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The Reinstatement Effect in Human Predictive Learning: Contextual Modulation and the Impact of Extinction Reminders

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Abstract. One of the most relevant phenomena both from a theoretical and clinical perspective is extinction. In particular, several researchers are interested in the response recovery effects from extinction. Reinstatement is an effect that has been proposed as a laboratory model to study relapse from extinction-based therapeutic treatments. We designed two experiments with humans to evaluate the reinstatement effect in a predictive learning task. In both experiments, participants learned a specific relationship between two cues (X and Y) and two outcomes (O1 and O2) during the first phase. Throughout extinction, both cues were presented without outcomes. After an exposure to the original outcomes, reinstatement of the first-learned information was observed during testing in both experiments. However, we found that the reinstatement effect was contextual modulated (Experiment 1; η_p^2 = .78, 90% CI [.48, .86], p < .0001). Furthermore, in Experiment 2 we showed a reduction of reinstatement when an extinction reminder was used η_p^2 = .45, 90% CI [.07, .65], p = .012. Theoretical implications are discussed, and some potential uses are mentioned.

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When cue-outcome pairings are followed by the presentation of the cue alone, responding to the cue decreases, leading to extinction (Pavlov, 1927). Despite the loss in responding, contemporary animal research suggests that extinction is not simply an unlearning or forgetting but rather a form of acquired inhibition that suppresses the original response (see Bouton, 2014). The reinstatement effect exemplifies that the original information is preserved. In this effect, an extinguished response is recovered when the outcome is presented alone between extinction and testing (Rescorla & Heth, 1975; Vila & Rosas, 2001).

Given that exposure-based cognitive behavioral treatments are based on extinction (Craske & Mystkowski, 2006), reinstatement is often proposed as a laboratory model of the return of a psychological disorder or relapse (e. g., experiencing a sudden panic attack might reinstate the fear of crowds). Thus, one primary goal of contemporary translational research is assessing behavioral techniques that can prevent or reduce the reinstatement effect (Vervliet, Craske, & Hermans, 2013).

In the last years, the learning model proposed by Bouton (1993, 1994) has served as a guide for the development of strategies to thwart relapse. In summary, this model assumes that during extinction subjects acquire a second learning about the conditioned stimulus (CS). This new learning is inhibitory and context-dependent (to retrieve it, it is mandatory to be in the context where it was learned; Bouton, 1994, 1997). A particularly important stance from this perspective is that there are situations that promote retrieval of conditioning (sources of relapse). These so-called context-switch effects are produced by contexts provided by diverse stimulus or events (Bouton, 2010). For example, when the *physical* extinction context is changed, conditioning performance is restored (renewal; see Bouton & Swartzentruber, 1991). In addition to changes in the external background, the passage of time (*temporal* context) produces spontaneous recovery (e. g., Pavlov, 1927). Furthermore, within this theoretical account reinstatement involves changing the *associative* context (i. e., presenting the outcome alone after extinction

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might change the current value of the context; García-Gutiérrez, Rosas, & Nelson, 2005). Thus, according to Bouton, despite the methodological differences, all three sources of relapse can be explained using the same mechanism. Hence, the same behavioral strategies should have the same impact on them. The present experimental series was designed to evaluate whether the reinstatement of predictive learning in humans is consistent with those assumptions. In Experiment 1, we tested the contextual specificity of the reinstatement effect, whereas the impact of an extinction reminder on reinstatement was explored in Experiment 2.

Experiment 1

The reinstatement effect is a well-known phenomenon that has been reported using aversive and appetitive preparations in humans (e.g., Haaker, Golkar, Hermans, & Lonsdorf, 2014) and nonhuman animals (Bouton, Winterbauer, & Vurbic, 2011). Although, there are different accounts for reinstatement (e. g., Dunsmoor, Niv, Daw, & Phelps, 2015), the theoretical view developed by Bouton has been the dominant account in this area. In his theoretical view, reinstatement (a source of relapse) has been proposed as a failure to retrieve the extinction learning outside the associative extinction context. A key evidence consistent with this assumption is provided by studies that show that context plays a major role. For instance, several experiments with rats have reported reinstatement when re-exposure and test contexts were the same, whereas no reinstatement was found when re-exposure and test were conducting in different contexts (e. g., Bouton & Bolles, 1979; Bouton & King, 1983; Bouton & Peck, 1989; Frohardt, Guarraci & Bouton, 2000; but see, Westbrook, Iordanova, McNally, Richardson, & Harris, 2002). Although similar findings in humans have found that reinstatement of fear is context dependent (LaBar & Phelps, 2005; Schiller et al., 2008), the literature in predictive learning task is mixed. On one hand, García-Gutiérrez and Rosas (2003) using a retroactive interference paradigm (e. g., food first paired with diarrhea, then paired with constipation) found reinstatement only when the context of re-exposure and the context of testing were the same; however Vila and Rosas (2001) in a task in which participants extinguished a relationship between a fictitious medicine and a side effect reported a partial reinstatement even when the participants were tested in a context different from the re-exposure phase. Thus, the present experiment was design to analyze whether the reinstatement of predictive judgments is context-specific. Contrary to the previous experiments (García-Gutiérrez & Rosas, 2003; Vila & Rosas, 2001) we used a within-subject design in order to obtain a finer analysis.

The design of the Experiment 1 is shown in the first row of Table 1. All participants first learned in a fictitious task that consumption of one food (X) produced diarrhea (O1) in a particular restaurant (Context A). They additionally learned that consumption of a second food (Y) produced vomit (O2) in a different restaurant (Context B). Then, both X and Y were presented in extinction in their respective contexts. Next, O1 and O2 were presented in Context A and in a new Context C respectively. Finally, all participants received a test where they were asked about the relationship between foods and outcomes in the presence of the original contexts (A and B). If the reinstatement effect relies on conducting the re-exposure and the test in the same context, then an increase in judgments to the relationship between X and the outcome would be expected, whereas no reinstatement should be observed for Y.

Method

Participants

Twelve undergraduate students from the Universidad de Cádiz (Spain) participated in this experiment in exchange for course credit (12 women; M_{age} = 20.08 years; age range = 18–26 years). They had no previous experience with this task. All students participated voluntarily and gave their informed consent before beginning the experiment, being free to abandon the task at any point of the process, though none of them did.

Apparatus and stimuli

Participants were trained individually in twelve adjacent PCs separated by fixed partitions. The procedure

Table 1. *Experimental Design*

Experiment	Acquisition	Extinction	Re-exposure	Test
1	A: X–O1 B: Y–O2	A: X-B: Y-	A: O1 C: O2	A: X-B: Y-
2	A: X–O1 B: Y–O2	A*: X-B*: Y-	A: O1 B: O2	A*: X-B: Y-

Note: Contexts A, B and C = Different restaurants, counterbalanced; X and Y = Garlic and corn, counterbalanced; O1 and O2 = diarrhea and vomit, counterbalanced. "*" Stands for the extinction-cue.

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was implemented using the program SuperLab Pro (Cedrus Corporation) software. Participants interacted with the computer using the mouse. Food used was chosen from the pool selected by García-Gutierrez and Rosas (2003). Garlic and corn were counterbalanced as cues X and Y. Diarrhea and vomit were counterbalanced as outcomes O1 and O2. Two fictitious restaurants (The Canadian Cabin and The Swiss Cow) were counterbalanced across participants as contexts A and B. Context C had no name.

Procedure

The instructions and all the necessary information were presented in participants' native language (Spanish) on the computer screen. Participants interacted with the computer using the mouse (left button). Instructions were presented in four screens using a black Times New Roman 22 bold font against a white background. To advance the instruction screens, participants had to click on a button labeled as "next" placed on the bottom right portion of the screen. Each participant was initially asked to read the following instructions (taken from León, Abad, & Rosas, 2011):

> "(Screen 1) Recent developments in food technology have led to the chemical synthesis of food. This is very advantageous as it is very low cost and easy to both store and transport. This revolution in the food industry may solve hunger in third world countries. (Screen 2) However, it has been detected that some foods produce gastric problems in some people. For this reason, we are interested in selecting a group of experts to identify the foods that lead to some types of illness, and how it is manifested in each case. (Screen 3) You are about to receive a selection test where you will be looking at the files of people that have ingested different foods in a specific restaurant. You will have to indicate whether gastric problems will appear. To respond you should click the option that you consider appropriate, and then click on the button that appears at the bottom corner of the screen. It is very important to respect this order, given that only your first choice will be recorded. Your response will be random at the beginning, but do not worry; as the files increase you will become an expert."

After reading the instructions, participants were required to call the experimenter who demonstrated the instructions. The demonstration was identical to an acquisition trial, with the exception that a new cue (pasta) was presented as a predictor within a restaurant that was not used again during the experiment.

Each trial began with the sentence "Loading file of . . . (a randomly chosen full name)" during 1500 ms. Then, a screen with a restaurant picture in the background appeared. In the middle of that screen the picture of a food was presented (garlic or corn), and below that food there were two 0–100 scales, one for each consequence, containing 21 small green buttons. Each button had two numbers representing 5 points in the scale (0–5, 5–10 and so on). On top of the buttons 0–5, 25–30, 55–60 and 95–100 appeared the words "none", "little", "quite" and "great", respectively, written in bold font. Participants were requested to respond by clicking on top of the option they considered appropriate, first for one of the outcomes, and then for the other one. Subsequently, another screen with the restaurant in the background and the name of the illness associated to that food was presented in acquisition phase during 2000 ms; in the extinction phase no outcome was presented, that is, instead of the name of the illness, the sentence "This person did not have any disease" appeared. A button appeared in the bottom corner of the screen and read "Press here to continue. . ." The experiment was conducted in four phases (see Table 1).

Acquisition. Each participant was trained during 10 trials in each context with cue X being followed by the outcome O1 in context A, while cue Y was presented followed by the outcome O2 in context B. Half of the participants received training first in context A and then in context B while the other half were first trained in context B and then in context A. Training in each context was preceded by a screen with the sentence "Now you should analyze the files of the people that ate at restaurant. . . (name of the restaurant: "The Canadian Cabin" or "The Swiss Cow", counterbalanced.).

Extinction. After acquisition phase, all participants received 15 extinction trials in each context, identical to acquisition trials except that after the participant judges no outcome was presented (as we said below, instead of the name of the illness, the sentence "This person did not have any disease" appeared). X underwent extinction in Context A and Y in Context B. As in acquisition phase, half of the participants received training first in context A and then in context B while the other half were first trained in context B and then in context A. Training in each context was preceded as well by the screen with the sentence "Now you should analyze the files of the people that ate at restaurant. . . (name of the restaurant)".

Re-exposure. This phase began with the following instruction: "Now you will be able to observe the diseases of some patients who have been analyzed by your colleagues". All participants received 10 re-exposure trials in each context. Each trial began with the sentence "Loading file of . . . (a randomly chosen full name)" during 1500 ms, followed by a screen with the

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context picture and the outcome associated with it during acquisition, so that context A was followed by O1 and a new context C was followed by O2. Half of the participants received this re-exposure phase first in context A and then in context C, the opposite was true for the other half.

Test. This phase began with the next instruction: "We have almost finished! You only have a few more files to analyze! Come on!" After that, all participants received a test trial in extinction in each context. Each trial was the same as in the extinction phase. The order of presentation of the contexts was counterbalanced across participants.

Dependent Variable and Statistical Analysis

Predictive judgments were requested throughout acquisition, extinction and test phases. The data was analyzed using analysis of variance (ANOVA). The rejection criterion was set at $p < .05$, and effect sizes were reported using partial eta-squared (η_p^2). Additionally, 90% confidence intervals for the effect sizes were calculated and reported for each analysis.

Results and discussion

Figure 1 shows the mean predictive judgments given by participants in each cue during five 2-trials blocks of acquisition (left panel) and five 3-trials blocks of extinction (right panel). A 2 (Cue, X vs. Y) x 5 (Block, 1–5) ANOVA confirmed that both responses were acquired similarly by all participants and that responding increased as acquisition progressed by only finding a significant main effect of Block, $F(4, 44) = 13.50$, $p < .001$, $\eta_p^2 = .55$, 90% CI [.33, .63]. The main effect of Cue and Cue x Block interaction did not reach significance, all *F*s < 1, showing there was no difference in acquisition between X and Y.

A 2 (Cue, X vs. Y) x 5 (Block, 1–5) ANOVA conducted on the extinction data only found a significant main effect of Block, $F(4, 44) = 12.58$, $p < .001$, $\eta_p^2 = .53$, 90% CI [.31, .62], but not of Cue, $F<1$. The main effect of Cue and Cue x Block interaction did not reach significance, all *F*s < 1, showing there was no difference in extinction between X and Y. Figure 2 shows the mean predictive judgments during the last extinction trial (Extinction test)

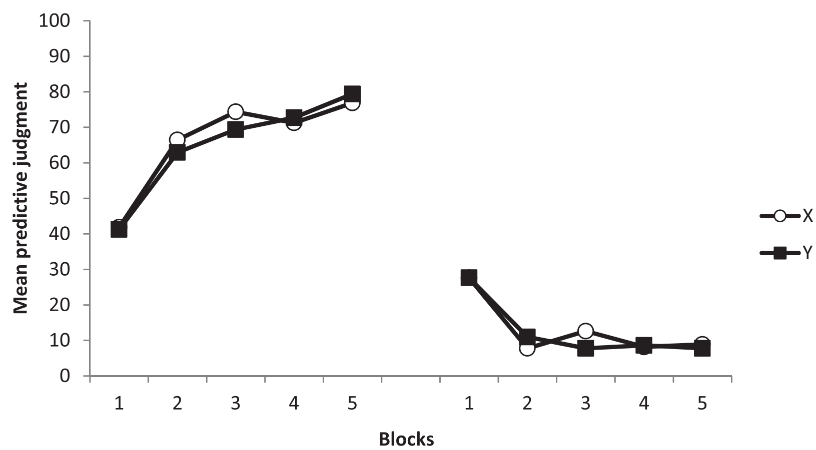

Figure 1. Mean Predictive Judgments for both Cues during the Five Blocks of Acquisition (Left Panel) and the Five Blocks of Extinction (Right Panel) of Experiment 1.

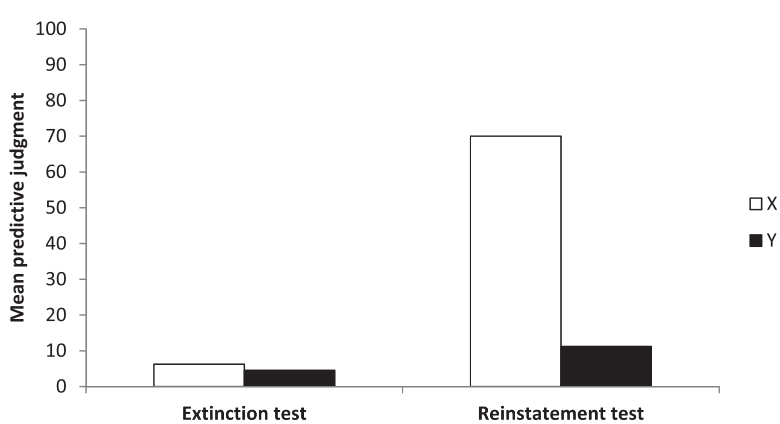

Figure 2. Mean Predictive Judgments for both Cues during the Last Extinction Trial (Extinction test) and the Reinstatement Test of Experiment 1.

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and the test phase (Reinstatement test) for cues X and Y. If reinstatement of the judgments that have been previously extinguished has occurred as a consequence of the isolated presentation of the outcome, and if that reinstatement effect takes place only when re-exposure and test contexts are the same, we should find higher predictive judgments in Reinstatement test than in Extinction, but only for cue X.

A 2 (Cue, X vs. Y) x 2 (Test, Extinction test vs. Reinstatement test) ANOVA found a significant main effect of Cue, $F(1, 11) = 36.44$, $p < .001$, $\eta_p^2 = .77$, 90% CI [.45, .85], and Test, $F(1, 11) = 46.02$, $p < .001$, $\eta_p^2 = .81$, 90% CI [.53, .88]. Cue x Test interaction was significant as well, $F(1, 11) = 25.87$, $p < .001$, $\eta_p^2 = .70$, 90% CI [.34, .81]. Subsequent analyses conducted to explore this interaction found, for one hand, that the simple effect of Cue was not significant in Extinction test, $F < 1$, indicating no differences between X and Y in the last extinction trial; however, the simple effect of Cue was significant in Reinstatement test, $F(1, 11) = 32.41$, $p < .001$, $\eta_p^2 = .75$, 90% CI [.42, .84], showing the mean predictive judgments for X (in which the pre-exposure and the test contexts were the same) were higher than for Y. In other hand, we found that the simple effect of Test was significant for cue X, $F(1, 11) = 39.57$, $p < .001$, $\eta_p^2 = .78$, 90% CI [.48, .86], but not for Y, $F(1, 11) = 3.14$, $p = .10$, $\eta_p^2 = .22$, 90% CI [.00, .48], showing the judgments were higher in Reinstatement test than in Extinction test only for cue X, that is, the reinstatement took place only for this cue.

In sum, our data showed that the reinstatement of predictive judgments is context-dependent. This result is consistent with Bouton's proposal and extended the findings of García-Gutiérrez and Rosas (2003) to a within-subjects paradigm that involved an extinction treatment.

Experiment 2

In Experiment 1 we found that reinstatement of predictive learning is context-dependent, which is consistent with the mechanism proposed by Bouton's theory. This finding strongly suggests that his theoretical view may have some potential to helping develop a behavioral strategy that successfully prevents reinstatement in a predictive learning task with humans. According to Bouton, reinstatement occurs because of a memory retrieval problem, so, if the subject is able to remember the extinction learning in other contexts, relapse should not be observed.

In agreement with that prediction, recent reports have found that using retrieval cues from extinction (e. g., neutral but salient stimuli within the extinction context) attenuates the reinstatement effect in rats. For example, Brooks and Fava (2017), using an appetitive Pavlovian preparation, found that the reinstatement of the conditioned response (CR) was reduced by an extinction reminder (a 30 s tone or turning off the houselights for 30 s). Similar data was reported by Bernal-Gamboa, Gámez and Nieto (2017) in a free operant procedure. In their Experiment 2, Bernal-Gamboa et al. (2017)used a whitin-subject design. Thus, throughout the experiment two daily sessions were conducted, one for each operant response (R1 and R2). During acquisition phase, hungry rats were trained to perform R1 in a particular operant conditioning chamber (Context A), whereas R2 was trained in a different operant conditioning chamber (Context B). In the next phase, R1 was extinguished in Context A, while extinction of R2 took place in Context B. During extinction of both responses, rats received brief and intermittent presentations of a tone (extinction reminder). Next, all rats received two daily sessions (each one in each context) in which free food was delivered (no levers were presented). On the following day, all rats were placed in both contexts (with levers presented) and lever-pressing was recorded. Bernal-Gamboa et al., (2017) reported that all rats showed reinstatement for both responses, nevertheless, reinstatement was attenuated if the tone was presented during the test.

Given that it has been suggested that the mechanisms underlying learning and memory processes in different animals may be similar (e.g., Le Pelley, 2004; Pearce & Bouton, 2001), the findings of Bernal-Gamboa et al. (2017) and Brooks and Fava (2017), indicates the potential value of using extinction reminders as a behavioral technique for preventing reinstatement. However, before incorporates this extinction-cue strategy into a therapeutic setting it would worth to analyze whether a reminder from extinction has similar effects in healthy humans. Thus, the main goal of the present experiment was to explore the impact of an extinction reminder on the reinstatement using a predictive judgment task with human participants.

The design of the experiment 2 is shown in the second row of Table 1. During extinction phase, an extinction reminder was presented for both foods. Next, as in previous experiment, O1 and O2 were presented in Context A and Context B respectively. During the test, the extinction reminder was presented only for X. We expected reinstatement of acquisition performance for both X and Y. However, we also expected that the presence of an extinction reminder would reduce the reinstatement for X.

Method

Participants

Twelve undergraduate students from the Universidad de Cádiz participated in this experiment in exchange for course credit (8 women, 4 men; $M_{age} = 22.25$ years;

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age range=20–29 years). The rest of characteristics are the same as those in the previous experiment.

Apparatus and stimuli

We conducted the present experiment in the same conditions as in Experiment 1, with the exception that we only used two contexts (The Canadian Cabin and The Swiss Cow) and we used as extinction reminder a neon picture representing someone drinking a juice presented on the left-top area of the screen. This picture stretched across one eighth of the computer screen.

Procedure

Except as noted, we used the same procedure as in Experiment 1.

Extinction. This phase was conducted in the same manner as in the previous experiment, except that in all extinction trials participants experienced the extinction reminder presented during the cue and the feedback.

Re-exposure. Half of the participants received this re-exposure phase first in context A and then in context B, the opposite was true for the other half.

Test. This phase was conducted in the same manner as in Experiment 1, however, in this case participants were tested with the extinction reminder, which was presented only in context A.

Results and discussion

Figure 3 shows the mean predictive judgments given by participants in each cue during five 2-trials blocks of acquisition (left panel) and five 3-trials blocks of extinction (right panel). A 2 (Cue, X vs. Y) x 5 (Block, 1–5) ANOVA confirmed that both responses were acquired similarly by all participants and that responding increased as acquisition progressed by only finding a significant main effect of Block, $F(4, 44) = 26.94$, $p < .001$, $\eta_p^2 = .71$, 90% CI [.55, .77]. The main effect of Cue and Cue x Block interaction did not reach significance, all *Fs* < 1, showing there was no difference in acquisition between X and Y.

A 2 (Cue, X vs. Y) x 5 (Block, 1–5) ANOVA conducted on the extinction data found a significant main effect of Block, $F(4, 44) = 190.28$, $p < .001$, $\eta_p^2 = .95$, 90% CI [.91, .96], but not of Cue, $F < 1$. The Cue x Block interaction was significant as well, $F(4, 44) = 5.20$, $p = .021$, $\eta_p^2 = .32$, 90% CI [.09, .43]. Subsequent analyses conducted to explore this interaction found that the simple effect of Block was significant for both, Cue X, $F(4, 44) = 154.04$, $p < .001$, $\eta_p^2 = .93$, 90% CI [.89, .95], and Cue Y, $F(4, 44) = 57.41$, $p < .001$, $\eta_p^2 = .84$, 90% CI [.74, .87], indicating a decrease in the mean predictive judgments at the end of extinction phase for both cues.

Figure 4 shows the mean predictive judgments during the last extinction trial (Extinction test) and the test phase (Reinstatement test) for cues X and Y. If reinstatement of the judgments that have been previously extinguished has occurred as a consequence of the isolated presentation of the outcome, we should find higher predictive judgments in Reinstatement test than in Extinction test. Moreover, if the presentation of the extinction-cue for X during Reinstatement test was effective to reduce that reinstatement effect, we should find lower predictive judgments for X than for Y.

A 2 (Cue, X vs. Y) x 2 (Test, Extinction test vs. Reinstatement test) ANOVA found a significant main effect of Cue, $F(1, 11) = 9.57$, $p = .010$, $\eta_p^2 = .46$, 90% CI [.08, .66], and Test, $F(1, 11) = 44.70$, $p < .001$, $\eta_p^2 = .80$, 90% CI [.52, .87]. Cue x Test interaction was significant as well, $F(1, 11) = 8.38$, $p = .015$, $\eta_p^2 = .43$, 90% CI [.06, .64]. Subsequent analyses conducted to explore this interaction found, for one hand, that the simple effect of Test was significant for both cues X, $F(1, 11) = 13.38$, $p = .004$, $\eta_p^2 = .55$, 90% CI [.15, .71], and Y, $F(1, 11) = 44.24$, $p < .001$, $\eta_p^2 = .78$, 90% CI [.52, .87], showing the

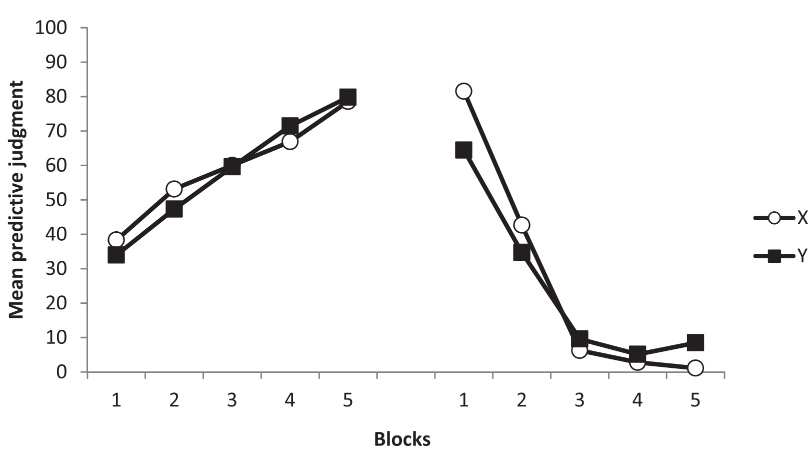

Figure 3. Mean Predictive Judgments for both Cues during the Five Blocks of Acquisition (Left Panel) and the Five Blocks of Extinction (Right Panel) of Experiment 2.

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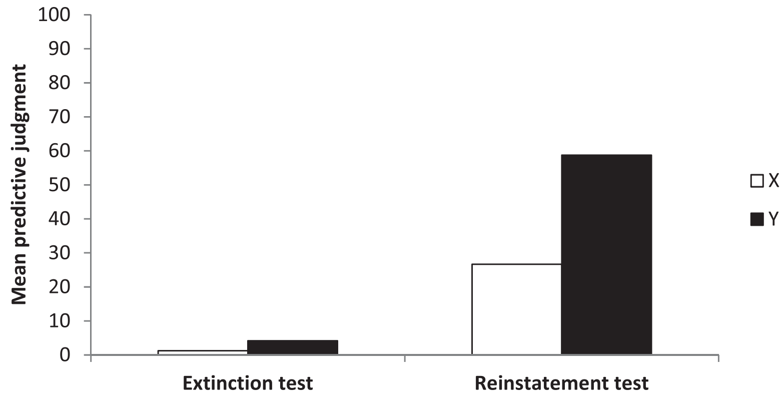

Figure 4. Mean Predictive Judgments for both Cues during the Last Extinction Trial (Extinction Test) and the Reinstatement Test of Experiment 2.

judgments were higher in Reinstatement test than in Extinction test, that is, the reinstatement took place for both cues. In other hand, we found the simple effect of Cue was not significant in Extinction test, $F(1, 11) = 4.11$, $p = .07$, 90% CI [.00, .52], indicating no differences between X and Y in the last extinction trial; however, and this is the most important result, the simple effect of Cue was significant in Reinstatement test, $F(1, 11) = 9.14$, $p = .012$, $\eta_p^2 = .45$, 90% CI [.07, .65], showing the mean predictive judgments for X (which received the extinction-cue presentations) were lower than for Y.

General discussion

Two experiments in a human predictive learning task showed that reinstatement is a context-switch effect (Experiment 1). Moreover, in Experiment 2 we found an attenuation of reinstatement produced by an extinction reminder. Our findings of the first experiment are consistent with the theoretical perspective that suggests the context change as a mechanism for reinstatement (e. g., Bouton et al., 2011). It is important to note that similar results have been reported with rats (e. g., Bouton & Woods, 2008) and with humans in fear conditioning (e. g., Haaker et al., 2014). Regarding the mixed data reported in a predictive learning literature, our results from Experiment 1 suggests that the contextual specificity of reinstatement found by García-Gutiérrez and Rosas (2003) is not restricted to their procedure (they used a counterconditioning-like treatment, while we used an extinction procedure). Thus, along with García-Gutiérrez and Rosas´ data, our findings suggest that the reinstatement of predictive judgments might be view as a response recovery effect produced by changes in the associative context (e. g., García-Gutiérrez et al., 2005).

The present results provide for the first time evidence that presenting a stimulus associated with extinction attenuated the reinstatement of predictive judgments in humans. This data parallels results with rats in appetitive Pavlovian conditioning (Brooks & Fava, 2017), and with both rats (Bernal-Gamboa et al., 2017) and humans (Gámez & Bernal-Gamboa, 2018) in an instrumental learning situation. Furthermore, the extinction-cue strategy has been shown to reduce other sources of relapse such as spontaneous recovery (reoccurrence after time passes following extinction) with rats (e. g., Bernal-Gamboa et al., 2017; Brooks & Bouton, 1993; Brooks, Palmatier, García, & Johnson, 1999), and renewal (retrieval produced by changing the extinction context) using both rats (Brooks & Bouton, 1994; Nieto, Uengoer, & Bernal-Gamboa, 2017; Willcocks & McNally, 2014) and humans (e. g. Collins & Brandon, 2002; Dibbets, Havermans, & Arntz, 2008; Mystkowski, Craske, Echiverri, & Labus, 2006; Vansteenwegen et al., 2006). The previous results strongly suggest that to prevent relapsing, the development of therapeutic strategies should be based on the idea of providing bridges between the clinical context and potential relapse contexts (Bouton, Woods, Moody, Sunsay, & García-Gutiérrez, 2006).

Additionally, reports that found a similar effect produced by the extinction-cue on reinstatement, spontaneous recovery and renewal favors the theoretical perspective that assumes that all three recovery effects after extinction might be explained by a similar mechanism (Bouton & Woods, 2008; but see McConnell & Miller, 2014). According to the retrieval theory of forgetting (Bouton, 1993, 1994, 1997), the CS-noUS memory formed in extinction competes with the CS-US memory acquired during conditioning, endowing the CS with two different meanings (US/noUS). Context (external, temporal or associative; see Bouton, 1993, 2010) is proposed to help subjects to solve this ambiguity: If the CS and the extinction context are presented together, an AND gate is activated, producing the retrieval of the CS-noUS memory (an extinction performance is expected). However, if the CS is presented in

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any context distinct from the extinction context, then, the CS-US memory would be retrieved and a conditioning performance would be observed (relapsing is predicted). So, even if testing takes place in a context different from extinction, the presence of the extinction-cue should produce a weak (or incomplete) retrieval of the extinction memory, therefore attenuation (but not elimination) of relapse is expected. In sum, our findings reported here are consistent with the proposal that facilitating the retrieval of extinction memories will prevent the return of the original behavior (Bouton et al., 2006).

It is important to mention an alternative explanation to the present results. For instance, assuming that the reduction of response during extinction is not controlled by independent representations of the extinction-cue and the context, but rather by a configural representation (extinction-cue/context), then during testing, the behavior should be modulated by the similarity between extinction and testing given the absence or presence of the extinction-cue. Thus, given that in the present experiment the conditions of extinction and testing of X are the same, the configural perspective prediction is that no reinstatement to X should be observed. However, although we found a higher reinstatement to Y, we also reported reinstatement to X. Nevertheless, the present data cannot be taken as an exhaustive evidence against the configural perspective.

Despite the fact that reinstatement is considered a laboratory model to understand relapse after therapeutic intervention (e. g., Bouton & Woods, 2008; Vervliet et al., 2013) until recently, studies have evaluated behavioral treatments to prevent it. Nevertheless, evidence in rats and our present findings with healthy humans (see also, Gámez & Bernal-Gamboa, 2018) strengthens the translational research perspective. For example, these reports might be promising to clinicians, because they suggest that using strategies that implement therapy reminders (extinction-cues) could favor long-term effectiveness of exposure-based therapy.

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