Acquisition and Performance Accounts of the Overexpectation Effect

by

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Abstract

Overexpectation occurs when a stimulus individually conditioned to become an excitor (conditioned stimulus, CS) elicits attenuated responding due to subsequent reinforcement in compound with another excitatory stimulus (Kamin & Gaioni, 1974; Kremer, 1978). In three experiments with albino rats we examined two theoretical accounts of the overexpectation effect. The Rescorla-Wagner (1972) model accounts for overexpectation using an acquisition-focused approach, in which the individual associations between the CSs and the unconditioned stimuli, US, combine and lead to an expectation of a US larger in magnitude than that predicted by each individual CS. Responding is reduced to match the actual US magnitude when the larger magnitude does not occur. An alternative approach is provided by the Comparator Hypothesis, a performance-based model that suggests overexpectation results from a comparison between associations that occurs at the moment of test. Conditioned responding to the test CS (T) is determined by the association between T and the US in comparison to the extent to which the other stimulus (comparator stimulus) predicts the US. Experiment 1 was an attempt to obtain overexpectation in our preparation. Experiment 2 assessed whether preexposure of the companion stimulus can attenuate overexpectation. Experiment 3 assessed whether compound preexposure attenuated the preexposure effect and whether attenuation of overexpectation occurs when one of stimuli that underwent compound preexposure is extinguished.

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Introduction

As a means for survival, organisms learn associations between stimuli and outcomes. This is known as Pavlovian conditioning in honor of Pavlov's (e.g., 1927) research of the phenomenon. An unconditioned stimulus (US) is a biologically significant stimulus that naturally elicits an unconditioned response (UR). After multiple pairings of a novel stimulus and the US, the stimulus becomes a conditioned stimulus (CS), thus eliciting a conditioned response (CR). It is important to note that the novel stimulus did not produce a response similar to that of the UR prior to conditioning; however, after conditioning the CR produces responses appropriate to the US (Pavlov, 1927). For example, when a tone is initially presented, it does not elicit a freezing response (fear response in rodents). After several pairings of the same tone with a shock, the tone will elicit a freezing response.

In 1972, Rescorla and Wagner proposed a model to describe changes in the strength of the association between a CS and a US during conditioning. According to the model, changes in associative strength of CS X (ΔV_x) are given by the equation:

$$\Delta V_x = \alpha_x \bullet \beta \bullet (\lambda - \sum V_i), \qquad (1)$$

where α_x represents the salience of Stimulus X, β represents the salience of the US, λ is the asymptote of learning (determined by the US), and $\sum V_i$ represents the total associative strength for all the stimuli presented during that particular training trial. Since the maximum amount of associative strength (V) supported by the US is determined by λ, if two stimuli were trained to asymptote in compound, each stimulus would become conditioned to $\lambda/2$ (assuming that they are of equal salience).

The Rescorla-Wagner model has been widely used due to its simplicity, low number of free parameters, and the ease with which qualitative and quantitative predictions can be derived from its equation. The model has also made several novel and surprising predictions. For example, imagine that two stimuli, A and X, are both conditioned to approach λ in a first phase of training (i.e., CS A→US and CS X→US). During the second phase of training, the same two stimuli are presented in compound and paired with a US of the same duration and intensity as that of the first phase of training (i.e., AX→US). The model anticipates that, during compound training, subjects will expect an increase in the absolute magnitude of the US (2λ) because each CS was independently conditioned to λ. The model predicts this overexpectation because the value for $\sum V_i$ exceeds λ and approaches 2λ (see Equation 1). When the US does not increase during Phase 2 (remaining at λ), the model predicts that subjects will revalue the situation by decreasing the value of V for each individual stimulus, reducing the value of $\sum V_i$ to λ, the maximum amount of associative strength the US can support. Consequently, CSs A and X will elicit attenuated responding when subsequently presented alone.

This novel prediction of the Rescorla-Wagner model was demonstrated experimentally by Kamin & Gaioni (1974). They paired each of two audiovisual stimuli with shock for three days, and then paired the compound of these two stimuli with the same shock. In a subsequent test, lever press suppression to the individual stimuli was attenuated, as compared to the control group in which no elemental conditioning occurred prior to the compound conditioning. More recent studies have conditioned both stimuli individually during the same sessions rather than on separate days like Kamin and Gaioni (see e.g., Blaisdell, Denniston, & Miller, 2001; Kehoe & White, 2004; Kremer, 1978; Lattal & Nakajima, 1998; Rescorla 1999, 2006, 2007). Although slight differences in the preparations for control groups were used in the aforementioned studies, all studies produced the same result: a decrement in responding to an excitor following compound conditioning. In one of the best-controlled series of overexpectation studies, Blaisdell and colleagues (2001) used three control groups: (1) individual presentations of the target stimulus during the compound training phase, which provides a baseline for responding; (2) reinforcement of a previously nonreinforced stimulus during the compound training phase, which provides a control examining the amount of acquisition that occurs during elemental training; and (3) compound pairings of the target stimulus and a previously nonreinforced stimulus during the compound training phase, which provides a generalization decrement control when two stimuli are presented in compound.

Although the overexpectation effect is one of the most successful, novel, a priori predictions of the Rescorla-Wagner model (Miller, Barnet, & Grahame, 1995), the Rescorla-Wagner model does not provide the only theoretical account of the overexpectation effect. The Comparator Hypothesis (Miller & Matzel, 1988) is a performance-based model in which responding to a target stimulus (T) can be affected by the extent to which other stimuli also predict the US. Thus, according to the comparator hypothesis, the strength of the association between T and the US is not the only determinant of conditioned responding as anticipated by the value of V_i in Rescorla-Wagner model. Instead, responding to T at test is determined by the extent to which T activates a representation of the US directly, compared to the extent to which T activates a representation of the US indirectly through other stimuli with which T has become associated (the so-called comparator stimuli; see Figure 1). Increasing the strength of the directly-activated US representation increases conditioned responding, whereas increasing the strength of the indirectly-activated US representation decreases conditioned responding.

In the case of overexpectation (C→US/T→US, then CT→US), during elemental training, the target (T) and comparator stimulus (C) establish an equivalent relationship to the US in the overexpectation group (Links 1 and 3 of Figure 1, respectively). The second phase of training establishes a strong target-comparator association (Link 2). Therefore, when comparing the representations of the US activated directly (T→US) and indirectly (the product of T→C and C→US) by T, the indirect activation of the US is stronger than the direct representation of the US. Consequently, when the subject's responding to T is analyzed, a decrement in responding is observed (see Figure 2) as compared to a subject that did not receive C→US pairings in phase 1 (see Figure3). The control groups should not be subject to overexpectation. For example, in Group compound control (CMPD-CTL; T→US /B→ noUS, then BT→US), B is not an excitor at the onset of compound conditioning, resulting in a weak B→US association, therefore, the product of the associations T→B and B→US is weaker than in the overexpectation group (see Figure 3). In the elemental control group (ELEM-CTRL; T→US /C→US, then T→US), T and C are not presented in compound, therefore, a strong T→C association is never established. The responding to T will be higher than the overexpectation group because the weight of Link 1 establishes a directly-activated representation of the US as compared to the product of the weights for Links 2 and 3.

Blaisdell et al. (2001) provided evidence in favor of the comparator hypothesis account of overexpectation. In their second study, the researchers extinguished the comparator stimulus after the compound training phase (T→US/C→US, then CT→US, then C→ noUS). By extinguishing the comparator stimulus, Link 3 (the association between the comparator and the US) was attenuated, and, as a result, decreased the strength of the indirectly activated US representation; thus increasing conditioned responding to T. In their third study, following the compound conditioning phase, Blaisdell et al. paired the comparator stimulus and the US at one of two different temporal locations. The time of presentation either matched or did not match the time of presentation of the US in the other conditioning phases. When there was a discord in the temporal relationship between the comparator stimulus and the outcome across the phases, the overexpectation effect was no longer evident. However, when the temporal relationship remained constant, overexpectation was observed. They interpreted this as a further demonstration that the disruption of Link 3 would attenuate the impact of the comparator stimulus and disrupt the overexpectation effect.

In recent years, Miller and colleagues (e.g., Denniston, et al. 2001; Stout & Miller, 2007) proposed a modification of the comparator hypothesis, which can be applied to the overexpectation effect. The Extended Comparator Hypothesis (Denniston, et al.) is very similar to the comparator hypothesis; however, in the extended comparator hypothesis, Links 2 and 3 are also subject to a comparator process (see Figure 4). These comparator processes can make the links more or less effective to activate a US representation. Take for example Link 2 (T →C in Figure 4). The T →C associations may be affected by other factors such as contextual stimuli related to the visual aesthetic or the smells in the chamber. All of these other stimuli may not develop and association to T strong enough that they became T's primary comparators, but they may also influence its associative strength by making C a more or less effective comparator for T. Stimuli that have a very strong association to T (e.g., C) become T's first order comparators. Other stimuli that may have become associated to both T and C during training will affect the extent to which target T activates C. Figure 5 demonstrates that a strong association between C, the first order comparator, and the context, a second order comparator, can have deleterious effects on Link 3. In this case, the extent to which T activates C (output of Link 2) is mediated by the extent to which the context activates C. Thus the output of Link 2 is determined by the strength with which T activates C as compared to the extent to which the context activates C. In this case, the context is T's second order comparator stimulus. Thus, increasing the strength of the T → context or the context → C association will decrease C's effectiveness as a comparator stimulus for T. Conversely, decreasing the strength of these associations will increase C's effectiveness as a stimulus for T. Thus, the extended comparator hypothesis predicts changes in responding to T as a result of manipulation of its second order comparator because this second order comparator will determine the effectiveness of C.

One of the great successes of the comparator hypothesis is that it easily accounts for latent inhibition. Latent inhibition occurs when a stimulus is presented multiple times prior to conditioning, leading to retarded subsequent acquisition of a stimulus-US association (Lubow & Moore, 1959). The Rescorla-Wagner model does not account for preexposure to a stimulus retarding acquisition because, prior to conditioning, presenting a stimulus without the US maintains the associative strength at zero, which is the same associative strength of a novel stimulus. Thus, according to the Rescorla-Wagner model, when a preexposed stimulus is later paired with the US, acquisition should continue just as if it was a novel stimulus. Because this does not occur, the model cannot account for latent inhibition. In contrast, the comparator hypothesis accounts for latent inhibition by assuming that, during the preexposure phase, the context becomes the CS's comparator stimulus. Due to the number of preexposure trials usually given, a strong CS-context (Link 2) association is formed (e.g., Escobar, Arcediano, & Miller, 2002). The strong association to the context results in a strong indirect activation of the US representation, and consequently attenuated responding to the CS.

Because latent inhibition is a phenomenon for which the comparator hypothesis and the Rescorla-Wagner model have incongruent predictions, we decided to use similar conditioning preparations as latent inhibition, and preexposed a stimulus in the present experiments. The Rescorla-Wagner model predicts that preexposure of a stimulus will have no impact on the rate of conditioning following the preexposure. Blaisdell et al. (2001) manipulated the strength of Link 3 (C→US) of the comparator hypothesis in order to attenuate overexpectation by using extinction. We attempted to disrupt Link 2 (T→C) using latent inhibition. We expected that preexposure made the comparator stimulus(C) develop a strong association with the context, thus down-regulating the ability of C to become an effective comparator for T (the context should become a second-order comparator for T; see figure 5). If the extended comparator hypothesis predictions are accurate, when a subjects experiences preexposure of C followed by the traditional preparations for the overexpectation effect, we should obtain an attenuation of overexpectation.

The comparator hypothesis assumes that latent inhibition is the result of strong CS C→ context associations, and therefore, can be disrupted by certain treatments such as context extinction (Escobar, et al., 2002; Pearce & Hall, 1979) and compound preexposure (CA→ noUS; Honey & Hall, 1989). Context extinction occurs when, following latent inhibition training, a subject is exposed to the context without the occurrence of any stimuli, which can attenuate the strength of the association between the stimulus and the context. Usually, compound preexposure results in attenuated latent inhibition to the stimulus presented in compound (Reed, 1995). The compound preexposure of A and C will establish a strong A → C association. If compound preexposure attenuates latent inhibition, it seems reasonable to expect that preexposing the comparator stimulus, C, in compound with an irrelevant stimulus, A, will attenuate any deleterious effects that preexposure may have on the effectiveness of C as a comparator for T, thus allowing for overexpectation to be expressed. Furthermore, extinguishing A should attenuate the protective effects of compound preexposure on C, thus allowing for the latent inhibition-driven attenuation of C's effectiveness as a comparator stimulus to be expressed. Consequently, if A is extinguished, overexpectation should be attenuated as it was with simple latent inhibition.

The following three experiments attempted to provide further support for either the Rescorla-Wagner model's or the Extended Comparator Hypothesis' account of overexpectation. If preexposure and compound preexposure attenuated the overexpectation effect, then these studies provided evidence in support of the extended comparator hypothesis's view that the overexpectation is a performance effect determined by competing training memories. If we were unable to attenuate the overexpectation effect using these methods, these studies provide evidence in support of the Rescorla-Wagner's explanation of an error correction mechanism underlying the overexpectation paradigm.

Experiment 1

The purpose of Experiment 1 was to obtain the overexpectation effect using the parameters reported by Blaisdell, et al. (2001, Experiment 1) as a guide. This study included a preexposure phase and an extinction phase in order to equate all handling and necessary context exposure to be used in subsequent studies. In the Overexpectation group, the target and comparator stimuli were conditioned independently to excitatory status. The compound of the two stimuli was subsequently paired with the same US as previously presented during the elemental training (See table 1). In the Compound control group (CMPD-CTL), a previously nonreinforced stimulus was paired with the target stimulus during the compound conditioning phase. This Group controlled for the possible response attenuation, which results from pairings with a novel stimulus (Blaisdell et al., 2001). The Elemental control group (ELEM-CTL) received presentations of the target stimulus paired with the US during the compound conditioning phase. This group provided a baseline of responding to an elementally-trained stimulus that does not have a discrete comparator stimulus to cause a decrement in responding beyond the effect of the context. This control group provided a direct comparison of responding for the overexpectation group because it represents the amount of excitatory responding that would be expected to an elementally-trained stimulus.

Methods

Subjects. Subjects were 32 male Sprague Dawley albino rats. The rats were housed in pairs with each rat in the pair allocated to a different group. The home cages were clear plastic with wire lids. The rats were on a water deprivation schedule, with food *ad lib.* Water availability was gradually decreased over the week preceding the study to 30 minutes per day, provided approximately two hours after the completion of the sessions for the day.

Apparatus. The apparatus were eight 30.5 x 24.1 x 21.0 cm Med Associates boxes. The front, top, and back walls of the chamber were made of clear Polycarbonate. The left and right sides of the chamber were made of aluminum sheet metal. The floor was constructed of 4.8 mm stainless steel rods, spaced 1.6 cm center-to-center. The rods were used to deliver a 0.75-mA volts direct current (VDC) footshock. Each individual chamber was housed in a melamine sound attenuation cubicle. Located on the side of the cubicle was an exhaust fan, which provided a constant, 70 dB background noise (this and all other sound pressure level measurements were made using the A scale). All chambers had four speakers used to deliver a white noise, 2900-hz tone, 800- Hz tone, and click train (3/s), all at 80 db.

A 100-mA house light (#1820) delivered at 28 VDC was located on a side wall. A 5.1 x 5.1 x 5.1 cm water niche was located 1.5 cm above the grid floors on the side wall opposite the house light. A ‘V’-shaped metal plate covered the back of the niche, and at the vertex of the plate was an opening through which the subjects could obtain water by extending their tongue to reach a drinking tube. An infrared photobeam was located behind the opening in the V plate and in front of the drinking spout, and it was disrupted by the tongue extension when the subject drinks. The number of times the photobeam was broken reflected the number of licks in a set time period, and it served as the dependent measure. The white noise and 800 Hz low tone served as CSs B and C, and were counterbalanced within groups. To ensure that these two stimuli resulted in equivalent behavioral control, stimulus was included as a factor in all statistical analyses in this and all subsequent experiments. The box assignments were counterbalanced between groups.

Procedure.

Acclimation. On Day 1, subjects were exposed to the experimental context for 60 minutes with the lick tubes present to acclimate them to the context and allow them to find the lick tubes. No nominal stimuli were delivered.

Preexposure. On Days 2–7, subjects received six presentations of CS D (low tone) in a 60 minute session for a total of 36 presentations. The CS was 10s in duration and the intertrial interval was 10 ± 4 minutes (two schedules were used on alternating days). The lick tubes were not available during this phase.

Elemental Conditioning. On each of Days 8-9, subjects received three CS C→US pairings, three T→US pairings, and three presentations of CS B alone. The intertrial interval was 6 ± 3 min. The order of occurrences for the three stimuli was pseudo-random, such that no stimulus occurred more than two consecutive times. Thus, there were a total of six CS C→US pairings, six CS T→US pairings, and six presentations of CS B across the two days of elemental conditioning. All stimuli were 10 s in duration, and the offset of CSs C and T coincided with the onset of the 0.5-s, 0.75-mA footshock US. Stimulus B was never paired with the shock. The lick tubes were not available during this phase.

Compound Conditioning. On Days 10–12, subjects in the Overexpectation group received six TC-US pairings, subjects in the CMPD-CTL received six BX-US pairings, and subjects in the ELEM-CTL group received six T-US pairings. The offset of all stimuli coincided with the onset of the 0.5-s, 0.75-mA footshock US. All stimuli were 10s in duration, and the intertrial interval was 10 ± 4 minutes. The lick tubes were not available during this phase.

Handling. On Days 13-15, the animals were placed in the transport cart, taken to the apparatus room, and then back into the colony room, where they were returned to their home cages. This phase is necessary to equate the training-testing intervals and handling with subsequent experiments in the series.

Reacclimation. On Day 16, subjects were exposed to the experimental context for 60 minutes with the lick tubes present. No nominal stimuli were delivered. The purpose of the reacclimation phase is to reestablish drinking behavior, which is usually disrupted by the shock treatment.

Test. On Day 17, subjects were tested for conditioned lick suppression to CS T. Animals were placed in the apparatus with the lick tubes present. After the subject completed 100 licks, CS T was presented. The amount of time each subject took to complete licks 72 to 100 (i.e., 28 licks) was used a baseline latency. Then the amount of time it took the subject to complete an additional 28 licks (licks 101 to 128) was used as the CS latency. Subjects had a maximum of two minutes to complete 28 licks in the presence of the test CS. Animals that fail to complete 28 licks during the CS presentation were assigned a score of 120 seconds. The amount of time it took to complete 28 licks prior to stimulus onset (licks 72 to 100; Pre-CS 28) established a baseline of responding to examine the rate of behavior prior to the presentation of T. Any subject that took longer than one minute to complete Pre-CS 28 was not used in the analysis of the study; four animals were eliminated from the analysis following this criterion. A log (base 10) transformation was used for the latencies in the analysis in order to normalize the responding. The rate of licking is faster at the beginning of a time interval than toward the end. The log transformation shifted the curvilinear pattern of responding to a linear pattern.

Results and discussion

Overexpectation (i.e., less conditioned responding to T than in the Control groups) was observed in Experiment 1. Thus, we successfully replicated Blaisdell et al.'s (2001) results. The following analyses support this conclusion.

A 3 (group: Overexpectation x Compound Control x Elemental Control) x 2 (stimulus C: Noise x 800Hz low tone) analysis of covariance (ANCOVA) revealed that the latencies to complete 28 licks prior to the CS onset differed across the three groups, $F(2,25) = 3.74$, $p < .05$, however the differences between the two stimuli were nonsignificant, $F(1,25) = 0.13$, $p = 0.72$, as well as the interaction, $F(2,25) = 0.44$, $p = 0.65$. Therefore, all analyses of CS latencies were adjusted for pre-CS times in order to attenuate the effect of baseline differences on responding during the CS presentation. To demonstrate the overexpectation effect was obtained, a 3 (group: Overexpectation x Compound Control x Elemental Control) x 2 (stimulus C: Noise x 800Hz low tone) ANCOVA, using pre-CS scores as the covariate, was conducted on the CS latencies recorded during the test stimulus presentation. This analysis revealed there was a significant difference amongst the three groups, $F(2,27) = 4.37$, $p < .05$.), There was not a difference in the nature of the stimulus used as C (white noise or 800 Hz low tone), $F(1,27) = 0.33$, $p = 0.60$, as well as no interaction, $F(2,27) = 0.47$, $p = 0.63$. Planned comparisons derived from the factorial ANOVA revealed that the Overexpectation group exhibited less conditioned responding than the Compound Control group, $F(1,27) = 8.49$, $p < .05$, and there was a marginal difference between the Overexpectation group and the Elemental Control group, $F(1,27) = 3.96$, $p = .06$. The two control groups did not differ from one another, $F(1,27) = 0.65$, $p = 0.427$. The physical stimulus used as C was a factor in the analysis in order to examine if there was a difference in responding to T depending on which stimulus was compounded with it. Because there was no significant effect or interaction found in this experiment we can assume that responding to T was not altered by which stimulus was used for C.

Experiment 2

The purpose of this experiment was to assess whether the overexpectation effect would be attenuated if the comparator stimulus (C) was preexposed alone prior to overexpectation training (see Group PRE-OX, Table 2). The extended comparator hypothesis predicts that the strong association between comparator stimulus C and the context should reduce C's effectiveness as a comparator stimulus for target stimulus T (see Figure 7).

One of the interesting characteristics of latent inhibition is that it is context dependent. Channell and Hall (1983) demonstrated that if the preexposure phase and conditioning phases occur in different contexts, then latent inhibition is attenuated. The context dependence of latent inhibition is an important part of this series of experiments. Placing a subject in a different context during preexposure to the comparator stimulus should attenuate the effect of preexposure on overexpectation (see Figure 8). Because the effectiveness of Link 2 was not attenuated, overexpectation should be observed. Consequently, subjects in Group PRE-OX-CTX received preexposure in a second context in order to determine whether any observed attenuation of overexpectation was due to preexposure of the comparator stimulus. If the preexposure of CS C had similar properties as latent inhibition, and if latent inhibition occurred due to a context-CS association, this would attenuate any effects of preexposure while maintaining exposure to C constant. Thus, the expected decrement in responding that occurs with overexpectation should be observed because the preexposure is performed in a different context. The PRE-OX-CTL group in this study was equivalent to Group compound control of Experiment 1 and served to establish a baseline responding during test.

Methods

Subjects. Thirty-two male albino rats served as subjects in this study. Subjects were housed and maintained as in Experiment 1.

Apparatus. The environmental chest and experimental chamber were the same as described in Experiment 1. However, the context manipulation programmed for this experiment required the use of two physical contexts. Context Plain was the chambers as previously described. Context Plexi was a modification of the plain chambers achieved by placing a piece of plexi glass inside the chamber at a 50 degree slant with a checkerboard pattern in black in white on the underside of the plexi glass. The same checkerboard pattern was used to cover all the clear walls of the chamber. The plain and plexi contexts served as Contexts 1 and 2, counterbalanced within groups.

Procedure.

Acclimation. On Day 1, subjects were acclimated to the context using the same procedure as Experiment 1.

Preexposure On Days 2–7, subjects received six daily presentations of CS C (either white noise of low tone, counterbalanced across subjects) in a 60 minute session, for a total of 36 presentations. The CS was 10 s in duration and the intertrial interval was 10 ± 4 min (two schedules were used on alternating days). Preexposure occurred in Context 1 for Group PRE-OX and half of Group PRE-OX-CTL and in Context 2 for Group PRE-OX-CTX as well as the remaining half of Group PRE-OX-CTL. The lick tubes were not available during this phase.

Elemental Conditioning, Compound Conditioning, Handling, Reacclimation, and Test. On Days 8-9, subjects received elemental conditioning; on Days 10-12, subjects received compound conditioning; on Days 13-15, subjects received handling; on Day 16, subjects received reacclimation; on Day 17, subjects were tested for suppression to T. All subjects were placed in Context 1 for all the training phases following the latent inhibition phase. The procedures for these phases of training were the same as that described in Experiment 1. Four subjects were eliminated from the analyses due to their high baseline scores, as described in Experiment 1.

Results and Discussion

Preexposure should attenuate overexpectation by reducing the capacity of C to compete with T (Group PRE-OX). The PRE-OX-CTX group should show normal overexpectation even if preexposed to C because C was preexposed in another context; thus more conditioned responding should be observed in the PRE-OX group than the PRE-OX-CTX group. If the context manipulation indeed disrupts preexposure, then the PRE-OX-CTX group should exhibit less conditioned responding than the OX-CTL group. Although the trend of data suggests that preexposure may have had the predicted effects on overexpectation, this trend did not achieve statistical significance

A 3 (group: PRE-OX x PRE-OX-CTX x OX-CTL) x 2 (stimulus: Noise x 800Hz low tone) ANCOVA analysis assessing the difference in baseline responses across the three groups suggests there is a difference in baseline responses, $F(2,27) = 4.24$, $p = .03$, however there was no effect of stimulus, $F(1,27) = 0.13$, $p = .72$, nor an interaction, $F(2,27) = 0.33$, $p = .72$, therefore, the latencies were used a covariate further analysis of this experiment. A 3 (group: PRE-OX x PRE-OX-CTX x OX-CTL) x 2 (stimulus: Noise x 800Hz low tone) ANCOVA, with the baseline scores as a covariate, revealed no difference amongst the groups, $F(2,27) = 0.99$, $p = 0.39$, as well as no effect of stimulus C, $F(2,27) = 0.37$, $p = 0.54$, (see Figure 9). The interaction of group and stimulus was marginally significant, $F(2,27) = 3.20$, $p = 0.06$. When stimulus C was the white noise, the conditioned responding was equivalent across the groups, as depicted Figure 10. However, when stimulus C was the 800 Hz low tone, there was a trend towards decreased conditioned responding in Group PRE-OX-CTX, as compared to Groups PRE-OX and PRE-OX-CTRL, which is consistent with our expectations based on the CH.

Experiment 3

The third experiment attempted to obtain and later reverse the overexpectation effect by using compound preexposure, and then extinguishing the compound preexposed stimulus, A, during the final phase of the study. Compound preexposure occurs when two stimuli are presented in compound without the presence of the US. Theoretically, compound preexposure is expected to assuage the predicted effects latent inhibition has on overexpectation due to the deleterious consequences compound preexposure presents on latent inhibition (Honey & Hall, 1959).

During Experiment 3, we expected that Group compound preexposure (CMPD-PRE) is predicted to elicit decreased responding to T as compared to the control group because compound preexposure attenuates latent inhibition, thus it should produce the opposite outcome as the OX-LI group in Experiment 2. We also predicted that a decrease in responding to T in the overexpectation group (OX), similar to that as CMPD-PRE. Group OX used similar training paradigms; however compound preexposure presentations of novel stimuli were presented in the initial training phase. Group compound preexposure extinction (CMPD-PRE-EXT) extinguished compound preexposure cue, A, as an attempt to attenuate overexpectation. The compound preexposure extinction (CPD-PRE-EXT) group presented compound pairings of C and A without the US. The final phase of training then extinguished A, the stimulus previously paired with C, thus, theoretically obtaining the overexpectation effect because extinguishing A should attenuate the effects of the compound preexposure in the first phase of training. The overexpectation control (OX-CTL) Group provided a control that allows us to demonstrate a baseline of responding for lick latencies to compare to the remaining three groups. Group OX-CTL used similar preparations as used for the control group in Experiment 2, with the exception of a novel cue presented during the compound preexposure and extinction training phases.

Methods

Subjects and Apparatus. Thirty-two male albino rats served as subjects in this study. Subjects were housed and maintained as in Experiment 1. The apparatus were the same as described in Experiment 1. Stimuli A, B, C, and D were counterbalanced within groups.

Procedure

Acclimation. On Day 1, subjects were exposed to the experimental context for 60 minutes with the lick tubes present. Stimuli (A, B, C, D, and T) were delivered twice in a random order with the purpose of preventing configural learning of the compounds, which would be otherwise experienced before the elements. The stimuli were 10 s in duration and the intertrial interval were 6 ± 3 minutes. No USs were scheduled to occur.

Compound Preexposure. On each of Days 2–7, subjects in the OX and OX-CTL groups received six presentations of the 10 s DC compound, whereas, subjects in the CMPD-PRE-EXT and CMPD-PRE groups received six presentations of the 10 s AC compound. Session duration was 60 minutes and the intertrial interval was 10 ± 4 minutes (two schedules were used on alternating days). The lick tubes were not available during this phase.

Elemental Conditioning and Compound Conditioning. On Days 8–9, subjects received elemental conditioning, and on Days 10–12, subjects received compound conditioning. The procedures for these phases of training were the same as that described in Experiment 1.

Extinction. On Days 13–15, all subjects underwent extinction of one of the stimuli presented during compound preexposure. This phase is necessary to extinguish the association established between the first order and second order comparator stimuli. During this phase, subjects in the Compound pre-exposure group received 60 daily presentations of CS D alone during a two hour session. Groups Overexpectation, Compound preexposure extinction, and overexpectation control received 60 daily presentations of CS C alone during the session. The intertrial interval was 2 ± 1 minutes. The lick tubes were not present during this phase.

Reacclimation and Test. On Day 16, the subjects received reacclimation training, and on Day 17, the subjects were tested for suppression to T. The procedures for these phases of training were the same as that described in Experiment 1. Seven subjects were eliminated from the analyses due to their high baseline scores, as described in Experiment 1.

Results and discussion

Compound preexposure should attenuate the effects of preexposure and thus allow stimulus C to effectively reduce responding to the target stimulus (Honey & Hall, 1959) because the retarded acquisition of C observed in Experiment 2 should no longer be present in Experiment 3. Consequently, the CMPD-PRE group should exhibit similar levels of responding as the OX group. Extinguishing C’s preexposure companion in

Group CMPD-PRE-EXT should attenuate the compound preexposure effect. Consequently, overexpectation should not be obtained in the CMPD-PRE-EXT group. However, this manipulation did not support the predictions of the Comparator Hypothesis. There were no observed decrements in conditioned responding in either Group OX or Group CMPD-PRE-EXT.

A 3 (group: OX, CMPD PRE EXT, CMPD PRE, and OX CTL) x 4 (stimulus: noise, 800Hz low tone, 2900Hz mid tone, and flashing house light) ANCOVA used to assess the possible group differences in baseline responses demonstrated there were no group differences, $F(3,24) = 1.74$, $p = 0.21$, as well as no differences in stimuli, $F(3,24) = 0.96$, $p = 0.44$ and a nonsignificant interaction, $F(3,24) = 1.34$, $p = 0.30$. Even though there were no differences in baseline responding, preCS scores were used as a covariate for consistency with the analyses of Experiment 1. The results of a 3 (group: OX, CMPD PRE EXT, CMPD PRE, and OX CTL) x 4 (stimulus: noise, 800Hz low tone, 2900Hz mid tone, and flashing house light) ANCOVA revealed no differences among groups, $F(3,24) = 1.35$ $p = 0.30$ (see Figure 11); that is, all groups exhibited equivalent responding. The factor analysis to assess the amount of behavioral control for each of the four physical stimuli used C was nonsignificant, $F(3,24) = 0.39$, $p = 0.76$, , as was the interaction of group and stimulus, $F(9,24) = 1.12$, $p = 0.41$. Alternatively stated, responding to T during test was not different when examining the use of one stimulus in comparison to another, and the two factors (i.e., group and stimuli) did not interact to determine responding to T.

Discussion

The overexpectation effect occurs when two independentally conditioned excitatory stimuli are presented in compound and paired with the same US, thus causing a decrement in responding to one of the stimuli during test. The experiments in this series examined the accounts of two different models for overexpectation (T+ / C+, then TC+). The design from one of the studies from Blaisdell et al. (2001) was used as a guide for Experiment 1, and replicated the overexpectation effect (attenuated responding to T as compared to a group in which C was not excitatory at the onset of compound conditioning).The Elemental Control group (T+ / C+, then T+) provided a baseline of conditioned responding to T because the target is paired with the US alone and never in compound with another stimulus. The Compound Control group (T+ / B-, then TB+) demonstrates that the decrement in responding observed in the overexpectation effect is not due to a generalization decrement that occurs from compound pairings with the US. The analysis conducted for Experiment 1 demonstrated that the Overexpectation group had decreased conditioned responding in comparison to the amount of conditioned responding in the Control groups.

The Rescorla-Wagner model (1972) is an acquisition-focused that examines the change in associative strength during conditioning. It is a simple model with few parameters, which provides the model to be commonly model. The Rescorla-Wagner model was the first to provide the a-priori prediction of the overexpectation effect. In the case of overexpectation, after the individual CSs are conditioned to assymptote (λ), the compound presentation of the CSs creates an an expectation of 2λ. When the compound training does not produce a larger US, the model predicts that the US expectation elicited by each stimulus will be reduced to match the actual US magnitude**.** An alternative theoretical account is the Compartor Hypothesis (Miller & Matzel, 1988). This model is a performance-based model in which responses to a target stimulus are affected by other stimuli, known as comparator stimuli. In the case of overexpectation, the amount of responding to T is dependent on the extent to which the US is activated by T as well as the extent to which the US is activated by T's training companion, comparator stimulus C. Responding to T will be higher if the stimulus activates a representation of the US directly more than it does indirectly.

In 2007, Rescorla suggested that the overexpectation effect has similar properties as extinction. Extinction is the decrement in responding that occurs when an excitatory stimulus is presented multiple times without the US (Pavlov, 1927). Conditioned responding following extinction is well known to renew if the CS alone trials occur in a different context than that of the excitatory training or the testing phases (Bouton & Bolles, 1979). Similarly, Rescorla observed that Overexpectation was susceptible to renewal when the context changed across the different phases. The preparations which Rescorla used were the ABA, AAB, and ABC, where each letter represents a different context of the initial training, compound training, and testing phases respectively. Although the Rescorla-Wagner model does not account for renewal in overexpectation, Rescorla concluded that the similarities between overexpectation and extinction were only captured by the concept of a calculation error (i.e., during the compound training the subjects expect 2λ to occur. When only λ is presented, the subjects must readjust their responding to account for the difference). The model that best supports the error in calculation, or the change of associative strength, is the Rescorla-Wagner model.

The error in calculation is not the only possible explanation for what is occuring during the overexpectation effect. According to Blaisdell and coleagues (2001), the overexpectation effect may be accounted for by the competition that occurs between the target stimulus and another stimulus that is presented. The performance of responding at test is affected by the associations the target cue establishes with the US as well as the associations it establishes with the comparator stimulus. Blaisdell and colleagues supported the notion of competition by using extinction of the comparator after the overexpectation training to attenuate its effectiveness.

Interestingly, according to the Comparator Hypothesis, every presentation of the CS alone will establish an association between the context and the CS. The CS-context association is the basis of latent inhibition (but see Stout & Miller, 2007). Because the Comparator Hypothesis predicts a specific effect of CS-preexposure and The Rescorla-Wagner model does not account for CS-preexposure, the predictions of the two models can be pinned against each other using the combination of preexposure and overexpectation as a tool. The Rescorla-Wagner model predicts that preexposing a stimulus will not change its associative strength from zero; thus, when the preexposed stimulus is later paired with a US, the conditioning will proceed normally (similar to a stimulus that has never been preexposed). In this series of experiments, the Rescorla-Wagner model would predict that preexposing stimulus C would not attenuate overexpectation. However, the Comparator Hypothesis predicts that preexposing comparator C will establish a strong association between it and the context, thus retarding the acquisition of the comparator during the elemental conditioning phase, and weakening the stimulus' abilitiy to be a comparator to T.

Experiment 2 tested the Comparator Hypothesis' prediction that preexposing the comparator stimulus will attenuate overexpectation by retarding the acquisistion of the comparator after the preexposure. Experiment 2 used preexposure to CS C to attenuate the overexpectation effect. Because preexposure uses a similar training procedure of the training procedure used to obtain latent inhibition, it was assumed that the preexposure used in the second study would result in latent inhibition of C, and consequently, retard acquisition of excitation by it in the subsequent conditionnig phase. The results from Experiment 2 did not indicate a difference between the groups, but the trend of the data suggests that preexposing the comparator stimulus establishes similar patterns of responding as the PRE-OX-CTL group, with a decrement in conditioned responding in Group PRE-OX-CTX. The trend of data will be discussed in more detail below.

Experiment 3 attempted to maintain the overexpectation effect by using compound preexposure during the first phase of training. Preexposing the comparator, C, in compound with another stimulus, A, should attenuate the retarded acquisition of the comparator. Stimulus C was not presented during compound preexposure in Group OX, thus the overexpectation effect should be observed. In the CMPD-PRE-EXT group, extinguishing the compound preexposure companion stimulus, A, should restore the effects of preexposure on C. Therefore, this group should exhibit similar conditioned responding as the OX-CTL goup. However, Experiment 3, revealed no difference in conditioned responding among the four groups. Thus, neither the overexpectation nor the compound preexposure manipulations produced decrements in conditioned responding in comparisons to the CMPD-PRE-EXT group or the OX-CTL group.

The design of Experiment 3 was exceedingly complex, which more than likely prevented any effects from being obtained. The initial phase of the experiment was compound preexposure, which was implemented to attenuate the retarded acquisition that is predicted to occur when a stimulus is preexposed. Following the compound preexposure, the traditional overexpectation training ensued. Then following the overexpectation compound training phase, the companion stimulus, presented with the comparator during compound preexposure, was extinguished in order to attenuate the compound preexposure effect. Thus, the comparator would exhibit retarded acquisition again, as predicted with preexposure. The complexity of the third experiment requires that several tentative effects are obtained in order for the overexpectation effect to be attenuated or obtained.

One possible reason for the failure of Experiment 2 is related to the contexts that were used for training. One of the contexts used in this study involved the experimental chambers unaltered; the other context involved the use of covering the exterior of the chamber in a checkerboard pattern. A piece of plexi glass with the same checkerboard pattern was placed inside the chamber at a slant. During the initial phase of the experiment, the degree of the slant for the plexi glass inside the experimental chamber (41 degrees) allowed the subjects to climb onto the plexi glass, possibly to avoid the shock. The angle was changed in Phase 2 to prevent the possible shock avoidance by creating a steeper slope of the plexi glass (50 degrees). The new position of the plexi glass plate partially occluded the speakers, and this may have changed the auditory properties of the stimulus, thus decreasing the sensitivity of the procedure. The marginal interaction of stimulus and group observed in Experiment 2 supports this possibility. A graphical representation of responding to T when C was either the white noise or the 800 Hz tone revealed that when C was the white noise, responding to T did not differ among groups. In contrast, Group PRE-OX-CTX revealed decreased responding to T when the comparator stimulus was a tone as compared to Groups PRE-OX and PRE-OX-CTL. It is possible that when the plexi glass was placed in the chamber the physical characteristics of the noise was changed because the speaker that emitted the nose was partially occluded. The difference in the noise characteristics may have attenuated the preexposure effect whenever a context change occurred in the experiment because it may have been perceived a new stimulus. Stimuli need to be better equated for a replication of this experiment.

Experiment 3 was designed to attenuate the effects of preexposure of the comparator stimulus (see Figure 12). However, the use of a compound preexposure manipulation resulted in a possible third-order comparator process. The overexpectation effect is a tenuous effect to obtain. By dealing with higher-order associations, the associations decay in strength, therefore, effects will not be obtained. In Experiment 3, the third-order effect occurs during the extinction phase when the association was established between the context and stimulus A, which occurs during the extinction phase. Described alternatively, C becomes a first-order comparator to T, stimulus A, a second-order comparator to T, and finally the context more than likely is conditioned as a third-order comparator to T. The possible higher-order associations previously mentioned may interact with the predicted overexpectation associations in this experiment, thus making the outcome of the study difficult to predict. This could possibly explain why there is not a large difference in responding across the four groups, as would be expected.

The intent of this series of experiments was to demonstrate that different preexpose manipulations to the comparator stimulus will attenuate the overexpectation effect or maintain the effect. Experiment 1 replicated the findings of Blaisdell and colleagues (2001), by obtaining a decrement in conditioned repsonding in the Overexpectation group as compared to the Elemental Control group and the Compound Control group. Preexposure was used to attenuate overexpectation, in Experiment 2, by weakening the comparator stimulus, C, as a comparator. Although the trend of data suggests that preexposure may attenuate overexpectation, the analsysis did not demonstrate significants results.The Rescorla-Wagner model predicts that preexposing stimulus C will not impact the outcome of overexpectation training, because preexposure does not have any change in associative strength. The Comparator Hypothesis predicts that preexposing the comparator stimulus will attenuate overexpectation by creating a strong association between the comparator and the context rather than the comparator and the US. This weakens the ability of stimulus C to be an effective comparator to T. In contrast, the model predicts that if the preexposure occurs in a different context, the strong association between the comparator and the context does not impact the overexpecctation effect. Since overexpectation was not obtained in Experiment 2, neither the Rescorla-Wagner model nor the Comparator Hypothesis was supported by this research.

In Experiment 3, compound preexposure was used in order to reverse the manipulations of Experiment 2. After compound preexposure, the comparator should maintain a normal acquisition curve as compared to a stimulus that was preexposed and demonstrated retarded acquisition. The Comparator Hypothesis predictst that Group OX and Group CMPD-PRE will echibit the same type of reduced conditioned responding as observed in overexpectatio. The decreased responding is predicted to occur in the Overexpectation group because the comparator is not presented in the compound preexposure phases. The decrement in conditioned responding is predicted to be observed in the Compound Preexposure group because the compound preexposure will attenuate the preexposure effect observed in Experiment 2. By extinguishing the compound companion stimulus to C in the CMPD-PRE-EXT group, the Comparator Hypothesis predicts that the attenuation of preexpsoure effect to C will assuage the overexpectation effect. The Rescorla-Wagner model predicts that overexpectation will be obtained in all groups aside from Group Overexpectation Control because compound preexposure and extinction of another stimulus does not alter responding to T since it occurs prior to or after the overexpectation training. After analyzing the results from Experiment 3, we were unable to obtain the overexpectation effect in any of the groups. This may have occurred due to the complexity in the design of Experiment 3 which provided the possible large number of higher-order associations, which would make it even more challenging to obtain such a sensitive effect. Therefore, Experiment 3 does not provide a good assessment of the predictions for the Comparator Hypothesis or the Rescorla-Wagner model.

The current studies do not allow us to conclude which model better accounts for the overexpectation effect: the Rescorla-Wagner model or the Comparator Hypothesis. However, due to the limitations of the current experiments, it is difficult to assess which model does better account for overexpectation. Overexpectation is a tentative effect, thus difficult to obtain. It is possible that it may be too difficult to combine other effects with overexpectation and maintain the effect.

Future Directions

It is obligatory to replicate Experiment 2 with the adjustment made to the context to prevent occluding the speaker. As demonstrated graphically, responding to T followed the predicted pattern of responding when the comparator was the 800 Hz tone. Therefore, with the correction to the context, it is a reasonable assumption that both stimuli will produce similar responding, thus observing a decrement in responding in the Overexpectation group.

The design of Experiment 3 more than likely produced several higher-order associations that were not predicted. It is pertinent to better control for the higher-order associations, therefore a simpler design must be implemented. Rather than extinguishing the compound companion stimulus to the comparator at the end of the experiment, it may be necessary to utilize preexposure of the comparator stimulus following the compound preexposre. Honey and Hall (1959) demonstrated that compound preexposure prior to latent inhibition conditioning attenuates the inhibitory potential of that stimulus. Therefore, it may be a more direct approach to use compound preexposure in the first phase of the experiment in a similar fashion as was used in the current study. However, instead of the elemental conditioning for the second phase, following the compound preexposure we will preexpose stimulus C. The traditional overexpectation training will follow this preexposure. The Comparator Hypothesis would predict that overexpectation would be observed in the group that the comparator was presented during compound preexposure because the preexposure effect would be attenuated. In contrast, the group that did not present compound preexposures of stimuli A and C would not observe overexpectation because the preexposure of C during the second phase would weaken the ability of stimulus C to become an effective comparator to T. The Rescorla-Wagner model would predict that neither the preexposure nor the compound preexposure would have any effects on overexpectation because it is unable to account for either effect.

References

Baker, A.G. & Mercier, P. (1982) Extinction of the context and latent inhibition. *Learning and Motivation, 13,* 391-416.

Blaisdell, A., Denniston, J. C., Miller, R. R. (2001). Recovery from the overexpectation effect: Contrasting performance-focused and acquisition-focused models of retrospective revaluation. *Animal Learning & Behavior, 4,* 367-380.

Bouton, M.E. & Bolles, R.C. (1979). Role of conditioned contextual stimuli in reinstatement of extinguished fear. *Journal of Experimental Psychology: Animal behavior processes, 5,* 368-378.

Channell, S. & Hall, G. (1983) *Contextual effects in* latent inhibition *with an appetitive conditioning procedure. Animal Learning & Behavior, 11,* 67-74.

Denniston, J. C., Savastano, H. I., & Miller, R. R. (2001). Learning by contiguity, responding by relative strength: The extended comparator hypothesis. In R. R. Mowrer & S. B. Klein (Eds.), *Handbook of contemporary learning theories* (pp. 65-117). Hillsdale, NJ: Erlbaum.

Escobar, M., Arcediano, F. & Miller, R. R. (2002). Latent inhibition and contextual associations. *Journal of Experimental Psychology: Animal behavior processes, 28,* 123-136.

Honey, R.C. & Hall, G. (1959). Attenuation of latent inhibition after compound pre-exposure: Associative and perceptual explanations. *The Quarterly Journal of*

Experimental Psychology B: Comparative and physiological psychology, 41, 355-368.

Kamin, L.J. & Gaioni, S.J. (1974). Compound conditioned emotional response conditioning with differentially salient elements in rats. *Journal of Comparative and Physiological Psychology, 87*, 591-597.

Kehoe, E.J. & White, N. E. (2004). Overexpectation: Response loss during sustained stimulus compounding in the rabbit nictitating membrane preparation. *Learning & Memory, 11,* 476-483.

Kremer, E. F. (1978). The Rescorla-Wagner Model: Losses in associative strength in compound conditioned stimuli. *Journal of Experimental Psychology: Animal behavior processes, 4*, 22-36.

Lattal, K.M. & Nakajima, S. (1998). Overexpectation in appetitive Pavlovian and instrumental conditioning. *Animal Learning & Behavior, 26,* 351-360.

Lubow, R.E. & Moore, A.U. (1959). Latent inhibition: The effect of nonreinforced pre-exposure to the conditional stimulus. *Journal of comparative and physiological psychology, 52*, 415-419.

Miller, R.R., Barnet, R.C.& Grahame, N.J. (1995). Assessment of the Rescorla-Wagner model. *Psychological Bulletin*, *117,* 363-386.

Miller, R. R., & Matzel, L. D. (1988). The comparator hypothesis: A response rule for the expression of associations. In G. H. Bower (Ed.), *The psychology of learning and motivation* (Vol. 22, pp. 51-92). San Diego: Academic Press.

Pavlov, I.P. (1927). *Conditioned reflexes.* London: Clarendon Press.

Pearce, J.M. & Hall, G. (1979). Loss of associability by a compound stimulus comprising excitatory and inhibitory elements. *Journal of Experimental Psychology: Animal behavior processes, 5,* 19-30.

Reed, P. (1995) *Compound* stimulus preexposure effects in an appetitive conditioning procedure. *Learning and Motivation, 26,* 1-10.

Rescorla, R.A. (2007). Renewal after overexpectation. *Learning & Behavior, 35,* 19-26.

Rescorla, R.A. (2006). Spontaneous recovery from overexpectation. *Learning & Behavior, 34,* 13-20.

Rescorla, R.A. (1999). Summation and overexpectation with qualitatively different outcomes. *Animal Learning & Behavior, 27,* 50-62.

Rescorla, R. A., & Wagner, A. R. (1972). A theory of Pavlovian conditioning: variations in the effectiveness of reinforcement and nonreinforcement. In A. H. Black & W. F. Prokasy (Eds.), *Classical conditioning: II. Current theory and research* (pp. 64–99). New York: Appleton-Century-Crofts.

Stout, C.S & Miller R.R. (2007). Sometimes-Competing Retrieval (SOCR): A Formalization of the Comparator Hypothesis. *Psychological Review*, 114, 759-783.

Table 1

Experiment 1 Design: Replication of Blaisdell, Denniston, & Miller (2001)

Overexpectation

Group	Acclim 1 Day	Phase 1 Preexp. 6 Days	Phase 2 Elemental Condition. 2 days	Phase 3 Compound Condition. 3 days	Phase 4 Handling 3 Days	Reacclim 1 Day	Test	Expect-ation
OX	60 min	6 $(D-)_1$	3 $(T+)_1$/ 3 $(C+)_1$/ 3 $(B-)_1$	6 $(CT+)_1$	Handle	60 min	T?	cr
CMP D-CTL	60 min	6 $(D-)_1$	3 $(T+)_1$/ 3 $(C+)_1$/ 3 $(B-)_1$	6 $(BT+)_1$	Handle	60 min	T?	CR
ELEM-CTL	60 min	6 $(D-)_1$	3 $(T+)_1$/ 3 $(C+)_1$/ 3 $(B-)_1$	6 $(T+)_1$	Handle	60 min	T?	CR

Note: C = First order comparator, B & D = Novel stimuli, T= Target stimulus that is a click train. All stimuli presented were auditory. The outcome was a 0.5s, 0.75-ma shock.

Table 2

Experiment 2 Design: Preexposure effects on Overexpectation

Group	Acclim 1 Day	Phase 1 Preexp. 6 Days	Phase 2 Elemental Condition. 2 days	Phase 3 Compound Condition. 3 days	Phase 4 Handling 3 Days	Reacclim 1 Day	Test	Expect-ation
PRE-OX	60 min	6 $(C-)_1$	3 $(T+)_1$/ 3 $(C+)_1$/ 3 $(B-)_1$	6 $(CT+)_1$	Handle	60 min	T?	CR
PRE-OX-CTX	60 min	6 $(C-)_2$	3 $(T+)_1$/ 3 $(C+)_1$/ 3 $(B-)_1$	6 $(CT+)_1$	Handle	60 min	T?	cr
PRE-OX-CTL	60 min	6 $(C-)_1$ 6 $(C-)_2$	3 $(T+)_1$/ 3 $(C+)_1$/ 3 $(B-)_1$	6 $(BT+)_1$	Handle	60 min	T?	CR

Note: C = First order comparator, B = Novel stimuli, T= Target stimulus that is a click train. All stimuli presented were auditory. The outcome was a 0.5s, 0.75-ma shock. The subscript numbers 1 and 2 dictate Context 1 or Context 2 respectively.

Table 3

Experiment 3 Design: Compound Preexposure effects on Overexpectation

Group	Acclim 1 Day	Phase 1 Compound Preexpos. 6 days	Phase 2 Elemental Condition. 2 days	Phase 3 Compound Condition. 3 days	Phase 4 Extinction 3 Days	Reacclim 1 Day	Test	Expect-ation
OX	60 min	6 AD-	3 C+/ 3 T+/ 3 B-	6 CT+	60 A-	60 min	T?	cr
CMPD-PRE-EXT	60 min	6 CA-	3 C+/ 3 T+/ 3 B-	6 CT+	60 A-	60 min	T?	CR
CMPD-PRE	60 min	6 CA-	3 C+/ 3 T+/ 3 B-	6 CT+	60 D-	60 min	T?	cr
OX-CTRL	60 min	6 AD-	3 C+/ 3 T+/ 3 B-	6 BT+	60 A-	60 min	T?	CR

Note: C = First order comparator, A, B & D = Novel stimuli, T= Target stimulus that is click train. Stimuli presented were auditory or a flashing house light. The outcome was a 0.5s, 0.75-ma shock.

Figure 1

The Comparator Hypothesis

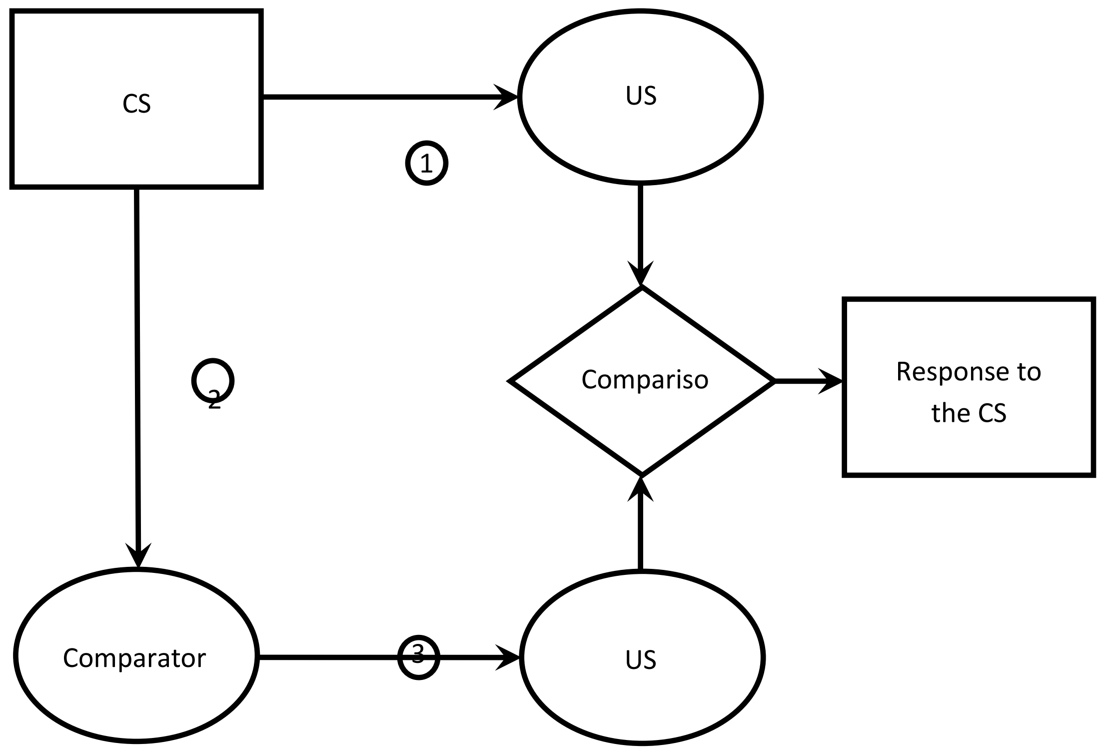

Figure 2

Explanation of overexpectation using the comparator hypothesis

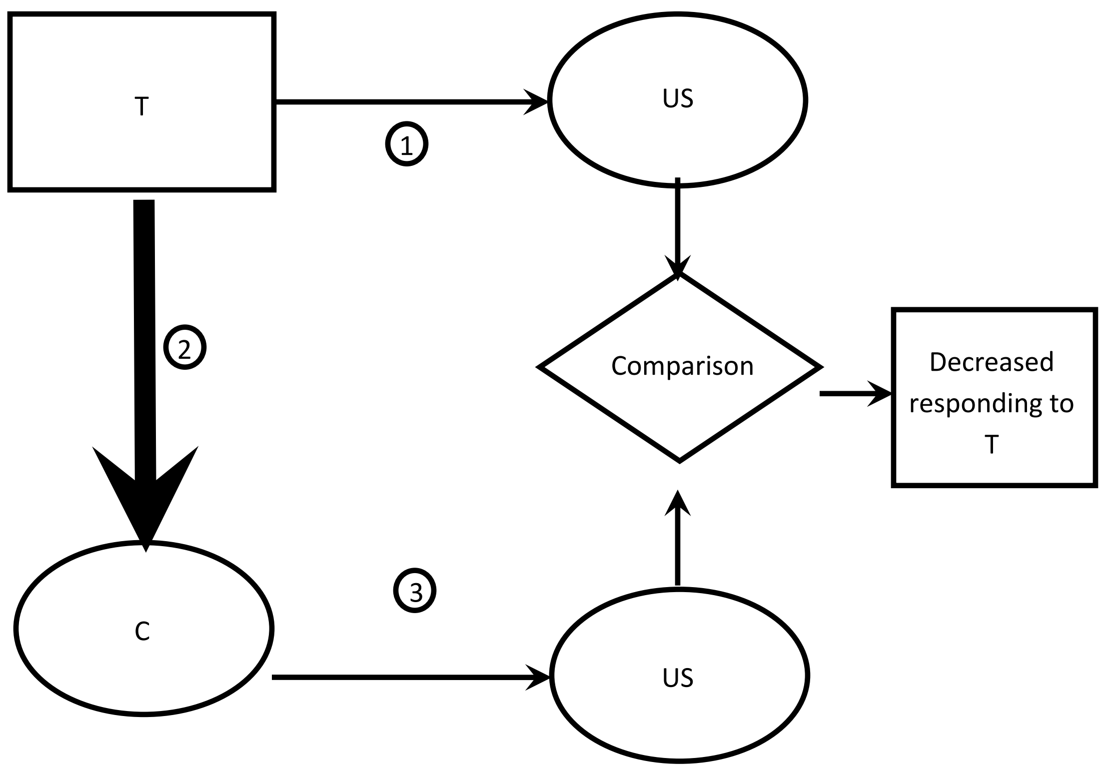

Figure 3

Overexpectation control group via comparator hypothesis

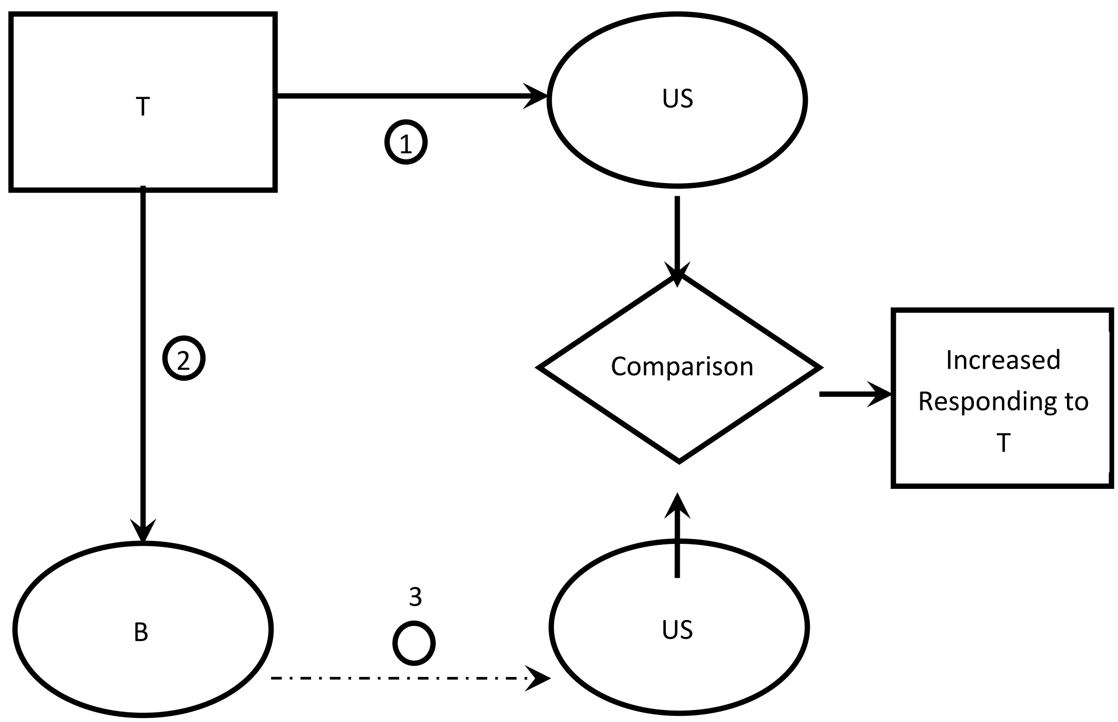

Figure 4

The Extended Comparator Hypothesis

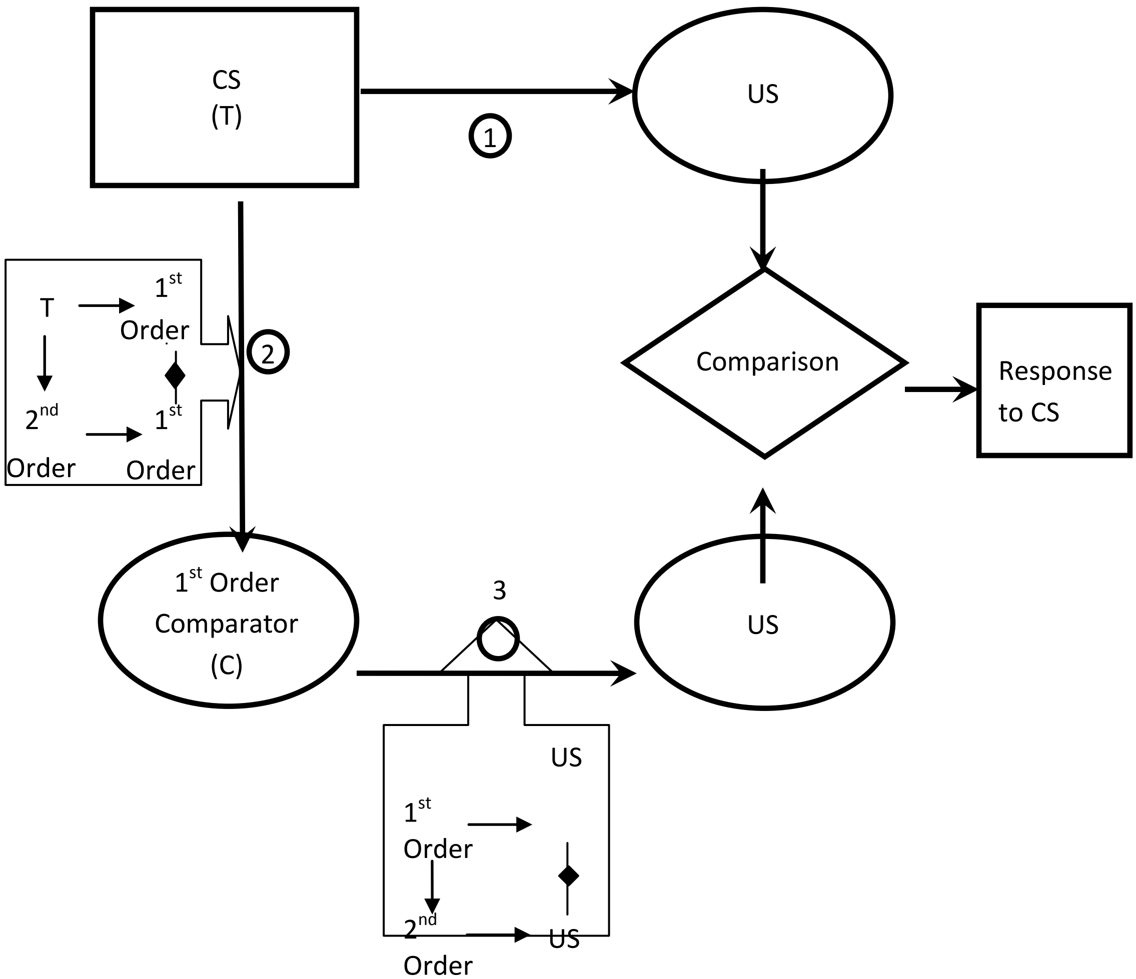

Figure 5

Latent Inhibition down-regulates comparator success

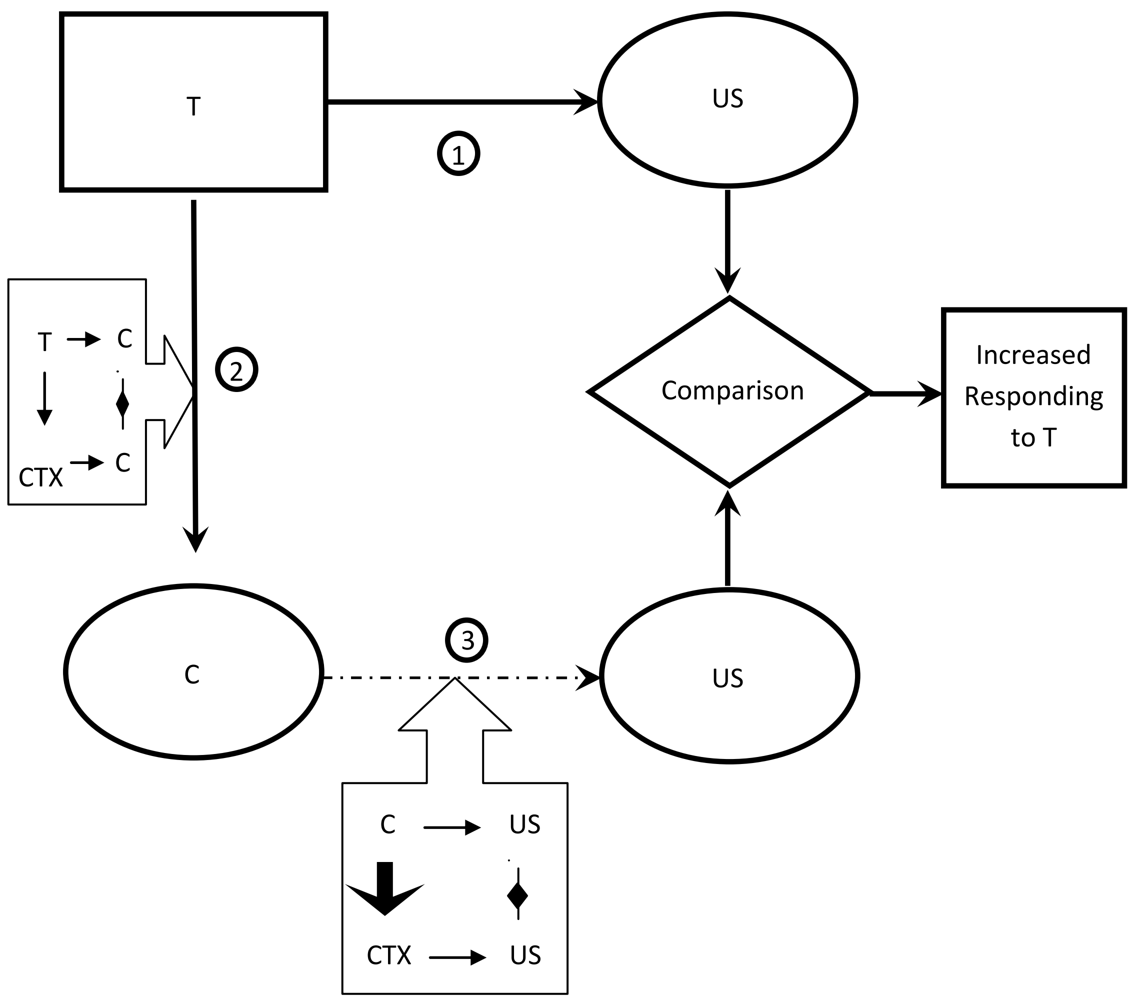

Figure 6

Results of Experiment 1: Overexpectation

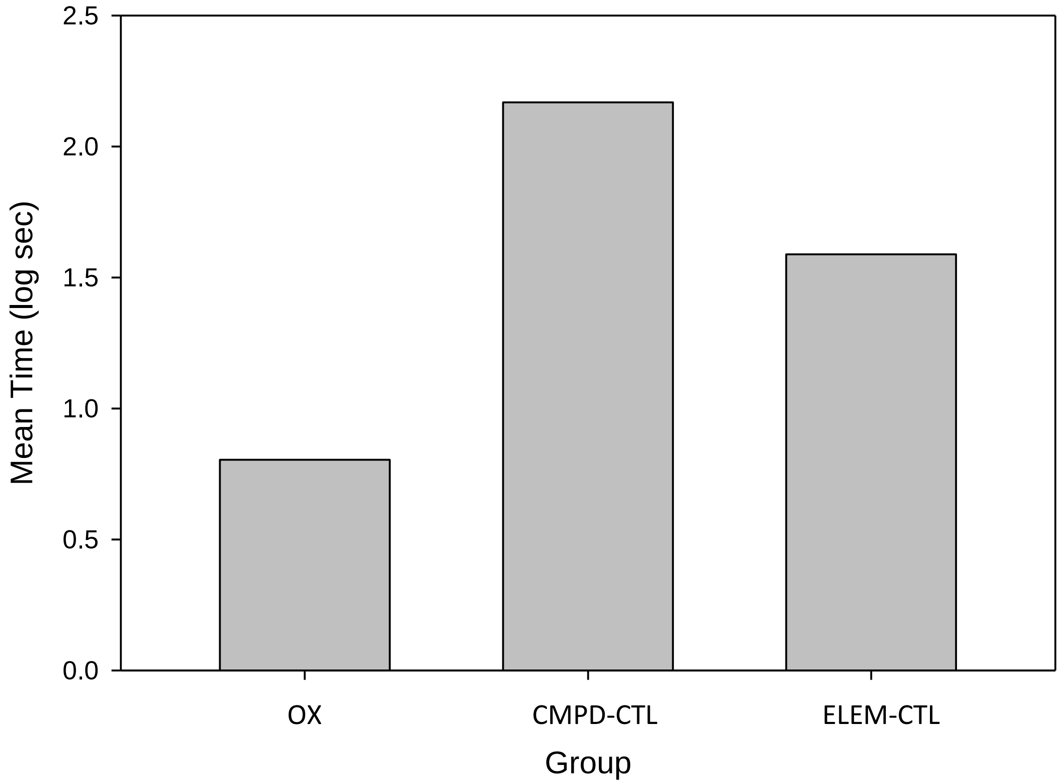

Figure 7

Explanation of context dependency of latent inhibition using the comparator hypothesis

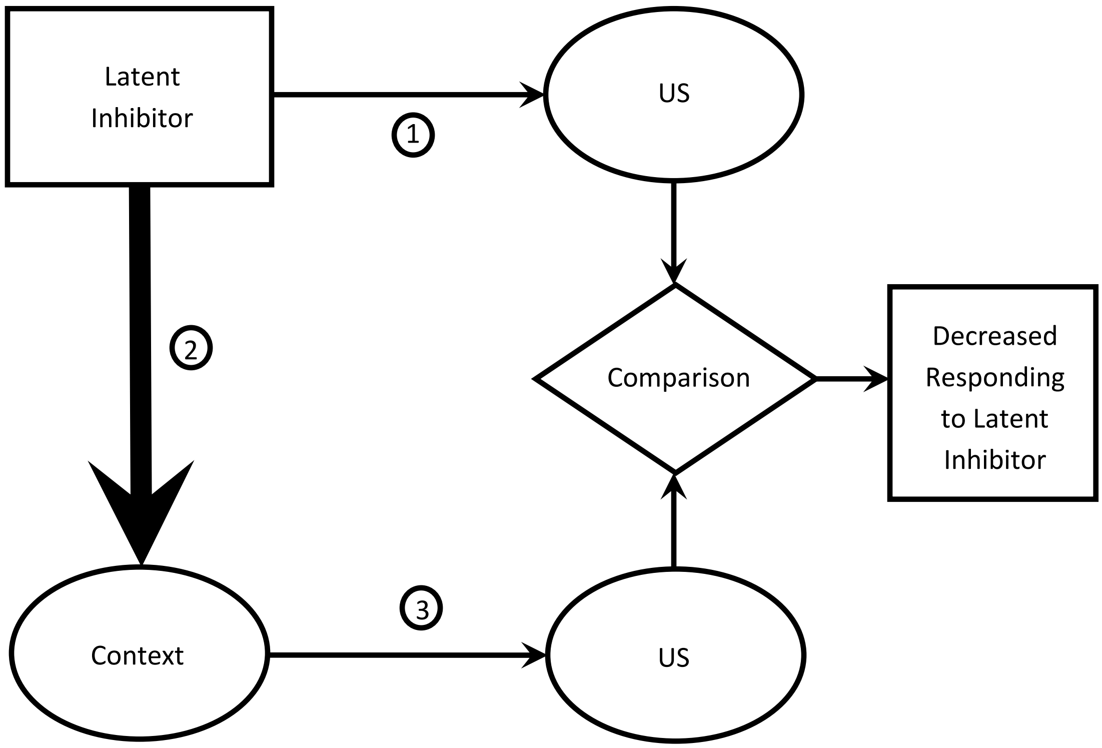

Figure 8

Context dependency of latent inhibition attenuates overexpectation

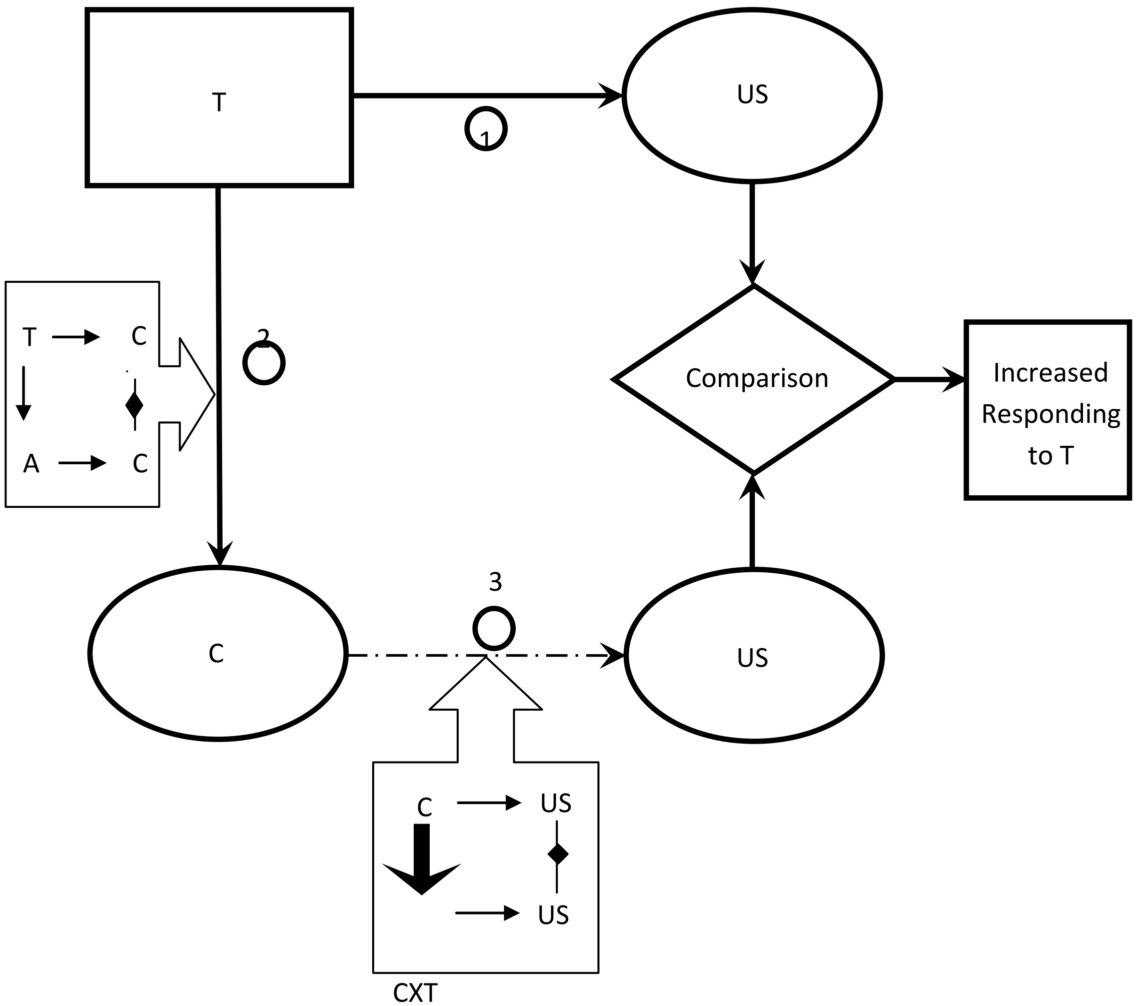

Figure 9

Experiment 2: Results of preexposure on overexpectation

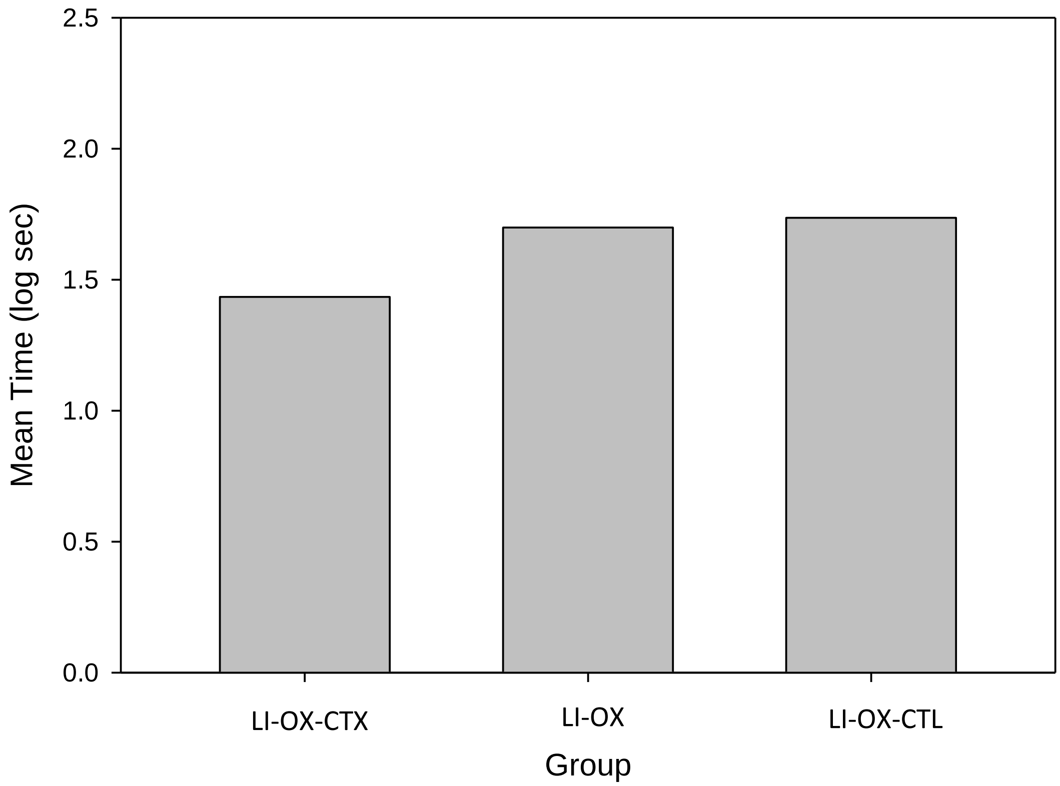

Figure 10

Experiment 2: Responding to stimuli

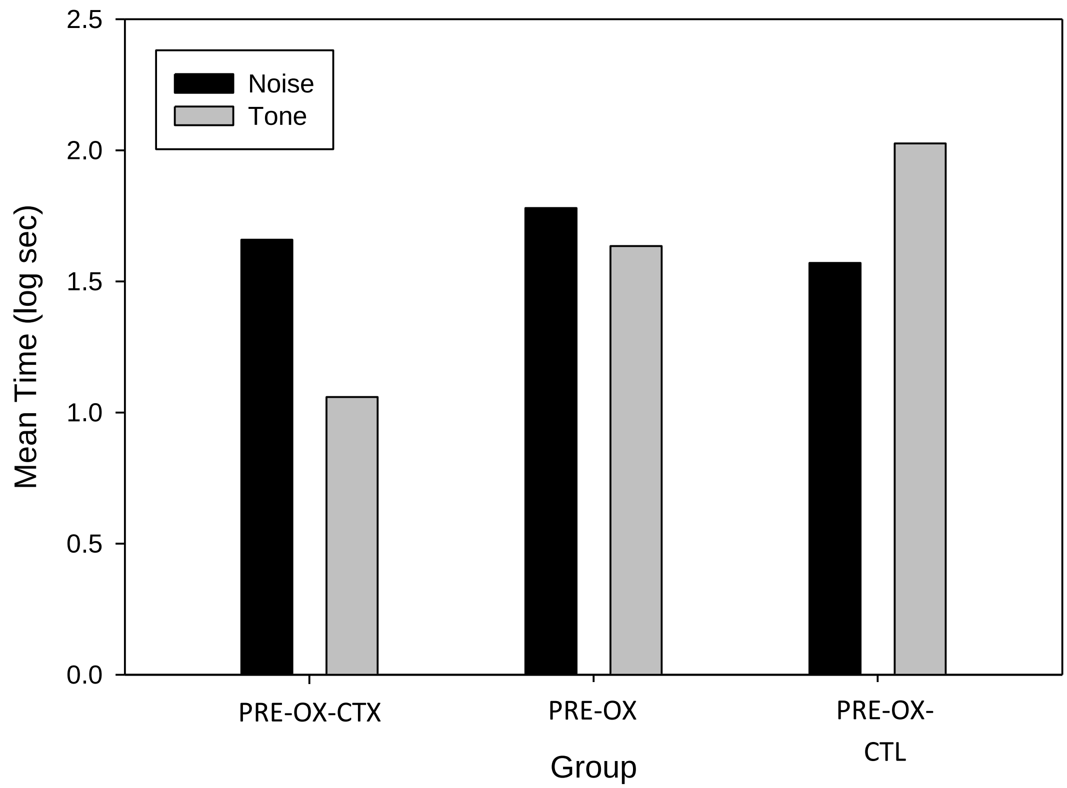

Figure 11

Experiment 3: Results of compound preexposure on overexpectation

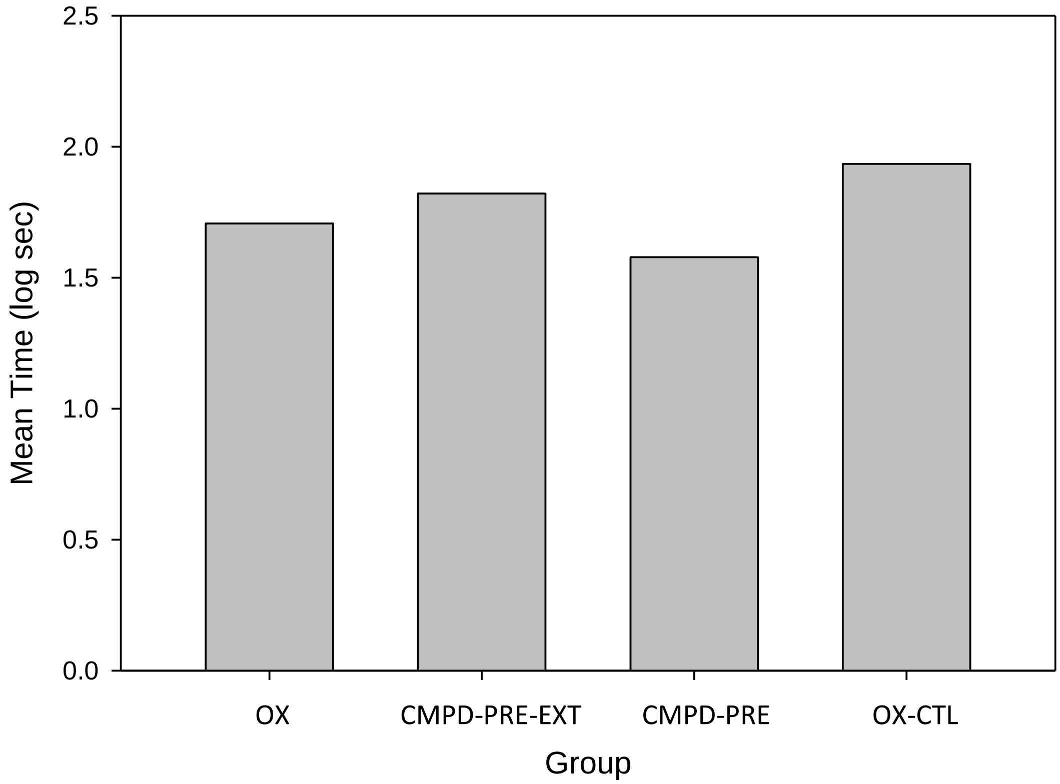

Figure 12

Second order comparator for Experiment 3: Compound Preexposure