Contextual renewal of an instrumental responses suppressed by punishment: an online study

Renovación contextual de una respuesta instrumental suprimida por castigo: un estudio en línea

Roberto Jiménez
Javier Vila
Maximiliano Aguilar*

Resumen

Un cambio en las características del contexto de extinción produce la reaparición del comportamiento extinguido, lo que se conoce como renovación contextual. Este experimento exploró la renovación contextual de una respuesta previamente extinguida utilizando un procedimiento de castigo. Los participantes resolvieron una tarea virtual en la que adquirieron dos respuestas operantes en la Fase 1 (Entrenamiento). Posteriormente, todos los participantes recibieron un procedimiento de castigo (Decremento)

Abstract

A change in the extinction context´s characteristics produces the reappearance of the extinct behavior, is known as contextual renewal. This experiment explored the contextual renewal of a previously extinguished response using a punishment procedure. The participants solved a virtual task in which they acquired two operant responses in Phase 1 (Training). Subsequently, all the participants received a pu-nishment procedure (Decrement) to eliminate response 1 (R1), while response 2 (R2) continued to receive reinforcement.

para eliminar la respuesta 1 (R1), mientras que la respuesta 2 (R2) continuó recibiendo refuerzo. Uno de los grupos (ABA) fue entrenado en el contexto A y fue castigado en el contexto B, mientras que el otro grupo (AAA) permaneció en el mismo contexto durante ambas fases. En la prueba en el contexto A, se observó que el cambio de contexto durante la fase de castigo solo afectó a R1 mostrando renovación contextual. Estos resultados extienden los hallazgos observados en animales a participantes humanos, son consistentes con la renovación contextual observada en otros procedimientos de disminución de respuesta.

One of the groups (ABA) was trained in context A and was punished in context B, while the other group (AAA) remained in the same context throughout both phases. During the test in context A, it was observed that the change in the context during punishment phase only affected R1 showing contextual renewal. These results extend the findings observed in animals to human participants, they are consistent with the contextual renewal observed in other response-decreasing procedures.

Palabras clave

Currently, it is recognized that context is a relevant factor during learning. In particular, the literature indicates that it is involved in the reappearance of extinguished responses (Bouton, 2019). This reappearance of the behavior is known as contextual renewal when the change in the physical characteristics of the extinction context produces the return of the response (Bouton, 1993); and spontaneous recovery when this reappearance occurs due to the passage of time after extinction (Rescorla, 2004).

Empirical evidence shows that these effects occur in procedures other than extinction. Contextual renewal of an instrumental response occurred when omission training was used in rats to suppress a response. Nakajima *et al.* (2002) trained a response in

rats in context A; this same response was subsequently subjected to omission training in context B. Upon returning to context A, the response reappeared. Moreover, there is evidence of the occurrence of spontaneous renewal and recovery effects of a previously suppressed response through omission training in human participants (Vila *et al.*, 2020) and Differentiated Reinforcement of Low Rates - DRL (Vila *et al.*, 2022b) also in human participants. These results suggest that recovery effects are not particular to extinction.

Most research has been done from a Pavlovian conditioning procedure, where it is proposed that the reappearance of the response occurs due to interference or inhibition that takes place when the learning of a second phase interferes with or inhibits the response acquired in the first phase (Miller & Escobar, 2002). Different authors suggest that the contextual dependence of a response may be a general mechanism used when retroactive interference in information occurs (Rosas *et al.*, 2006).

However, research conducted from operant conditioning frameworks present results consistent with this interpretation of context dependency of response decremental procedures (Bouton & Schepers, 2015; Marchant, 2014 ; Nakajima *et al.*, 2002). Studying other procedures that involve interference in information in operant conditioning, such as extinction, omission training, and pu-nish-ment, among others. These studies are relevant, since they have been consistently used as tools for intervention in different fields to reduce maladaptive behaviors, and as such, it is usual to observe relapses after using these procedures (Mallot & Kohler, 2021). The relationship between the effects of recovery and relapse emphasizes the role of the context in everyday situations, since the recovery of maladaptive behaviors is observed by changing the physical or temporal context where the response was suppressed (Bouton, 2019, Podlesnik *et al.*, 2017, Vila *et al.*, 2022a).

For example, Kelley *et al.* (2015) demonstrated renewal of destructive behavior such as hitting, throwing objects, and biting, in children. The destructive behavior rates of four children in their home (Context A) were measured; subsequently, the destructive behavior was extinguished while they were taught a new behavior that allowed access to a reinforcer in Context B. A decrease in destructive behavior and an increase in the new behavior was observed. However, when tested in Context A, all four children showed renewal of the destructive behavior. These findings support that context specificity is not subject to a single behavior elimination treatment, furthermore, it offers evidence in favor of renewal effects as models of relapse.

Punishment is a procedure in which a previously reinforced instrumental response is subsequently suppressed by making an aversive event contingent to this response (Azrin & Holz, 1966). Contextual renewal research of this procedure has focused entirely on non-human animals. The contextual renewal effect of an operant behavior previously suppressed by punishment was observed in rats in an experiment where they were trained to press a lever and receive food in Context A. Subsequently, this same operant behavior was suppressed by punishment, presenting a response-contingent shock in the paw in Context B. However, when tested in both Contexts A and B, a strong renewal effect was observed in Context A (Bouton & Schepers, 2015; Marchant *et al.*, 2013). Following these experiments, Broomer & Bouton (2022) made a comparison of recovery effects, such as renewal, spontaneous recovery and reacquisition, after receiving either punishment or extinction; all three effects occurred with similar strength, regardless of the interfering procedure. Therefore, the evidence was expanded regarding the generality of the effect of contextual renewal in procedures that produce response decrement.

Based on these results, its suggested to consider the role of the context for the intervention in maladaptive behaviors in humans

using punishment. Nonetheless, the lack of evidence that specifically demonstrates this case of contextual renewal in humans, implies that the possibilities of the intervention are limited, since the particularities of this population are unknown.

Additionally, Estes (1944) proposed that the effects of punishment procedures are temporary, once the punishing stimuli is removed, the suppressive effect decreases, and the punished instrumental response reappears. Thus, it suggests that the effects of punishment might be context dependent.

Even though empirical evidence indicates that punishment is also dependent on the context in which it is learned, and that different procedures that involve interference occur in a similar way in non-human and human subjects (Bouton & Schepers, 2015, Marchant, 2013 ; Broomer & Bouton, 2022). More evidence is needed, specifically with human participants, to know more about the generality of contextual renewal, its particularities when it occurs in humans, and, above all, its implications for intervention. Punishment a procedure that has been commonly implemented to decrease problem behavior. Mallot & Kohler (2021) present a vast array of uses for punishment procedures, such as reducing self-injurious behaviors (hitting their head repeatedly) with mild shocks, or stopping undesirable habitual behaviors, like nail-biting or eye-rubbing by clenching one's fists.

Based on the existing evidence, the present investigation supposes that the contextual renewal of a response suppressed by punishment will occur in humans similarly as it occurs in animals. In addition, a second hypothesis is proposed, contextual renewal of punished behavior will be similar to that generated by other response decrement procedures in humans, such as DRO, DRL and extinction (Kelley *et al.*, 2015; Saini *et al.*, 2018 : Vila *et al.*, 2022a).

Methodology

Participants

Forty university students participated in this study (20 per group) from which 25 were women, the mean age was 22.5 years, and the participants age range was between 18 and 24 years. All were contacted by email and their consent to participate was requested prior to the experiment, they could abandon the task at any time. The participants were assigned to two groups, AAA and ABA, both described below, by means of the software used for the experimentation (SuperLab© 6, Cedrus Co.), aided by its remote extension (SuperLab Remote©, Cedrus Co.).

Experimental design

Group	Training	Decrement	Test
AAA	(12) E1 – R1 +	(12) E1–R1+ (P) (12) E2 – R2 +	A: (1) E1? (1)E2?
ABA	(12) E2 – R2 +	(12) E1–R1 + (P) (12) E2 – R2 +	B: (1) E1? (1)E2?

Experimental design. R1 and R2 indicate two different responses to destroy each of the enemy ships E1 and E2. "+" indicates destruction of the ships. "(P)" indicates the presentation of the aversive event in Interference. The numbers indicate the number of trials.

The experimental design is shown in Table 1. A Mixed design with two groups (AAA & ABA) in two phases (Training and Decrement). They both received Training in the same context (A), then group ABA received Decrement in a Different context (B), while group AAA received it in the same context (A). Afterwards, both groups went through a Test Phase, in both the A and B contexts. In the Decrement Phase only R1 is affected as R2 continues to be reinforced throughout.

Apparatus and stimuli

All the participants were trained individually on their personal computer equipment in which they carried out their participation, using a task based on "The Learning Game" (Nelson *et al.*, 2014) programmed using the SuperLab© 6 Software, Remote Extension (Cedrus Co.). A remote package was generated through the Super-Lab Remote© extension; used to carry out experiments online, this allows the experimenter to program a task with events, trials, and blocks in an identical way to how it would be done in person, to later generate a remote package that contains the necessary files so that the participant could execute the experiment without the need to install any additional software.

The participants were contacted by email and their participation began by means of a Google Forms questionnaire that contained the informed consent form, demographic questions (age, sex, academic level, and school in which they are studying), instructions to access to the online experiment and contact information in case there were any questions. If they agreed to participate and gave their consent, the questionnaire they answered presented them with a Google Drive folder, which contained two instructional videos, one to decompress the remote package, and one to realize the experimental task. Once the files were downloaded, and the executable file was opened, the task started.

In the task, a planet visible from the cockpit of a ship served as the context. The planets were counterbalanced between groups, such as Context A and Context B. All given instructions were originally delivered in Spanish. At the end of all the phases, a data file was generated which we requested to be sent back, either through the questionnaire itself, which had a section to upload it, or through the contact email.
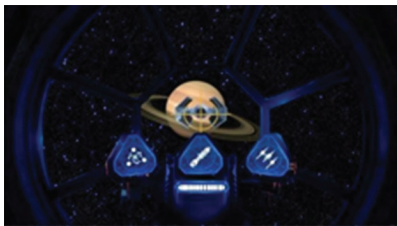
Procedure

Figure 1.
Contexts A and B, counterbalanced between groups, ships corresponding to E1 and E2, counterbalanced between groups, and results screen, when hitting (S1) or missing (S2) the objective in the Training Phase, as well as the Punishment in the Decrement Phase (S3).
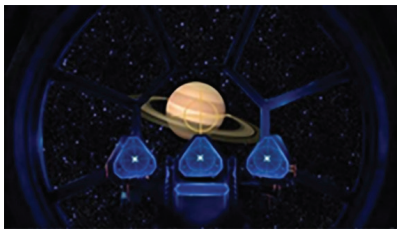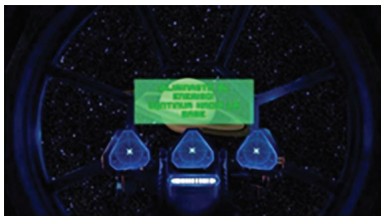

A

B

E1

E2

S1

S2

S3

Training Phase. The task presented the message: "You are a pilot who must defend the Earth from an alien attack, use the weapons you have available to destroy the ships that appear". The participants received 12 training trials with each enemy, E1 and E2, which were destroyed by clicking on one of the available weapons, in this case R1 and R2 respectively, at a variable interval of 3s (IV). In each trial, E1 or E2 was randomly presented, and emitting the correct response was reinforced with screen 1 (S1) with the destruction of the enemy, when emitting a different response resulted in missing the target screen 2 (S2) was shown. At the end of this phase, a screen indicated "Press the button to continue the battle!"

Decrement Phase. In Group AAA participants would continue to see the same planet in the background when continuing with the task; however, Group ABA participants would see a different planet. After the last trial of Training, the participants received 12 more trials with each of the enemies. Participants could continue responding R1 to E1; however, now contingent on this response, a red screen 3 (S3) flashing was presented with the message "Your ship is taking damage!" For the E2 enemy, the response R2 and reinforcement did not change. Enemies were randomly presented. At the end of this phase the screen appeared indicating "Press the button to continue the battle!"

Test Phase. For all the participants, this phase began with the phrase "The battle continues...", presented for 2s on screen. After this time, all participants received an extinction trial for each con-

text and enemy. Each trial lasted 4 seconds and the enemies and contexts were presented randomly, as we intend to observe the very first responses to R. Figure 1 shows both enemies and the contexts used, as well as the punishment screen.

Data analysis

For the exposed experiment, the total number of clicks on each enemy was recorded; this number was divided by the duration of each trial, obtaining the measure of responses. These responses were analyzed using a Mixed Analysis of Variance. The rejection criterion was established as $p < 0.05$ and the effect sizes were reported using partial eta squared (ηp^2). Additionally, 90% confidence intervals were calculated and reported for each analysis. Dataset is available in an public online repository (https://kaggle.com/datas ets/494dc8ab699829471d389fab34b54d4755242492883c17b2c8346 c04feb770b5)

Ethics

This study was carried out following the ethical and legal guidelines for human research published by the Ethics Committee of the Facultad de Estudios Superiores Iztacala (Universidad Nacional Autónoma de México, https://psicologia.iztacala.unam.mx/psi_ bioetica_codigoeti.php) and the psychologist's code of ethics (Sociedad Mexicana de Psicología, 2009). To comply with the ethical regulations for research through the Internet (Frankel & Siang, 1999), variables that could affect the privacy of the participants were not recorded; in addition, measures were taken to safeguard access to the information obtained so that only the experimenters had access to it.

Results

Figure 2 shows the average responses per 4 second for R1 and R2 during blocks of three trials in Training Phase and Decrement Phase for groups AAA and ABA. A 2 (Group) x 2 (Responses) x 4 (Blocks of three trials). ANOVA performed on the Training Phase data indicates that both responses were acquired similarly by all participants and that responses increased with a similar frequency as the Training Phase progressed. The interaction between the main effects of Group, F (1, 44) = 1.57, p = 0.22, and Group x Responses, $F < 1$, was not significant. The main effect of the three trials Block, F (3, 132) = 205.32, $p < 0.0001$, ηp^2 = 0.82, [CI: 0.78-0.85] was significant. However, the Responses x Block interaction of three trials was not significant F (3, 132) = 2.12, p = 0.099. Showing that both responses incremented during this phase.

Figure 2.
Average responses per 4 second for R1 and R2 in the Training (left panel) and Interference (right panel) phases, for groups AAA (black) and ABA (white). The bars indicate the standard error of the mean. The asterisks show the significant differences between blocks.
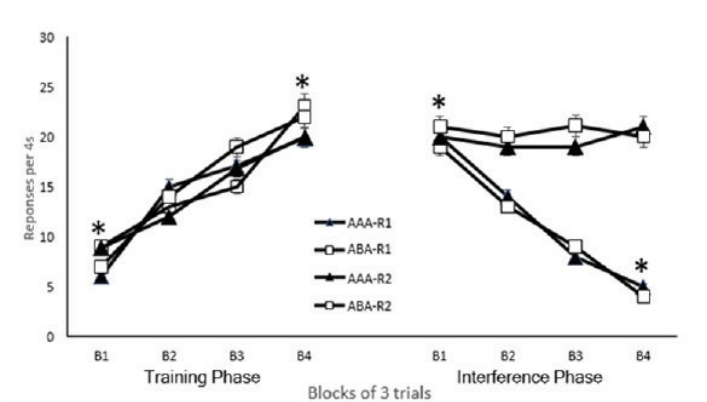
An ANOVA on the Decrement data, 2 (Group) x 2 (Responses) x 4 (Block of three trials, found significance of the main effect of Responses, $F_{(1, 44)} = 451.01$, $p < 0.0001$, $\eta p^2 = 0.91$, [CI: 0.86-0.93] and Block of three trials, $F_{(3, 132)} = 52.42$, $p < 0.0001$, $\eta p^2 = 0.54$, [CI: .44–0.61]. The interaction Response x Block of three trials was also significant $F_{(3, 132)} = 145.38$, $p < 0.0001$, $\eta p^2 = 0.76$ [CI: 0.71-0.80] Showing that R1 decremented while R2 remains the same during this phase. Subsequent comparisons showed a decrease in R1 during Decrement phase. Not known observed differences in R1 and R2 responses in the first block, $p > 0.05$. However, in subsequent blocks lower levels of R1 were observed, the lowest $F_{(1, 44)} = 57.76$, $p < 0.0001$. The analysis confirms that the punishment procedure caused R1 to decrease similarly in both groups while all participants continued emitting R2 levels during Decrement Phase, like those observed during the Training Phase.

Figure 3 shows the average responses for R1 and R2 during the last trial of Decrement and the Test for both groups. If contextual renewal occurs, a higher level of responses to R1 would be observed during the Test than in the last Decrement trial in the ABA group. A 2 (Group) x 2 (Response) x 2 (Trial) ANOVA indicated significance of the Group main effect. $F_{(1, 44)} = 4.96$, p = 0.03, $\eta p^2 = 0.10$, [CI: 0.00-0.25] Response, $F_{(1, 44)} = 861.67$, $p < 0.0001$, $\eta p^2 = 0.95$, [CI: 0.93-0.96] and Test, $F_{(1, 44)} = 6.28$, $p = 0.001$, $\eta p^2 = 0.12$, [CI: 0.01-0.28]. Although the interaction between Group and Response was not significant, $F_{(1, 44)} = 2.12$, $p = 0.15$; Group x Response, $F_{(1, 44)} = 6.05$, $p = 0.02$, $\eta p^2 = 0.12$, [CI: 0.01-0.27], Group x Trial, $F_{(1, 44)} = 10.61$, $p = 0.002$, $\eta p^2 = 0.19$, [CI: 0.05-0.35] and Response x Trial, $F_{(1, 44)} = 63.04$, $p < 0.0001$, $\eta p^2 = 0.59$, [CI: 0.42-0.69] were significant. In the ABA group, there is a significant difference between the last response to R1 in the Decrement Phase and the first response to it in the Test; this would indicate that the contextual renewal effect occurred. This difference does not exist for R1 in group AAA or for R2 in any of the groups.

Figure 3.

Responses per four seconds by group in the last trial of the Decrement Phase and in the Test. The left panel shows R1 for both groups (AAA and ABA) in Decrement and Test. The right panel shows the same for R2. The asterisks show the significant differences between blocks.
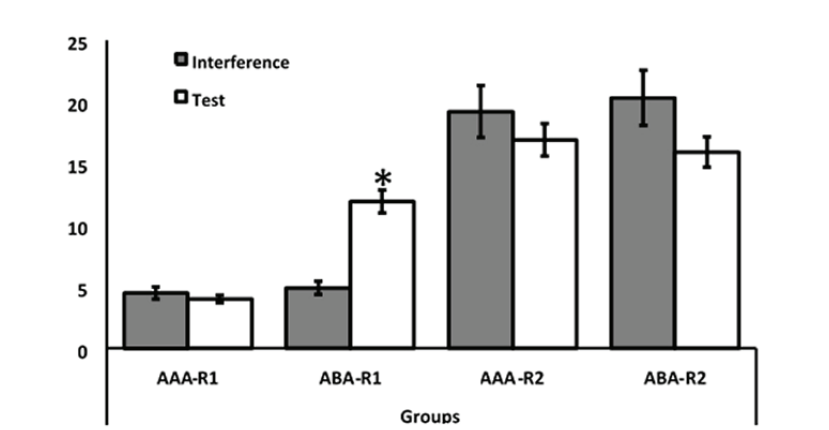
Planned comparisons showed that participants in the ABA group emitted higher levels of R1 responses than participants in the AAA group during Test $F(1, 44) = 21.37$, $p = 0.0001$, $\eta p^2 = 0.65$, [CI: 0.14-0.47], indicating the contextual renewal of an instrumental response previously suppressed by punishment.

Discussion

This study observed the contextual renewal of an instrumental response suppressed by punishment in human participants. The data suggested that the behavior that was decremented by producing an aversive consequence contingent, reappears in the original context. These results obtained with university students are coherent with studies carried out with non-human animals that show contextual

renewal using punishment procedures (Bouton & Schepers, 2015, Marchant, 2013; Broomer & Bouton, 2022). Additionally, with the renewal studies in human, with different response- decreasing procedures (Vila *et al.*, 2022a; 2022b).

These results are coherent with the theoretical perspective that emphasizes the importance of context when participants learn information that generates interference (Bouton, 1993, 2019). It is proposed that effects such as renewal or spontaneous recovery illustrate how decremental response procedures are context dependent, so that the impact of context switching should only be visible after the decrement occurs. The findings of this study are consistent with this theoretical approach, as the context switch between Interference and Test produced a higher level of R1 in the ABA Group; Furthermore, it is important to highlight that this context sensitivity only affected the response subject to interference (R1), while the R2 response was not affected, maintaining similar levels in both groups.

In the AAA group, R1 decreased as well, but context switching did not occur, so it remained at a consistently low level all throughout the different phases. Thus, the present results extend the contextual specificity to punishment in human participants.

Given that renewal effects have been proposed as a model to study relapse on problem behaviors, the results obtained in this study have applied implications, particularly in treatments that seek to modify or reduce unwanted behavior. Taken together, the literature suggests that despite successful treatment using extinction, omission training, DRL or punishment, relapse occurs when the person returns to the context where the problematic behavior was learned Vila *et al.*, 2022a; 2022b). Different authors have reported renewal effects after using another well-documented behavior suppression procedure, such as differential reinforcement of other behaviors, with clinically relevant populations (Kelley *et al.*, 2015). These findings support that context specificity is not subject to a

single behavior elimination treatment, furthermore, it offers evidence in favor of contextual renewal effects as a model of relapse.

The applied implications of the context during an intervention have not been widely explored; however, there are studies that, based on these, offer strategies to maximize the effectiveness and duration of treatment. For example, Craske *et al.* (2014) propose strategies to cope with contextual renewal include procedures such as the implementation of recovery signals that allow learning to be recovered in a different context; or training in multiple physical and temporal contexts, to facilitate generalization. The present results can be taken as a translational study, that shows the contextual specificity of punishment treatment.

In summary, these preliminary results, showcase the effect of contextual renewal in university participants, which together with the previously mentioned studies supports the idea that the recovery of instrumental responses produced by context is not typical of extinction, but occurs in response decreasing procedures, such as extinction, omission training, and DRL (Kelley *et al.*, 2015; Saini *et al.*, 2018).

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