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The development of an attentional bias for angry faces following Pavlovian fear
conditioning

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Abstract

Although it is well documented that fear responses develop following aversive Pavlovian conditioning, it is unclear whether fear learning also manifests in the form of attentional biases for fear-related stimuli. Boschen, Parker and Neumann (2007) showed that despite the acquisition of differential skin conductance conditioned responses to angry faces paired (CS+) and unpaired (CS-) with an aversive shock, development of implicit associations were not subsequently observed on the Implicit Association Test. In the present study, participants ($N = 76$) were assigned either to a Shock or NoShock group and completed a similar aversive Pavlovian conditioning procedure with angry face CS+ and CS- stimuli. Participants next completed a visual probe task in which the angry face CS+ and CS- stimuli were paired with angry face control stimuli and neutral faces. Results confirmed that differential fear conditioning was observed in the Shock group but not in the NoShock group, and that the Shock group subsequently showed a selective attentional bias for the angry face CS+ compared with the CS- and control stimuli during the visual probe task. The findings confirm the interplay between learning-based mechanisms and cognitive processes, such as attentional biases, in models of fear acquisition and have implications for treatment of the anxiety disorders.

KEYWORDS: Pavlovian conditioning, fear conditioning, attentional bias, cognitive bias, phobic responses.

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1.0 Introduction

1.1 Phobic Responding in the Anxiety Disorders

Anxiety disorders are highly prevalent and represent the most common cluster of mental health disorders in the general population (Kessler, Chiu, Demler, & Walters, 2005). Fear responses are thought to be acquired through three (Rachman, 1977, 1978) or four (Lovibond, 2003) learning mechanisms, including Pavlovian conditioning which has been considered a central mechanism in the pathogenesis of anxiety disorders for almost 90 years (Davey, 1992; Lissek, et al., 2005). A continued interest in the Pavlovian conditioning model of anxiety disorders has lead researchers to produce more complex conditioning models (e.g., Bouton, Mineka, Barlow, 2001; Maren, 2001; Mineka & Öhman, 2002; Mineka & Zinbarg, 2006) and more recently, to consider the role that cognitive processes play in such learning (Boschen, Parker, & Neumann, 2007; Hofmann, 2008).

Many human fear learning studies employ a differential Pavlovian conditioning procedure in which the offset of one conditioned stimulus (CS), the CS+, coincides with an aversive stimulus such as an electric shock (UCS), and a second CS, the CS-, is presented alone without an accompanying shock (Öhman, Fredrikson, Hugdahl, & Rimmö, 1976; Öhman & Mineka, 2001). Conditioning is apparent by differential responding to the CS+ and CS-, and is usually found within four trials (Lipp, 2006). Despite extensive use of the differential conditioning paradigm, there is less evidence linking the acquisition of differential conditioned responses with the development of cognitive phenomena such as attentional biases.

Several researchers have suggested that a limitation of Pavlovian conditioning models of fear acquisition has been the failure to account for cognitive processes such as biases in the deployment and dwell of attention (Merckelbach, de Jong, Muris & van den Hout, 1996; Öhman & Soares, 1993). Conditioning has been previously demonstrated to exert effects on numerous different outcome variables, beyond overt behavioural responding. Autonomic responses such as skin conductance have been repeatedly shown to change in response to conditioning procedures. Furthermore, cognitive variables such as subjective stimulus valence (e.g., Hermans, Vansteenwegen, Crombez, Baeyens, & Eelen, 2002) and implicit associations as measured by the affective priming task (e.g., Hermans, Dirikx, Vansteenwegen, Baeyens, Van den Bergh & Eelen, 2005) have also recently been demonstrated to be affected by classical conditioning procedures. Less well studied, however is whether aversive learning through Pavlovian conditioning produces attentional biases typically seen in anxiety and phobic responses (Öhman & Soares, 1993).

1.2 The Attentional Bias Phenomena

According to cognitive models of anxiety, individuals with elevated anxiety levels show a preferential allocation of attention to fear-relevant stimuli (Mogg & Bradley, 1998; Öhman & Mineka, 2001; Williams, Watts, MacLeod, & Mathews, 1997). It has been suggested that biased attention may maintain hypervigilance for threat, which in turn elevates an individual's fear level, thereby serving to maintain the anxious state (Davey, 2006; Merckelbach, van Hout, de Jong, & van den Hout, 1990).

While it is acknowledged that various paradigms can detect attentional biases (e.g., dichotic listening and spatial orienting tasks; Kelly & Forsyth, 2007), the emotional Stroop task and the dot probe task (DPT) have been two of the more commonly applied techniques for studying attentional biases to threat (McNally, 1998).

To overcome methodological problems with earlier tasks such as Stroop-type procedures, MacLeod, Mathews and Tata (1986) designed the dot probe attention task. This task isolates attentional processes through the assessment of spatial attention as measured by reaction times to visual probes (Logan & Goetsch, 1993; Mogg & Bradley, 1999). Using this task, MacLeod et al (1986) found that anxious individuals responded faster when probes appear in the location of threat stimuli, compared with when probes appeared in the location of neutral stimuli. Similar results have been documented in numerous subsequent studies, and the consistency of these findings has been demonstrated in a recent meta-analysis of the attentional bias phenomenon (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenberg, & van Ijzendoorn, 2007).

Increasingly, visual stimuli such as human faces have been used instead of the word stimuli employed in earlier versions of the DPT (e.g., Bradley et al., 1997). Emotional faces are considered to be more ecologically valid than words, and address other limitations of earlier versions of the DPT highlighted by previous authors such as the relatively limited threat value of words, and their inability to assess attentional bias across the entire timecourse of the orienting process (Bradley, Mogg, Falla & Hamilton, 1998; McNally, Kaspi, Reimann, & Zeitlin, 1990; Mogg, Millar, & Bradley, 2000; Bar-Haim et al., 2007; Bradley et al., 1997; Mogg & Bradley, 1999).

Most studies that have studied attentional biases have pre-selected individuals from clinically anxious populations or individuals with low and high trait anxiety. Very few studies have experimentally induced phobic-like responding in unselected non-anxious participants and measured an attentional bias to threat stimuli (Dawson, Schell, Beers, & Kelly, 1982; Merckelbach et al., 1990). Furthermore, human experiments that have utilised Pavlovian conditioning procedures have often only considered participants' physiological responses (and not the role of cognitive biases)

to various fear-relevant stimuli that have been paired with a mild electric shock (Öhman & Mineka, 2001). Thus, the aim of the current study was to investigate whether unselected non-clinical participants would show an attentional bias towards a stimulus they had been conditioned to fear.

1.3 Conditioning-Induced Attentional Biases

Hermans et al. (2005) reported on a study in which attention bias was assessed using a reaction time task based on that used by Dawson et al. (1982). In this study, the researchers paired a stimulus of one human face (the CS+) with an electric shock, while presenting another human facial stimulus (the CS-) consistently without a shock. This resulted in significantly slower reaction times to a tone probe when it was later presented during a period when the CS+ was visible, as opposed to the CS-, suggesting an attention bias for the CS+. Similar results have also been reported previously by Dawson et al. (1982) and Lipp, Siddle, & Dall (1993) using similar methods, by Hermans et al. (2002) using an affective priming task, and by Van Damme, Crombez, Hermans, Koster, & Eccleston (2006) using a spatial cueing paradigm.

One previous study has attempted to assess the acquisition of attention biases using the Dot Probe Task (DPT). Beaver, Mogg, & Bradley (2005) used a differential conditioning procedure, conditioning an association between photographs of snakes and spiders with a loud burst of white noise. In this study the authors did find a preferential allocation of attention to pictures paired with the aversive noise. They also reported, however, that the attention bias was dependent on the level of aversiveness of the noise. The authors also suggested that stimuli that are generally perceived as more aversive, such as electrical shock, may demonstrate more powerful attention bias effects.

Boschen et al. (2007) recently investigated whether an attentional bias for angry faces can arise from aversive Pavlovian conditioning. Specifically, Boschen et al.

(2007) contrasted skin conductance conditioned responses with a measure of cognitive change: changes in implicit associations. The concept of implicit associations arose out of social psychology research, and has since been applied in several studies of psychopathology. An implicit association is an unconscious association of two or more concepts in memory. Results showed that while it was possible to elicit conditioned skin conductance responses (SCR) when an angry face stimulus was paired with a mild electric shock, a subsequent Implicit Association Test (IAT) did not detect changes in implicit concept associations. However, it was unclear whether this was due to failure of the conditioning task to lead to changes in information processing, or whether the IAT was not sufficiently sensitive to these changes.

1.4 Aims, Overview and Hypotheses

The current study was designed to further develop and extend the research findings of Boschen et al. (2007) by replacing the IAT with a more sensitive measure of cognitive change, the DPT. For both the fear conditioning paradigm and the DPT, pictorial stimuli of angry and neutral human facial expressions were used. Similarly to Boschen et al. (2007), this study used a differential conditioning procedure whereby participants were exposed to images of neutral and angry faces. For half the participants (Shock group), one of the angry faces was paired with a shock (CS+) and the other angry face was not (CS-) (Öhman & Mineka, 2001). The remaining participants (NoShock group) received presentations of the angry face CS+ and CS- stimuli without any shock stimulus. Directly following the conditioning procedure, participants in both groups completed the DPT to test for the presence of an attentional bias for the angry face CS+ that had been paired with the shock. The present experiment thus employed both within and between-subjects controls to assess conditioning and attentional bias effects.

This investigation posited a series of *a priori* hypotheses. Firstly, it was hypothesised that during the acquisition phase, Pavlovian fear conditioning would occur, as demonstrated by differential skin conductance responses between the angry face CS+ and angry face CS-, in the Shock group only. In contrast, there would be no differences in skin conductance activity between the CS+ and CS- for the NoShock group. Secondly, it was expected that participants in the Shock group only, would preferentially allocate attention towards the angry face CS+ as evidenced by faster reaction-time to the CS+ angry face than the CS- angry face or the control angry faces. By contrast, no such selectivity effects would be observed in the NoShock group.

2.0 Method

2.1 Participants

Ninety-four students undertaking a first year psychology course volunteered in exchange for partial course credit. Fifteen participants were excluded due to equipment malfunction and a further three due to unusually slow reaction times. Thus, the final sample consisted of 76 participants (47 women, 29 men) with an age range from 17 to 71 years ($M = 22.08$, $95\% CI = 20.20$ to 23.95). Participants were alternately allocated to one of two groups: the Shock group (i.e., those that would be exposed to an electrotactile stimulus) or NoShock group (where no electrotactile stimulus would be delivered), with the constraint that a similar gender ratio was maintained across both groups. All participants reported normal or corrected-to-normal vision.

2.2 Apparatus, Materials and Experimental Stimuli

Two self-report questionnaires were utilized to quantify the level of stress, depression, and most importantly, anxiety symptoms in the sample, and ensure that these were similar to those reported by non-clinical populations.

2.2.1 Trait anxiety. The 20-item Trait Anxiety scale of the State Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, Lushene, Vagg & Jacobs, 1983) was used to measure participant trait anxiety.

2.2.2 Depression, anxiety and stress. Participants completed the 42-items of the Depression Anxiety and Stress Scales (DASS; Lovibond & Lovibond, 1995) to assess the extent to which they had experienced symptoms across the three dimensions over the past week.

2.2.3 Facial Stimuli. The NimStim Faces Set (Tottenham et al., submitted) is a standard set of facial images, with a variety of emotional expressions. In pilot testing, 12 angry facial images were obtained from the overall set, which were as similar as possible in hair length, skin colour and facial expression. All faces depicted adult male Caucasians, and were displayed in full 16-bit colour. The four images selected were randomly assigned to: Angry CS+ (*34m_an_o.BMP*), Angry face CS- (*25m_an_o.BMP*), Angry Control 1 (*37m_an_o.BMP*) or Angry Control 2 (*31m_an_o.BMP*). The other two images were of neutral expression: Neutral Control 1 (*27m_ne_o.BMP*) and Neutral Control 2 (*23m_ne_o.BMP*). All facial stimuli were presented during the conditioning procedure and the dot probe task. The experiment thus employed two angry faces as CS+ and CS- and two additional angry face control stimuli to be used during the dot probe task. The neutral face stimuli acted as filler trials during the dot probe task.

2.2.4 Initial responses to facial stimuli. Prior to commencing the task, participants rated their emotional reactions to the six facial stimuli using a 7-point scale (1 = It elicits positive feelings; 4 = Neutral; 7 = It elicits negative feelings).

2.2.5 DPT. A pictorial version of the DPT was developed using the DMDX experimental software package (Forster & Forster, 2003), and run on an IBM-

compatible PC, with a 17-inch screen, using a screen refresh rate of 60 ms. All six facial images were used to produce pairs of facial stimuli that served as fillers and critical trials. The task consisted of 144 trials and consisted of six experimental conditions with 24 trials per condition (see Table 1). The stimulus position (i.e., left; right) for each face in the pair and for the visual probe that followed one of the faces in each trial was counterbalanced across trials. The order of the trials was randomised for each participant. An initial series of 24 practice trials was also completed involving trials from all experimental conditions.

Each trial began with a white central fixation cross displayed for 500 ms, followed by a face pair for 500 ms. Each 45×70 mm colour image was displayed on a black background, with a distance of 70 mm between the inner edges of the two pictures and a distance of 115 mm between the two probe positions. The face pair was immediately followed by a white dot probe (5 mm diameter) presented in the location of one of the faces and to which participants were required to respond within 2000 ms by pressing the left or right <SHIFT> key on the keyboard. Reaction times (and errors in correctly locating the probe) were measured. The inter-trial duration varied randomly between 750 ms and 1250 ms.

2.3.1 Psychophysiological Equipment. Trial-by-trial measures of SCRs and respiration were recorded via a physiological data acquisition system interfaced with a personal computer. Skin conductance responses were measured via a GSR amplifier with standard electrodes attached to the phalanx distalis manus of the first and second digits of the non-preferred hand. Respiration was also monitored using a piezo respiratory belt transducer, attached below the sternum to monitor for any respiratory influences (e.g., coughs, sneezes, sighs, deep breaths) on skin conductance. Both SCRs

and respiration were measured during Phases 2 to 5 of the experiment using a sampling rate of 1000 Hz and were stored off-line for later quantification and analysis.

2.3.2 Electrotactile Stimulus. The UCS was a 200 ms shock delivered by a stimulus isolator via two disposable Ag/AgCl electrodes, attached to the wrist of the participant's preferred forearm. The stimulus isolator functions as a constant current device that will output the voltage necessary to maintain the set current flow, up to a maximum of 100 V. The maximum current that can be set is 10 mA.

2.4 Procedure

2.4.1 Phase 1 – Demographics and Questionnaires. Following completion of the consent form and the pen-and-paper questionnaires, participants washed their hands and were guided into a 3 m × 3 m sound attenuated experimental room, while the experiment was monitored via a closed circuit video camera in an adjoining room. The mean temperature, humidity and pressure in the participants room was 19.87°C ($SD = 1.04^\circ\text{C}$), 58.46% ($SD = 9.52\%$) and 1045.23 hPa ($SD = 2.91$ hPa), respectively.

2.4.2 Phase 2 – Checking of responses. In the sound attenuated room, participants had the respiration transducer applied, before being seated at a desk in front of computer monitor and keyboard. Once seated, SCR electrodes and electrotactile stimulus electrodes were applied, and baseline skin conductance level recorded.

2.4.3 Phase 3 – Shock Work-up and Rest Period. Starting at an intensity of zero (no shock), 200 ms shocks of gradually increasing intensity were delivered (in increments of 10 V) until the participant reported that the shock was “unpleasant but not painful” (maximum voltage 100 V). This final level was used for the remainder of the experiment. Prior to the experiment proper, participants were given a two minute rest period, where they were required to sit quietly without moving.

2.4.4 Phase 4 – Habituation. Prior to conditioning, participants were allowed to habituate to the experimental environment while SCRs were being recorded.

Participants sat approximately 600 mm from the screen, with their hands relaxed on either their lap or the desk. Participants were informed that they would be shown photographs of different faces and that while they watched the images, their physiological reactions would be recorded, and therefore it was important they did not move unnecessarily. During this phase the six facial stimuli were displayed individually in random order for 8 s, with a 13 s inter-trial interval (and a total of 6 exposures per image). No shocks were delivered during this phase.

2.4.5 Phase 5 – Acquisition. All participants were informed that for approximately 15 minutes, they would be required to sit as still as possible while they were shown photos of different faces, and that shocks may be delivered during this stage. A series of 36 trials were conducted, in which the 6 facial images were randomly displayed for a total of 6 exposures each. The facial images were displayed for 8 s. At the offset of the facial image (for the CS+ only), participants in the Shock group (only) were delivered the 200 ms shock. The inter-trial interval was 13 s.

2.4.6 Phase 6 - Attention Bias Assessment. Following the acquisition phase, SCR electrodes (but not electrotactile stimulus electrodes) were removed as both hands were required to complete the DPT. Participants were given no instructions regarding the potential for shocks in this phase. Instructions for completing the DPT were read to participants and they completed the practice trials followed by the 144 trials in the experiment proper.

2.5 Data scoring, design and analysis

2.5.1 Participant Characteristics and Equivalence of Groups. Independent group *t*-tests were conducted between the two experimental groups on a number of

variables as measured by the various questionnaires to ensure group equivalence from the outset. Additionally, several mixed factorials ANOVAs were conducted to assess equivalence of facial stimuli between groups.

2.5.2 Skin Conductance Responses. Previous research has demonstrated that SCRs typically show three distinct phases when the duration of the CS is 8 to 10 s (Öhman, Hamm & Hugdahl, 2000; Prokasy & Kumpfer, 1973). The first interval response (FIR) occurs within the first four seconds of CS onset. This interval reflects initial orienting and the significance of the CS, and is resistant to habituation in stimuli that have acquired threat value (Öhman, 1983). The second interval response (SIR) reflects anticipation of the UCS (Öhman, 1983) and occurs approximately 4 to 9 s following CS onset. The third interval response (TIR) occurs following CS offset/UCS onset (Neumann & Waters, 2006) and reflects responding to the UCS for the CS+ and omission of the UCS for the CS- (Öhman, 1983). With regard to the FIR and SIR, research has noted that the FIR is typically larger than the SIR, as it is highly sensitive to conditioning manipulations, and as a result, is usually the only one reported alongside the TIR (Lipp, 2006).

To ensure SCRs were not affected by respiratory artefacts the respiration trace was examined trial by trial as the magnitude of each SCR was computed. The magnitude of SCRs (for both the habituation and acquisition phases) were measured as the distance between trough and apex of the curve (in microsiemens, μS) for each trial, and was scored within the FIR (1 to 4 s following CS onset) and TIR (9 to 13 s following CS onset) windows. Responses were scored only if they began in the window, and if two responses occurred in one time window, the first response was recorded. As significant positive skew was present, skin conductance responses were subjected to a square root transformation to normalise the distributions before statistical

analyses in line with recommendations for this measure (Venables & Christie, 1980).

A series of mixed factorial ANOVAs with planned contrasts (as per hypotheses) were conducted on the first and third interval response skin conductance data for the habituation and acquisition phases.

2.5.3 Reaction Times. Mean reaction times from the DPT were calculated for each combination of the critical trials referred to in Table 1. Reaction times were averaged across all valid responses (from six trials) to produce a mean score. Invalid responses were defined as trials in which participants did not respond, made the wrong response (e.g., errors in locating the probe), or had reaction times less than 250ms or greater than 2000 ms. Assumptions of the statistics were tested and only where violations are detected, will these be reported.

2.5.4 Analyses. The assessment of statistical significance in all abovementioned analyses for each dependent variable was based on a critical α level of .05. Effect sizes were computed for relevant ANOVA effects and are reported as partial eta squared (η_p^2). Planned contrasts of means were made with *t*-tests, and were adjusted where appropriate for the accumulation of Type 1 error by using a Bonferroni corrected alpha, and their effect sizes are reported as Cohen's *d*. Statistical assumptions for each inferential test were examined, and corrected results are reported where these were violated.

3.0 Results

3.1 Initial Data Preparation

The main focus of the experiment was the results from the critical trials of the reaction time data from the DPT. A total of six cases were identified as having excessively long reaction times (that is, greater than 2.5 standard deviations above each group's overall mean reaction time). However, closer inspection of these outliers

revealed that only three cases were clearly deviant from the rest of the data. As a result, these were excluded before data analysis was conducted. Response times shorter than 250 ms were also excluded.

3.2 Participant Characteristics and Equivalence of Groups and Stimuli

The final sample comprised of 39 participants in the Shock group (16 men, 23 women) and 37 in the NoShock group (13 men, 24 women). Results of the independent group *t*-tests indicated that both groups did not differ significantly ($p > .05$) on any of the measures (refer to Table 2 for participant characteristics). Additionally, all responses from the STAI-T and DASS were within normal limits for a non-clinical population.

Equivalence of facial stimuli was assessed via three separate 2 Group (Shock; NoShock) $\times$ 2 Stimulus mixed factorial ANOVAs. The Stimulus factor for each ANOVA was composed of the angry face stimulus pairs used in the subsequent dot probe task and were (a) the Angry CS+ versus Angry CS-, (b) the Angry CS+ versus Angry Control 1, and (c) the Angry CS- versus Angry Control 2. The DV was mean scores from responses to the “Initial Responses to Facial Stimuli” question, yielding scores on a 1-7 point scale. Results showed that prior to conditioning, participants overall felt more negative towards the Angry Control 2 ($M = 5.87$, $SE = .14$) than the CS- ($M = 5.53$, $SE = .12$) as indicated by a significant main effect of Stimulus ($F_{(1,74)} = 5.87$, $p = .018$, $\eta_p^2 = .07$). The interaction and main effect for Group were non-significant ($F_{(1,74)} = 1.14$, $p = .289$, $\eta_p^2 = .02$ and $F_{(1,74)} = .012$, $p = .75$, $\eta_p^2 = .001$, respectively). Furthermore, the CS+ and CS-, and the CS+ and Angry Control 1, did not differ between the groups as indicated by no significant interactions and main effects ($F_s < 3.39$, $p > .05$ and $F_s < 2.48$, $p > .05$, respectively).

The effects of Shock or NoShock on SCR were analysed with separate 2 Group (Shock, NoShock), $\times$ 2 Stimulus $\times$ 6 Trial (1, 2, 3, 4, 5, 6) mixed factorial ANOVAs for first and third interval responses. Similar to the previous analyses, separate ANOVAs were conducted for the three levels of the Stimulus factor: CS+ versus CS-; CS+ versus Angry Control 1, and CS- vs. Angry Control 2. Results of the separate ANOVAs revealed there was no differential skin conductance activity prior to fear conditioning between each pair, for either group, as no significant main effects or interactions were found for first and third interval response data (F 's < 2.98 , $p > .05$).

3.3 Hypothesis 1: SCRs During Conditioning

The effects of the shock stimulus (Shock vs NoShock) on SCR were analysed with separate 2 Group $\times$ 2 Stimulus $\times$ 6 Trial mixed factorial ANOVAs for first and third interval responses. The same three levels of the Stimulus factor were compared in each analysis, as in the Habituation phase.

3.3.1 CS+ vs. CS-. The ANOVA revealed a significant Group $\times$ Stimulus $\times$ Trial interaction ($F_{(5,370)} = 2.41$, $\epsilon = .86$, $p = .045$, $\eta_p^2 = .03$). Therefore, the ANOVA was split by group, into two separate 2 $\times$ 6 repeated measures ANOVAs, to determine the effects of Stimulus and Trial in each group. Firstly, for the Shock group, there was a significant Stimulus $\times$ Trial interaction ($F_{(5,190)} = 2.66$, $p = .024$, $\eta_p^2 = .07$), a significant main effect of Stimulus ($F_{(1,38)} = 15.04$, $p < .0001$, $\eta_p^2 = .28$), but no main effect for Trial ($F_{(5,145)} = .61$, $p = .647$, $\eta_p^2 = .02$). The interaction was broken down and revealed that the Shock group had significantly larger SCRs during the CS+ than during the CS-, across Trials 2 to 6 (all t s > 2.35 , $p < .05$; see Figure 1 for mean FIRs). No significant differences for Trial 1 were found, as participants were not aware that the CS+ was excitatory, until its first association with the shock (see Figure 1). Next, for the NoShock group, there were no significant differences (see Figure 1 for mean first

interval responses) in SCRs between the CS+ and CS- ($F_{(1,36)} = 1.14, p = .293, \eta_p^2 = .03$), and no significant Stimulus $\times$ Trial interaction ($F_{(3,124)} = 0.54, p = .683, \eta_p^2 = .02$). There was a significant main effect of Trial ($F_{(3,114)} = 3.66, \epsilon = .63, p = .013, \eta_p^2 = .09$) due to a response decrement over trials.

The second ANOVA for the third interval response data revealed two significant interactions, a Stimulus $\times$ Group interaction ($F_{(1,74)} = 145.51, p < .0001, \eta_p^2 = .66$) and a Trial $\times$ Group interaction ($F_{(5,370)} = 4.38, \epsilon = .79, p = .002, \eta_p^2 = .06$). In addition, there was a main effect of Stimulus ($F_{(1,74)} = 134.75, p < .0001, \eta_p^2 = .65$), Trial ($F_{(5,370)} = 9.68, \epsilon = .79, p < .0001, \eta_p^2 = .12$), and Group ($F_{(1,74)} = 130.43, p < .0001, \eta_p^2 = .64$). Therefore, in relation to Hypothesis 3, the Stimulus $\times$ Group interaction was broken down, and as expected the planned comparison revealed that, third interval responses were larger for the CS+ than for the CS- for Shock group (see Figure 2) and this was significant ($t_{(38)} = 17.05, p < .0001$, Cohen's $d = 2.76$). In contrast, there was no significant differences in SCRs between the CS+ and CS- for the NoShock group ($t_{(36)} = 0.31, p = .75, d = 0.05$, see Figure 2).

3.4 Hypothesis 2: Attentional Bias

The effects of facial stimuli (CS+ and CS-) on reaction times were analysed with separate $2 \times 2 \times 2$ mixed factorial ANOVAs. The between-groups factor was Group (Shock, NoShock), whereas Stimulus pair (CS+ vs. CS-, CS+ vs. Angry Control 1, or CS- vs. Angry Control 2) and Probe position (Left, Right) were the within-subjects variables.

3.4.1 Pair 1: CS+ versus CS-. The ANOVA revealed a significant Stimulus $\times$ Group interaction ($F_{(1,74)} = 6.33, p = .014, \eta_p^2 = .08$). There was a significant main effect of Stimulus ($F_{(1,74)} = 4.40, p = .04, \eta_p^2 = .06$) and Group ($F_{(1,74)} = 4.61, p = .035, \eta_p^2 = .06$) but not for Probe Position ($F_{(1,74)} = .42, p = .521, \eta_p^2 = .006$). Next, the

interaction was broken down and the planned comparison revealed that the Shock group responded significantly quicker to the CS+ than the CS- ($t_{(38)} = 3.31, p = .001$, Cohen's $d = .53$, see Figure 3). Additionally, there was no significant differences in reaction time between the two stimuli for the NoShock group ($t_{(38)} = 3.31, p = .001$, Cohen's $d = .53$, see Figure 3).

3.4.2 Pair 2: CS- versus Angry Control 2. Consistent with Hypothesis 4, there were no significant differences in reaction times (see Figure 3) between the CS- and Angry Control 2 for either group, as there were no significant main effects or interactions (all $F_s < 3.80, p > .05$).

3.4.3 Pair 3: CS+ versus Angry Control 1. The ANOVA revealed two significant interactions, a Probe $\times$ Group interaction ($F_{(1,74)} = 5.66, p = .02, \eta_p^2 = .07$) and Stimulus $\times$ Group interaction ($F_{(1,74)} = 4.23, p = .043, \eta_p^2 = .05$). There was also a main effect of Stimulus ($F_{(1,74)} = 17.73, p < .0001, \eta_p^2 = .19$). All other interactions and main effects were not significant (All $F_s < 1, p > .05$). The first interaction was broken down by Probe. Participants in the NoShock group showed a preference towards the left hand side of the screen, irrespective of stimulus, as indicated by quicker reaction times ($M = 351.67, SE = 7.01$) compared to right hand side of screen ($M = 363.87, SE = 8.38$), and this was significant ($t_{(36)} = 2.31, p = .02$, Cohen's $d = 0.38$). There was no significant probe bias for participants in the Shock group ($t_{(38)} = 1.03, p = .304, d = 0.17$). Next, the Stimulus $\times$ Group interaction was broken down, and consistent with hypothesis 5, Shock group participants responded significantly faster to the CS+ than the Angry Control 1 ($t_{(38)} = 4.49, p < .0001$, Cohen's $d = 0.72$, see Figure 3). There was no significant difference in reaction times between the two stimuli for NoShock group participants ($t_{(36)} = 1.50, p = .14, d = 0.25$).

4.0 Discussion

The present study was designed to examine attentional biases to angry faces in unselected, non-anxious participants, addressing the question of whether aversive learning through Pavlovian fear conditioning can produce attentional biases for threatening faces (Boschen et al., 2007). It was hypothesised that non-clinical participants would show increased skin conductance activity to a facial stimulus (CS+) that had acquired a threat value (i.e., had been paired with an electric shock). Furthermore, it attempted to assess whether this, in turn, would produce an attentional bias to a probe that replaced a conditioned stimulus (CS+), as measured by reaction times in a pictorial DPT. The following sections provide a summary of the study's findings, its integration and broader implications with previous research, its limitations, as well as suggestions for future research in this field.

4.1 Summary of Findings

Two equivalent groups existed from the outset of the study, which was imperative as one group underwent fear conditioning, whereas the other group served as a control for conditioning. Although participants felt more negative towards the Angry Control 2 than the CS-, the habituation phase (which provided an empirical measure of participants' reactions to the stimuli) revealed no differential skin conductance responding between the Angry Control 2 and CS-. Additionally, there were no reported differences in skin conductance activity between the other two critical pairs of facial stimuli, the CS+ vs CS- and CS+ vs Angry Control 1. This was particularly important for the CS+ and CS- in the acquisition phase, as it would clearly demonstrate that any conditioning effects reflected the pairing of the CS+ with the shock and not some other confounding influence such as the facial image used or trial sequences. Furthermore, consistent with our hypotheses, Shock group participants

produced significantly larger SCRs across trials for both first and third interval responses during presentation of the CS+ than the CS-, a difference not observed in the NoShock group.

The current research also supported the main research question by demonstrating that unselected, non-anxious participants who received fear conditioning showed a preferential allocation of attention towards the CS+ over the CS-. The CS- and Angry Control 2 were contrasted for both groups. Again, consistent with this hypothesis, there were no differences in reaction times for either group towards the CS- and Angry Control 2.

Finally, to demonstrate conditioning of the CS+, reaction times for the CS+ and Angry Control 1 were compared within and between groups. Consistent with the aforementioned attentional bias findings, Shock group participants showed a preferential allocation of attention towards the CS+ over the Angry Control 1, whereas this difference was not observed for NoShock group participants.

4.2 Integration and Broader Implications with Previous Research

Results of the Pavlovian fear conditioning paradigm used in this study replicated previous research (Öhman & Mineka, 2001). For example, first interval skin conductance responses for Shock group participants showed differential responding between the CS+ and CS-, thus reflecting both orienting toward the CS+ and its significance value (Öhman, 1983). According to Maltzman (1987), when the participant realises that the CS+ is a cue for the UCS (which was noted on Trial 2 of this study) the significance value of the stimuli is increased, resulting in the subject's capture of attention to the stimuli.

The finding of concordant changes in attention bias as measured by the DPT and first interval SCRs also supports previous interpretation of the FIR as an index of

the orienting response (e.g., Öhman, 1983). Where a stimulus has acquired threat value through conditioning, as in this study, this orienting response is resistant to the typical habituation observed in non-threatening stimuli. It is, perhaps, not surprising then, that in the current study, the FIR measuring orienting shows results that are consistent with the attention bias measured by the DPT. This finding is consistent with previous research. Our results also add to the growing body of literature demonstrating that Pavlovian conditioning exerts broad effects on affect, behaviour, and cognition.

4.3 Attentional Bias

The fact that Shock group participants came to show selective speeded responses to probes that replaced the CS+, demonstrated that Pavlovian conditioning produces attentional biases. This finding is in contrast to Boschen et al. (2007) who were unable to find changes in cognitive variables, an observation that the authors attributed to the lack of sensitivity of their measure of cognitive change. Therefore, results of the current study suggest that a DPT using facial stimuli is a more valid and sensitive tool to measure newly developed attentional biases. This concurs with the studies by Mogg and Bradley (1999, 2002) that showed attentional biases to angry faces in high trait anxious individuals using a pictorial DPT. It is also consistent with the report of Beaver et al. (2005) who demonstrated the ability of Pavlovian conditioning to generate attentional biases using noise as an aversive stimulus. However, as this study is among the first using a pictorial DPT to determine if attentional biases originate from Pavlovian conditioning, its results require replication.

The current study also responds to previous studies that have criticised the Pavlovian model of phobia acquisition for its failure to account for information processing biases (Merckelbach et al., 1996; Öhman & Soares, 1993). This study

showed that a more comprehensive model of Pavlovian conditioning can be formulated, as findings demonstrate that Pavlovian fear conditioning can produce a measurable change in allocation of attention to threat stimuli (Dawson et al., 1982). In clinical terms, the results of the present study suggest that anxious individuals who have acquired a phobia through Pavlovian conditioning processes will show an attentional bias towards objects or situations they have learned to fear. However, such a hypothesis would need to be tested with clinical populations.

Furthermore, the observation that attentional biases can be acquired in response to experience with threatening stimuli reveals that an attentional bias to threat is not necessarily a trait-like characteristic, that is, only typical of high trait anxious individuals, but rather it may reflect a normal process that critically depends on learning experiences (Koster, Crombez, Van Damme, Bershuere & de Houwer, 2005). Finally, this study questions earlier concepts that Pavlovian conditioning occurs in isolation from changes in cognitive variables, thereby providing a reason to consider including Pavlovian conditioning within a cognitive framework (Dawson et al., 1982).

4.4 Limitations of the current study

Despite the findings from this research, several limitations must be considered when considering the results. A significant limitation in the current study is the inability of the experimental method to account for the potential effects of leaving the shock electrodes in place during the DPT. Additionally, participants were given no instructions that shocks would not be delivered during this phase. In the design of the experiment this method had been chosen to reduce the effect of change in context (removal of the electrodes, or clear instructions that shocks would not be delivered) on the assessment of attention bias. It is unclear however, whether the same attention bias effect would have been observed had shock electrodes been removed after the

conditioning phase, or if participants had been informed that no shock would be delivered after this point.

A second limitation is that contextual conditioning may have occurred as part of the experimental design, particularly during the acquisition phase. During acquisition all images used in the study were exposed to participants, with only one image being paired with a shock. However, this experimental context may have been sufficient for the CS-, Angry Control 1 and Angry Control 2 to take on the conditioning effects of the experimental environment, such that contextual conditioning occurred. An alternative design would not present the Angry Control 1 and Angry Control 2 control stimuli during the conditioning paradigm and reserve these stimuli for the DPT where participants would be exposed to these controls for the first time. This would allow the assessment of whether the CS- acquired significance through its presentation as part of the acquisition procedure. It would, however introduce the confound that these new stimuli may elicit an SCR response due to their novelty.

A third limitation in the current study is the failure to assess a number of key variables which would have assisted in interpreting the results of our research. Assessments of variables such as US expectancy effects, contingency awareness, and CS valence are now commonplace in conditioning research (e.g., Blechert, Michael, Williams, Purkis, & Wilhelm, 2008; Hermans et al., 2002) and allow the researcher to assess the participants' conscious awareness of the conditioning process. Unfortunately, these measures were not included in our research design, limiting our ability to differentiate between explicit and unconscious associations of shock with the facial stimuli.

The fourth limitation relates to the 500 ms stimulus presentation during the DPT. Although 500 ms is the standard timing used in most previous research, it has

been noted that such a duration may be long enough to allow more than one shift of attention between the stimulus pairs (Mogg et al., 2000). In other words, an individual might initially orient towards the CS-, but then shift their attention to the CS+ (Mogg et al., 2000). According to Cooper and Langton (2006), researchers who are investigating attentional biases should use a number of presentation times (e.g., 100 ms, 250 ms) to enable a more accurate reflection of the time course of allocation of attentional resources.

A fifth limitation is that the DPT has been criticised by some previous authors as being unable to differentiate between attention capture, increased attentional dwell time, and difficulty in attentional disengagement (e.g., Fox, Russo, & Dutton, 2002). The DPT used in our study has been interpreted as indicating enhanced attention capture, but this interpretation should be considered in light of the limitations of the paradigm highlighted by previous authors such as Fox et al.

There also exist a number of other minor limitations that require acknowledgement. While we did measure the equivalence of the facial stimuli at the baseline, the same stimuli were used in the same role (e.g., CS+) for each participant. This leaves open the question of whether there were pre-existing attentional biases for the stimuli that were not detected in our initial equivalency test. Due to programming error, we also did not have data comparing each stimulus with each other stimulus in all combinations. A follow-on effect from this is that the CS+ was used in more trials of the DPT than the CS-, which may have allowed stimulus novelty to enter as a confound in our results.

4.5 Future Directions

Findings from this study highlight several suggestions worthy of future investigation. First, it would be interesting to examine whether different components of

phobia, such as increased heart rate, behavioural avoidance, elevated blood pressure, to name a few, are acquired in parallel. Second, it is unclear from this study as to whether attentional biases persist after extinction (i.e., treatment). While this study did not measure the effects of extinction on attentional bias, it would be worthy of consideration, as it would be expected that a behavioural treatment to reduce phobic responding (e.g., exposure treatment, systematic desensitisation) should eliminate attentional biases (Barlow, 2002). Following such extinction, it would also be worthwhile to assess whether attention bias demonstrates the same recovery effects (e.g., renewal, reinstatement, etc.) as conditioned responses. This second avenue of investigation may also shed some light on the causality issue. Finally, consideration of the work on attention training by Mathews and MacLeod (2002; 2005) would be interesting as it shows that attentional biases can be acquired in a number of ways. It would be worthwhile to assess whether attention training exerted effects on state anxiety. More specifically, whether or not experimentally induced attentional biases could produce increased skin conductance responses, particularly first interval responses. The inability of the DPT to differentiate between attentional capture and disengagement also suggests an avenue for future investigation. The development of newer methods such as those involving measurement of eye movements (e.g., Rinck, Reinecke, Ellwart, Heuer, & Becker, 2005) may help disentangle the effects of conditioning on different phases of the attention.

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Table 1

Facial stimuli pair presentations with number of trials used during the dot probe task

Pair Number	Facial Stimuli Position ^a		Number of Trials
	Left	Right	
1 ^b	Neutral 1	Neutral 2	24
2 ^b	Neutral 1	CS+	24
3 ^b	Neutral 2	CS+	24
4 ^c	Angry Control 1	CS+	24
5 ^c	Angry Control 2	CS–	24
6 ^c	CS+	CS–	24

^a Counterbalanced for presentation (left, right) and probe position (left, right) resulting in four combinations per pair. ^b Filler trials. ^c Critical trials.

Table 2

Characteristics of participants (N=76)

Variables	Group						Equivalence of Groups		
	Shock			NoShock					
	95% CI			95% CI					
	M	Lower	Upper	M	Lower	Upper	<i>t</i>	<i>df</i>	<i>p</i> *
Age (years)	22.92	19.82	26.03	21.19	19.03	23.35	.92	74	.361
Education (years full- time)	13.21	12.65	13.76	13.10	12.66	13.53	.32	74	.753
Trait Anxiety (STAI-T) ^a	39.41	35.99	42.83	42.49	39.09	45.89	-1.29	74	.201
DASS ^b Depression Score	4.56	2.86	6.27	5.14	3.63	6.64	-.51	74	.614
DASS ^c Anxiety Score	4.87	3.09	6.66	6.47	4.12	8.86	-1.11	74	.271
DASS ^d Stress Score	10.03	7.56	12.49	9.59	7.40	11.78	.26	74	.792
Level of ETS (V) ^e	45.51	40.30	50.73	45.95	38.47	53.42	-.10	65.07 ^h	.924
Baseline SC level (μS) ^f	24.69	22.59	26.80	24.92	22.37	22.47	-.14	74	.889
Spontaneo us SCR ^g : 2min rest period	18.13	15.62	20.64	17.95	15.18	20.71	.10	74	.921

^a State-Trait Anxiety Inventory (Trait) - Scores range from 20 to 80 (normal range: 34-44); ^b Depression, Anxiety, Stress Scale (Depression) - Scores range from 0 to 42 (normal range: 0-9); ^c Depression, Anxiety, Stress Scale (Anxiety) - Scores range from 0 to 42 (normal range: 0-7); ^d Depression, Anxiety, Stress Scale (Stress) - Scores range from 0 to 42 (normal range: 0-14); ^eETS (electrotactile stimulus) measured in Volts (V); ^f SC (skin conductance), μ S (microsiemens); ^g SCR, skin conductance responses; ^hAdjusted degrees of freedom (Levene's test <.05); * $p > .05$

Figure Captions

Figure 1. Mean first interval response skin conductance responses to the CS+ and CS- for Shock and NoShock group participants during the acquisition phase. Error bars are omitted to maintain clarity.

Figure 2. Mean third interval response skin conductance responses to the CS+ and CS- for Shock and NoShock group participants during the acquisition phase. Error bars are omitted to maintain clarity.

Figure 3. Means (and standard errors) for reaction times on the three stimulus pairs of the Dot Probe Task, for the Shock and NoShock groups. Significant differences are indicated with an asterisk above the stimulus pair.

Author Note

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