Published in final edited form as:

Behav Brain Res. 2011 January 1; 216(1): 59–65. doi:10.1016/j.bbr.2010.07.005.

Deficient proactive interference of eyeblink conditioning in Wistar Kyoto rats

Thomas M. Ricart^{1,2}, Matthew A. De Niear², Xilu Jiao², Kevin C. H. Pang^{1,2,3}, Kevin D. Beck^{1,2,3}, and Richard J. Servatius^{1,2,3}

¹ UMDNJ-GSBS, Newark, NJ

² Stress and Motivated Behavior Inst., Newark, NJ

³ Neurobehavioral Res. Lab. (129), DVA Med. Center, NJHCS, East Orange, NJ

Abstract

Wistar Kyoto (WKY) rats exhibit behavioral inhibition and model anxiety vulnerability. Although WKY rats exhibit faster active avoidance acquisition, simple associative learning or the influence of proactive interference (PI) has not been adequately assessed in this strain. Therefore, we assessed eyeblink conditioning and PI in WKY and outbred Sprague Dawley (SD) rats. Rats were pre-exposed to either the experimental context, the conditioned stimulus (CS), the unconditional stimulus (US), or the CS & US in an explicitly unpaired (EUP) manner, to examine latent inhibition (LI), US pre-exposure effect, or learned irrelevance (LIRR), respectively. Immediately following pre-exposures, rats were trained in a delay-type paradigm (500 ms CS coterminating with a 10-ms US) for one session. During training SD rats exhibited LI and inhibition from US pre-exposures without evidence of LIRR. PI was less evident in WKY rats; LI was absent in WKY rats. Even in the context of reduced PI to CS-alone and US-alone pre-exposures, LIRR was not apparent in WKY rats. The more normal acquisition rates exhibited by WKY rats, under conditions which degrade performance in SD rats, increases the overall likelihood for WKY rats to acquire defensive responses. Enhanced acquisition of defensive responses is a means by which anxiety vulnerability (e.g., behavioral inhibition) is translated to anxiety psychopathology.

Keywords

anxiety; anxiety vulnerability; latent inhibition; learned irrelevance; US pre-exposure effect; temperament; classical conditioning

Introduction

Converging evidence suggests that inbred Wistar-Kyoto rats (WKY) are models of inherent anxiousness and vulnerability to stress. When challenged with environmental stimuli, WKY rats respond to a greater degree than outbred comparison strains. WKY rats exhibit greater hypothalamic-pituitary adrenal axis reactivity [2;37;39;40] and increased susceptibility to ulceration following forced swim stress [32;39]. WKY rats also exhibit reduced open field activity [33;35;49], reduced active coping in the forced swim test [35;37;40], and increased basal acoustic startle response magnitudes [29].

Although a consistent pattern of increased reactivity has been observed, questions remain concerning associative learning capabilities in WKY rats. Fear-potentiated startle is absent in this strain [31], suggesting reduced ability to form stimulus-stimulus associations. On the other hand, WKY rats exhibit enhanced acquisition of passive [34] and active lever-press [49] avoidance; enhanced avoidance acquisition could result from enhanced acquisition of stimulus-stimulus associations. One standard means of assessing stimulus-stimulus associability is through the use of the classically conditioned eyeblink response. Studying this response allows for evaluation of general reactivity to the conditional stimulus (CS) and the unconditional stimulus (US) in addition to associative learning itself in the freely moving rat [50].

Enhanced stress reactivity has several implications for eyeblink conditioning. For one, enhanced stress reactivity may manifest as increased reactivity to the appreciation of the US, expressed as the magnitude of the unconditional response (UR) [16]. Differences in US sensitivity account for the generally faster acquisition of eyeblink conditioning by unstressed female rats compared to those exposed to inescapable stress [5]. For another, emotional state generally enhances acquisition of the eyeblink response. Faster acquisition of the eyeblink response in male rats is observable after exposure to inescapable stressors [48;52], corticotrophin releasing hormone [46] or interleukin 1 β [45], with changes seen in the absence of changes in UR magnitudes. Further, facilitated acquisition of the eyeblink response in previously stressed male rats appears to be dependent upon glucocorticoids [7], an intact basolateral amygdala [59], and bed nucleus of the stria terminalis [4]; these pathways appear to be hyperactive in WKY rats [39;40;53].

Aside from a potential direct effect on acquisition, the impact of increased stress reactivity may be more apparent under conditions of proactive interference (PI), the inhibition of learning through prior experience. The literature on the PI of classical conditioning in stress sensitive or hyper-reactive individuals is confined to latent inhibition (LI), that is, the reduced rate of acquisition after pre-exposure to CS. LI is thought to be induced through decreased attention to the CS [27], or the inhibited transition from an absence of, to the presence of, consequence [60]. LI is absent in humans exposed to situational stress [13] or those with trait anxiety [12; 14]. Given the WKY strain's enhanced reactivity to stressors, one may expect reduced or absent LI in WKY rats.

Enhanced stress reactivity would also be expected to influence PI in response to US pre-exposure. PI consequent to US pre-exposure may be a result of non-associative processes, such as habituation or adaptation to the US, or associative processes, such as the formation of a US-context association, either of which would later impede the formation of a CS-US association [38]. The enhanced stress reactivity of WKY rats would be expected to decrease habituation to the US, which in turn would inhibit PI from US pre-exposure.

A more restrictive form of PI arises specifically from uncorrelated CS and US pre-exposures, termed learned irrelevance (LIRR). The nature of LIRR is a matter of debate; it could result from learning the CS and US are uncorrelated [3], or more simplistically a result of the additive effects of CS pre-exposure and US pre-exposure or increased context specificity of CS pre-exposures [10;11]. Inasmuch as the enhanced stress reactivity of WKY rats could lessen both LI and the US pre-exposure effect, LIRR may be more evident (greater than the sum of the other two learning decrements). Further, if the enhanced associative learning generalizes to learning the lack of a predictive relationship between the stimuli, LIRR would be expected to be more prominent in WKY rats.

Thus, enhanced stress reactivity may directly affect acquisition of the classical conditioned eyeblink response or forms of PI. Therefore, we compared acquisition of the eyeblink response in WKY and SD rats, following pre-exposure to context (CON), CS-alone (CSA) pre-

exposures, US-alone (USA) pre-exposures, and explicitly unpaired CS and US (EUP) pre-exposures. Due to their stress sensitivity, we hypothesize that WKY rats will acquire the eyeblink response faster than SD rats. SD rats will exhibit all three forms of PI: LI, US pre-exposure effect, and LIRR. In contrast, WKY rats will be less affected by the pre-exposures, only exhibiting LIRR.

Materials and Methods

Subjects

Male SD and WKY rats obtained from Harlan Sprague Dawley (Indianapolis, IN). All rats were individually housed in shoebox cages with *ad libitum* access to food and water upon arrival and throughout the experiment. Shoebox cages were kept in chambers that controlled light, temperature, humidity and ambient noise in the local environment. Rats were kept on a 12:12 light:dark cycle with lights on at 0600 hr. All experiments were conducted during the light phase, between 0800 and 1500 hrs. Rats were 3–4 months of age when the experiment was conducted.

Surgery

Electrodes were surgically implanted into the upper eyelid of the rats as previously described [44]. Briefly, rats were anesthetized with a ketamine (80 mg/kg)/xylazine (10 mg/kg) mixture. Rats were then fitted with a headstage with four metal wire electrodes, two each for US administration and electromyography (EMG) recording. These electrodes were then threaded subcutaneously and emerged through the eyelid. Animals were allowed at least 72 hrs to recover before eyelid conditioning.

Apparatus

Eyeblink conditioning was conducted within a 27 cm × 29 cm × 43 cm sound-attenuating test chamber (Med Associates, St. Albans, VT). The EMG electrodes were connected to a differential AC amplifier equipped with a 300-to-500-Hz bandpass filter (A-M Systems Model 1700, Everett, WA) and were amplified by 10,000. A computer with an A/D board (National Instruments, Austin, TX) collected the EMG signal at 1000 Hz and LabVIEW (National Instruments) was used to control stimulus presentations and EMG recording. The US, a 10-ms, 10-V square-wave stimulus to the periorbital musculature, was produced by a Bioelectric Stimulus Isolator (Coulbourn Instruments, Whitehall, PA). The CS was a 500-ms, 82-dB white noise pulse with a rise/fall of 10 ms.

Procedure

After surgery and recovery as described above, rats were acclimated to the experimental apparatus for thirty minutes and their EMG signals evaluated to determine signal quality. The following day rats were randomly assigned, within strain, to one of four pre-exposure conditions: CON ($n = 8$ for SD, $n = 10$ for WKY), CSA (30 CS-alone pre-exposures, $n = 9$ for SD, $n = 9$ for WKY), USA (30 US-alone pre-exposures, $n = 9$ for SD, $n = 9$ for WKY), or EUP (30 CS and 30 US pre-exposures presented in an explicitly unpaired manner, $n = 9$ for SD, $n = 10$ for WKY). For EUP pre-exposures, a pseudo-random order was determined such that a certain type of pre-exposure (either CS or US) could not occur in a string of more than three consecutive presentations. The duration of each pre-exposure session was 15 min. Consistent pre-exposure duration was accomplished by varying the interstimulus interval (ISI). For CSA and USA pre-exposures the ISI was 20–40 s, whereas for EUP pre-exposures the ISI was 10–20 s. Immediately following pre-exposures, eyeblink conditioning commenced using a delay-type paradigm (CS and US coterminating) for one session. Delay conditioning consisted of 100 trials, with 10 sets of 10 trials. Each set of trials consisted of one CS-alone trial, followed

by four paired trials, then one US-alone trial, followed by four more paired trials. The rate of acquisition under these training conditions is moderate, allowing for increases and decreases in rate and asymptotic level of the eyeblink CR [48]. Parameters for pre-exposures were derived from human literature [1], as the rate of acquisition and the effects of other parametric manipulations, such as interstimulus interval [48], have indicated similarities between the effects of these manipulations on acquisition rates in humans and rats.

Data processing and statistics

EMG data were analyzed with S-Plus, version 7 (Insightful Corporation, Seattle, WA). The EMG data were filtered using a locally weighted low-pass filter with a time constraint of 0.01 and a smoothing interval of 3. The 250 ms immediately prior to the onset of a CS were treated as a baseline for comparison for elicited eyeblinks and URs. An eyeblink was recorded when EMG activity after the onset of the CS, but before the start of the US, exceeded a threshold activity level [44]. Threshold activity was established as the sum of the maximum amplitude, the mean, and a standard deviation of the EMG activity during the baseline period. Responses during the first 30 ms of the CS duration were treated as orienting responses (ORs) and reported separately from CRs (eyeblinks elicited during the remainder of the CS period). ORs rarely occur in the preparation given the gradual rise/fall of the acoustic stimulus. On trials in which a CR occurred, latency of the response was also recorded. The UR magnitudes were evaluated from US-alone trials only and method for analysis has been previously described [44]. Briefly, the administration of the US produces a stimulus artifact in the EMG that dissipates by 40 ms after US offset. The period 41–100 ms after US-offset was low-pass filtered to remove ringing from the amplifier, and filtered EMG activity during this period, which corresponds to eyelid opening, was utilized as a surrogate UR for analysis. Mixed analyses of variance (ANOVA) for repeated measures were used to analyze the data. For analysis of UR magnitude and reactivity to the CS during pre-exposures, trials were grouped into 3 blocks, with 10 trials per block. For EUP pre-exposures, the 30 US-alone trials were grouped into 3 blocks of 10, while the 30 CS-alone trials were grouped separately into 3 blocks of 10. Although the pattern of conditioning trials consisted to 10 sets of 10 trials, for analysis of CR acquisition during paired conditioning, all 90 trials that contained a CS (80 paired trials, 10 CS-alone trials) were grouped into 5 blocks, with 18 trials per block. For analysis of UR magnitudes during paired conditioning, the 10 US alone trials were grouped into 5 blocks, with 2 trials per block. F-tests for simple effects were used for post-hoc analyses [25]. Statistical significance was established at an α level of $p < .05$. All data are expressed as mean $\pm$ standard error of the mean.

Results

Pre-exposure Phase

For groups given CS pre-exposures (CSA and EUP groups), the occurrence of eyeblink responses segregated by onset latency was evaluated. Both SD and WKY rats generally exhibited low rates of eyeblinks during the pre-exposure phase. ORs were elicited at extremely low rates, $.7 \pm .4\%$ and $1.2 \pm .5\%$ for SD and WKY rats respectively. The presence of US pre-exposures did not affect the rate of ORs. Given the extremely low rates these data were not analyzed further. For eyeblinks with longer onset latencies than ORs, WKY rats exhibited lower rates than SD rats (see Table 1). The rates of responding did not change during the pre-exposure period, nor were they affected by the presence of US pre-exposures. These impressions were confirmed with a $2 \times 2 \times 3$ (Strain $\times$ Pre-exposure $\times$ Block) mixed-ANOVA that yielded only a main effect of strain, $F(1, 33) = 6.9, p < .05$.

For groups given US pre-exposures (USA and EUP groups), the magnitude of the URs were evaluated. UR magnitudes were not influenced by either strain or the presence of CS pre-exposures. Moreover, UR magnitudes did not decrease across the pre-exposure session (see

Table 1). These impressions were confirmed with a $2 \times 2 \times 3$ (Strain $\times$ Pre-exposure $\times$ Block) mixed-ANOVA in which no effect reached significance. The URs of WKY rats ($1.66 \pm .08$) did not differ from those of SD rats ($1.47 \pm .13$).

Conditioning Phase

The pre-exposure conditions formed a 2×2 (CS presence or absence $\times$ US presence or absence) contingency matrix. The contingency matrix allowed for the direct evaluation of pre-exposures (i.e., one-way analyses) as well as the interaction of CS and US pre-exposures. Therefore, the acquisition data were subjected to a $2 \times 2 \times 2 \times 5$ (Strain $\times$ CS presence $\times$ US presence $\times$ Block) mixed-ANOVA. As in the pre-exposure phase, ORs occurred at very low rates ($1.4 \pm .4\%$ and $.8 \pm .2\%$ of trials, for SD and WKY rats, respectively) and did not differ between the strains or as a function of pre-exposures. Therefore, these responses were not analyzed further. As for acquisition, WKY rats generally exhibited greater rates of CRs during training. The generally high rates of CRs was confirmed by a main effect of Strain, $F(1, 65) = 4.7, p < .05$. The analysis also revealed a main effect of Block, $F(4, 260) = 31.6$, and interactions of CS presence $\times$ Block, $F(4, 260) = 5.5$, and US presence $\times$ Block, $F(4, 260) = 3.2$, all $ps < .05$ (see Figures 1 and 2). All effects, however, were subordinate to a Strain $\times$ CS presence $\times$ US presence $\times$ Block interaction, $F(4, 260) = 3.0, p < .05$. To characterize these interactions, the strains were separately analyzed.

In SD rats, pre-exposures inhibited acquisition. This impression was confirmed by a $2 \times 2 \times 5$ (CS presence $\times$ US presence $\times$ Block) mixed-ANOVA. Analysis yielded a significant main effect of Block, $F(4, 124) = 9.7$, and a US presence $\times$ Block interaction, $F(4, 124) = 4.0$, all $ps < .05$. Thus, the presence of the US during the pre-exposure phase inhibited learning in SD rats (see Figure 2). The lack of a CS presence $\times$ US presence interaction confirmed the lack of LIRR in SD rats. In addition, the presence or absence of LI was specifically of interest. As the CS pre-exposure protocol was designed to inhibit learning in SD rats, we had an *a priori* expectation of slower acquisition. Thus, Dunn's multiple comparison tests were conducted on the first 3 blocks of training between the CON and CSA groups. Inhibited learning was apparent in Blocks 2, $tD=3.9$ and 3, $tD=3.0, p < .05$ (see Figure 2). Thus, LI was confirmed in SD rats.

In WKY rats, PI was less evident. Moreover, the patterns of acquisition among the pre-exposure groups were more complicated. Analysis revealed a significant main effect of Block, $F(4, 136) = 23.7$, and a CS presence $\times$ Block interaction, $F(4, 136) = 3.11$, all $ps < .01$. For WKY rats, US pre-exposures did not affect acquisition. Post-hoc Dunn's tests were performed to analyze the CS presence $\times$ Block interaction, which revealed that the CS pre-exposed WKY rats responded less in the first block of training, but to a greater degree in the 4th block than the WKY rats that did not receive CS pre-exposures, $tD = 2.75$, and $tD = 2.63$, all $ps < .05$, respectively. These effects were primarily driven by differences between the USA and EUP groups (see Figure 2).

Also of interest was the direct comparison of SD and WKY rats that did not receive any discrete stimuli pre-exposure. A direct comparison of the acquisition rates in context-alone groups yielded a significant main effect of Block, $F(8, 128) = 6.0, p < .001$. Thus, SD and WKY rats acquire the eyeblink response at a similar rate and to a similar degree in the absence of pre-exposures (see Figure 1).

As with CR analysis, UR magnitudes during training were analyzed via a $2 \times 2 \times 2 \times 5$ (Strain $\times$ CS presence $\times$ US presence $\times$ Block) mixed-ANOVA. Analysis only yielded main effects of Strain, $F(1, 65) = 8.9, p < .01$, and Block, $F(4, 260) = 5.0, p < .001$. WKY rats (1.5 ± 0.1 AU) demonstrated greater UR magnitudes than SD rats (1.1 ± 0.1 AU). The URs of both strains decreased as training progressed. In that the URs did not differ between SD and WKY rats exposed to the US prior to training (a pure measure of UR magnitude) and the UR magnitudes

during the first training block of WKY rats were similar in magnitude to that strain's pre-training exposures, the generally higher URs of WKY rats likely reflect inhibited reductions during training. The larger UR magnitudes of WKY rats are coincident with generally faster CR acquisition, suggesting a sustained reactivity in WKY rats is in the face of enhanced learning.

To facilitate strain comparisons, two additional figures are provided. In Figure 3, acquisition is presented collapsed over the entire training session. In addition, CR onset latencies are depicted in histogram form (see Figure 4). As expected, CRs are generally timed to the mid point of the CS-US interval. Although the distributions for the SD and WKY rats do not differ, the skewing of the WKY rats is generally rightward, toward the US onset.

Discussion

The primary impetus for this investigation was to expose strain differences in both the acquisition of the classically conditioned eyeblink response and the effects of PI. Yet this study marks one of the few investigations into the effects of both CS and US pre-exposures on eyeblink conditioning in adult outbred rats. Therefore, our observations regarding PI in SD rats bear elaboration.

Robust PI of eyeblink conditioning was observed following CS-alone, US-alone, and EUP pre-exposures immediately preceding paired conditioning. The decrements in learning after EUP pre-exposures were not greater than those observed after CS-alone or US-alone exposures, indicating LIRR was not evident. The present results suggest greater sensitivity to the interference of the CS and US delivered individually than reported in previous studies with rats. The greater sensitivity may be related to the relative US saliency. The previous studies cited utilized forms of shock of various amperage (2.0–3.0 mA) and durations (25 ms to 100 ms) [30;41]. Relatively low US saliency may facilitate PI from CS and US pre-exposures with a concomitant decrease in sensitivity to detect LIRR.

Comparatively, rats appear to be similar to humans in their sensitivity to PI of eyeblink conditioning, with both species differing substantially from rabbits. In rabbits, LI requires at least 100 pre-exposures administered immediately prior to conditioning [54], but is more reliably found with greater numbers of pre-exposures administered over multiple sessions [1; 54]. Similarly, PI from US pre-exposures effect is more apparent when pre-exposures are given over multiple pre-exposure sessions [42;55]. In humans, LI is apparent following either 20 [43] or 30 [1] CS-alone pre-exposures administered immediately prior to paired training with a similar ITI as is used in the current study. US pre-exposure effect is apparent with as few as 20 US-alone pre-exposures [57] administered immediately prior to conditioning. Thus, humans and rats may have a similar disposition to PI from US and CS pre-exposures as indexed by eyeblink conditioning.

Reflecting their inherent stress sensitivity, we hypothesized that WKY rats would acquire the eyeblink CR faster than SD rats. Although a strain difference in acquisition was generally apparent, acquisition in the absence of CS or US pre-exposures was equivalent. Facilitated acquisition of eyeblink conditioning was presumed to be secondary to enhanced stress reactivity, likely to be reflected in US magnitudes. However, UR magnitudes were only subtly different with WKY rats exhibiting less steep reduction in UR magnitudes during training, somewhat akin to conditioning-specific reflex modification[15]. Regardless of US sensitivity, enhanced defensive learning would be expected given the generally enhanced emotionality of WKY rats; they acquire passive and active avoidance faster than outbred strains [36;49]. Previous studies have demonstrated that enhanced emotionality of outbred rats, either through exposure to inescapable stress [48] or via drug-induced stress states [5;45;47] induced prior to

training, enhanced eyeblink acquisition. Extended exposure to the experimental context, required for comparisons with groups that received pre-exposures, may have allowed for emotional reactions of the WKY rats to dissipate prior to the initiation of training.

Acquisition of the classically conditioned eyeblink response in WKY rats also contrasts with genetically manipulated offshoots bred back against the spontaneously hypertensive (SHR) to isolate the hypertensive (WKHT) and hyperactive (WKHA) phenotypes of the SHR. These hybrids show normal acquisition, but the CR latencies of WKHA rats were leftward skewed, that is, earlier in the CS-US interval [58]. WKY rats are certainly not hyperactive, moreover CR latencies of WKY rats are slightly more rightward skewed, that is, later in the CS-US interval compared to the CRs of SD rats.

Nevertheless, WKY rats demonstrated less PI compared to SD rats. The net result for WKY rats was generally faster acquisition than SD rats. LI was absent in WKY rats; the acquisition curves of CON and CSA groups did not differ. WKY rats did exhibit a subtle decrement from CS pre-exposures, the combined CSA and EUP groups were lower in the initial block of training compared to the combined CON and USA groups. However, the inhibition was reversed later in training. The crossing – from lower CRs to greater CRs – was most apparent in the comparison of the USA and EUP groups, suggesting a complicated interaction of CS and US pre-exposures on acquisition of WKY rats. For all WKY rats, URs generally decreased over training, albeit at a slower rate than SD rats. Thus, US sensitivity or reactivity to the US would not provide a clear explanation for resistance to PI in WKY rats.

An alternative interpretation for the lack of PI in WKY rats is enhanced attention to or vigilance towards exteroceptive stimuli. WKY rats demonstrate hypervigilance and an inability to disengage from discrete environmental stimuli relative to SD rats [29]. Further, WKY rats exhibit greater startle responses with a greater disposition toward sensitization or dishabituation. The known strain differences in acetylcholinergic and dopaminergic tone supports this position. WKY rats do have lower levels of peripheral butyrylcholinesterase [51], and more specifically, demonstrate greater acetylcholine levels in the cortex [29] and lower cortical acetylcholinesterase [6]. Moreover, WKY have substantial differences in dopaminergic tone with regional specificity [22–24]. The body of data describing the WKY rats as more reactive to environmental stimuli would seemingly be countermanded by the reduced percentage of eyeblinks apparent during the pre-exposure phase relative to SD rats. These eyeblinks, however, occur with latencies greater than those of orienting responses (reflexive responses to novel stimuli) [56] and thus more likely reflect differences in spontaneous blink rates. Reduced spontaneous blink rates in WKY rats, regardless of US exposure suggests that WKY rats were more vigilant during the pre-exposure phases than SD rats.

The WKY rat's decreased PI further strengthens the assertion that they represent a strain expression of anxiety vulnerability. WKY rats exhibit a number of features which are reminiscent of human behavioral inhibition (BI), a temperament typified by withdrawal from social and novel nonsocial challenges that predisposes individuals for anxiety disorders [8;9; 17;21]. WKY rats display reduced activity in the open field [49], and reduced social interactions [19;28], but acquire avoidance learning faster and are more resistant to extinction than SD rats [49].

As vulnerability factors for anxiety disorders are further elucidated, the translation of risk to actual psychopathology will be traceable through alterations in learning. Individuals with BI treat neutral stimuli as potentially harmful, and have difficulty shifting attention away from fear inducing stimuli [18;20]. The inability to disengage from stimuli has been proposed as a key factor underlying vulnerability for anxiety disorders [26]. Such an inability to disengage

from stimuli would result in greater ability to associate interoceptive and exteroceptive cues with aversive cues, regardless of prior experience.

In summary, this study was conducted to analyze classical conditioning and PI in outbred SD control rats and stress sensitive, inbred WKY rats. In SD rats, LI and US pre-exposure effect were evident, but LIRR was not. Without stimuli pre-exposure, WKY rats exhibited similar acquisition of the eyeblink CR to SD rats. Yet, WKY rats demonstrated decreased PI following CS or US pre-exposures. These findings were discussed as they relate to the WKY rat as a model of anxiety vulnerability.

Acknowledgments

Support for this study was provided by Department of Veterans Affairs Medical Research Funds, the Stress & Motivated Behavior Institute of the New Jersey Medical School and NIH grant NS044373. The authors wish to thank Toni Marie Dispenziere, Tracey Longo, Swamini Sinha, and Eric Zaccone for their technical assistance.

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Figure 1.

Acquisition of eyeblink CRs in SD and WKY rats following CON, CSA, USA, and EUP pre-exposure. Strain designations are in the figure legend. For CON groups, SD and WKY rats acquired at equivalent rates. For CSA, USA and EUP pre-exposures WKY rats acquire to a higher degree than SD rats.

Figure 2.

Acquisition of eyeblink CRs separated by strain. The top row compares the CON and CSA groups while the bottom row compares the USA and EUP groups. In SD rats, latent inhibition was apparent as slower learning in the CSA group compared to the CON group in blocks 2 and 3; WKY rats do not demonstrate latent inhibition. LIRR is not apparent in either strain.

Figure 3.

Overall CR during conditioning in SD (Panel A) and WKY (Panel B) rats. In SD rats, acquisition was inhibited by US pre-exposure. In contrast, acquisition in WKY rats was similar under all pre-exposure conditions. * $p < .05$.

Figure 4.

Latency of the eyeblink CRs in SD and WKY rats during conditioning. Response latencies are summed across all pre-exposure types and grouped into 50 ms bins. The distributions of responses are generally timed to the mid-point of the CS-US interval. Although the strains do not differ, WKY rats demonstrate a slight right ward skew, with latencies towards US onset.

Table 1

Reactivity to CS and US during pre-exposures. Overall, SD rats demonstrated greater blink rates in response to the CS. UR magnitudes did not differ between the strains or pre-exposure groups.

	SD	WKY
Eyeblink Response to CS (%)		
CSA	40.7±5.2	20.4±5.6
EUP	34.4±7.8	24.7±3.7
UR Magnitude (AU)		
USA	1.64±0.23	1.71±0.13
EUP	1.30±0.13	1.64±0.11