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Learned, instructed and observed pathways to fear and avoidance

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ABSTRACT

Background and objectives: Conditioned fear may emerge in the absence of directly experienced conditioned stimulus (CS) – unconditioned stimulus (US) pairings. Here, we compared three pathways by which avoidance of the US may be acquired both directly (i.e., through trial-and-error instrumental learning) and indirectly (i.e., via verbal instructions and social observation).
Methods: Following fear conditioning in which CS+ was paired with shock and CS− was unpaired, three separate groups of participants learned by direct experience (Instrumental-learning), were instructed about (Instructed-learning), or observed (Observational-learning) a demonstrator performing an avoidance response that canceled upcoming US (shock) presentations. Groups were then tested in extinction with presentations of the directly experienced CS+ and CS−, and either a novel CS (Instrumental and observational groups) or an instructed CS (instructed-group).
Results: Similar to instrumental learning, results demonstrate that avoidance may be acquired via instructions and social observation in the absence of directly learning that an avoidance response prevents the US. Retrospective US expectancy ratings were modulated by the assumed presence or absence of avoidance. Overall, these findings suggest that instrumental-, instructed-, and observational-learning pathways to avoidance in humans are similar.
Limitations: Alternative experimental designs would permit direct comparison between the pathways for stimuli with no prior experience of fear conditioning, and trial-by-trial US expectancy ratings would help track the modulation of fear by avoidance pathway.
Conclusions: Instrumental-, instructed-, and observational-learning pathways of avoidance are similar. Findings may have implications for understanding the etiology of clinical avoidance in anxiety.

1. Introduction

The fear-conditioning paradigm is widely used to investigate the behavioral processes underpinning anxiety (Beckers, Krypotos, Boddez, Effting, & Kindt, 2013; Boddez, Baeyens, Hermans, & Beckers, 2014). In this paradigm, a neutral stimulus (the conditioned stimulus; CS+), is repeatedly paired with an aversive, unconditioned stimulus (US), such as a brief electric shock, and comes to elicit a conditioned fear response (CR), in the absence of the US. Another cue (CS−) is never paired with shock and as a result takes on the functions of safety relative to the threat properties of the CS+. An instrumental avoidance response made in the presence of the CS+, which cancels upcoming US presentations, may then be added to this procedure to study acquisition and maintenance of avoidance. The behavioral dynamics of fear-conditioning paradigms such as this are generally considered to be important translational models of the acquisition of debilitating fear and avoidance behavior in anxiety disorders (Dymond & Roche, 2009; Vervliet & Raes, 2013).

It is notable that individuals with anxiety do not always report prior direct conditioning episodes like those described in fear-conditioning studies (Beckers et al. 2013; Coelho & Purkis, 2009; Muris, Merckelbach, de Jong, & Ollendick, 2002; Ost & Hugdahl, 1983). To account for these cases, Rachman (1977) first postulated alternative pathways to fear. That is, Rachman argued the environment provides other, indirect means of learning fear-relevant information, which can then be used to avoid potential harm, without the need to directly experience either the aversive event or the

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behavior that prevents it (here, defined as differential Pavlovian fear-conditioning and instrumental learning of avoidance). These indirect pathways include *verbal instruction* and *social observation.* The verbal instruction (or information) pathway relies on knowledge provided by another individual about CS–US pairings or the role of instrumental avoidance in canceling US delivery. The social observation pathway relies on the transmission of information obtained by viewing another individual experience the relevant CS–US pairings and performing the instrumental avoidance response. To date, limited research has been conducted on Rachman's pathways to fear account and those studies that have been conducted have focused near-exclusively on fear (Askew & Field, 2007; Field, Argyris, & Knowles, 2001; Kelly, Barker, Field, Wilson, & Reynolds, 2010; Muris & Field, 2010; Olsson & Phelps, 2004, 2007). For example, Olsson and Phelps (2004) compared fear learning acquired through direct (CS–US pairings) and indirect experience (instructions and observation) and found similar levels of fear learning across all three groups, as measured by skin conductance response (SCR). These findings have been supported by studies using functional magnetic resonance imaging (fMRI) identifying activation in the amygdala for both direct and observed pathways (Olsson, Nearing, & Phelps, 2007) and correlations between SCR and amygdala activation during instructed pathways (Phelps, Connor, Gatenby, Gore, & Davis, 2001), suggesting a common neural circuitry underlying direct and indirect pathways to fear.

Avoidance is a basic coping strategy driven by the anticipation of threat and/or further fear (Aldao, Nolen-Hoeksema, & Schweizer, 2010). Surprisingly little is known about the potentially different pathways by which avoidance may be acquired and whether they result in equivalent levels of maintained avoidance under extinction. There is, however, a growing body of evidence to suggest that avoidance can be acquired vicariously, in the absence of either direct CS–US pairings or experience of the avoidance response canceling the US, through one such pathway: verbal information (Dymond, Schlund, Roche, De Houwer, & Freegard, 2012; see also, Olsson & Phelps, 2004; Phelps et al., 2001). Dymond et al. (2012) not only demonstrated the acquisition of avoidance responding via learned and instructed pathways, but also that the proportion of avoidance was equivalent between these routes. In their study, a fear-conditioning procedure was employed in which one CS was paired with shock (CS+) and another was not (CS−). Using a between-subjects design, one group then directly learned that avoidance canceled an impending US and another group were *instructed* that avoidance canceled the US. The latter group were also presented with a second instructed CS, which participants were verbally instructed would be followed by a US. The two groups reported greater shock expectancy ratings for the CS+ relative to the CS− and made a greater proportion of avoidance responses to the CS+ than the CS−. Furthermore, the instructed group did not differ in avoidance or ratings towards the instructed CS compared to the directly learned CS+. These results show that despite the different pathways by which avoidance was acquired, avoidance levels did not differ.

The present study sought to extend the findings of Dymond et al. (2012) by including an observed avoidance pathway. This would allow for a well-controlled simultaneous comparison of the three major pathways of avoidance acquisition with a single paradigm. The inclusion of an observed pathway is important because the behavior of others provides a rich source of information that individuals use to model their own behavior in order to avoid potential harm. Social fear learning affords the transmission of biologically relevant information between individuals and is a likely driving force in human evolution, which has allowed humans to readily understand and imitate the actions of others (Boyd & Richerson, 1985; Boyd, Richerson, & Henrich, 2011). This idea is supported by evidence from the fear conditioning literature which shows that observing the arm movement of another person in response to a shock, can generate fear. Interestingly, this was only the case when the observer believed that it was caused by a shock and not when the model's arm moves without a shock or when a shock is delivered without arm movements (Berger, 1962; see also, Helsen, Goubert, & Vlaeyen, 2013). This suggests that observing an actor avoid an aversive outcome by making an avoidance response in the presence of threat-related cues would result in an understanding of those cues as being potentially threatening leading to the same level of avoidance behavior to that observed (Olsson et al., 2007).

We predicted that groups would not differ following fear conditioning; retrospective US expectancy ratings for CS+ were expected to be greater relative to CS−. Furthermore, after avoidance learning, we expected all groups to make a greater proportion of avoidance responses to CS+ relative to CS−, give lower retrospective US expectancy ratings in the assumed presence of avoidance and higher ratings in the assumed absence of avoidance to CS+ relative to CS−. We also predicted that this trend would be maintained during extinction testing and that levels of avoidance and US expectancy ratings occasioned by either a novel CS or an instructed CS would not differ.

2. Method

2.1. Participants

Eighty-three participants, 22 men and 61 women (*M* age = 21.16, *SD* = 4.64) were randomly assigned to one of three groups: Instrumental-learning, Instructed-learning, and Observational-learning. Due to a programing error, one participant's behavioral and ratings data from the Instructed-learning group was removed from analysis of the avoidance learning and test phases. One participant's behavioral data from the Instrumental-learning group was also removed from analysis of the avoidance learning and test phases due to a programing error. Two participants were removed from the Instrumental-learning group for failing to meet criterion during avoidance learning. The final sample sizes included participants who contributed to the analysis of one or more dependent measures: Instrumental-learning ($n = 26$; 9 men), Instructed-learning ($n = 28$; 5 men), and Observational-learning ($n = 26$; 8 men). All participants provided written informed consent and were compensated with either course credit or £5. The Department of Psychology Ethics Committee approved the study.

2.2. Apparatus and material

Stimuli consisted of three colored circles (red, blue and yellow) presented on a white background, which served as the CSs for all groups. Stimuli were presented on a 17″ computer screen with a 60 Hz refresh rate through a program written in Visual Basic.NET. Electric shocks (250 ms duration), delivered via a bar electrode fitted to each participant's non-dominant forearm, served as the US and were controlled by an isolated stimulator (STM200-1, BIOPAC Systems, Santa Barbara, CA). At the outset, all groups underwent a shock calibration procedure in which they selected a shock level that was “uncomfortable, but not painful”.

2.3. Procedure

The procedure consisted of four phases: pre-conditioning, fear conditioning, avoidance learning and extinction. All groups experienced the same pre-conditioning and fear conditioning phases, and extinction phases, but differed in the avoidance learning phase (for an overview of the procedures, see Fig. 1). Stimuli were presented for 3 s followed by an intertrial interval (ITI) of 6 s. The order of stimulus presentation was quasi-randomized within each phase, with the constraint that no more than two consecutive trials of either type could occur.

2.3.1. Pre-conditioning

Here, participants were presented with one of two colored circles, the CS+ and CS− (red and blue circles, counterbalanced), each presented in the center of the screen 3 times in the absence of shock (6 trials in total).

2.3.2. Fear conditioning

Participants were informed that on every trial they would be presented with one of two colored circles which would be followed by either shock or no shock and that the shock was set at the level they had selected. CS+ and CS− trials were each presented 6 times (12 trials in total). Shock was presented following offset of all CS+ trials (i.e., a 100% CS–US reinforcement schedule). Shock never followed CS− presentations. After the 12th trial, participants rated their expectancy of shock using a 7-point scale (where 0 = *not at all* and 6 = *very likely*).

2.3.3. Avoidance learning

During the avoidance learning phase, the Instrumental-learning and Instructed-Learning groups were both presented with the previously seen CS+ and CS−, and informed that when colored circles appeared on screen the two marked keys on the keyboard would be available and that pressing one of the keys in the presence of one colored circle will cancel upcoming shock. The correct key was counterbalanced across participants. The CS+ and CS− were each presented 6 times in a block of 12 trials. In addition, the Instructed-learning group was also presented with an instructed CS (a colored circle not presented during fear conditioning) and was given further instructions that when the yellow circle was presented, (instructed CS) they should press the marked key on the right/left (counterbalanced) to prevent upcoming shock. For the Instructed-learning group, this necessitated a block of 18 trials (i.e., CS+, CS− and Instructed CS each 6 times in a quasi-random order). When the correct key was pressed in the presence of the CS+, the upcoming shock was canceled. For both the Instrumental-learning and Instructed-learning groups, shock was presented following offset of the CS+, unless the correct key was pressed (please contact the first author for a copy of the actual instructions used). Shock never followed any CS− or, where relevant, Instructed CS presentations. Following the final trial, US expectancy ratings were made when the avoidance response was and was not assumed to be present.

The Observational-learning group did not experience any learning trials but instead watched a short video recording of a demonstrator participating in the same experiment (see Fig. 1). Prior to watching the video, they were told that they would observe a person taking part an experiment similar to the one that they themselves would be taking part in after the video had ended. They were also told that the person in the video would learn to press one of the keys to cancel an upcoming shock and that they should pay close attention to the key presses because they too would have to learn to press a key in order to cancel upcoming shocks. Participants in the Observational-learning group observed a total of 12 trials (i.e. CS+ and CS− each presented 6 times) in which avoidance always occurred in the presence of the CS+ and never in the presence of the CS−. Therefore, no shocks were administered to either the demonstrator or participant in this phase.

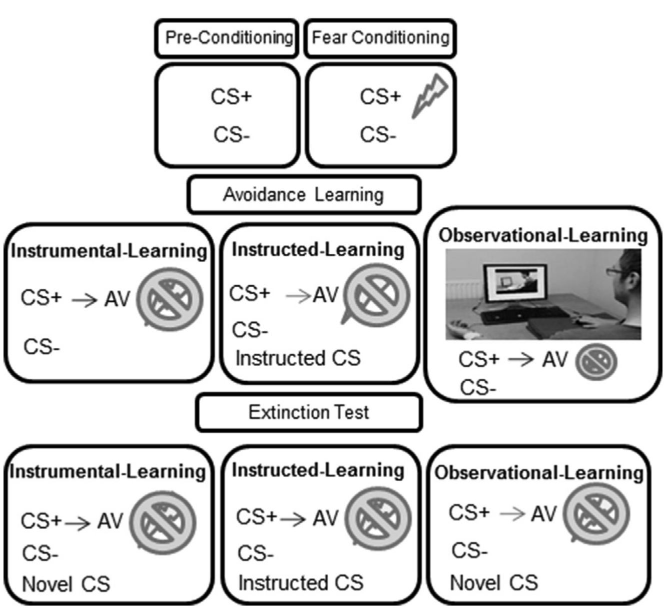

Fig. 1. Schematic overview of the experimental design. All groups received pre-conditioning, fear conditioning, avoidance learning, and extinction test phases. During the avoidance learning phase, the Instructed-learning group was presented with an additional, instructed CS and the Observational-learning group viewed a video of a male demonstrator making the correct avoidance response to the CS+ but not in the presence of the CS−. Crossed circles represent the absence of shock following avoidance.

2.3.4. Extinction test

This phase began immediately following avoidance learning. For all groups, the CS+ and CS− were each presented 6 times. The Instructed-learning group also received 6 presentations of the Instructed CS, while the Instrumental-learning and Observational-learning groups received 6 trials of a novel CS (see Fig. 1). No shocks were presented in this phase. Once again, participants made retrospective US expectancy ratings for each stimulus in the assumed presence and absence of avoidance, respectively.

2.4. Data analysis

During fear conditioning, mean ratings of the likelihood of shock following the CS+ and CS− were measured. During the avoidance learning phase, the mean number of trials during which the avoidance response was and was not performed and mean ratings of the likelihood of shock following the CS+, CS− and, for the Instructed-learning group, the Instructed CS+, were recorded. No analysis was computed for the Observational-learning group during this phase as no data were collected. During the extinction test, the total number of trials in which the avoidance response was and was not performed, and mean ratings of the likelihood of shock following the CS+, CS−, Instructed CS and novel CS with and without the assumed presence of avoidance, were recorded. For the instrumental and instructed groups, a minimum criterion of 5/6 avoided directly learned CS+ trials during both the avoidance learning and extinction test phases was applied. This criterion ensured that stable avoidance in the presence of the learned CS+, with which all groups had direct experience, was matched across the two groups (instrumental and instructed) that were exposed to it in a trial and error format. Note that no criterion was applied to avoidance in the presence of the instructed CS or any other stimulus. Separate two-way repeated measures ANOVAs were used to compare within and between subject differences for the dependent measures, with stimulus type (CS+, CS−, and where relevant, the novel CSs and instructed CS) as the within subjects measure, and group (Instrumental-, Instructed-, and Observational-learning) as the between subjects measure. Separate analyses were performed for avoidance behavior and expectancy ratings with (i.e., assumed presence) and without (i.e., assumed absence) of the avoidance response. Paired sample *t*-tests were conducted to test for differences in US expectancy ratings and avoidance behavior between the Instructed CS, CS+ and CS− during avoidance learning. For all tests, the alpha level was set at .05 and, where necessary, *p*-values reflect the Huynh–Feldt correction for sphericity. Finally, we performed repeated-measures Bayesian ANOVA and paired-samples Bayesian t-tests with JASP (Love et al., 2015) and used default priors to estimate the Bayes Factor (BF; Rouder, Morey, Speckman, & Province, 2012). The BF indicates the likelihood of the data fitting under the null hypothesis with the likelihood of fitting under the alternative hypothesis. In our analysis, we compared the null hypothesis against the alternative (BF_{01}), where the greater the BF value, the greater the likelihood of the data fitting the null hypothesis (e.g., a BF greater than 3 indicates substantial evidence for the null hypothesis; Wetzels & Wagenmakers, 2012).

3. Results

3.1. Fear conditioning

Analysis of expectancy ratings during the fear conditioning phase revealed a significant main effect of stimulus type $F(1, 80) = 828.111$, $p < .001$, $\eta p^2 = .912$, $BF_{01} = 5.871e{-77}$ but no interaction between stimulus type and group $F(2, 80) = .776$, $p = .464$, $\eta p^2 = .019$, $BF_{01} = 2.550e{-75}$, and no significant differences between group $F(2,80) = .333$, $p = .718$, $BF_{01} = 14.396$. As predicted, pairwise comparisons showed that CS+ and CS− ratings differed significantly in the Instrumental-learning, Instructed-learning, and Observational-learning groups (all *p's* < .001), indicating that clear US expectancy ratings following the CS+, but not the CS− were formed for each of the three pathways.

3.2. Avoidance learning

Expectancy ratings made during avoidance learning revealed a significant main effect of stimulus type when participants assumed they had, $F(1,52) = 7.610$, $p = .008$, $\eta p^2 = .128$, $BF_{01} = .118$, or had not performed the avoidance response, $F(1,52) = 153.033$, $p < .001$, $\eta p^2 = .746$, $BF_{01} = 6.632e{-24}$. However, when the avoidance response was assumed to be present, there was no significant interaction between group and stimulus $F(1,52) = 1.202$, $p = .278$, $\eta p^2 = .023$, $BF_{01} = .905$, and no significant difference in ratings between groups $F(1,52) = .340$, $p = .562$, $\eta p^2 = .006$, $BF_{01} = 3.621$. Follow-up analyses confirmed differences in ratings to the CS+ and CS− ($p < .01$) in the Instrumental-learning group, but not the Instructed learning group ($p = .236$) when the avoidance response was assumed to be present. However, the these two groups did not differ in ratings made of the CS+ ($p = .791$) or CS− ($p = .113$) (see Fig. 2).

In the assumed absence of avoidance, there was no significant interaction between group and stimulus type $F(1,52) = .378$, $p = .542$, $\eta p^2 = .007$, $BF_{01} = 7.168e{-23}$, and no significant differences between groups $F(1,52) = .524$, $p = .472$, $\eta p^2 = .010$, $BF_{01} = 4.518$. Pairwise comparisons revealed significant differences in ratings for CS+ compared to CS− for the Instrumental-learning ($p < .001$), and Instructed-learning ($p < .001$) groups (Fig. 2b, c). This demonstrates that the assumed absence of avoidance responding modulated retrospective US expectancy.

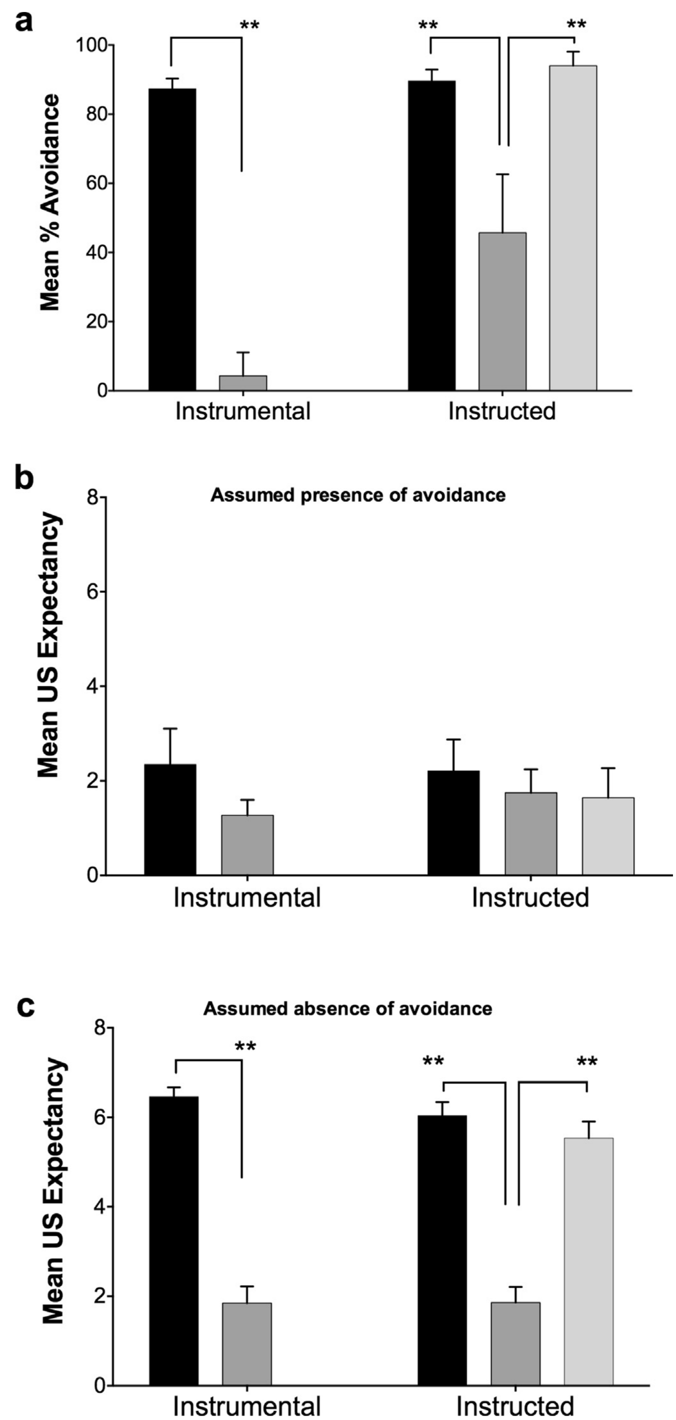

Fig. 2. (A) Mean proportion of avoidance to the CS+, CS− and Instructed CS during Avoidance Learning as a function of learning group. (B) Mean ratings with and without (C) the assumed presence of avoidance responding, respectively. Error bars show standard errors. *$p < .05$ (two-tailed), **$p < .01$ (two-tailed).

Paired sample *t*-tests also revealed that ratings did not differ between the instructed CS and CS + $t(27) = 1.893$, $p = .069$, $BF_{01} = 1.049$, or the instructed CS and CS− $t(27) = .291$, $p = .773$, $BF_{01} = 4.797$, indicating low levels of US expectancy to all stimuli in the assumed presence of the avoidance response. However, in the assumed absence of avoidance, no differences were found in ratings between the CS+ and instructed CS $t(27) = 1.491$, $p = .148$, $BF_{01} = 1.855$, but a significant difference between the instructed CS and CS− $t(27) = 7.801$, $p < .001$, $BF_{01} = 1.600e{-}6$, indicating higher expectancy of shock following both the CS+ and instructed CS compared to the CS−.

Analysis of the proportion of avoidance behavior during avoidance learning revealed a significant main effect of stimulus type $F(1, 51) = 169.389$, $p < .001$, $\eta p^2 = .769$, $BF_{01} = 8.025e{-}19$, suggesting there was a greater proportion of avoidance responding to CS+ compared to CS− in both the Instrumental-learning and Instructed-learning groups. However, there was a significant difference between groups $F(1, 51) = 20.336$, $p < .001$, $\eta p^2 = .285$, $BF_{01} = .328$, and a significant interaction, $F(1, 51) = 16.057$, $p < .001$, $\eta p^2 = .239$, $BF_{01} = 1.890e{-}23$, indicating a greater proportion of avoidance made during the CS+ than the CS− by both the Instrumental-learning and Instructed-learning groups (both *p's* < .001). Also, a significantly higher proportion of avoidance responding by the Instructed-learning group compared to the Instrumental-learning group was found during the CS− ($p < .001$) but not during the CS+ ($p = .304$) (see Fig. 2a).

Further paired sample *t*-tests were also carried out to compare the CS+, CS− and Instructed CS for the Instructed-learning group. Results revealed no significant difference between CS+ and the instructed CS $t(27) = -1.897$, $p = .069$, $BF_{01} = 1.044$, but a significant difference between CS− and Instructed CS $t(27) = -5.496$, $p < .001$, $BF_{01} = 3.852e{-}4$, indicating higher levels of avoidance responding to both the CS+ and instructed CS compared to the CS−.

3.3. Extinction test

Analysis of US expectancy ratings made during the extinction test phase revealed no main effect of stimulus type when the avoidance response was assumed to be present $F(2, 154) = 2.842$, $p = .072$, $\eta p^2 = .036$, $BF_{01} = 2.283$, but a significant interaction between both factors was found, $F(4, 154) = 3.230$, $p \leq .05$, $\eta p^2 = .077$, $BF_{01} = 2.836$. Fig. 3b shows that ratings were uniformly low in each of the three groups for all stimuli presented and no significant differences were found between the groups $F(2, 77) = 1.590$, $p = .211$, $\eta p^2 = .04$, $BF_{01} = 3.892$. However, ratings made to the CS+ were significantly higher in the Observational-learning group compared to the Instructed-learning group ($p < .01$), while both the Instrumental-learning and Instructed-learning ($p = .224$) and Instrumental-learning and Observational-learning ($p = .140$) groups did not differ. These findings suggest that the observed group's ratings remained consistently high throughout the extinction test and were not modulated by the assumed presence or absence of the avoidance response (Fig. 3).

When ratings were made in the assumed absence of avoidance, results revealed a significant main effect of stimuli type $F(2, 154) = 99.587$, $p < .001$, $\eta p^2 = .564$, $BF_{01} = 4.842e{-}24$, indicating that higher ratings were given to the CS+ than CS−. Furthermore, the results revealed a significant interaction of stimulus and group $F(4, 154) = 10.556$, $p < .001$, $\eta p^2 = .215$, $BF_{01} = 9.800e{-}31$, and significant differences between groups $F(2, 77) = 8.049$, $p = .001$, $BF_{01} = .231$, indicating differences in ratings to the novel and instructed CS for both the Instrumental-learning ($p < .001$) and Observed-learning groups ($p < .001$), but no differences in ratings made to the CS+ between Instrumental-learning and Observed-learning ($p = .433$), Instrumental-learning and Instructed-learning ($p = .906$) or Observed-learning and Instructed-learning ($p = .360$) groups (see Fig. 3).

Ratings made by the instrumental-learning group of the CS+ and novel CS did not differ when avoidance was present ($p = .661$), but did when it was assumed absent ($p < .001$). However, this pattern was not evident for the other groups. That is, ratings made by the observational group for the CS+ and novel CS differed both when avoidance was assumed present ($p < .01$) and absent ($p < .001$). For the Instructed-learning group, ratings made for the CS+ and instructed CS did not differ (avoidance present, $p = .735$; avoidance absent, $p = .579$). Taken together, these results suggest that avoidance modulated shock expectancy for the CS+ in both the Instrumental- and Instructed-learning groups, and for the instructed CS for the Instructed-learning group. Expectancy ratings for the CS+ remained high for the Observational-learning group, even in the assumed presence of avoidance, while ratings for the novel CS remained low for both the Instrumental-learning and Observational-learning groups (Fig. 3).

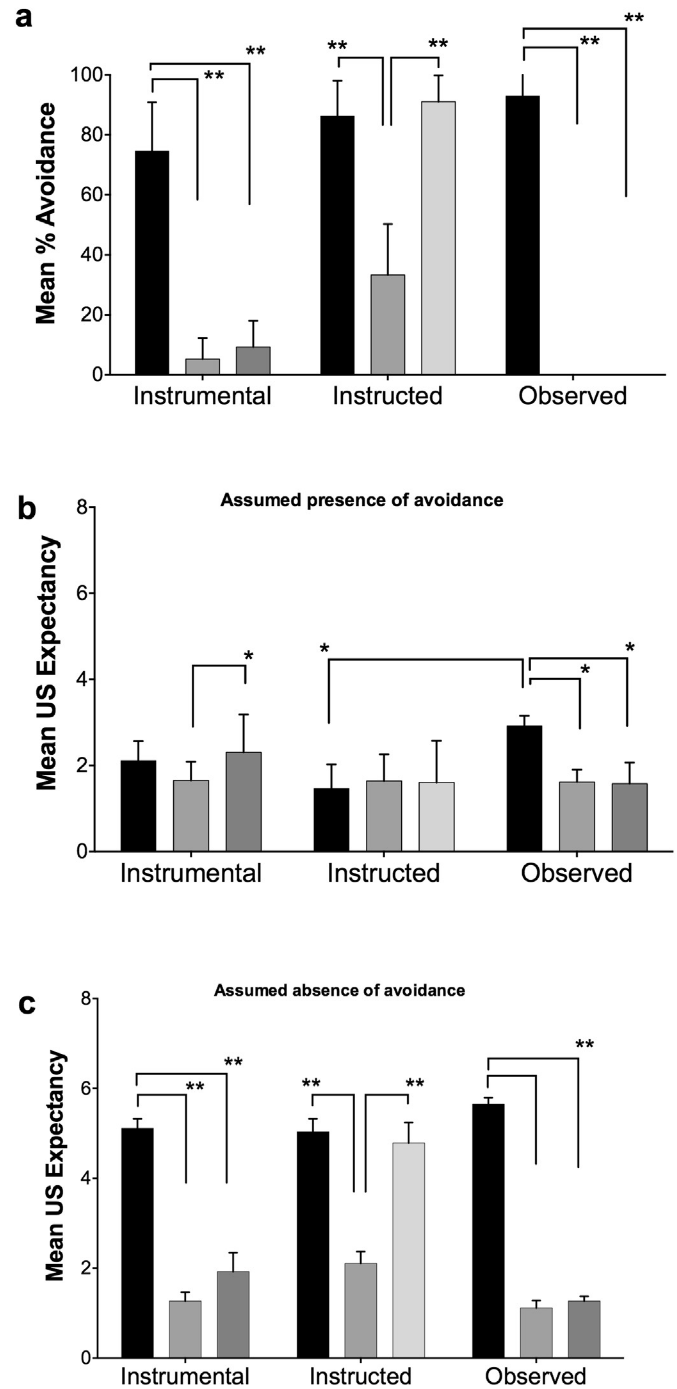

Fig. 3. (A) Mean proportion of avoidance to the CS+, CS−, Instructed CS and Novel CS in the test phase as a function of learning group. (B) Mean ratings with and without (C) the assumed presence of avoidance responding, respectively. Error bars show standard errors. *$p < .05$ (two-tailed), **$p < .01$ (two-tailed).

Analysis of the proportion of avoidance responses evoked by the CS+ and CS− during the extinction test phase showed there was a significant main effect of stimulus type, $F(2, 152) = 174.188$, $p < .001$, $\eta p^2 = .696$, $BF_{01} = 4.933e{-}28$, indicating greater avoidance of the CS+ than CS−. A significant difference was also found between groups $F(2, 152) = 43.68$, $p < .001$, $BF_{01} = 6.697e{-}6$. However, pairwise comparisons confirmed a greater proportion of avoidance of the CS+ than the CS− by each group (all p's < .001). Moreover, there was a significant difference in levels of avoidance evoked by the CS− and the instructed CS ($p < .001$) for the Instructed-learning group. However, avoidance made during the CS− did not differ from either the novel CS in the Instrumental-learning group, ($p = .551$) or the novel CS for the Observational-learning group ($p = 1.00$), respectively (Fig. 3a). The results also revealed a significant interaction of group and stimulus, $F(4, 152) = 29.140$, $p < .001$, $\eta p^2 = .434$, $BF_{01} = 2.919e{-}53$, indicating that avoidance responses to the CS− and novel CS+ varied between groups. Finally, follow-up analyses revealed that groups did not differ in the proportion of avoidance responses evoked by the CS+ (all p's > .05).

4. Discussion

The present findings indicate that the acquisition and maintenance under extinction of avoidance behavior, acquired via social observation and verbal instruction, relies on associative and operant conditioning mechanisms similar to those underlying fear conditioning (Olsson & Phelps, 2007). We found comparable results for both retrospective US expectancy ratings and avoidance behavior measures across the pathways. Participants in all three groups made higher ratings towards CS+ compared to CS− during fear conditioning, a differential trend which continued into the avoidance learning phase for both the instrumental and instructed groups. Furthermore, during the avoidance learning phase, all participants made a greater proportion of avoidance responses to CS+ than CS−, and reported higher ratings to CS+ compared to CS− in the assumed absence of avoidance. Consistent with our predictions, these trends also persisted during extinction testing as all groups made a greater proportion of avoidance responses to CS+ relative to CS− and gave lower ratings in the assumed presence, and higher ratings in the assumed absence, of the avoidance response, to CS+ compared to CS−. Taken together, our findings show that instrumental-, instructed, and observational-learning pathways of avoidance are similar in humans and corroborate previous, but separate reports of the equivalence of instructed (Funayama, Grillon, Davis, & Phelps, 2001; Olsson & Phelps, 2004; Raes et al., 2014) and observed (Golkar, Castro, & Olsson, 2015; Olsson et al., 2007) fear learning pathways.

During avoidance learning, avoidance behavior and ratings evoked by the CS+ in both the instructed and instrumental groups was similar, which demonstrates that verbal instructions about the appropriate avoidance response did not differ from directly learned avoidance behavior (Dymond et al., 2012). This pattern remained intact during the (relatively brief) extinction test phase for the instructed CS, showing that instructions continued to exert an influence in the absence of any scheduled US presentations. However, the novel CS for both the observational and learned groups did not differ significantly from the CS− on avoidance and rating measures. The factors responsible for the notable lack of difference in ratings of the observed novel CS and instructed CS, for instance, may be explained by the presence of the instructed CS and absence of the observed novel CS during the avoidance learning phase. That is, prior to the avoidance learning phase, participants in the instructed group were informed that the instructed CS would be followed by shock and that they should learn to cancel the impending shock by learning to press one of two keys. It is possible, therefore, that participants treated the CS+, which they had previously learned was paired with shock, as equivalent to the instructed CS. However, the movie watched by the observed group did not present any novel CS trials, and therefore did not illustrate any shock presentations or avoidance behavior following the novel CS (during the avoidance learning phase) or during the crucial test phase. Instead, this group simply observed avoidance of the CS+, which they directly learned was paired with shock in the previous phase. Therefore, it is possible that having not encountered the novel CS before (for both the instrumental and observational groups), the test phase might have lead participants to initially withhold avoidance responding to determine whether or not shocks would be delivered. This "wait and see" approach may have lead the observed group to surmise that the novel CS was, at best, a safety signal or, at worst, an ambiguous stimulus (see Lommen, Engelhard, & van den Hout, 2010). Indeed, previous studies on fear conditioning attest to the fact that the ability to inhibit fear response in the presence of safety cues is mediated by individual differences in trait anxiety (e.g., Grillon & Ameli, 2001; Grillon & Morgan, 1999), which may be a risk factor for anxiety (Davis, Falls, & Gewirtz, 2000). Future research should investigate the role of individual differences variables such as trait anxiety in mediating avoidance responding in the presence of the novel CS presented during avoidance learning.

Levels of avoidance behavior to the learned CS+ and instructed CS for the instructed group were equivalent, suggesting that a direct fear conditioning history is not necessary for avoidance to emerge via the instructed pathway. Merely instructing participants about the correct avoidance response is sufficient for avoidance behavior to be acquired and maintained in the absence of any US presentations for non-avoidance. However, the same conclusion cannot be applied to the observed pathway as the novel CS, although never paired with shock, was never observed as a potentially threatening stimulus (by being followed by the US). To address this potential shortcoming, future research should present an observed CS during the avoidance learning phase that is never paired with shock, which would then permit a comparison of avoidance made during the observed CS with and without a direct history of conditioning.

The present study has potential limitations that should be addressed in future research. First, during avoidance learning, both a novel CS and an observed CS, which were not involved in fear conditioning, could have been presented in order to draw direct comparisons between an instructed CS, novel CS and observed CS. If participants avoided an observed CS and instructed CS equally based on the knowledge that they might be followed by shock, which they obtained via verbal instruction or social observation pathways, then it may suggest that both fear and the avoidance behavior that it is assumed to motivate may be acquired indirectly via these pathways within the same participant. The lack of instructions or observation of avoidance for the novel CS for the instrumental-learning group would then determine if these factors underlie avoidance. We would predict that avoidance on the novel CS trials would be low relative to the CS+, and in-line with the CS−, but avoidance of the observed and instructed CS would remain high. Similarly, the observational and instructed groups could also have been presented with an instructed CS− and observed CS− to test whether non-avoidance is shown to generalize like avoidance of CS+. Second, trial-by-trial US expectancy ratings should be measured rather than ratings taken at the end of the respective phases (Boddez et al., 2014). Post-hoc measures are notoriously unreliable, particularly after a period of extinction (Lovibond & Shanks, 2002). Moreover, physiological measures of fear, such as skin conductance responses (SCR) and fear-potentiated startle reflex, should be used to objectively measure fear learning of the CS+ and the fear responses elicited by the instructed and observed CSs. Inferences could then be made as to whether the learned CS+ elicit an equivalent physiological response to indirectly acquired fears. Third, the mechanisms supporting different pathways to avoidance are likely to differ in individuals with anxiety disorders, and thus the present paradigm should be extended to clinical populations as a means of testing the reliability of the effects obtained (see Dymond, Dunsmoor, Vervliet, Roche, & Hermans, 2014; Lissek, 2012). Finally, alternative paradigms could be employed to measure the effect of unreliable instructions or negative modeling of avoidance on subsequent behavior and expectancies. Within-participant designs such as that used by Raes et al. (2014) in which all participants first receive fear-conditioning with three CSs (CS1, C2, and CS3) and are then required to learn avoidance from experience (CS1) or via instructions (CS2) or social observation (CS3) may provide a more thorough test of the pathways account. Future research should adopt such designs when addressing these issues.

In conclusion, the present findings confirm that equivalent levels of avoidance are occasioned by instrumental- and instructed-learning pathways (Dymond et al., 2012) and add to the existing literature on the social transmission of fear and avoidance through observation (Olsson & Phelps, 2004, 2007). All groups experienced the same direct fear conditioning of shock following the CS+, but acquired avoidance behavior via different learning pathways. Despite these differences all groups demonstrated avoidance of, and gave elevated ratings to, cues that acquired fear-provoking properties via verbal instructions or observation. These results suggest that contrary to well-established fear conditioning models of anxiety, a direct history of both fear conditioning and avoidance learning is not necessary in order to show subsequent avoidance of potential threat.

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References

Aldao, A., Nolen-Hoeksema, S., & Schweizer, S. (2010). Emotion-regulation strategies across psychopathology: a meta-analytic review. *Clinical Psychology Review, 30*, 217–237. http://dx.doi.org/10.1016/j.cpr.2009.11.004.

Askew, C., & Field, A. P. (2007). Vicarious learning and the development of fears during childhood. *Behaviour Research and Therapy, 45*, 2616–2627. http://dx.doi.org/10.1016/j.brat.2007.06.008.

Beckers, T., Krypotos, A.-M., Boddez, Y., Effting, M., & Kindt, M. (2013). What's wrong with fear conditioning? *Biological Psychology, 92*, 90–96. http://dx.doi.org/10.1016/j.biopsycho.2011.12.015.

Berger, S. (1962). Conditioning through vicarious instigation. *Psychological Review, 69*, 450–466. http://dx.doi.org/10.1037/h0046466.

Boddez, Y., Baeyens, F., Hermans, D., & Beckers, T. (2014). A learning theory approach to anxiety disorders: human fear conditioning and the added value of complex acquisition procedures. In P. Emmelkamp, & T. Ehring (Eds.), *The Wiley handbook of anxiety disorders* (pp. 85–103). Chichester, UK: John Wiley & Sons, Ltd.

Boyd, R., & Richerson, P. J. (1985). *Culture and the evolutionary process*. Chicago: University of Chicago Press.

Boyd, R., Richerson, P. J., & Henrich, J. (2011). The cultural niche: why social learning is essential for human adaptation. *Proceedings of the National Academy of Sciences (USA), 108*, 10918–10925. http://dx.doi.org/10.1073/pnas.1100290108.

Coelho, C. M., & Purkis, H. (2009). The origins of specific phobias: influential theories and current perspectives. *Review of General Psychology, 13*, 335–348. http://dx.doi.org/10.1037/a0017759.

Davis, M., Falls, W. A., & Gewirtz, J. (2000). Neural systems involved in fear inhibition: extinction and conditioned inhibition. In M. Myslobodsky, & I. Weiner (Eds.), *Contemporary issues in modeling psychopathology* (pp. 113–142). Norwell, MA: Kluwer.

Dymond, S., Dunsmoor, J. E., Vervliet, B., Roche, B., & Hermans, D. (2014). Fear generalization in humans: systematic review and implications for anxiety disorder research. *Behavior Therapy*. http://dx.doi.org/10.1016/j.beth.2014.10.001.

Dymond, S., & Roche, B. (2009). A contemporary behavior analysis of anxiety and avoidance. *The Behavior Analyst, 32*, 7–27.

Dymond, S., Schlund, M. W., Roche, B., De Houwer, J., & Freegard, G. P. (2012). Safe from harm: learned, instructed, and symbolic generalization pathways of human threat-avoidance. *PLoS One, 7*, e47539. http://dx.doi.org/10.1371/journal.pone.0047539.

Field, A. P., Argyris, N. G., & Knowles, K. A. (2001). Who's afraid of the big bad wolf: a prospective paradigm to test Rachman's indirect pathways in children. *Behaviour Research and Therapy, 39*, 1259–1276. http://dx.doi.org/10.1016/S0005-7967(00)00080-2.

Funayama, E. S., Grillon, C., Davis, M., & Phelps, E. A. (2001). Activation of the left amygdala to a cognitive representation of fear. *Journal of Cognitive Neuroscience, 13*, 721–729. http://dx.doi.org/10.1038/86110.

Golkar, A., Castro, V., & Olsson, A. (2015). Social learning of fear and safety is determined by the demonstrator's racial group. *Biology Letters, 11*. http://dx.doi.org/10.1098/rsbl.2014.0817.

Grillon, C., & Ameli, R. (2001). Conditioned inhibition of fear-potentiated startle and skin conductance in humans. *Psychophysiology, 38*, 807–815. http://dx.doi.org/10.1111/1469-8986.3850807.

Grillon, C., & Morgan, C., III (1999). Fear-potentiated startle conditioning to explicit and contextual cues in Gulf War veterans with posttraumatic stress disorder. *Journal of Abnormal Psychology, 108*, 134–142. http://dx.doi.org/10.1037/0021-843X.108.1.134.

Helsen, K., Goubert, L., & Vlaeyen, J. W. (2013). Observational learning and pain-related fear: exploring contingency learning in an experimental study using colored warm water immersions. *The Journal of Pain, 14*, 676–688. http://dx.doi.org/10.1016/j.jpain.2013.01.771.

Kelly, V. L., Barker, H., Field, A. P., Wilson, C., & Reynolds, S. (2010). Can Rachman's indirect pathways be used to un-learn fear? A prospective paradigm to test whether children's fears can be reduced using positive information and modelling a non-anxious response. *Behaviour Research and Therapy, 48*, 164–170. http://dx.doi.org/10.1016/j.brat.2009.10.002.

Lissek, S. (2012). Toward an account of clinical anxiety predicated on basic, neurally mapped mechanisms of Pavlovian fear-learning: the case for conditioned overgeneralization. *Depression and Anxiety, 29*, 257–263. http://dx.doi.org/10.1002/da.21922.

Lommen, M., Engelhard, I., & van den Hout, M. (2010). Neuroticism and avoidance of ambiguous stimuli: better safe than sorry? *Personality & Individual Differences, 49*, 1001–1006. http://dx.doi.org/10.1016/j.paid.2010.08.012.

Love, J., Selker, R., Marsman, M., Jamil, T., Verhagen, A. J., Ly, A., et al. (2015). *JASP (Version 0.6.6) [Computer software]*.

Lovibond, P. F., & Shanks, D. R. (2002). The role of awareness in Pavlovian conditioning: empirical evidence and theoretical implications. *Journal of Experimental Psychology: Animal Behavior Processes, 28*, 3–26. http://dx.doi.org/10.1037/0097-7403.28.1.3.

Muris, P., & Field, A. P. (2010). The role of verbal threat information in the development of childhood fear. "Beware the Jabberwock!". *Clinical Child and Family Psychology Review, 13*, 129–150. http://dx.doi.org/10.1007/s10567-010-0064-1.

Muris, P., Merckelbach, H., de Jong, P. J., & Ollendick, T. H. (2002). The etiology of specific fears and phobias in children: a critique of the non-associative account. *Behaviour Research and Therapy, 40*, 185–195. http://dx.doi.org/10.1016/S0005-7967(01)00051-1.

Olsson, A., Nearing, K. I., & Phelps, E. A. (2007). Learning fears by observing others: the neural systems of social fear transmission. *Social Cognitive and Affective Neuroscience, 2*, 3–11. http://dx.doi.org/10.1093/scan/nsm005.

Olsson, A., & Phelps, E. A. (2004). Learned fear of "unseen" faces after Pavlovian, observational, and instructed fear. *Psychological Science, 15*, 822–828. http://dx.doi.org/10.1111/j.0956-7976.2004.00762.x.

Olsson, A., & Phelps, E. A. (2007). Social learning of fear. *Nature Neuroscience, 10*, 1095–1102. http://dx.doi.org/10.1038/nn1968.

Ost, L. G., & Hugdahl, K. (1983). Acquisition of agoraphobia, mode of onset and anxiety response patterns. *Behaviour Research and Therapy, 21*, 623–631. http://dx.doi.org/10.1016/0005-7967(83)90080-3.

Phelps, E. A., Connor, K. J. O., Gatenby, J. C., Gore, J. C., & Davis, M. (2001). Activation of the left amygdala to a cognitive representation of fear. *Nature Neuroscience, 4*, 437–441. http://dx.doi.org/10.1038/86110.

Rachman, S. J. (1977). The conditioning theory of fear acquisition: a critical examination. *Behaviour Research and Therapy, 15*. http://dx.doi.org/10.1016/0005-7967(77)90041-9, 375–287.

Raes, A. K., Houwer, J. D., Schryver, M. D., Brass, M., Kalisch, R., & Perales, J. C. (2014). Do CS–US pairings actually matter? A within-subject comparison of instructed fear conditioning with and without actual CS–US pairings. *PLoS One, 9*, e84888. http://dx.doi.org/10.1371/journal.pone.0084888.

Rouder, J. N., Morey, R. D., Speckman, P. L., & Province, J. M. (2012). Default Bayes factors for ANOVA designs. *Journal of Mathemtaical Psychology, 56*, 356–374. http://dx.doi.org/10.1016/j.jmp.2012.08.001.

Vervliet, B., & Raes, F. (2013). Criteria of validity in experimental psychopathology: application to models of anxiety and depression. *Psychological Medicine, 43*, 2241–2244. http://dx.doi.org/10.1017/S0033291712002267.

Wetzels, R., & Wagenmakers, E. J. (2012). A default Bayesian hypothesis test for correlations and partial correlations. *Psychonomic Bulletin & Review, 19*, 1057–1064. http://dx.doi.org/10.3758/s13423-012-0295-x.