ranged between 21 and 59 with a mean of 36.83 (*SD* = 9.19). Because of the small sample, STAI scores were not included as a variable in the analyses. Participants indicated that the instructions were clear (*Range* = 5-10; *Mean* = 9.43; *SD* = 1.17) and believable (*Range* = 5-10; *Mean* = 8.77; *SD* = 1.42). Two participants who rated the believability as 5 were excluded from analyses[3].

3.4.2 US expectancy ratings.

3.4.2.1 Practice phase.

[3] As in Experiment 1, exclusion of these participants did not alter our conclusions.

The main effects of all three factors were significant: CS, $F(1.39, 48.57) = 218.50$, $p < .001$, $\eta^2_p = .86$; Fear-relevance, $F(1, 35) = 9.07$, $p = .005$, $\eta^2_p = .21$; Block, $F(2, 70) = 6.21$, $p = .003$, $\eta^2_p = .15$. The main effect of CS reflects significantly higher US expectancy ratings for CS+1, $F(1, 35) = 1291.37$, $p < .001$, $\eta^2_p = .97$, and CS+2, $F(1, 35) = 60.26$, $p < .001$, $\eta^2_p = .63$, compared to CS- (see Figure 2). Furthermore, US expectancy ratings were also significantly higher for CS+1s than for CS+2s, $F(1, 35) = 105.47$, $p < .001$, $\eta^2_p = .75$. The main effect of Fear-relevance was due to higher US expectancy ratings for fear-relevant CSs ($M = 4.39$, $SD = 0.91$) than for fear-irrelevant CSs ($M = 4.09$, $SD = 0.87$). The main effect of Block was due to gradually lower US expectancy ratings throughout the Practice phase (see Figure 2).

The main effects of CS and Block were partially qualified by an interaction between these two factors, $F(2.67, 93.34) = 3.39$, $p = .015$, $\eta^2_p = .09$. This interaction reflects changes in the difference between CS+1 and CS+2 over blocks. While US expectancy for CS+1 dropped from Block 1 to Block 2 and then remained constant, US expectancy for CS+2 slightly increased in Block 2 and then dropped in Block 3. Furthermore, and crucially, the interaction between CS and Fear-relevance, $F(1.69, 59.05) = 6.74$, $p = .004$, $\eta^2_p = .16$, was significant because of larger conditioning effects for the fear-relevant CS+2 ($M = 2.92$, $SD = 2.22$) than for the fear-irrelevant CS+2 ($M = 2.48$, $SD = 2.05$; $t(35) = 2.79$, $p = .008$, *Cohen's d* = .47) (see Figure 2).

Finally, neither the interaction between Fear-relevance and Block, $F < 1$, nor the three-way interaction between CS, Fear-relevance and Block, $F(3.29, 115.02) = 1.70$, $p = .167$, $\eta^2_p = .05$, was significant.

3.4.2.2 Test phase.

As in the Practice phase, all three main effects were significant: CS, $F(2, 70) = 157.07$, $p < .001$, $\eta^2_p = .82$, Fear-relevance, $F(1, 35) = 10.00$, $p = .003$, $\eta^2_p = .22$, Block, $F(1.73, 60.38) = 56.67$, $p < .001$, $\eta^2_p = .62$. These effects are due to similar patterns as in the Practice phase. Importantly, however, the difference between CS+1 and CS+2 was still significant, $F(1, 35) = 30.51$, $p < .001$, $\eta^2_p = .47$, despite instructions that both would be equally predictive of the shock during this phase.

Furthermore, the interaction between CS and Block was significant, $F(2.75, 96.16) = 30.14$, $p < .001$, $\eta^2_p = .46$. This interaction is due to decreasing US expectancy ratings for CS+1 and CS+2 throughout the test phase, while US expectancy remained similar for CS- (i.e., extinction; see Figure 2). The interaction between Fear-relevance and Block approached significance, $F(2, 70) = 2.72$, $p = .073$, $\eta^2_p = .07$, due to a slightly slower decrease of US expectancy ratings throughout the Test phase for fear-relevant CSs (see Figure 2).

The crucial interactions between CS and Fear-relevance, $F(1.65, 57.68) = 1.95$, $p = .159$, $\eta^2_p = .05$, and between CS, Fear-relevance and Block, $F < 1$, did not reach significance in the test phase.

3.4.2.3 Reinstatement effect.

Only the main effect of CS was significant, $F(1.68, 58.91) = 78.15$, $p < .001$, $\eta^2_p = .69$, again reflecting the same differences between CSs as in the practice phase. The effects of all other main and interaction effects did not reach significance threshold, *F'*s < 2.1, *p*-values > .15.

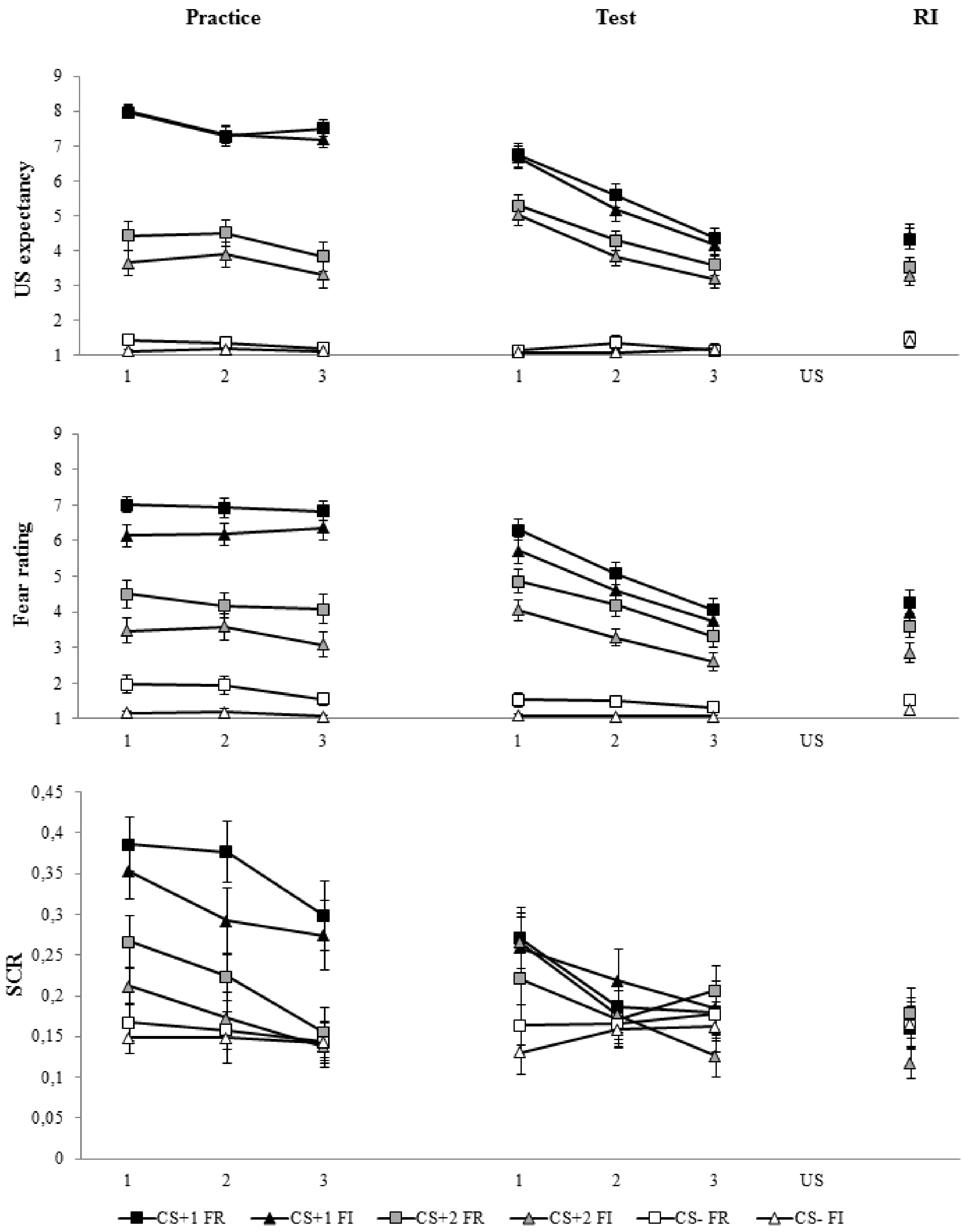

Figure 2. Mean US expectancy ratings, fear ratings and SCRs for all CSs throughout Experiment 2. Error bars represent Standard Error. RI = reinstatement; FR = fear-relevant; FI = fear-irrelevant; CS+1 = instructed + paired with US; CS+2 = instructed.

3.4.3 Fear ratings.

3.4.3.1 Practice phase.

Both the main effects of CS, $F(2, 70) = 135.16$, $p < .001$, $\eta^2_p = .79$, and of Fear-relevance, $F(1, 35) = 24.79$, $p < .001$, $\eta^2_p = .42$, were significant. The main effects of CS reflects higher fear ratings for CS+1s, $F(1, 35) = 349.61$, $p < .001$, $\eta^2_p = .91$, and CS+2s, $F(1, 35) = 54.61$, $p < .001$, $\eta^2_p = .61$, than for CS-s. Fear ratings for CS+1s were in turn higher than for CS+2s, $F(1, 35) = 66.43$, $p < .001$, $\eta^2_p = .66$ (see Figure 2). The effect of Fear-relevance is explained by higher fear ratings for fear-relevant CSs than for fear-irrelevant CSs (see Figure 2). All other main and interaction effects were not significant, *F'*s < 1.7, *p*-values > .2.

3.4.3.2 Test phase.

The main effects of all three main factors were significant: CS, $F(1.70, 59.54) = 113.69$, $p < .001$, $\eta^2_p = .77$, Fear-relevance, $F(1, 35) = 13.39$, $p = .001$, $\eta^2_p = .28$, Block, $F(1.39, 48.80) = 53.39$, $p < .001$, $\eta^2_p = .60$. The first two effects reflect similar patterns as in the Practice phase. Importantly, the difference between CS+1s and CS+2s remained significant in the Test phase, $F(1, 35) = 31.15$, $p < .001$, $\eta^2_p = .47$, despite instructions that both would be equally predictive of the US during this phase.

Furthermore, the interaction between CS and Block was significant, $F(2.26, 78.94) = 24.77$, $p < .001$, $\eta^2_p = .41$, due to decreasing fear ratings for the CS+1s and CS+2s throughout the Test phase while fear ratings for the CS-s remained constant (i.e., extinction; see Figure 2).

The interactions related to the factor Fear-relevance failed to reach significance: interaction between CS and Fear-relevance, $F(1.64, 57.46) = 2.31$, $p = .118$, $\eta^2_p = .06$;

interaction between Block and Fear-relevance, $F(2, 70) = 1.75$, $p = .182$, $\eta^2_p = .05$; three way interaction between CS, Trial and Fear-relevance, $F < 1$.

3.4.3.3 Reinstatement effect.

Both the main effects of CS, $F(1.68, 58.74) = 65.15$, $p < .001$, $\eta^2_p = .65$, and of Fear-relevance, $F(1, 35) = 12.19$, $p = .001$, $\eta^2_p = .26$, were significant. Importantly, the main effect of Time approached significance, $F(1, 35) = 3.73$, $p = .062$, $\eta^2_p = .10$, due to higher fear ratings after the reinstatement US compared to before (see Figure 2).

The only interaction effect that approached significance was that between CS and Fear-relevance, $F(1.76, 61.61) = 3.03$, $p = .062$, $\eta^2_p = .08$. This interaction was due to larger conditioning effects for the fear-relevant CS+2 ($M = 2.01$, $SD = 1.58$) than for the fear-irrelevant CS+2 ($M = 1.58$, $SD = 1.25$; $t(35) = 2.39$, $p = .023$, *Cohen's d* = .40) (see Figure 2). The other interaction effects were not significant, *F'*s < 1.

3.4.4 SCRs.

3.4.4.1 Practice phase.

The main effect of CS was significant, $F(1.40, 49.09) = 33.36$, $p < .001$, $\eta^2_p = .49$. This was due to significantly stronger SCRs for CS+1s, $F(1, 35) = 43.02$, $p < .001$, $\eta^2_p = .55$, and CS+2s, $F(1, 35) = 9.88$, $p = .003$, $\eta^2_p = .22$, compared to CS-s (see Figure 2). Furthermore, SCRs to CS+1s were in turn significantly stronger than to CS+2s, $F(1, 35) = 28.99$, $p < .001$, $\eta^2_p = .45$. The main effects for Fear-relevance, $F(1, 35) = 6.71$, $p = .014$, $\eta^2_p = .16$, and for Block, $F(1.70, 59.35) = 7.05$, $p = .003$, $\eta^2_p = .17$, were also significant. The former was due to stronger SCRs to fear-relevant CSs than to fear-irrelevant CSs, while the latter was the result of gradually lower SCRs for all CSs throughout the practice phase (see Figure 2). None of the interaction effects between these factors was significant, all *F'*s < 1.5.

3.4.4.2 Test phase.

Both the main effects of CS, $F(1.63, 56.97) = 4.24$, $p = .026$, $\eta^2_p = .11$, and of Block, $F(1.61, 56.31) = 4.79$, $p = .018$, $\eta^2_p = .12$, were significant. The main effect of CS was due to stronger SCRs to CS+1s, $F(1, 35) = 5.78$, $p = .025$, $\eta^2_p = .14$, and marginally stronger SCRs to CS+2s, $F(1, 35) = 3.35$, $p = .076$, $\eta^2_p = .09$ than to CS-s (see Figure 2). Importantly, the difference between CS+1s and CS+2s was not significant, $F(1, 35) = 2.00$, $p = .166$, $\eta^2_p = .05$, which is in line with the instructions that both CSs would be equally predictive of the US during the Test phase.

Furthermore, the interaction between CS and Block was also significant, $F(4, 140) = 3.32$, $p = .012$, $\eta^2_p = .09$, which was due to gradually decreasing SCRs for CS+1s and CS+2s while SCRs to the CS-s remained constant (extinction, see Figure 2).

The main effect of Fear-relevance, $F < 1$, and the crucial interactions between CS and Fear-relevance, $F < 1$, Block and Fear-relevance, $F < 1$, and between CS, Block and Fear-relevance, $F(4, 140) = 1.34$, $p = .257$, $\eta^2_p = .04$, did not reach significance.

3.4.4.3 Reinstatement effect.

The only significant effect observed was the interaction between factors CS and Fear-relevance, $F(2, 70) = 3.73$, *p*-value = .029, $\eta^2_p = .10$. This interaction was due to larger differential SCRs to the fear-relevant CS+2 ($M = 0.02$, $SD = 0.16$) than to the fear-irrelevant CS+2 ($M = -0.04$, $SD = 0.14$; $t(35) = 2.08$, $p = .045$, *Cohen's d* = .35; see Figure 2). The main effects of and interaction effects of the other factors did not reach significance: main effect of Fear-relevance, $F(1, 35) = 2.26$, $p = .142$, $\eta^2_p = .06$; all other F's < 1.

3.5 Discussion

In Experiment 2, we again obtained acquisition and extinction of fearful CRs on the basis of verbal instructions on all collected measures. A reinstatement manipulation only generated a trend for increased fear ratings for all CSs, but did not generate effects for US expectancy and SCRs. Furthermore, in line with the results of Raes et al. (2014), we observed additional effects of previous CS-US pairings for both fear ratings and US expectancy ratings in the test phase, while such an effect was not significant for SCRs.

Regarding our main research question, however, no evidence was obtained for the hypothesis that selective learning effects are especially pronounced for the fear-relevant CS+ that had actually been paired with the US as compared to the fear-relevant CS+ that was merely involved in verbal instructions. On the contrary, during the practice phase, conditioning effects were especially pronounced for the fear-relevant *verbally conditioned* CS+. Specifically, conditioning effects for the fear-relevant CS+2 were stronger than those for the fear-irrelevant CS+2 on US expectancy ratings during the practice phase and for fear ratings and SCRs at the time of the reinstatement manipulation.

4. Bayesian Analysis of Experiment 1 and 2

We performed Bayesian analyses to complement the traditional analyses of Experiment 1 and 2. There are a number of advantages of using Bayesian statistics over classical null hypothesis significance testing, which we will not all reiterate here (arguments for using Bayesian analyses can be found in, Dienes, 2011, and Rouder, Speckman, Sun, Morey, & Iverson, 2009). With regard to our own research questions, performing Bayesian analyses allowed us to (a) evaluate to what extent non-significant effects actually provided evidence for the null hypothesis (i.e., the absence of preparedness effects) (Dienes, 2014); and (b) interpret the evidence for preparedness effects from the different tests we have conducted, without being confronted with the multiple testing problem (Dienes, 2011).

The primary tool for statistical inference in a Bayesian framework is the Bayes Factor (BF). The BF expresses the likelihood of the alternative hypothesis relative to the null hypothesis. For instance, a BF of 2 would indicate that the likelihood of the alternative hypothesis being true based on the data is two times larger than the null hypothesis being true. In line with Jeffreys (1961; see also: Andraszewicz et al., 2015), we consider BFs larger than 3 (moderate evidence) or larger than 10 (strong evidence) as providing evidence for the alternative hypothesis. Likewise, BFs smaller than 0.33 (moderate evidence) or smaller than 0.10 (strong evidence) were considered as evidence for the null hypothesis. BFs between three and 0.33 are considered to provide only anecdotal evidence for either the null or alternative hypothesis. BFs for our different tests of preparedness in the two experiments were calculated using Bayesian repeated measures (with default priors; see: Rouder, Morey, Speckman, & Province, 2012) in JASP (version 6.0; Love et al., 2014) and are summarized in Tables 1 to 3.

As can be seen in Tables 1 to 3, most tests of preparedness in both experiments provided moderate (BF < 0.33) to strong (BF < 0.1) evidence for an absence of a preparedness effect. However, in a few instances, the overall test for preparedness effects was inconclusive (i.e., a BF > 0.33 and < 3). Specifically, this was the case for the interaction between fear-relevance and CS in the practice phase for US expectancy ratings and the interactions between fear-relevance and CS in the test phase and at the time of the reinstatement manipulation for fear ratings (see Tables 1 and 3). When these interactions were analyzed further using Bayesian paired samples t-test (Cauchy prior width = 0.707), evidence for preparedness effects (i.e., larger differential conditioning for the fear-relevant CS+ than for the fear-irrelevant CS+) were obtained for CS+2. That is, moderate evidence for preparedness effects for the fear-relevant CS+2 was obtained on US expectancy ratings in the practice phase (BF = 4.89) and on fear ratings in the test phase (BF = 3.11). At the time of the reinstatement manipulation, there was anecdotal evidence for larger differential fear ratings for the fear-relevant CS+2 (BF = 2.13). In contrast, corresponding tests for the CS+1s resulted in moderate evidence for an absence of preparedness effects (BFs < 0.3; see also Figure 2).

Taken together, these results demonstrate that our data provided moderate to strong evidence for an absence of most of the potential preparedness effects in our experiments. However, in cases of uncertainty with regard to the presence of preparedness effects, our data favored the conclusion that preparedness effects were present for the fear-relevant CS+2.

Table 1. *F*-values, *p*-values and BF's for the different tests for preparedness effects for US expectancy ratings.

	F-value	*p*-value	BF
Experiment 1			
Extinction phase			
Fear-relevance*CS	$F(1, 28) = 1.93$	.176	0.032
Fear-relevance*CS*Trial	$F(3.58, 100.17) = 1.91$	.122	< 0.001
Reinstatement			
Fear-relevance*CS*Time	$F(1, 28) = 2.03$	.165	0.023
Experiment 2			
Practice phase			
Fear-relevance*CS	$F(1.69, 59.05) = 6.74$	.004	0.509
Fear-relevance*CS*Trial	$F(3.29, 115.02) = 1.70$	.167	< 0.001
Test phase			
Fear-relevance*CS	$F(1.65, 57.68) = 1.95$	.159	0.082
Fear-relevance*CS*Trial	$F < 1$	.821	< 0.001
Reinstatement			
Fear-relevance*CS	$F(2, 70) = 1.20$	.308	0.033
Fear-relevance*CS*Time	$F(2, 70) = 1.23$	.300	< 0.001

Table 2. *F*-values, *p*-values and BF's for the different tests for preparedness effects for SCRs.

	F-value	*p*-value	BF
Experiment 1			
Extinction phase			
Fear-relevance*CS	*F* < 1	.867	0.021
Fear-relevance*CS*Trial	*F* < 1	.815	< 0.001
Reinstatement			
Fear-relevance*CS*Time	*F* < 1	.942	0.008
Experiment 2			
Practice phase			
Fear-relevance*CS	*F*(2, 70) = 1.02	.368	0.107
Fear-relevance*CS*Trial	*F* < 1	.868	< 0.001
Test phase			
Fear-relevance*CS	*F* < 1	.592	0.010
Fear-relevance*CS*Trial	*F*(4, 140) = 1.34	.257	< 0.001
Reinstatement			
Fear-relevance*CS	*F*(2, 70) = 3.73	.029	0.041
Fear-relevance*CS*Time	*F* < 1	.954	< 0.001

Table 3. F-values, *p*-values and BF's for the different tests for preparedness effects for fear ratings. Note that fear ratings were only collected in Experiment 2.

	F-value	*p*-value	BF
Practice phase			
Fear-relevance*CS	$F < 1$	.683	0.091
Fear-relevance*CS*Trial	$F(3.20, 112.06) = 1.42$	.238	< 0.001
Test phase			
Fear-relevance*CS	$F(1.64, 57.46) = 2.31$	.118	0.350
Fear-relevance*CS*Trial	$F < 1$	.872	0.002
Reinstatement			
Fear-relevance*CS	$F(1.76, 61.61) = 3.03$	.062	0.384
Fear-relevance*CS*Time	$F < 1$	.962	< 0.001

5. General Discussion

Two experiments were conducted to assess whether selective learning effects can be obtained when conditioning is established via verbal instructions. In the first experiment, participants were verbally instructed about the contingency between fear-relevant and fear-irrelevant CSs and an electrical stimulus. In the second experiment, we additionally manipulated whether the contingency described in the instructions was actually experienced by the participants, using a design developed by Raes et al. (2014). This allowed us to test whether selective learning depends on actual experience of the fear-relevant CS-US pairing. As a secondary aim, we also examined reinstatement of fear induced by verbal instructions.

Below we will first summarize and discuss the findings related to selective learning. Afterwards, we focus on the reinstatement results.

In both experiments, participants reacted more fearfully towards instructed CS+s than to CS-s. These fearful reactions tended to extinguish throughout the test phase. These results replicate the well-known finding that fear conditioning can be observed on the basis of verbal instructions (Cook & Harris, 1937; Grings, 1973; Lovibond, 2003). However, the extinction of fear reactions was not modulated by the fear-relevance of the CSs in either experiment. Hence, we did not find evidence for resistance to extinction when learning took place via verbal instructions, even when participants had experienced the instructed CS-US pairings in Experiment 2. This result is in contrast with those from Hugdahl (1978), who did find strong resistance to extinction for fear-relevant CS+s on the basis of verbal instructions, but is reminiscent of the results of several subsequent studies that failed to replicate this effect (see: Lovibond, 2004; McNally, 1981; 1987).

In Experiment 2, however, stronger acquisition effects were observed for fear-relevant verbally conditioned CSs compared to fear-irrelevant verbally conditioned CSs. This result can be regarded as an instance of selective learning (i.e., stronger acquisition) and is in line with the results of the only relevant study (i.e., Hugdahl & Öhman, 1977). Specifically, this effect was observed during the practice phase for US expectancy ratings and at the time of the reinstatement US for fear ratings and SCRs. Surprisingly, this selective learning effect was specifically observed for the CS that was merely instructed to be contingent with the US (CS+2), but not for the CS that was instructed and actually paired with the US (CS+1). Our Bayesian analyses confirmed that there was substantial evidence for this preparedness effect on the US expectancy ratings and fear ratings for the CS+2s. Conversely, there was substantial evidence for an *absence* of preparedness effects on all different measures of conditioned fear for the CS+1s.

Hence, some aspects of our results suggest that selective learning effects can be obtained when conditioning is established on the basis of verbal instructions. Furthermore, our results provide no indication that actual CS-US pairings strengthen selective learning effects. On the contrary, we obtained selective learning effects specifically for the CS that was *not* actually paired with the US in Experiment 2.

These results do not fit well with the proposal that an evolved fear learning module explains selective learning effects (Mineka & Öhman, 2002; Öhman & Mineka, 2001). As mentioned before, this module is thought to be specifically and automatically activated by fear-relevant stimuli and to be encapsulated from conscious cognitive control. Based on this model, we would predict that selective learning would not be observed when conditioning is established through verbal instructions, unless the CSs are actually paired with the US (Olsson & Phelps, 2004, 2007). However, we obtained the opposite pattern of results in Experiment 2: selective learning was observed on the basis of verbal instructed conditioning and only for the CSs that were *not* paired with the US. Furthermore, if prepared learning is due to affective learning, prepared learning effects should have been particularly pronounced on measures that are thought to be particularly sensitive to capture this type of learning (i.e., fear ratings; Mertens et al., 2015; Soeter & Kindt, 2012). This was not the case in our results. If anything, according to our Bayesian analyses, preparedness effects seemed to be especially pronounced on US expectancy ratings, which is considered to be a cognitive measure of learning (e.g., Kindt, Soeter, & Vervliet, 2009).

We believe that our results fit better with the expectancy bias model of Davey (Davey, 1992; Honeybourne, Matchett, & Davey, 1993). According to this model, fear-relevant CSs are accompanied by a bias to expect aversive events before any conditioning has taken place. This bias rapidly disappears when the fear-relevant CSs are not reinforced but is maintained when fear-relevant CSs are reinforced, resulting in an expectancy bias specifically for the fear-relevant CS+. This bias is translated into stronger conditioned reactions on other measures, such as SCRs (Davey, 1992; Lovibond, Siddle, & Bond, 1993). In our Experiment 2, selective learning effects were obtained on US expectancy ratings, replicating the US expectancy bias effect of Davey (1992) and Lovibond et al. (1993). Arguably, the no-reinforcement instructions rapidly abolished the expectancy bias for the fear-relevant CS- whereas the threat instructions retained the expectancy bias for the fear-relevant CS+2, resulting in a selective learning effect on US expectancy ratings. However, in our experiment, the US expectancy bias is not accompanied by selective learning effects on other measures during the practice phase. Only later in the experiment, at the time of the reinstatement shock, are selective learning effects obtained for SCRs and fear ratings (but not US expectancy, see Figure 2). These inconsistencies between US expectancy ratings and other measures do not fit with the expectancy bias model of Davey (1992) and may be accounted for by subtle differences in the measures. However, taken together, selective learning effects are most pronounced on US expectancy ratings, and therefore we believe that our data are best accounted for by the model of Davey (1992).

It is still not clear, however, why selective learning effects are obtained for the fear-relevant CS+2, but not for the fear-relevant CS+1 or for the fear-relevant CS+ in Experiment 1. We propose that expectancy bias for fear-relevant threatened CSs is especially pronounced under conditions of uncertainty. While uncertain, there is opportunity for expectancy biases to shift conditioned responses. In our own experiment, there is most uncertainty for the CS+2s, as indicated by the US expectancy ratings for these CSs that are situated in the middle of the scale. For the CS+1s the training phase of Experiment 2 and for CS+s in Experiment 1, US expectancy ratings are at an extreme end of the scale. These differences in uncertainty might explain why we observe selective learning for CS+2s but not for CS+1s. Indeed, research on expectancy biases of anxious populations has shown that these biases are especially pronounced under conditions of uncertainty (Calvo & Dolores Castillo, 2001; Chan & Lovibond, 1996; Ly & Roelofs, 2009). However, while there is some suggestive correlational evidence showing that the spatiotemporal uncertainty of aversive events (US) related to the CS makes this CS fearful (Harald Merckelbach, van den Hout, Jansen, & van der Molen, 1988), our suggestion that expectancy biases for fear-relevant CSs are especially pronounced under uncertainty remains to be explicitly tested (for instance by manipulating the CS-US contingency).

Whereas our data are generally in correspondence with the expectancy bias model of Davey (1992), our experiments did not include a replication of the resistance to instructed extinction effect (Hugdahl & Öhman, 1977; Hugdahl, 1978). This effect strongly favors the theory of a fear learning module because it shows that fear for fear-relevant CSs seems to be insensitive to cognitive interventions once it has been installed (Öhman & Mineka, 2001). Interestingly, Hugdahl (1978) and Öhman and Hugdahl (1977) show that verbal threat instructions can install prepared learning, but safety instructions do not disrupt this learning. Thus, the limitations of learning via verbal instructions may be primarily pronounced during safety (i.e., extinction) learning (see also: Luck & Lipp, 2015 and Sevenster et al., 2012 for related results). However, as mentioned previously, this effect has proven difficult to reproduce in subsequent experiment (see: Lovibond, 2004; McNally, 1981; 1987). It would certainly be worthwhile for future studies to further explore this intriguing finding. This could help us to pinpoint the conditions under which the effect occurs and, in doing so, map the possible limitations of learning through instructions. Furthermore, we want to stress that the systematic inclusion of expectancy ratings in these studies is necessary to evaluate whether these effects could be explained by expectancy biases, or are independent of higher-order cognitions as proposed by Öhman and Mineka (2001).

Finally, we turn to the issue of reinstatement. We observe a selective return of US expectancy ratings and SCRs to the CS+s in the first experiment, and marginally increased fear ratings for all CSs in the second experiment after the reinstatement US. This is the first study, to our knowledge, to demonstrate differential reinstatement on US expectancy ratings and SCRs when conditioning was established on the basis of verbal instructions (Haaker et al., 2014). This is an interesting finding because it suggests that similar mechanisms of return of fear may exist for fear acquired through verbal instructions and fear acquired through direct CS-US pairings (see also: Mertens et al., 2015). Unfortunately, due to the absence of (strong) preparedness effects in our experiments, it is difficult to evaluate the (lack of) impact of fear-relevance on the return of fear through reinstatement. As we noted in the final paragraph of the introduction, stronger acquisition and/or less extinction for fear-relevant CSs are probably necessary conditions to observe an effect of fear-relevance on subsequent reinstatement of fear. Hence, the fact that reinstatement effects in our studies were similar for fear-relevant and fear-irrelevant CSs could simply be due to the limited effect of fear-relevance on acquisition and extinction. It would certainly be interesting for future studies to further investigate the impact of fear-relevance on the return of fear through reinstatement or other manipulations in situations where there are strong preparedness effects in the preceding acquisition or extinction phase.

In summary, our data suggest that selective learning can be obtained when conditioning is established through verbal instructions, without requiring direct CS-US pairings. Our results further suggest that these selective learning effects are due to US expectancy biases for fear-relevant CSs, which are proposed to be especially pronounced under conditions of uncertainty. Finally, our results revealed reinstatement of fear that was induced by verbal instructions, but reinstatement was not modulated by fear relevance.

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