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The effect of emotional and attentional load on attentional startle modulation

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ABSTRACT

The interactive effects of emotion and attention on attentional startle modulation were investigated in two experiments. Participants performed a discrimination and counting task with two visual stimuli during which acoustic eyeblink startle-eliciting probes were presented at long lead intervals. In Experiment 1, this task was combined with aversive Pavlovian conditioning. In Group Attend CS+, the attended stimulus was followed by an aversive unconditional stimulus (US) and the ignored stimulus was presented alone whereas the ignored stimulus was paired with the US in Group Attend CS−. In Experiment 2, a non-aversive reaction time task US replaced the aversive US. Regardless of the conditioning manipulation and consistent with a modality non-specific account of attentional startle modulation, startle magnitude was larger during attended than ignored stimuli in both experiments. Blink latency shortening was differentially affected by the conditioning manipulations suggesting additive effects of conditioning and discrimination and counting task on blink startle.

1. Introduction

The modulation of startle eyeblink reflex latency and magnitude varies with the onset asynchrony between lead and startle-eliciting stimulus (lead interval), the valence of the lead stimulus, and the attention allocated to it. Attentional startle modulation at long lead intervals was thought to be affected by the sensory modality in which lead and probe stimuli are presented as well (Anthony and Graham, 1985). However, more recent research suggests that startle is facilitated during attended stimuli regardless of stimulus modality (Lipp et al., 2003; Böhmelt et al., 1999). Emotional startle modulation, larger startles during aversive pictures or sounds (Lang et al., 1990), has also been demonstrated during conditional stimuli (CS+) paired with an aversive unconditional stimulus (US; Hamm et al., 1993; Lipp et al., 1998). However, larger startle is also observed during the CS+ in non-aversive human Pavlovian conditioning using a reaction time (RT) task as the US, even though this CS+ did not acquire negative valence (Lipp, 2002).

The sensitivity of startle modulation to both emotional and attentional processes can be problematic as these are not independent (Lang et al., 1997). However, little is known about the interactive effects of attention and emotion on startle modulation. Vanman et al. (1996) presented negative and positive pictures in a discrimination and counting task (Dawson et al., 1989). Participants were asked to judge the duration of pictures preceded by one tone and to ignore those preceded by a second. Emotional startle modulation was evident at lead intervals of 750 and 2450 ms. At 4450 ms, startle varied with both attention and emotion. In a second experiment participants attended either to pleasant or to unpleasant pictures. No attentional startle modulation emerged and affective startle modulation occurred at the 250 and 750 ms probe positions. Lipp et al. (2001) simplified the procedure by using only one pleasant and one unpleasant picture in the standard discrimination and counting task. Blink inhibition at 250 ms was greater during attended than during ignored pictures regardless of valence. At the 4450 ms probe position, an interaction emerged with larger startles during attended than during ignored unpleasant pictures with no difference for pleasant pictures. Interestingly, no emotional startle modulation was found in their first experiment which yielded larger startles during attended stimuli regardless of valence.

The goal of the present study was to investigate further the effects of lead stimulus valence and attention to the lead stimulus on blink startle. More specifically, the aim was to establish whether the *effects* of attention and emotion on startle modulation are additive or interactive, and to determine whether the *processes* underlying these effects are independent or share common elements. The discrimination and counting task was employed as the attentional task manipulation. Facilitation of the startle reflex has consistently been shown during attended relative to ignored stimuli in this task, with uni-modal and cross-modal stimulus and probe presentation (Filion et al., 1993; Lipp et al., 1998, 2003; Böhmelt et al., 1999). Aversive conditioning was chosen as the emotional manipulation (e.g., Hamm et al., 1993; Lipp et al., 1998). Experiment 1 investigated whether the modulation of startle in the discrimination and counting task would

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change if the attended or the ignored stimulus was emotionally toned by aversive conditioning.

2. Experiment 1

The aim of Experiment 1 was to investigate the interactive effects of attention and emotion on the modulation of the startle blink reflex. Attentional startle modulation was assessed in the discrimination and counting task and aversive differential conditioning was used to alter the emotional valence of the task stimuli. In one group of participants (Group Attend CS+), the attended stimulus was followed by an electric shock whereas the ignored stimulus was presented alone. In a second group (Group Attend CS−), the ignored stimulus was followed by an electric shock whereas the attended stimulus was presented alone. The assumption that attention to a stimulus and its emotional valence exert independent, modality non-specific effects on blink startle, generates the following predictions: a) blink startle during the attended stimulus will be larger in Group Attend CS+ (attention effect + emotion effect) than in Group Attend CS− (attention effect); b) startle during both the attended (attention effect) and the ignored stimulus (emotion effect) in Group Attend CS− will be larger than during the ignored stimulus in Group Attend CS+ (neither); c) the difference in startle modulation during CS+ and CS− will be larger in Group Attend CS+ (attention effect + emotion effect vs. neither) than in Group Attend CS− (attention effect vs. emotion effect).

In addition to startle modulation, electrodermal activity was monitored. Electrodermal activity, like blink startle modulation, is enhanced during attended stimuli and during the CS+ in aversive conditioning (Lipp et al., 1998), and should replicate the pattern of results seen for blink startle modulation assuming modality non-specificity of startle effects. Further, participants' ability to verbalise the CS–US relationship and their affective evaluation of the stimuli were assessed following the experiment. Awareness of CS–US contingency is considered necessary to obtain electrodermal conditioning (Dawson and Schell, 1987), and possibly also affective conditioning (e.g., Lovibond and Shanks, 2002; but see Weike et al., 2007).

3. Method

3.1. Participants

Forty-eight (32 female) undergraduate students aged 17 to 35 ($M = 19.35$) participated in the experiment for course credit and provided informed consent. The data from an additional eight participants with too many zero or missing startle eyeblink responses (Group Attend CS+: 4; Group Attend CS−: 4), and from two participants who failed to follow instructions, were excluded from startle analyses. Participants were randomly allocated to two groups until there were 24 participants with complete startle data in each, with 8 males and 16 females per group. Participants with electrodermal responses to at least the first two stimuli were selected from these groups for electrodermal response analysis (Group Attend CS+: 23; Group Attend CS−: 21), with additional data provided by participants excluded from startle analysis for insufficient responses. Ratings and task performance data are reported for participants who contributed startle data.

3.2. Apparatus

Electrodermal responses were measured with two domed Ag/AgCl electrodes placed on the distal phalanges of the index and middle fingers of the left hand. A constant voltage of .5 V was applied across the electrodes. Responses were amplified via a Grass 7P1F preamplifier and recorded at a sensitivity of .05 microSiemens (μS)/mm pen deflection. Electrodes were filled with KY Jelly and attached with surgical tape. Respiration was measured by a Phipps and Bird chest strain gauge and recorded on polygraph paper via a Grass 7P1 preamplifier to allow identification of respiratory artefacts in skin conductance.

Two miniature (4 mm) Ag/AgCl electrodes filled with standard electrode gel (Surgicon ECI) and attached with double-sided adhesive collars recorded raw electromyogram (EMG) from over the orbicularis oculi of the left eye. Placement of the first electrode was approximately 1 cm below the lower lid; the second electrode was placed 1 cm edge-to-edge laterally. Electrode placement sites were prepared with electrode gel and a ground electrode was attached to the left forearm. A Grass 7P3C preamplifier amplified (100 μV/cm) and filtered (low pass 3000 Hz, high-pass 10 Hz) the EMG. Raw EMG was sampled by an IBM compatible computer at a rate of 1000 Hz in a time window of 500 ms beginning 100 ms prior to startle stimulus onset.

The startle-eliciting stimulus was a 50 ms 105 dB burst of white noise with near-instantaneous rise-time, produced by a custom-built noise generator and delivered binaurally over Sennheiser headphones. Visual stimuli were backprojected by a Leitz Pradovit slide projector fitted with a tachistoscopic shutter onto a screen approximately 1.6 m in front of the participant at eye-level and subtending a visual angle of approximately 7°. The electrotactile shock stimulus was a 50 Hz pulse, which lasted for 500 ms, and was produced by a battery-powered custom-built shock generator with voltage set individually by each participant. The electrotactile stimulus was delivered to the volar surface of the right forearm through a concentric Tursky electrode with electrode pads soaked in a saline solution. Presentation of stimuli and recording of responses were controlled by a custom-written computer program.

3.3. Procedure

Upon arrival in the laboratory, participants provided consent, received basic information about the experiment and washed their hands and under their left eye with soap. Participants were seated in a chair in a partially illuminated, sound attenuated room. Electrodes were attached and two presentations of the startle probe were given to check EMG electrode placement. During shock work-up, the shock level was increased until participants reported the sensation to be “unpleasant, but not painful”. A three-minute baseline phase, during which no stimuli were presented and during which non-specific electrodermal responses were monitored, preceded the experiment proper. Participants were asked to watch the slide screen and to refrain from moving.

Pictures of geometric shapes, a circle and an ellipse (ratio of height to width, 5:4), served as attended and ignored stimuli in the discrimination and counting task. Shapes were presented for either 5 s (75% of the trials) or 7 s (25% of the trials). Participants were asked to count the number of longer-than-usual presentations of one shape (e.g., the circle) and to ignore the presentations of the second (e.g., the ellipse). A monetary reward was provided contingent on correct performance of the counting task (AUD$5 if correct, AUD$4 if one off, etc.). Although Hawk et al. (2002) have shown that a monetary incentive is not necessary for long lead interval attention effects during a simple attention task, provision of a reward was consistent with previous use of the discrimination and counting task in our laboratory. The electrotactile shock US was presented at the offset of the attended shape in Group Attend CS+ and at the offset of the ignored shape in Group Attend CS−.

Participants received 32 trials, consisting of 16 presentations each of the attended and the ignored shape. Sixteen startle-eliciting stimuli were presented during shapes, eight during attended and eight during ignored. Half the startle-eliciting stimuli were presented at a lead interval of 3.5 s and the others at a lead interval of 4.5 s after shape onset. They were scheduled such that equal numbers of trials were probed at the same lead interval in the first and second half of the