A MULTIMODAL INVESTIGATION OF RENEWAL OF HUMAN AVOIDANCE, PERCEIVED THREAT, AND EMOTION

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Many people who receive exposure-based treatments for anxiety disorders exhibit a return of fear and avoidance which is often referred to as renewal or relapse. Human and nonhuman research on fear conditioning and renewal has been instrumental in helping understand relapse in anxiety disorders. The purpose of this investigation was to examine renewal of human avoidance and assess whether avoidance may aid in sustaining renewal of fear responses. We adopted a multimodal measurement approach consisting of an approach-avoidance task along with ratings of perceived threat and fear and measures of skin-conductance, a widely used physiological measure of fear. A traditional, single-subject research design was used with six healthy adults. All tasks employed a discrete trial procedure. Experimental conditions included Pavlovian fear conditioning in which increased probability of money loss was paired with a “threat” meter in Context A and later followed extinction in Context B. Fear and avoidance increased to higher threat levels in Context A but not Context B. Renewal testing involved presenting the threat meter on a return to Context A to determine if it evoked fear and avoidance (i.e., relapse). As predicted, renewal testing in Context A showed that increased threat was associated with increased avoidance, ratings of perceived threat and fear, and higher skin-conductance. Moreover, results showed that renewal maintained over six blocks of trials. This is the first investigation of renewal of threat and avoidance in humans that highlights avoidance as a mechanism that may contribute to maintaining fear in anxiety pathology.
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INTRODUCTION

Many prominent psychological theories of clinical anxiety implicate Pavlovian learning processes in the acquisition and maintenance of excessive negative emotional responses (fear, and threat perceptions) to stimuli. Pavlovian fear conditioning (FC) paradigms have been used for decades in behavioral and neurophysiological research to understand the behavioral and brain mechanisms of fear. Moreover, an equally important counterpart of fear learning research has been Pavlovian research on learning to no longer express fear with respect to a stimulus. The latter research area has broadly been known as fear extinction learning. But, importantly, it has direct relevance to psychological treatments designed to eliminate fear responses to stimuli, such as spiders, crowds, and other phobias.

FC occurs when pairing a neutral cue with an aversive unconditioned stimulus (US), such as an electric shock, transforming the neutral stimulus to a conditioned stimulus (CS) capable of eliciting a variety of conditioned fear responses (CR; e.g., “fear responses” such as startle, arousal, avoidance, freezing) by reliably predicting US delivery (CS+>US). Other stimuli that are predictive of the absence of US delivery are often referred to as CS-. Extinction learning occurs when the CS+ is no longer followed by the US (CS+>NoUS). The resulting outcome is that CS+ presentations no longer elicit fear responses because they reliably predict the absence of US delivery.

Current laboratory research often includes biometric measures of galvanic skin responses (GSR; Mooney, Scully, Jones, & Smeaton, 2006) such that GSR, along with a handful of other physiological responses, are used to measure affective states of the participant. “Affective states” represent the combination of physiological and psychological responses (Mooney et al., 2006, p.
570) which produce a unique measure of a participant’s condition. Because these measures have shown significant differences between baseline and at other points within a procedure, GSR is now used more widely during investigations of fear.

**Relapse and Return of Fear**

Bouton (2002) noted that while extinction of fear responses involving US omission forms the basis of many exposure-based psychological treatments, treatments for anxiety are not always successful. Specifically, after successful treatment, some people relapse and show renewal or a “return of fear” to the original CS despite the absence of the US (CS>NoUS). Bouton points out that extinction of fear responses in vivo does not eliminate or otherwise “undo” the original CS+>US relation or erase that learning history. Rather, the extinction process decreases the probability of fear responses occurring when the CS is presented. Moreover, the contexts in which fear learning and extinction learning occur become additional acquired associative relations that affect the probability of fear responses.

Rosas, Todd, and Bouton (2013) described the relation between Pavlovian conditioning and the role of context in the case of relapse. Traditionally, researchers study relapse using a design with two or three different contexts. In Context A, fear conditioning establishes the CS+ and CS- cues. Subsequently, CS+ presentation elicits fear responses while CS- presentation does not. In Context B, extinction learning occurs to the CS+ when the CS+ is presented without the US. Finally, when the CS+ is presented again in Context A during recovery testing, but this time without being followed by the aversive US, many investigations show CS+ presentation will elicit fear responses – despite having extinguished fear responses to the CS+ in Context B (Bouton & Bolles, 1979 [as cited in Bouton, 2002]; Bouton, Todd, Vurbic, & Winterbauer, 2011;
Rosas & Callejas-Aguilera, 2006). Such findings highlight the role of context in mitigating renewal and have been offered as an account of the “return of fear” following successful exposure-based psychological treatments.

**Research Areas on Renewal Effects**

**Pavlovian (fear) conditioning.**

Renewal effects have been the most extensively studied using *fear conditioning* paradigms (Bouton & King, 1983; Effting & Kindt, 2007; Harris, Jones, Bailey, & Westbrook, 2000; Rauhut, Thomas, & Ayers, 2001; Vansteenwegan, Dirikx, Hermans, Vervliet, & Eelen, 2006 [as cited in Nakajima, 2014]). For example, Bouton and King (1983) conducted four conditioned suppression experiments with rats to examine the effects of context on fear expressed in rats to an aversive CS—following extinction. The CS was first paired with shock (in Context A), and then underwent respondent extinction in Context B where the CS was not paired with shock. When the rat returned to Context A, the fear response was renewed.

Rauhut et al. (2001) integrated different treatments in the extinction phases of their experiments in order to determine those effects during renewal testing. The researchers allowed rats to bar press for sucrose throughout all conditions and conditioned the cessation of light in the chamber with shock. They measured fear by comparing the rate of bar presses before the onset of the CS to the rate after the onset of the CS. In Experiment 1, the researchers conditioned lights out with shock. For treatment, they exposed one group to 20 extinction trials and another to 100 extinction trials. Renewal returned slowly to both groups before coming back full strength. Researchers followed the same conditioning process for experiment 2 but changed treatment. One group was treated following the typical extinction where the CS was never followed by
shock, while two groups – EU-4 and EU-16 (EU – explicitly unpaired) – received an even pairing of CSs and USs though neither were displayed together – e.g., L (lights off), S (shock) – i.e., LSSLSLL. (See Rescorla, 1967, p. 72, for EU definition.) Renewal returned more slowly for the two EU groups but, like experiment 1, eventually regained full strength. Next, up to three CSs underwent conditioning to shock – X (lights out), Y (tone), and Z (clicking). During treatment, two trials of CS Y+ were presented, then five trials of CS YX-. This created a conditioned inhibitor (CI) group. (See Rescorla, 1969, p. 79, for CI definition.) One other group of rats became the differentially conditioned (DC) group by two trials of CS Y+ and five trials of CS X-. During this treatment condition, the authors noted an initial weakening of the renewal for the CI and DC groups. Experiment 4 compared renewal for the EU, CI, DC groups and found weaker renewal than the traditional CS-, and U (US-alone) groups. In all experiments, the effects of weakened renewal lasted a finite number of trials before returning to full renewal.

A study with rats by Harris et al. (2000) paired two different CSs with shock in one context (i.e., CS A in Context A and CS B in Context B) and subsequently put both on extinction in a novel context (i.e., Context C). Testing for renewal in the original context netted the greatest associative strength while renewal in the unique context (i.e., CS A in Context B and CS B in Context A) showed the next greatest return of relapse.

Another example, this time with human participants, was the research by Effting and Kindt (2007) that conditioned one picture with shock and another picture with no aversive consequences. In Experiment 1, the experimenters divided participants so that half were exposed to conditions ABA and the other were exposed to the AAA renewal paradigm. For all three contexts, the researchers presented both CS+ and CS-. Different colored ceiling lights indicated
different contexts in the running room. With the ABA paradigm, Context A served as the conditioning context; Context B acted as the extinction context; and, again, the return to the original Context A represented the test condition with the outcome still extinguished. Context A for the AAA paradigm was the context in which conditioning, extinction, and testing all occurred. A trial began with the presentation of a picture. While viewing the picture, the participant rated his expectancy of upcoming shock. Researchers recorded galvanic skin responses (GSRs) to identify any autonomic arousal that may have occurred simultaneously with the delivery of shock or the prediction of shock. The ratings responses measured renewal, and the ABA paradigm demonstrated renewal while AAA did not. Testing of the AAA paradigm seemed a continuation of extinction. Effting and Kindt ran Experiment 2 to test their hypothesis that ABC would show weaker renewal, that AAA would show none, and that ABA would show the strongest. The results matched their expectations.

**Appetitive conditioning.**

While not as prominent in the literature base, renewal effects have also been explored when appetitive conditioning procedures have been used (Bouton & Peck, 1989; Brooks & Bouton, 1994; Shapiro, Jacobs, & LoLordo, 1980). In appetitive conditioning procedures, cues are paired with reinforcers, such as food. For example, Bouton and Peck investigated the role of conditioning a CS with an appetitive US by pairing a 10 s tone (CS) with the delivery of a food pellet (US). They divided the rats into three groups: 1) one-third of the rats, the AT group, followed the AAA paradigm; 2) another group, BT, followed the ABA renewal paradigm. The CTRL group received explicitly unpaired (EU) conditioned and appetitive stimuli. No renewal was seen with the AAA and CTRL groups, but renewal returned for ABA. For appetitive
conditioning, however, the researchers were able to capture iterations of head jerking as a dependent measure by calculating the percentage during the condition. From this number, they were able to extrapolate the associative strength or excitatory strength of the CS. The results indicated that the behavior of head jerking began at low rates and increased (CS+) during conditioning. Further, head jerks decreased during extinction of the CS- and showed a slight escalation during renewal before showing a decrease (CS-).

Shapiro et al. (1980) used a combined auditory-visual CS when testing pigeons for recovery to an appetitive reinforcer (i.e., food) or to an aversive stimulus (i.e., shock). In conditioning, Shapiro et al. noted that birds who received food all behaved similarly – pecking around and in the magazine – but upon presentation of the reinforcer, birds who had been shocked behaved similarly during the shock – prancing and head-raising. In a second experiment, Shapiro et al. paired an illuminated red light (CS) with food and a tone (CS) with shock and saw the same patterns in responding as seen in conditioning with birds who received food or shock. In both experiments, recovery testing resulted in responses beginning at moderate levels and dropping off to the CS-.

Brooks and Bouton determined that conditioning and extinction require some recall for future access to performance. They extended previous research by conditioning an appetitive and testing for the effect of an extinction cue on renewal. In order to test this, they preceded some extinction trials with a cue T (tone). During testing for renewal, the experimenters presented the CS alone or with the extinction cue preceding it. The extinction cue briefly attenuated renewal.

Finally, Todd, Winterbauer, and Bouton (2012a), in an attempt to explain food consumption in a sated organism, presented a unique Pavlovian conditioning procedure. During
conditioning, rats with unlimited access to food in their cages lever-pressed for access to sweet and/or fatty food. During extinction, lever presses were not followed by food access. Testing occurred in a context other than extinction. When once again lever pressing provided access to the sweet and/or fatty foods, Todd et al. (2012a) saw a renewal of food-seeking behavior. This condition was arranged based on the logic that overeaters and drug addicts do not require a state of deprivation to engage in food- or drug-seeking behavior.

**Operant learning with positive reinforcement.**

Renewal effects have also been observed and explored in instrumental or operant learning paradigms. For example, Bouton, Winterbauer, and Todd (2012) examined a variety of methods to better understand renewal during testing conditions. Like Bouton et al. (2012), Todd, Winterbauer, and Bouton (2012b) focused on what strengthened renewal to comprehend more completely the processes involved. To that end, they increased significantly the number of acquisition trials; they compared renewal of the ABA paradigm against renewal in the ABC paradigm; they slightly modified the conditioning and extinction contexts to see if acquisition or extinction would generalize; and finally they conditioned in multiple contexts to see the effects on renewal. In all situations, they reported stronger renewal. They also saw generalization occur when acquisition and extinction were repeated in contexts similar to the original contexts. In Bouton et al. (2011), the attention was on extinction. Their findings supported the conclusion that extinction is context-specific and that moving from the extinction context to another was sufficient to see renewal of lever pressing. Perhaps the most unusual result was the conditioning, extinction, and testing using an AAB paradigm. Again renewal occurred in context B, ostensibly by moving outside the extinction context.
In a different experiment, Crombag and Shaham (2002) conditioned rats to “self-administer” a heroin-cocaine mixture. They separated the rats into one of four groups by unique combinations of training, extinction, and “renewal” contexts: the renewal group (ABA); the novel group (AAB); ½ control group (AAA); and the remaining ½ of control (ABB). All groups demonstrated similar rates of drug-seeking during training and extinction conditions. For the control groups (AAA and ABB) whose data were reported as a single group, renewal testing resulted in comparably low rates of drug-seeking. The novel group, AAB, had renewal rates higher than the control group, but less than half that of the renewal group (ABA). The authors concluded that simply removing the organism from an inhibitory extinction context to the training context or to a novel context increased drug-seeking renewal.

**Operant learning with negative reinforcement.**

While the extant literature highlights renewal effects under aversive, appetitive, and operant learning paradigms, one notable gap in the literature on renewal effects concerns instrumental avoidance behavior. But, there appears to be a growing interest in examining renewal of avoidance behavior, especially given the prominent role of avoidance behavior in anxiety disorders (cf., Nakajima, 2014).

Nakajima compared performance of signaled avoidance in different contexts to determine what role context might play in renewal. In conditioning, he paired a tone (CS) with shock (US). The tone came on and stayed on for 10 s. To prevent the activation of shock, a rat had to cross the midline of the shuttle box within that 10 s window. Failure to do so resulted in the onset of 10 s of shock that then could be terminated only by crossing the midline. Throughout extinction and testing trials, the tone sounded for 20 s with no presentation of shock. Nakajima measured
the number of avoidance responses and found a similar pattern within groups across the same conditions. Acquisition showed an increasing trend of avoidance behavior. Extinction showed a decreasing rate of avoidance offset by an increasing rate of approach. And, for a single session of testing, the rats engaged in renewal at fairly low levels. Nakajima concluded that avoidance responding changed for testing because of the release from the extinction context rather than associations with the context.

**Summary**

Collectively, the review of the literature highlights the processes and scope of renewal and translational value for understanding relapse in anxiety. While renewal is highly relevant to our understanding of treatment relapse, there are a number of concerns and challenges facing a strict application of renewal findings to account for “return of fear.” One concern in particular is that renewal testing often involves only a few trials. For example, Effting and Kindt (2007) showed a renewal effect in humans during the first few trials of testing, but the effect was transient and subsided rather quickly under additional testing. Failure to show sustained renewal in laboratory studies is a serious challenge to renewal accounts of clinical anxiety because pathology is characterized by lasting fear responses. Moreover, the absence of a sustained renewal response suggests another factor(s) or process may be at play in clinical anxiety that helps sustain fear responses. Another concern is the lack of investigations addressing renewal of avoidance behavior. This concern gains importance in light of the fact that avoidance is a prominent emotional coping strategy and is a behavioral characteristic of clinical anxiety, which may highlight avoidance as key individual difference variable or vulnerability factor contributing to the maintenance of fear responses.
Accordingly, in this investigation, experimenters sought to advance our understanding of relations between renewal and human avoidance. Results of this investigation could expand research on renewal to human avoidance and highlight avoidance and negative reinforcement as potential mechanisms that support renewal effects. Consequently, the first aim of this experiment was to assess renewal of human avoidance behavior. Results of nonhuman and human avoidance studies show that CS+ cues can motivate avoidance behavior and CS+ removal and associated US reductions can serve as negative reinforcers (Bolles, 1972 [as cited in Bouton et al., 2011]; Dymond & Roche, 2009). It follows from FC studies and studies on Pavlovian to instrumental transfer (Holmes, Marchand, & Coutureau, 2010) that presentation of CS+s that predict a US in Context A will prompt avoidance behavior. Subsequently, CS+s that have undergone extinction in Context B will not prompt avoidance behavior. Results of FC studies on renewal predict that when previously extinguished CS+s are returned to the original Context A they should motivate avoidance behavior. Such findings would be the first demonstration of renewal of human avoidance. The second aim of this experiment was to assess whether renewal could be sustained when subjects have a prior history of successfully preventing US delivery through avoidance. The current investigators propose that when renewal testing occurs, which involves CS+ presentation without the US in Context A, a prior history of avoidance in Context A may sustain renewal because avoidance responding was previously maintained by negative reinforcement (i.e., prevented US delivery). Therefore, renewal may be sustained indefinitely by avoidance because avoidance responding is followed by absence of the US.
METHOD

Participants

Seven participants, six women and one man, who ranged in age between 20- and 26-years old, were recruited via word-of-mouth or via flyers posted in public areas at a university in north-central Texas. The participants completed a screening to confirm eligibility, read and signed consent, and provided limited demographic information. Four of the seven participants were currently enrolled at the university while the remaining three participants had already earned their bachelor’s degrees.

Materials and Apparatus

All behavioral tasks were run using E-Prime® software. Galvanic skin responses (GSRs) were collected with Shimmer® which was clipped to a bracelet with electrodes attached to the participant’s non-dominant palm.

Experimental Design

Figure 1 shows the experimental design used was a modified comparison design and consisted of these conditions: Pretesting; Context A: CS>Lost; Context A: Choice; Context B: CS>NoLoss; Context B: Choice; Context A: Renewal Ratings; and Context A: Renewal Choice.

Experimental Conditions

Stimuli. Figure 2 shows the relation between threat level and programmed probability of US delivery. Figure 3 shows the basic computer display for all conditions. CSs were positions of a “NOW” prompt on a vertical “meter”. The aversive US was a compound stimulus consisting of an image of an alien face, 300 ms scream and $1.00 money loss. Reinforcement consisted of earning $0.10.
**Trials.** Each trial lasted 9 s. Ten trials of each CS and ten trials of instructed responding (baseline) were presented. CS stimuli were presented for 4 s, followed a 5 s intertrial interval.

**Pretesting.** The purpose of this 10-minute Pretesting task was to provide baseline for subsequent responses to CSs and ensure no differential responding to CS stimuli. The following instructions were presented on the monitor.

*This is a 10 minute task.*
*Your task is to pay attention.*
*During this task, you will see several shapes on the screen.*
*One shape is a standing rectangle.*

*Every 9 s or so the word <NOW> will appear by the rectangle.*
*You will also see PRESS #3 printed in the middle of the screen.*
*When these occur, press number 3.*
*That's it! Very simple.*

*It is important that you follow these directions.*
*This task is very boring (sorry), so try to stay alert.*

*What we are doing is measuring your skin-conductance when you see the word <NOW> and press #3. This information tells us about your unique level of reactivity.*
*So, relax and please follow the instructions.*
*If you don't, it will ruin the data we do collect.*

**Any questions? Experimenter Press #6 to start task.**

During the task, participants watched the monitor as the “NOW” moved up and down vertically to various positions within the threat meter. Every 9 s, the participant was prompted to “Press 3 now.” At the end of the task, the participant completed the online ratings for feelings of threat and expectancy of money loss (*see Dependent measures below*).

**Context A: CS>Loss.** This 10-minute Pavlovian Conditioning process was intended to teach the participant the relation between threat levels and probabilities associated US delivery in Context A. The following instructions were presented on the monitor.
YOU ARE NOW IN SECTOR A

This is a 10-minute learning task.
It is designed to prepare you for games you will play later.
In this and the upcoming games, you fly through space Sector A and
meet up with other ships. However, some ships contain Aliens.
You have scanner that searches ships and displays the Alien threat level.
When a ship is found, the threat level will appear as NOW.
In this task you must look at the threat level and learn
how likely it is you will lose $1. All you need to do is watch.
PAY ATTENTION!! DO NOT PRESS ANY BUTTONS.

So, watch the threat level and note how often you
DO and DO NOT lose $1. What you learn will help later on.
For now, we will give you $25. But YOU WILL LOSE A LOT now.
Any questions? Experimenter Press #6 to start task.

During the task, the participant watched as higher threat levels were paired with money loss, the
different face, a statement informing him that he “Lost $1,” and the sound of a scream. Because
acquisition required exposure to money loss, the experimenter endowed the participant with
$25.00 at the start of the condition. At the end of the task, the participant completed both sets of
ratings questions. The experimenters considered that the participants had acquired requisite
learning of the CS-US relations if expectancy of money loss increased with threat level. Only
one subject required two sessions.

**Context A: Practice.** During this condition, the participant engaged in a 3-minute
practice session. The purpose was to ensure that the participant “approached” when threat level
was lowest and avoided when the threat level was highest. Instructions explained that a bag of
money would appear on the left side of the screen and prompts in the screen’s center would
direct the participant to press the numbers “1” or “2” on the keyboard: “<< 1 = Money or 2 =
Reduce Threat >>.” The following instructions were presented against a white background:
YOU ARE NOW IN SECTOR A
This is a 3-minute PRACTICE game to prepare you for the real game.
Your job is to earn money AND keep aliens from taking your money.
If you quit early, you don't get ANY money from this task.
In this game, you fly through space and meet up with other ships in Sector A.
You have a scanner that searches ships and displays the Alien threat level.
SO: Remember what you learned earlier about the threat levels!!

When a ship is found the threat level will appear as NOW.
Here is when you MUST make a CHOICE in less than 3 seconds:
1. You can BOARD the ship by pressing #1, and you will earn $0.10 cents.
   BUT the threat level will still exist!
   OR
2. You can avoid the ship and REDUCE the threat level to 0 by pressing #2.

Finally, every once in a while you will be told to <Press #3>.
Please do so when asked. It is important.
Any questions? Experimenter Press #6 to start task.

Successful approaches (i.e., boarding at a threat level not programmed for money loss) earned
the participant $0.10 while unsuccessful approaches (i.e., boarding at a higher threat level
programmed for money loss; see Figure 2) resulted in earning $.10 and losing $1.00. Once the
participant had earned at least $0.50 by the end of the condition, he moved on to the next
condition. If that did not occur during the first three-minute practice session, the participant
could repeat the task up to two more times until he earned $0.50.

Context A: Choice. The purpose of this 10-minute “choice” condition in Context/Sector
A was to test whether approach would occur at lower threat levels and avoiding money loss
would occur at higher threat levels, with a transition from approach to avoidance at intermediate
levels. Instructions were presented against a white background as follows:

YOU ARE NOW IN SECTOR A
We are giving you $5.00 now. This is a 10 minute game.
Your job is to earn money AND keep aliens from taking your money.
If you quit early, you don't get ANY money from this task.
In this game, you fly through space and meet up with other ships in Sector A. You have a scanner that searches ships and displays the Alien threat level. SO: Remember what you learned earlier about the threat levels!!

When a ship is found the threat level will appear as NOW. Here is when you MUST make a CHOICE in less than 3 seconds:
1. You can BOARD the ship by pressing #1 and you will earn $0.10 cents. BUT the threat level will still exist!
OR
2. You can avoid the ship and REDUCE the threat level to 0 by pressing #2.

Finally, every once in a while you will be told to <Press #3>. Please do so when asked. It is important.
Any questions? Experimenter Press #6 to start task.

At the end of the task, the participant completed ratings.

**Context B: CS>NoLoss.** During this 10-minute task, instructions were shown with yellow background and no US delivery occurred at any threat level. Thus, context B served as an extinction condition for CSs. The participant received the following instructions;

YOU ARE NOW IN SECTOR B
This is a 10-minute learning task.
It is designed to prepare you for games you will play later.
In this and the upcoming games, you fly through space Sector B and meet up with other ships. However, some ships contain Aliens.
You have scanner that searches ships and displays the Alien threat level.
When a ship is found, the threat level will appear as NOW.
In this task you must look at the threat level and learn how likely it is you will lose $1. All you need to do is watch.
PAY ATTENTION!! DO NOT PRESS ANY BUTTONS.

So, watch the threat level and note how often you DO and DO NOT lose $1. What you learn will help later on.
For now, we will give you $3
Any questions? Experimenter Press #6 to start task.

At the task’s termination, ratings were completed.

**Context B: Choice.** This choice condition lasted was a 10-minute task in which CSs
were presented following extinction. All approaches earned $.10, while avoidance produced no a
blank screen. None responding produced the US. The following instructions were presented
against a yellow background:

YOU ARE NOW IN SECTOR B
We are giving you $5.00 now. This is a 10-minute game.
Your job is to earn money AND keep aliens from taking your money.
If you quit early, you don't get ANY money from this task.
In this game, you fly through space and meet up with other ships in Sector B.
You have a scanner that searches ships and displays the Alien threat level.
SO: Remember what you learned earlier about the threat levels and losing!!

When a ship is found the threat level will appear as NOW.
Here is when you MUST make a CHOICE in less than 3 seconds:
1. You can BOARD the ship by pressing #1 and you will earn $0.10 cents.
BUT the threat level will still exist!
OR
2. You can avoid the ship and REDUCE the threat level to 0 by pressing #2.

Finally, every once in a while you will be told to <Press #3>.
Please do so when asked. It is important.
Any questions? Experimenter Press #6 to start task.

When the task finished, the participant completed the ratings.

Context A: Renewal Ratings. Instructions stated the participant returned to
Context/Sector A and asked him to complete the ratings. The condition served as a test for
renewal of ratings. That is, the purpose was to return the participant to the original Context A
and discover if he would report an increased probability of money loss as the threat level itself
increased. Increasing rating were indicative of renewal.

Context A: Renewal Choice. This 10-minute task was a return back to Context A. The
condition served as a test for renewal of avoidance. During this condition, however, no money
loss was programmed. The following instructions were presented against a white background:
YOU ARE NOW BACK IN SECTOR A
We are giving you $5.00 now. This is a 10-minute game.
Your job is to earn money AND keep aliens from taking your money.
If you quit early, you don't get ANY money from this task.
In this game, you fly through space and meet up with other ships in Sector A.
You have a scanner that searches ships and displays the Alien threat level.
SO: Remember what you learned earlier about the threat levels!!

When a ship is found, the threat level will appear as NOW.
Here is when you MUST make a CHOICE in less than 3 seconds:
1. You can BOARD the ship by pressing #1 and you will earn $0.10 cents.
   BUT the threat level will still exist!
   OR
2. You can avoid the ship and REDUCE the threat level to 0 by pressing #2.

Finally, every once in a while you will be told to <Press #3>.
Please do so when asked. It is important.
Any questions? Experimenter Press #6 to start task.

Although instructions alerted the participant that this condition was a return to Sector A (i.e., the background color of the instruction screen was again white), those instructions did not reveal that no aversive US would be delivered. The participant received an endowment of $5.00 before engaging in the task. Once done, ratings were completed.

Dependent Measures

**Threat and US expectancy ratings.** At the end of each condition, the experimenter provided participants with a Likert scale to rate how threatened they felt when the word “NOW” in a red box was at one of 10 positions on the threat meter. The Likert scale ranged from “1/None” to “9/Severe.” Additional ratings for the expectancy of money loss were also displayed on a Likert scale and were ordered from “1/Never” to “9/Definitely.” All threat levels were presented for both questions. When the “Now” in the red box stopped at one position on the threat meter, the participant responded with a rating from the Likert scale. Threat levels were not
presented sequentially.

**Approach-Avoidance choice behavior.** Three Choice tasks – Context A: Choice; Context B: Choice; and Context A: Renewal Choice – provided the participant with opportunities to “approach” by pressing “1” or to “avoid” by pressing “2.” This data was tracked during all 60 trials of the specific Choice condition. Responses not entered within the three-second window were not counted. Due to that, a percent choice measure may not reflect a total of 100% on the graph.

**Choice reaction time.** Latency to responding in the Choice conditions provided a measure of the duration between the onset of the instructions to press and button pressing.

**Galvanic skin responses.** The Shimmer measured galvanic skin response (GSR) levels (i.e., moisture on the palms establishing conduction between the two electrodes). The GSR maximum peak was the highest peak difference between the GSR level at 1 s before trial onset subtracted from the GSR level at 4 s after trial onset. Maximum peak was obtained for all threat levels, and mean calculated for each level. Median groups levels were also plotted.
RESULTS

Pretesting

The first column of Figures 4 – 9 show threat and US expectancy ratings for each threat level. For each subject, ratings of threat and expectancy were low across all threat levels. The bottom row shows GSR responses were unsystematic.

Context A: CS>Loss

Figures 4 – 9 (second column) show threat and US expectancy ratings following threat conditioning were low initially but increased with increasing threat level. These results show differential conditioning occurred because of the increases in the probability of money loss. The bottom row of this column shows GSR responses unsystematic.

Context A: Choice

Figures 4 – 9 (third column) show that threat and US expectancy ratings increased with an increasing threat level. The second row of this column shows that avoidance increased (i.e., pressing “2”) and approach (i.e., pressing “1”) decreased with increasing threat. The red dashed line represents the programmed money loss by threat level. The third row of this column shows reaction times were longer for threat levels in the middle. The bottom row of this column shows GSR responses were generally variable across threat levels.

Context B: CS>NoLoss

Figures 4 – 9 (column four) show threat and US expectancy ratings did not increase with an increasing threat level and GSR responses were generally variable across threat levels.

Context B: Choice

Figures 4 – 9 (fifth column) show threat and US expectancy ratings did not increase with
increasing threat level. The second row of this column shows avoidance was zero and approach near 1.0 with increasing threat levels. These results show extinction was successful. The third row of this column shows stable reaction times. The bottom row of this column shows GSR responses that were generally variable across threat levels.

**Context A: Renewal Ratings**

Figures 4 – 9 (sixth column) show threat and US expectancy ratings increased when the threat level increased. These data highlight renewal of ratings.

**Context A: Renewal Choice**

Figures 4 – 9 (seventh column) show that threat and US expectancy ratings increased with an increasing threat level. The second row of this column shows avoidance increased and approach decreased with increasing threat, highlighting renewal of avoidance. The third row of this column shows longer reaction times for threat levels in the middle. The bottom row of this column shows GSR responses were generally variable across threat levels. Heat maps presented in Figure 10 for individual subjects highlight distributions of approach (green) and avoidance responses (red) as a function of threat level (with 10 as the highest probability of loss and 1 as the lowest probability of loss) over time (blocks of six trials per threat level presented randomly). Maps show results during the Context A: Renewal Choice. All subjects exhibited renewal of avoidance. Median GSRs are presented in Figure 8. Results show GSR responses were higher for intermediate threat levels compared to low threat levels during threat conditioning which highlights successful conditioning. Importantly, grouped GSR responses during renewal testing showed a similar differentiation consistent with renewal.
DISCUSSION

In this investigation, we sought to advance our understanding of the relation between human avoidance and renewal. The first aim was to assess renewal of human avoidance behavior. The second aim of this experiment was to assess whether renewal could be sustained when subjects have a prior history of successfully preventing US delivery through avoidance. As predicted, results showed that, with increased threat, avoidance and ratings of perceived threat and fear persisted in the context in which aversive consequences had previously been delivered, even when no aversive consequences were currently arranged. Moreover, results showed renewal was maintained over six blocks of trials. This is the first investigation of renewal of threat and avoidance in humans and highlights avoidance as a mechanism that may contribute to maintaining renewal of fear in anxiety pathology.

Our preparation combined both Pavlovian and operant conditioning and was the first to create acquisition of avoidance responding at higher threat levels with humans (commonly seen in clinical cases of fear of particular stimuli). Once the participants approached at low threat levels and avoided at higher threat levels, they rated feeling threatened only at higher threat levels and expected money loss at those same levels. Both behavior and ratings matched the expected outcomes of threat conditioning. Next, we exposed participants to an extinction of the aversive US at all threat levels in a new context which subsequently resulted in approach responding. When we returned the participant to the original context where threat conditioning occurred (such as when clinical patients return to their day-to-day environments), participants emitted avoidance behaviors and reported feelings of threat with expectations of money loss. A widely reported disadvantage of negative reinforcement and avoidance or escape behavior is
that, although avoidance allows individuals to safely circumvent potentially detrimental situations, the individual often no longer tests the original contingency to see if it still maintains.

Results of Nakajima (2014) were representative of the pattern of results seen in most renewal paradigms in that renewal increased following the extinction condition. Nakajima’s Pavlovian conditioning plus the instrumental training allowed rats to terminate shock by crossing a midpoint in the operant chamber. He explored different variables to assess their effects on renewal but found little new that changed prior reported results. While ABA renewal returned as the most robust, ABC and AAB successfully showed renewal, though weaker than ABA. From this, Nakajima extrapolated that the extinction process within the renewal paradigm was context-dependent while the conditioning process was not. Bouton (2002) concluded that the second conditioned CS-US relation became the one identified as dependent on context alone for identifying its function. The functions of the initially conditioned CS-US relations could not be context-dependent because the second conditioning context rendered the meaning of the CS as ambiguous.

Outcomes from this research identified limitations. First, the device used to measure GSRs did not provide patterns that matched our expectations at the individual subject level. We thought that increased exposure to aversive events would lead to higher GSRs for each subject. No consistent patterns emerged from those data. Although a powerful, aversive US such as shock may quickly result in behavior seeking to avoid the US, being faced with a US of money loss our participants experienced might show an explainable reduction in the magnitude of GSR. As noted here, the ABA renewal measures proved the most robust but may be limited by other factors not yet identified. Furthermore, our participants were all healthy subjects. A population of
anxious individuals may show greater GSRs. Since many preparations have shown significant results in GSR measures, the particular device we selected to measure these might have been less sensitive than that used by other researchers. These are but a few of the ways future work can be addressed.

Other future efforts can be as varied as those studies that have come before. Might preventing relapse be successful if we had a better or different understanding of all the variables involved? Would it be beneficial to study variables involved previously in learning avoidance? Certainly identifying a population of people who, for whatever reasons, are predisposed to anxiety might result in more evidence or new insights surrounding relapse and renewal. Perhaps pairing a stimulus of someone’s actual phobia could provide clues to better understanding – e.g., present a spider to those who fear spiders or a video of falling from great heights to those who fear falling. The opportunities or the ways in which we could learn more seem vast.

Most important for the results of this research is that renewal was observed for avoidance, threat beliefs, and expectations of money loss. These findings contribute to a large body of research on renewal and a relapse environment and provide a new laboratory model for examining variables that impact renewal of avoidance. Moreover, this is the first demonstration of renewal of avoidance responding and perceived threat. In general, our findings highlight some important consistencies between avoidance, self-reports, and conventional measures of fear that warrant further investigation. It is our hope that further investigation will aid our understanding of factors associated with risk of psychopathology, particularly excessive avoidance associated with anxiety.
## Experimental Design and Conditions

- **Modified comparison design**

- **Conditions**
  - **Pretesting**
    - Context A: CS>Loss (i.e., Pavlovian conditioning of CS and aversive US)
    - Context A: Practice (no data analyzed)
    - Context A: Choice
  - **EXT**
    - Context B: Choice (i.e., Pavlovian extinction learning; CS no longer followed by aversive US)
  - Context A: Renewal ratings
  - Context A: Renewal Choice

*Figure 1. Experimental Design*

* Context A

**Context B
Figure 2. Each threat level was presented six times during each 10-minute condition. Below are the number of trials by threat level programmed for money loss.

<table>
<thead>
<tr>
<th>Threat Level</th>
<th>Of six trials, how many were programmed for money loss?</th>
<th>% of six trials programmed for money loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
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</table>
Figure 3. Screen format for various experimental conditions.
**Figure 4.** Data for participant P9. Ratings were collected across all conditions. Choice conditions ran three times: after Pavlovian conditioning – i.e., after Context A: CS>Loss; after Pavlovian extinction learning – i.e., after Context B: CS>NoLoss; and again in Context A: Renewal Choice. Participant approached or avoided. Those results are seen in the Percent Choice row of panels (note the dashed red line in Panel 2 for Percent Choice; this line represents programmed money loss at all threat levels). Reaction time for latency-to-responding with choice stimuli onset. GSRs.
Figure 5. Data for participant P11. Ratings were collected across all conditions. Choice conditions ran three times: after Pavlovian conditioning – i.e., after Context A: CS>Loss; after Pavlovian extinction learning – i.e., after Context B: CS>NoLoss; and again in Context A: Renewal Choice participant approached or avoided. Participant approached or avoided. Those results are seen in the Percent Choice row of panels (note the dashed red line in Panel 2 for Percent Choice; this line represents programmed money loss at all threat levels). Reaction time for latency-to-responding with choice stimuli onset. GSRs.
Figure 6. Data for participant P16. Ratings were collected across all conditions. Choice conditions ran three times: after Pavlovian conditioning – i.e., after Context A: CS>Loss; after Pavlovian extinction learning – i.e., after Context B: CS>NoLoss; and again in Context A: Renewal Choice participant approached or avoided. Participant approached or avoided. Those results are seen in the Percent Choice row of panels (note the dashed red line in Panel 2 for Percent Choice; this line represents programmed money loss at all threat levels). Reaction time for latency-to-responding with choice stimuli onset. GSRs.
Figure 7. Data for participant P18. Ratings were collected across all conditions. Choice conditions ran three times after Pavlovian Conditioning: Context A: CS>Loss; after Pavlovian extinction learning: Context B: CS>NoLoss; and again in Context A: Renewal Choice participant approached or avoided. Those results are seen in the Percent Choice row of panels (note the dashed red line in Panel 2 for Percent Choice; this line represents programmed money loss at all threat levels). Reaction time for latency-to-responding with choice stimuli onset. GSRs.
Figure 8. Data for participant P20. Ratings were collected across all conditions. Choice conditions ran three times: after Pavlovian conditioning – i.e., after Context A: CS>Loss; after Pavlovian extinction learning – i.e., after Context B: CS>NoLoss; and again in Context A: Renewal Choice participant approached or avoided. Participant approached or avoided. Those results are seen in the Percent Choice row of panels (note the dashed red line in Panel 2 for Percent Choice; this line represents programmed money loss at all threat levels). Reaction time for latency-to-responding with choice stimuli onset. GSRs.
Figure 9. Data for participant P26 Ratings were collected across all conditions. Choice conditions ran three times: after Pavlovian conditioning – i.e., after Context A: CS>Loss; after Pavlovian extinction learning – i.e., after Context B: CS>NoLoss; and again in Context A: Renewal Choice participant approached or avoided. Participant approached or avoided. Those results are seen in the Percent Choice row of panels (note the dashed red line in Panel 2 for Percent Choice; this line represents programmed money loss at all threat levels). Reaction time for latency-to-responding with choice stimuli onset. GSRs.
Figure 10. Heat maps. Distributions of approach (green) and avoidance (red) for each threat level (with 10 as the highest probability of loss and 1 as the lowest probability of loss) as a function of time (blocks of 6 trials per threat level).
Figure 11. Median GSR responses for each experimental condition.
References


