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Conditioned Arousal to Slot Machine Wins:
An Examination of Renewal Following Extinction

by

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Abstract

The objective of this study was to explore whether an appetitive response extinguished in one context would remain extinguished when tested in the extinction context, but show renewal when tested in a different context. Forty college students played a slot machine while their physiological arousal (skin conductance and heart rate) and desire to play were being recorded. During the acquisition phase, wins on the slot machine were associated with a tone serving as a conditioned stimulus (CS) that preceded the machine’s payout (US) and elicited conditioned arousal. During the following extinction phase, the CS was presented repeatedly without the US to extinguish the arousal response to that tone (i.e., Pavlovian extinction). In a test phase conducted one day later, participants’ response to the CS was tested in one of two follow-up contexts to which they had been randomized: the same context (AAA design) or a different context (AAB design). Results of the current study indicate that participants’ skin conductance, heart rate, and subjective desire did not differ significantly between the two follow-up contexts.

Keywords: renewal, extinction, cue reactivity, gambling, slot machine
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Research has shown that cue-induced urge or craving can increase the risk of relapse in addictive behaviors (Ferguson & Shiffman, 2009). This has led to the development of cue exposure therapy on the assumption that repeated presentations of cues can reduce craving (Ferguson & Shiffman). However, research has failed to show cue exposure therapy as an effective treatment for reducing cue-induced lapse and relapse (Conklin & Tiffany, 2002). For example, Conklin and Tiffany (2002) showed in a meta-analysis that the overall effect size for cue-exposure treatment was not significantly different from zero. That is, of the nine studies chosen by the authors for the analysis, only five demonstrated that cue exposure treatment led to increased abstinence or less drug use, and these effects were rather modest compared to control groups or other treatments. The lack of efficacy of cue exposure therapy may be related to conceptual issues often not considered in these studies. Although experimental research has shown that appetitive responses linked to cues can be extinguished using traditional extinction procedures (Lazev, Herzog, & Brandon, 1999; O’Connell, Shiffman, & DeCarlo, 2011), there are several phenomena identified in theories of learning which limit the applied efficacy of extinction procedures (Havermans & Jansen, 2003). For instance, extinction procedures for addictive behaviors are typically based on Pavlovian (classical) conditioning theories of learning. Contemporary accounts of these theories suggests that extinction does not mean the elimination of a response from the organism’s repertoire, but it represents learning a new association between the conditioned stimulus (CS) and the unconditioned stimulus (US); specifically, the CS is not followed by the US within
the context of the extinction environment (Bouton, 2004). Within this model, research has shown that both conditioning and extinction are context dependent and are affected by spontaneous recovery and renewal (Bouton, 2002). Renewal takes place when a CS is presented in a different context than the one in which extinction took place and the extinguished response re-emerges. Spontaneous recovery takes place when a CS elicits a previously extinguished response in a similar context after some passage of time. Some theorists posit that change in time represents a change in context in and of itself, making spontaneous recovery similar to renewal. Thus, from a theoretical perspective the context controls which learning will influence behavior (Bouton, 2004).

To illustrate how this process might function in an applied context, assume a therapist attempts to extinguish a client’s urges to smoke (conditioned response CR), by repeatedly presenting cigarettes (CS) to the client without allowing the client to smoke and experience the effects of nicotine (US). Following extinction, as long as the CS continues to be presented in the extinction context (i.e., the therapist’s office), the new extinction-based response (i.e., a “no” urge) tends to occur. However, if the CS is presented in the extinction context after some passage of time or in a different context (e.g., in the client’s home), then the previously learned response will be elicited (i.e., the urge will recur).

In summary, both renewal and spontaneous recovery demonstrate the context dependency of extinguished associations and thus are limiting factors in the application of cue-exposure therapy because these phenomena limit the generalizability of extinction learning outside of the immediate context in which the therapy took place (MacKillop & Lisman, 2008). Thus, further research is required to examine how spontaneous recovery
and renewal might be attenuated. Extinction-related processes have been widely studied in animal research; however, only a handful of studies have been conducted with human participants, often with conflicting results.

Researchers have suggested that by modifying traditional extinction procedures based on contemporary research, as well as the use of technological advances in the field, the effectiveness of cue exposure therapy can be improved (Conklin & Tiffany, 2002). In recent years, many novel procedures have been proposed to enhance the effectiveness of cue exposure treatment. These include using retrieval cues which recall extinction learning in new contexts (Collins & Brandon, 2002; Stasiewicz, Brandon, & Bradizza, 2007), the use of drugs which facilitate extinction learning (Dhonnchadha & Kantak, 2011), modifying cue exposure procedures to take advantage of optimal conditions for extinction (i.e., optimal spacing of extinction trials) (Bouton, Westbrook, Corcoran, & Maren, 2008), and the use of virtual environments via virtual reality and/or other computer simulated environments to enhance the extinction environment (García-Rodríguez, Pericot-Valverde, Gutiérrez-Maldonado, Ferrer-García, & Secades-Villa, 2012). All of these approaches have both strengths and weaknesses, however to date none has proven both effective and practical in significantly attenuating the effects of spontaneous recovery and/or renewal.

The use of a gambling paradigm as an analog for studying the effects of conditioning, extinction, and renewal with appetitive cues has yet to be explored. This approach has several strengths as compared to previous approaches. Researchers have noted the advantage in clinical analog studies of having control not only over extinction but also over the learning or acquisition phase of a response (Thewissen, Snijders,
Havermans, van den Hout, & Jansen, 2007). In this way researchers can fully control the frequency, duration, and contexts in which the CS-US associations occur, all of which could mask or counteract experimental effects in studies that do not have control over the acquisition phase. Thus, it is preferable to use experimental analogs in which this phase can be controlled and measured. However, most studies do not include an acquisition phase. The majority of studies opt to recruit individuals with a history of substance use, relying on randomization to conditions to control for idiosyncratic effects of conditioning histories. However, there are limitations to this approach even when appropriate sampling methods and randomization are used. For example, perceived availability (i.e., the opportunity to ingest substances or engage in addictive behaviors) in cue reactivity paradigms is known to affect the strength of the conditioned response elicited during experiments (MacKillop & Lisman, 2005). Thus, it is presumed that in studies where extinction trials are conducted in contexts where the US has never been or could not perceivably accompany the CS, the processes of extinction and renewal are likely to be affected. That is, during extinction trials the cue will not elicit the same response initially as it would if the US were available, and this may affect the overall strength of the extinction learning and subsequent renewal of the response in other contexts. This presents a weakness of analogue studies with substances for which it would not be feasible for ethical or practical purposes to include an acquisition phase. The use of a gambling paradigm overcomes these limitations because the ability to engage in a realistic gambling task can be more easily implemented in an experimental setting. Additionally, with experimental control over the acquisition phase of the cue exposure paradigm, as well as the cues themselves, this methodology could give researchers the
ability to explore the processes of extinction, spontaneous recovery, and renewal of addictive behaviors in human participants with greater empirical scrutiny. This would also potentially enhance our knowledge of existing processes or lead to novel findings. One final benefit is that cue reactivity towards gambling cues has been reliably shown in prior studies (Blanchard, Wulfert, Freidenberg, & Malta, 2000; Wulfert, Maxson, & Jardin, 2009) and the process involved in conditioning is believed to be comparable to the process by which cues become associated with substances.

The first aim of the present study was to investigate whether in a given context an initially neutral tone, after becoming associated with winning money at a slot machine, would become a CS and elicit physiological and subjective arousal in participants similar to the responses elicited by a monetary win itself (US). The second aim was to investigate whether these conditioned reactions, once extinguished in the acquisition context, would remain extinguished if tested in the same context but recur when tested in a different context (i.e., renewal).

**Method**

**Participants**

Participants were 40 students (12 men and 28 women) recruited from introductory Psychology classes and via flyers posted at a northeastern university. The mean age of the sample was 21.43 ($SD = 3.35$) with a range from 19 to 33 years. The majority of participants were Caucasian (45%), followed by African American (32.5%), Asian (10%), and Other (12.5%). Ninety-five percent of participants reported having engaged in some type of gambling behavior in their lifetime, and 70% reported having gambled on a slot machine at least once. The average score on the South Oaks Gambling Screen
(SOGS) revised question assessing lifetime frequency of slot machine gambling was 1.48 ($SD = 1.47$), indicating on average between 1 and 2-3 times total. The mean SOGS score for the sample was 0.50 ($SD = 1.01$).

**Design**

The procedure used in the current study consisted of two parts and included the following sequence of events conducted one day apart (Part 1: consent, equipment calibration, questionnaire completion, context pre-exposure, habituation, conditioning, extinction; Part 2: equipment calibration, questionnaire completion, follow-up) (see Table 1). After participants completed the first part, they were randomly assigned to one of the two experimental conditions for the second day in either the same or different context. The design was a mixed models analysis of variance with two within-subjects factor (acquisition - conditioning - extinction - follow-up; CS+ - CS-) and one between-subjects factor (test in the same or a different context), such that the conditions for one group were AAA and for the second group AAB. The main dependent variables measured were skin conductance, heart rate, and subjective desire to play the slot machine.

**Apparatus and Materials**

**Experimental contexts.** The experimental contexts included a room decorated to resemble a casino or a conference room located on a different floor within the same building. The casino context was built in a 16 x 20 x 10 ft room with a double arched ceiling decorated with wallpaper displaying a blue sky with white clouds, walls lined with metallic gold corrugated paper, and a busy patterned red and gold carpet. Lighting in the room was provided by two florescent black lights mounted on opposite sides of the room and white rope lighting mounted around the upper perimeter of the room. Low
ambient background noise, meant to simulate sounds usually heard in a real casino (e.g., talking, chips shuffling, slot machines, waitresses taking drink orders), was played from two speakers mounted on opposite corners of the room.

The conference room context was in a 12 x 12 x 12 ft room with no decorations and neutral visual cues (i.e., book shelves with books on one wall, bright overhead lighting, a large round table with four chairs). No background noise was played within this context.

**Customizable slot machine.** The study used a realistic, customizable three-reel slot machine using a modified version of AllJSlots 2.2 slot machine program (Baker, 2012). The program allowed custom images, probabilities, payouts, and custom sounds to be programmed by the researchers. Participants could bet one, two, or three credits using a small button for betting and then spinning the reels by pressing a medium sized button on the front of the machine or by pulling a custom slot machine arm on the right side of the slot machine. Alternatively, participants could press a large red button labeled “Max Bet” which would automatically bet three credits and spin the reels. The slot machine was loaded with 500 tokens, each worth 5 cents, for each participant to play with. On winning trials, the software was programmed to play a winning tone (CS+) once the last reel stopped, about 1 second prior to tokens being dispensed. On losing trials, a different tone (CS-) was played after the last reel stopped. The slot machine was set to dispense 24 mm tokens, roughly the size of a U.S. quarter, using a 24 V Asahi Seiko SH-400-P coin hopper after each win. For the extinction and follow-up trials an additional sound input allowed researchers to play these tones through the slot machine’s speakers from a separate audio device.
**Tones.** The study attempted to condition a response to a tone by associating that tone with winning money while playing the slot machine (i.e., CS+). For comparison, another tone was created which was never associated with winning (i.e., CS-). Realistic tones were selected as CSs in an attempt to increase the ecological validity of the study. The CS+ tone consisted of a short sequence of alternating chimes (approximately 500-1600 Hz) similar to sounds signaling a win that might be heard from a typical slot machine. The CS- tone consisted of a steady “ambient” sound (approximately 150-450 Hz) of a noticeably lower pitch than the CS+ tone. Two other tones, here termed latent inhibitors (LIs), were created to be presented instead of the CSs during habituation trials for half of the participants in counterbalanced order. The purpose of the tones was to assess conditioning via latent inhibition; specifically, that there would be an inhibiting of participants’ responses to the CS due to repeated presentations of that CS prior to conditioning trials as compared to those that received LIs during conditioning trials. The LIs consisted of one higher pitch (500 Hz, 950 Hz, 1400 Hz), and one lower pitched (150 Hz, 285 Hz, 420 Hz) multiple frequency tone, respectively named LI+ and LI-. All tones where calibrated to 85 dB and were 1 s in duration. Tones played through the slot machine’s speakers, either automatically by the AllJSlots 2.2 program while participants played the slot machine, or by the researchers using one of several prerecorded mp3 tracks which were played during the habituation, extinction, and follow-up phases of the experiment. The mp3 tracks for each phase consisted of a specific sequence of two tones (CSs or LIs during habituation, CSs for all other phases) with varied intertrial intervals between 10-30 s (shortened to 4-30 s for the extinction phase). For each track, an alternate track with the opposite sequence of tones (counterbalanced between
participants) was created to control for order effects. Background sound effects (i.e., spinning reels, bet chime, reel stop) played by the AllJSlots 2.2 program were calibrated between 50-60 dB so that the CS+ and CS- tones would be more salient. Ambient background “casino” sounds played through two speakers mounted in the casino context were also set to between 50-60 dB. All sounds levels were calibrated using a Digital Instruments SL-814 digital sound level meter.

**Physiological measures.** Skin conductance responses (SCRs) to the stimuli were measured with a Q electrodermal skin conductance monitor (palm; Affectiva Inc.) at a sampling rate of 4 Hz. This portable skin conductance device, which is allegedly not affected by movement artifacts, allowed the researchers to measure participants’ SCRs during each phase of the experiment as well as movement using a three-dimensional motion sensor embedded within the device. The skin conductance data were transferred from the Q sensor pod to the Q software (Version 1.07.19; Affectiva Inc.) via a USB cable. Cue-elicited change in heart rate (HR) was measured with a Polar WearLink+ heart rate monitor (Polar Electro Inc.), which wirelessly transmitted data to a heart rate receiver module (RS400; Polar Electro Inc.) at a sampling rate of 1 Hz. The HR data were transferred from the receiver module into the Polar ProTrainer 5 software (Version 5.40.172; Polar Electro Inc.) via a Polar IrDA USB adapter. Physiological data was exported from both software packages into comma delimited text files, and data cleaning was then carried out in Microsoft Excel 2010 before being imported into SPSS 20.0.0 for statistical analyses. Specific SCRs were defined as any increase in skin conductance within a 4 s latency window beginning at stimulus onset. Cue-elicited changes in HR were defined as any increase in HR within a 4 s latency window beginning at stimulus
onset. Participants’ activities during all phases of the experiment were recorded using a
webcam mounted on the top of the slot machine. While the skin conductance and heart
rate monitor were recording, an event marker was set on both devices in view of the
webcam. This enabled the researchers to synchronize the data recorded on each sensor
with stimulus presentations and participants’ behaviors for subsequent data analysis.

Desire self-report. A 17 in. flat screen computer monitor was situated on a stand
next to the slot machine which displayed instructions throughout the study. Participants
also gave answers via this screen using a mouse by placing a vertical mark on a
horizontal 100 mm visual analogue scale (VAS) with descriptors on both ends of the
scale (i.e., “No Desire” and “Very Strong Desire”) in response to the following question:
“How strong is your desire to play the slot machine right now?”

Gambling measures. Gambling habits and behaviors were assessed using the
South Oaks Gambling Screen (SOGS; Lesieur & Blume, 1987). The South Oaks
Gambling Screen is a 20 item questionnaire that yields a score between 0 and 20 based on
the American Psychiatric Association’s Diagnostic and Statistical Manual of Mental
Disorders (3rd ed., rev.; DSM-III-R; 1987) criteria for pathological gambling. A score of
≥ 5 indicates probable pathological gambling. The SOGS has well-established
psychometric properties, including strong test-retest reliability and high internal
consistency (Lesieur & Blume, 1987), and has been validated for use with college
students (Weinstock, Whelan, Meyers, & McCausland, 2007). Items 1(a-j), which assess
lifetime frequency of 10 methods of gambling, were revised to include an expanded
frequency rating reported on a 0-6 point scale (“not at all,” “1 time,” “2-3 times,” “4-6
times,” “7-12 times,” “12+ times,” respectively) and two additional questions (i.e., 1k.
“How often have you played other ‘paper’ games other than lotteries [e.g., pulltabs]?” and 11. “Have you played any other game for money that I did not already mention? How often?”). These changes had no effect on the reliability or validity of the instrument, as these items are not included within the total score. Frequency of overall lifetime gambling activities was assessed by summing items 1a-11. Furthermore, frequency of playing slot machines (and other gambling machines) was assessed using scores on item 1i (“How often have you played slot machines, poker machines, or other gambling machines?”).

Procedure

**Consent and Questionnaires.** All procedures were approved by the university’s institutional review board. Upon arrival, participants were led into a testing room adjacent to the casino context where they were provided with an introduction to the study. The experimenter explained that they would play a slot machine which would dispense tokens. They were informed that these tokens could be redeemed for money upon completion of the study at the rate of 1 nickel per token up to 20 dollars. After informed consent was obtained, the experimenter assisted participants in putting the skin conductance monitor onto their left hand. The participants privately fastened the heart rate monitor following a demonstration by the experimenter on proper attachment. Participants engaged in 2 min of physical activity (i.e., climbing stairs) to elevate HR and maximize the connection to the skin conductance monitor. Upon returning to the testing room, participants completed the first set of self-report questionnaires. Following this, participants were instructed to sit and relax for approximately 10 min to ensure the skin conductance monitor would be properly acclimated.
**Context Pre-exposure.** Participants were led into the simulated casino context and were provided with instructions regarding how to play the slot machine and provide answers on the VAS scale. An event marker was then set on the skin conductance and heart rate monitors. Before leaving the room, the experimenter reminded participants that tokens won would be exchangeable for money at the end of the experiment. Participants were also instructed to remain as still as possible during the experiment. Once alone, participants were directed via the instruction monitor to familiarize themselves for 30 s with the room and the slot machine in as much detail as possible. Participants were then asked to repeat out loud all of the details they could remember about the room with their eyes closed. This procedure was used to ensure that participants were paying attention to salient visual and auditory cues in the context. Participants were then asked to give a VAS rating on the instructions monitor, which served as a baseline of desire to play the slot machine.

**Habituation.** During the habituation phase, participants were instructed to sit still while the equipment was calibrating and to become familiar with the pay chart on the left side of the slot machine. During this time, one of the habituation soundtracks (i.e., CS or LI soundtrack), consisting of six presentations of each tone (+ or -), was played over the slot machine’s speakers in order to habituate participants’ orienting/startle response prior to conditioning.

**Conditioning.** Participants were asked to begin playing the slot machine and to pay attention to both wins and losses. The slot machine dispensed quarter-sized tokens after every win in order to maximize the salience of each win. Immediately following each winning combination on the reels and prior to tokens being dispensed from the slot
machine, the slot program played the CS+ tone through the slot machines speakers. Similarly, immediately following each losing combination the program played the CS- tone. After winning eight times, participants were instructed to stop playing and to give a VAS rating. Although the probability of receiving a win was fixed for all participants, the exact sequence of wins and losses varied between participants.

**Extinction phase.** Participants were again instructed to sit still while the equipment was calibrating. During this time, the extinction soundtrack, consisting of 10 presentations of the CS+ and two presentations of the CS-, was played over the slot machine’s speakers. Following the last extinction trial, participants were asked to give a VAS rating. Afterwards, participants were led into the testing room where they removed the physiological equipment. Participants were then randomized to one of the two follow-up conditions (i.e., same versus different context) and instructed to return to either the same location or a different location at the same time the following day.

**Follow-up phase.** Participants randomized to the “same context” condition returned to the original experimental room the next day; those in the “different context” condition went to an office-like room on a different floor of the building. Upon arrival, participants were fitted with the physiological equipment and then completed 2 min of physical activity. Afterwards, they were asked to complete a second set of self-report questionnaires and then were instructed to relax for acclimation of the skin conductance monitor. After filling out questionnaires, participants were seated in front of the slot machine and asked to give a VAS rating. The participants were then presented with the follow-up soundtrack, consisting of two presentations of each CS tone in alternating order, while their physiological reactions (SCR and HR) were being recorded. They were
then asked to provide another VAS rating. At the conclusion of the follow-up phase, participants were debriefed, received course credit and were paid their winnings from the previous day’s slot machine play, an average of $5.45 (SD = $2.55) with a range of $1.85 to $10.25.

Results

Preliminary Analyses

SCR and HR data for the tone presentation trials were first screened for artifacts due to movement. Quadrant data from the three-dimensional motion sensor and video recordings from the webcam were examined for values more than 3 standard deviations from the within-subjects mean for each participant. If substantial movement (e.g., coughing, stretching, standing to adjust chair) was identified by observing the quadrant data and video recording, the value was replaced with the within-subjects mean. Five SCR values (0.6% of each participant’s responses on average) and 4 HR values (0.4% of each participant’s responses on average) were replaced due to excessive movement.

Upon examination of the 8 winning trials, it was observed that arousal occurred to the matching of the reel images during each spin as well as in response to the win itself. To account for this arousal which could also become associated with the CS+, the SCR and HR latency window for winning and losing trials was extended to include the 4 s period prior to the occurrence of each win (8 s total). These values were used for subsequent analyses examining the conditioning phase.

Assessing the raw data, the assumption of normality at many levels of both repeated measure factors (i.e., SCR and HR) could not be met, although VAS scores were normally distributed. In the case of SCRs, such data are typically positively skewed.
However, for both SCR and HR data it was also observed that the habituation and extinction trials likely contributed to skewing the data since many responses were likely to be at or close to zero. Subsequently, SCR and HR data were standardized (using the within-subjects mean and standard deviation of the 28 tone presentations trials) as it both improved the distributions and reduced variability due to physiological differences not related to the manipulation (as suggested by Dawson, Schell, & Filton, 2007). VAS scores were also standardized (using the within-subjects mean and standard deviation for all VAS ratings) to correct for baseline levels of desire to play the slot machine.

Standardized scores from each cell of the within-subjects factors and the between-subjects factors for SCR, HR, and VAS data were then examined. Outliers were replaced with windsorized values which were calculated using the 25% and 75% Tukey Hinges from each cell. For analyses examining only the within-subjects factors, tone type (1-2) and trials (habituation trials 1-6, conditioning trials 1-8, extinction trials 1-10, follow-up trials 1-2), the total number of outliers was 121 for SCR zs (6.9 % of each participant’s responses on average) and 77 for HR zs (4.6 % of each participant’s responses on average). There were no outliers for analyses examining VAS scores. For analyses that included habituation version (CS, LI) as a between-subjects factor along with the two within-subjects factors the total number of outliers was 99 for SCR zs (5.6 % on average) and 55 for HR zs (3.3% on average). For analyses that included follow-up condition (same, different) as a between-subjects factor along with the two within-subjects factors the number of outliers was 116 for SCR zs (6.6 % on average) and 89 for HR zs (5.3 % on average). These corrections greatly improved normality at each level of the between-subjects and within-subjects factors for each analysis. However, to be certain that
remaining departures wouldn’t impact the analyses, a univariate approach was selected as it is robust to departures from normality. The assumptions of sphericity and compound symmetry were met for most univariate repeated measures analyses, but when these assumptions were suspected to have been violated adjusted degrees of freedom were used for the $F$-test. Means and standard deviations of the standardized data are reported instead of raw scores for all dependent variables.

Examining the “same” versus “different” context groups, no statistically significant group differences were found for demographic variables of age [$F(1,38) = 2.52, p = .121$], gender [$\chi^2 (1, N = 40) = 0.00, p = .999$], or race [$\chi^2 (3, N = 40) = 2.77, p = .429$]. Furthermore, there were no group differences in overall gambling frequency [$F(1,38) = 2.39, p = .130$], slot machine gambling frequency [$F(1,38) = 0.56, p = .458$], or problem gambling [$F(1,38) = 0.38, p = .539$].

**Habituation, Conditioning and Extinction**

**Skin conductance.** Analyses to examine habituation, conditioning, and extinction were first conducted with SCR zs as the dependent variable. To test habituation of SCRs, we conducted a trend analysis using a three-way repeated measures univariate analysis of variance (rANOVA) with habituation trials (1-6) and tone type (+/-) as the within-subjects factors, and habituation version (CS, LI) as the between-subjects factor. Mauchly’s test indicated that the assumption of sphericity had been violated for the habituation trials main effect, $\chi^2 (14, N = 40) = 26.42, p = .023$. Therefore, degrees of freedom for that analysis were corrected using the Greenhouse-Geisser estimate of sphericity ($\varepsilon = .77$). The rANOVA yielded a significant main effect for habituation trials, $F(3.87,147.25) = 61.27, p < .001, \eta_p^2 = 0.62$ (see Figure 1), a significant main effect for
CS type, $F(1,38) = 6.88, \ p = .012, \ \eta_p^2 = 0.15$, and a significant CS type by habituation version interaction, $F(1,1) = 4.54, \ p = .040, \ \eta_p^2 = 0.11$. No other main effects or interactions were significant. Trend analysis on the habituation trials main effect indicated a significant linear trend across habituation trials, $F(1,38) = 136.29, \ p < .001, \ \eta_p^2 = 0.78$. Collapsing across tone type and habituation version, SCR zs decreased linearly across the six habituation trials from a mean of 1.65 ($SD = 0.78$) on the first trial to a mean of -0.05 ($SD = 0.55$) on the last trial. Trend analyses did not reveal a significant interaction between habituation trials and tone type or habituation version suggesting that the linear trend in SCR zs was similar for all tones. Collapsing across habituation trials, Bonferroni corrected post hoc analysis revealed that during habituation trials the average SCR z to the CS+ ($M = 0.43, SD = 0.38$) was significantly larger, $F(1,38) = 11.29, \ p = .002, \ \eta_p^2 = 0.23$, than the average SCR z to the CS- ($M = 0.13, SD = 0.28$), but average SCR zs did not differ significantly ($p = .730$) between the LI+ ($M = 0.22, SD = 0.26$) and LI- ($M = 0.19, SD = 0.37$). Since the last two habituation trials were chosen to be used in subsequent analyses, Bonferroni corrected post hoc analyses were conducted to determine if SCR zs to the CS+ and CS- differed on the last two habituation trials (5-6). Bonferroni corrected post hoc analysis did not indicate a significant difference between the CS+ ($M = 0.10, SD = 0.78$) and CS- ($M = -0.20, SD = 0.49$) on habituation trial 5 or the CS+ ($M = -0.12, SD = 0.73$) and CS- ($M = -0.01, SD = 0.86$) on habituation trial 6, $F(1,38) = 2.47, \ p = .124; \ F(1,38) = 0.19, \ p = .666$, respectively. SCRzs in response to the CS+ during habituation may have initially been larger than those to the CS-, but by the end of the habituation phase they no longer differed.
To assess arousal due to playing the slot machine, we compared SCR zs on the last two habituation trials to SCR zs during the conditioning trials. In order to include losing trials in the analyses it was necessary to average each participant’s responses on losing trials (ranging from 21 to 115 total) ordinarily into 8 values. Thus, the analysis included conditioning type (+ /win, - /loss) as the between-subjects factor and conditioning trials (habituation trials 5-6; conditioning trials 1-8) as the within-subjects factor. Mauchly’s test indicated that the assumption of sphericity had been violated for the conditioning trials main effect, $\chi^2(44, N = 40) = 71.04, p = .006$, and conditioning trials by conditioning type interaction, $\chi^2(44, N = 40) = 79.23, p = .001$. Therefore, degrees of freedom for these analyses were corrected using Greenhouse-Geisser estimates of sphericity, $\varepsilon = 0.69$ and $\varepsilon = 0.68$ respectively. The rANOVA yielded a significant main effect for conditioning trials, $F(6.21, 242.13) = 14.36, p < .001, \eta^2_p = 0.27$ (see Figure 2), a significant main effect for conditioning type, $F(1, 39) = 13.80, p = .001, \eta^2_p = 0.26$, and a significant conditioning trials type by conditioning type interaction, $F(6.14, 239.44) = 2.93, p = .008, \eta^2_p = 0.07$. Complex contrast analysis revealed that SCR zs on winning trials 1 ($p < .001$), 2 ($p = .004$), 4 ($p = .023$), and 7 ($p = .006$) were all significantly larger than the mean SCR z to the CS+ during the final two habituation trials. However, only the SCR z on the 1st losing trial ($p < .001$) differed significantly from the mean SCR z to the CS- during the final two habituation trials. SCR zs on conditioning trials 1 ($p < .001$), 2 ($p = .026$), 3 ($p = .021$), 6 ($p = .043$), and 7 ($p = .011$) were all significantly larger for wins than for losses.

To determine if the increase in SCR during wins became associated with the CS+ following conditioning, we conducted a three-way rANOVA with averaged trials
(average of habituation trials 5 and 6, average of extinction trials 1 and 2) and tone type
(+ / -) as the within-subjects factors, and habituation version (CS or LI) as the between-
subjects factor. The rANOVA yielded a significant main effect for trials, $F(1,39) = 15.96,$
$p < .001, \eta_p^2 = 0.29.$ No other main effects or interactions were significant. Collapsing
across tone type and habituation version, Bonferroni corrected post hoc analysis revealed
that the mean SCR z following conditioning ($M = -0.40, SD = 0.25$) was significantly
smaller ($p = .003$) than the mean SCR z during the final two habituation trials ($M = -0.08,$
$SD = 0.35$). The absence of a significant interaction suggests that the CS+ did not elicit a
conditioned response following conditioning trials, contrary to what was hypothesized,
and also that the CS+ was not latently inhibited. A trend analysis examining SCR zs
during the extinction using an rANOVA with CS+ extinction trials (1-10) as the within-
subjects factor failed to show a significant linear trend ($p = .196$) further suggesting an
absence of a conditioned SCR to the CS+.

**Heart rate.** Each of the analysis conducted with SCR data were repeated using
HR zs as the dependent variable. Trend analysis using a three-way rANOVA with
habituation trials (1-6) and tone type (1-2) as the within-subjects factors and habituation
version (CS, LI) as the between-subjects factor indicated a non-significant linear trend ($p$
$= .064$) for the habituation trials main effect, with no other significant main effects or
interactions. The current analysis was not able to show that change in HR accompanied
habituation to the tones.

To assess arousal due to playing the slot machine, we conducted a rANOVA with
conditioning type (+ / win, - / loss) as the between-subjects factor and conditioning trials
(habituation trials 5-6; conditioning trials 1-8) as the within-subjects factor. Mauchly’s
test indicated that the assumption of sphericity had been violated for the conditioning trials main effect, \( \chi^2 (44, N = 38) = 69.64, p = .009 \). Therefore, degrees of freedom for this analysis was corrected using a Greenhouse-Geisser estimate of sphericity, \( \varepsilon = 0.69 \).

The rANOVA yielded a significant main effect for conditioning trials, \( F(6.22, 230.30) = 11.95, p < .001, \eta^2_p = 0.24 \) (see Figure 2) and a significant main effect for conditioning type, \( F(1, 37) = 11.40, p = .002, \eta^2_p = 0.24 \). Complex contrast analysis revealed that, collapsing across conditioning type, HR zs during every conditioning trial were significantly larger \( (p < .17) \) than the mean HR z during the final two habituation trials.

Similar to SCR data, changes in HR increased during conditioning trials as compared to habituation trials. Collapsing across conditioning trials, HR zs were significantly larger \( (p = .001) \) during losses than during wins. However, this was most likely an artifact of the losing trials being averaged.

A three-way rANOVA with averaged trials (average of habituation trials 5 and 6, average of extinction trials 1 and 2) and tone type (1-2) as the within-subjects factors and habituation version (CS, LI) as the between-subjects factor did not yield any significant main effects or interactions. A trend analysis on a rANOVA with CS+ extinction trials (1-10) as the within-subjects factor resulted in a significant linear trend, \( F(1, 37) = 6.57, p = .015, \eta^2_p = 0.15 \). However, contrary to what was hypothesized HR zs appeared to increase linearly across extinction trials. These data suggest that there was no conditioned HR increase to the CS+.

**Visual Analog Scale.** Analyses were conducted to assess self-reported desire to play the slot machine prior to habituation (1st VAS), following conditioning (2nd VAS), and following extinction (3rd VAS) using VAS zs as the dependent variable. The two-way
rANOVA with VAS trials (1-3) as the within-subjects factors and habituation version (CS, LI) as the between-subjects factor did not yield a significant main effect ($p = .073$) or interaction. This suggests that playing the slot machine did not significantly increase self-reported desire to play, nor did extinction trials with the CS+ decrease desire.

**Renewal**

**Skin conductance.** To assess renewal of SCRs, we conducted a three-way rANOVA with averaged trials (average of last two extinction trials [9 and 10 for CS+, 1 and 2 for CS-], average of follow-up trials 1 and 2) and tone type (CS+ - CS-) as the within-subjects factors, and follow-up context (same, different) as the between-subjects factor. The rANOVA indicated a significant main effect for averaged trials, $F(1,38) = 14.35, p = .001, \eta_p^2 = 0.27$ (see Figure 3). Collapsing across tone type and condition, Bonferroni corrected post hoc analysis revealed that the average SCR z to the CSs at follow-up ($M = -0.08, SD = 0.46$) was significantly larger ($p = .001$) than SCRs z to the CSs during extinction ($M = -0.39, SD = 0.25$). The absence of any main effect or interaction for condition suggests that renewal did not take place.

**Heart rate.** A three-way rANOVA with averaged trials (average of last two extinction trials [9 and 10 for CS+, 1 and 2 for CS-], average of follow-up trials 1 and 2) and tone type (CS+ - CS-) as the within-subjects factors, and follow-up context (same, different) as the between-subjects factor did not yield any significant main effects or interactions.

**Visual Analog Scale.** A two-way rANOVA with VAS z as the within-subjects factor (3rd VAS, 4th VAS, 5th VAS) and follow-up context as the between-subjects factor did not yield a significant main effect or interaction.
Discussion

The study was unable to show conclusively that conditioning to a previously neutral tone took place as a result of being paired with wins during slot machine play. SCR and HR data indicated an increased level of arousal while playing the slot machine, as compared to the simple presentation of novel stimuli. However, SCRs and HR in response to discrete presentations of the CS following conditioning did not increase (i.e., a conditioned response), but rather decreased compared to the responses observed during the habituation phase. Given the fact that there was not an increase in SCR or HR during early extinction trials, it is difficult to determine if subjective or physiological arousal was indeed extinguished. The fact that subjective desire to play the slot machine decreased on average lends some support to the idea that there was an effect due to extinction. However, this change was not significantly different from the desire rating following the conditioning phase, possibly due to the analysis being underpowered.

While renewal was not demonstrated in cue-elicited SCRs during follow-up, because there was no differential responding to the original conditioning context compared to a different context, it is possible that the observed increase in cue-elicited SCRs in both contexts during follow-up were due to spontaneous recovery. This would suggest that more extinction trials or repeated extinction sessions over a more extended period of time might have been necessary to demonstrate renewal without it being overshadowed by spontaneous recovery. Also, this finding was isolated to SCR responses and was not demonstrated in either HR or subjective desire ratings. Subjective desire ratings appeared to increase as a result of tone presentations at follow-up, although the difference was not statistically significant which was likely due to the analysis being
underpowered. This trend in the data could be related to the fact that cue-elicited urge may not always underlie physiological arousal, as most theories of conditioning posit (Havermans, Mulkens, Nederkoorn, & Jansen, 2007). This would support the observation that subjective desire ratings appeared visually to increase and decrease following tone presentations during extinction and follow-up, whereas physiological arousal did not.

One possible explanation for the results is that the number of conditioning trials was insufficient for a reliable response to be conditioned to the CS. Problem gamblers are exposed to hundreds of CS-US pairings over the course of many trips to the casino. While it is highly likely that a conditioned response to a tone associated with wins develops, it is possible that such a response could require a large number of trials to be conditioned. Furthermore, the level of risks and rewards in realistic gambling scenarios are significantly greater than in those in an analogue study. If gamblers in real-world settings on rare occasions have had significant wins of hundreds if not thousands of dollars, interspersed by multiple unpredictable smaller wins, it is easy to see how a tone could elicit strong emotional reactions, although this that was not observed within the constraints of the current study.

Alternatively, if the increase in SCR observed during follow-up is genuinely due to spontaneous recovery, then this would demonstrate one of the limitations of cue exposure therapy. If this was the case, then it is obvious that, even with a relatively equal number of conditioning and extinction trials, the response to the CS returned within one day. A crucial next step would therefore be to develop and implement procedures within the extinction phase that significantly improve extinction learning and would minimize the spontaneous recovery of the extinguished response.
Limitations

Several limitations must be taken into account in interpreting the outcome of this study. First, the study was an experimental analog examining the behaviors of student participants without a significant history of gambling. Also, participants did not actually wager their own money while playing the slot machine. Tokens were preloaded into the machine and participants did not incur losses on losing trials. Thus, there was no risk involved in betting tokens on any given spin. For practical reasons, the slot machine was also programmed so that the maximum total amount that any participant could win was $20. Wins varied from $1.85 to $10.25, with the maximum amount that could be won on a given trial being $3.00. As the wins, on average, were modest and a cap was placed on the total amount participants could win, it is possible that these constraints did not elicit the intense excitement that gamblers may experience in real-world settings where stakes are high and playing slot machines entails the possibility of both winning and losing significant amounts of money. For these reasons, the findings will likely not generalize to the reactions experienced by frequent gamblers and to the learning processes involved in real-world gambling environments.

A potential problem with the procedures used during the extinction phase is the lack of consideration given to the bi-conditional nature of appetitive conditioning. For instance, gambling behavior involves the simultaneous interaction between both operant and Pavlovian conditioning processes. Thus, it may be insufficient to focus only on Pavlovian conditioning while disregarding the operant processes that are part of any real-world gambling endeavor. Therefore, future efforts should attempt to implement a combined operant and Pavlovian extinction procedure to fully maximize the effects of
extinction. Alternatively, studies could be conducted with treatment seeking problem or pathological gamblers who have a long-standing conditioning history and would bring to the experimental situation a well-developed repertoire of reactivity to cues signaling their preferred gambling mode. Attempts could be made to extinguish the conditioned reactions to stimuli signaling wins, likely over repeated sessions, and then examine renewal and spontaneous recovery processes through appropriate context manipulations.

Finally, a potential confound of the study was the fact that the conditioned response to the CS could be confused with an unconditioned response to the loudness of the tone (i.e., US startle response). Although we observed some increase in subjective desire to play which would not accompany a fear or startle response, it is possible that the increase seen in skin conductance was due to a return of the startle reflex instead of spontaneous recovery. In the future, the use of CSs without any US properties would be preferred, such as a lower dB tone or perhaps a visual stimulus.

**Future Directions**

Despite the limitations, this study represented an important first step in the development of a new experimental paradigm for the study of conditioning, extinction, and renewal with appetitive cues. Further research should be conducted which improves upon this methodology and enhances the effect of conditioning as well as extinction. If this methodology can be successfully developed, then it could be used to explore novel cue exposure therapy techniques in an attempt to maximize treatment outcomes and improve the efficacy of such an approach.
References


<table>
<thead>
<tr>
<th>Phase</th>
<th>Length</th>
<th>Cue Presentations and Activities</th>
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<td><strong>Part 1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consent</td>
<td>2 min</td>
<td>Introduction and informed consent provided.</td>
</tr>
<tr>
<td>Equipment calibration</td>
<td>3 min</td>
<td>Participant attached equipment then completed 2 min of physical activity.</td>
</tr>
<tr>
<td>Questionnaire completion</td>
<td>10 min</td>
<td>Participant completed self-report questionnaires then relaxed as equipment acclimated.</td>
</tr>
<tr>
<td>Context pre-exposure</td>
<td>1 min</td>
<td>Participant asked to view surroundings for 30 s then repeat details from memory for 30 s. Participant then provided 1st VAS rating.</td>
</tr>
<tr>
<td><strong>Habituation</strong></td>
<td>3 min 30 s</td>
<td>CS presentations ($n = 20$):12 variably alternating presentations of the CS+ and CS-, 6 presentations each LI presentations ($n = 20$): 12 variably alternating presentations of the LI+ and LI-, 6 presentations each.</td>
</tr>
<tr>
<td>Conditioning</td>
<td>Varied</td>
<td>Participant played slot machine until acquiring 8 wins. CS+ played during each winning trial. CS- played during each losing trial. Participant then provided 2nd VAS rating.</td>
</tr>
<tr>
<td>Extinction</td>
<td>2 min 30 s</td>
<td>CS presentations ($n = 40$): 10 presentations of CS+. 2 presentations of the CS-, always within the first 4 trials. Participant then provided 3rd VAS rating.</td>
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<tr>
<td><strong>Part 2</strong></td>
<td></td>
<td></td>
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<tr>
<td>Equipment calibration</td>
<td>3 min</td>
<td>Participant attached equipment then completed 2 min of physical activity.</td>
</tr>
<tr>
<td>Questionnaire completion</td>
<td>10 min</td>
<td>Participant completed self-report questionnaires then relaxed as equipment acclimated.</td>
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<tr>
<td>Follow-up</td>
<td>1 min 10 s</td>
<td>Participant provided 4th VAS rating. CS presentations ($n = 40$): 4 variably alternating presentations of CS+ and CS-, 2 presentations each. Participant Provided 5th VAS rating.</td>
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</tbody>
</table>
Figure 1. SCR zs on habituation trials (1-6) by habituation version (CS, LI).
Figure 2. SCR zs and HR zs across conditioning type (i.e., wins, losses) habituation trials (5-6) and conditioning trials (1-8).
Figure 3. Mean SCR zs from the final two extinction trials and the two follow-up trials for each CS.