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Stress improves selective attention towards emotionally neutral left ear stimuli

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ABSTRACT

Research concerning the impact of psychological stress on visual selective attention has produced mixed results. The current paper describes two experiments which utilise a novel auditory oddball paradigm to test the impact of psychological stress on auditory selective attention. Participants had to report the location of emotionally-neutral auditory stimuli, while ignoring task-irrelevant changes in their content. The results of the first experiment, in which speech stimuli were presented, suggested that stress improves the ability to selectively attend to left, but not right ear stimuli. When this experiment was repeated using tonal stimuli the same result was evident, but only for female participants. Females were also found to experience greater levels of distraction in general across the two experiments. These findings support the goal-shielding theory which suggests that stress improves selective attention by reducing the attentional resources available to process task-irrelevant information. The study also demonstrates, for the first time, that this goal-shielding effect extends to auditory perception.

1. Introduction

Psychological stress can be defined as the response of an organism to threats (stressors) in the environment (Lazarus, 1993). An open question within behavioural science relates to how psychological stress alters the ability to selectively attend to task-relevant aspects of the sensory scene. While periods of stress may be expected to alter the response to threatening stimuli, it is not clear whether (and how) stress affects selective attention when the information being perceived is not associated with any emotional significance. It has been proposed that stress reduces the level of attentional resources available for perception, and that in response to this change, the processing of distracting, task-irrelevant information is sacrificed in order to preserve goal-relevant processing (Chajut & Algom, 2003). This 'goal-shielding' effect (Plessow, Fischer, Kirschbaum, & Goschke, 2011) produces an improvement in selective attention under stress because relatively less processing is available to be dedicated to task-irrelevant information (Chajut & Algom, 2003). The majority of evidence in support of the goal-shielding theory comes from visual tasks, such as those assessing the impact of stress on the Stroop effect (Booth & Sharma, 2009; Chajut & Algom, 2003; Hu, Bauer, Padmala, & Pessoa, 2012), Simon task (Plessow et al., 2011) or flanker task (Caparos & Linnell, 2012).

An alternative view of how stress might affect attention is offered by attentional control theory (ACT: Eysenck, Derakshan, Santos, & Calvo, 2007). ACT proposes that aversive emotional states serve to reduce the attentional control required to inhibit distracting information. In contrast to goal-shielding theory, one would predict from ACT that the appearance of a stressor would increase the susceptibility to distraction during selective attention tasks. Existing evidence tends to support the predictions of ACT as regards the processing of threatening distracters (Eysenck et al., 2007). However there are only a small number of (visual) selective attention studies which demonstrate an increase in distraction by emotionally neutral stimuli when stressors are present (Moser, Becker, & Moran, 2012) in contrast to those which show the opposing, goal-shielding effect (e.g. Booth & Sharma, 2009).

Although there is a growing literature on the effect of stress on visual selective attention, there are very few studies concerning the impact of stress on auditory selective attention. A recent study found electrophysiological evidence which suggested that selective attention towards emotionally neutral auditory stimuli is disrupted during stress, in concert with the predictions of ACT (Elling et al., 2011). However as no behavioural metrics of task performance were recorded during this study it is not certain whether the electrophysiological changes found actually

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relate to alterations in attention. The current study utilises a novel passive oddball paradigm to test the impact of psychological stress on selection attention towards emotionally neutral sounds. In the first experiment participants were required to report the side to which a monaural speech stimulus was presented. The content of the speech stimuli was arranged in an oddball pattern, with same word (the 'standard') being presented during the majority of trials, while a different word (the 'deviant') was presented only on occasional trials. As the semantic content of the speech stimuli was irrelevant to the task, the unexpected appearance of the deviant speech content serves to distract attention away from the task. Thus reaction times to deviant trials were expected to be longer than reaction times to standard trials, a characteristic known as the 'oddball effect.' The size of the oddball effect during passive oddball paradigms can be taken as a behavioural metric of distraction, as its size reflects the ability of the distracting information within the deviant stimuli to interfere with task processing. Since in the aforementioned paradigm the distracting information is contained within the task stimulus itself, the task requires selective auditory attention to resist this distraction. Psychological stress was manipulated during the task by interspersing either aversive or neutral auditory-visual stimuli between trials. Goal-shielding theory predicts that the oddball effect will reduce during the stress condition (improved selective attention), whereas ACT predicts that the oddball effect will increase during the stress condition (thus showing a reduced ability to inhibit distracting information).

ACT proposes that aversive emotional states cause a loss of attentional control regardless of whether the aversive emotional state is provoked by the presence of a stressor (i.e. psychological stress) or by high trait anxiety (Eysenck et al., 2007, p. 336). Trait anxiety refers to an individual's general predisposition to perceive threats in the environment. Trait anxiety is therefore distinct from the psychological stress engendered by a particular stressor, although the two concepts are, of course, related. The majority of studies showing support for the predictions of ACT have utilised between-participant differences in trait anxiety, rather than variations in psychological stress (Eysenck et al., 2007). A self-report measure of trait anxiety was therefore included in the study to allow the impact of both psychological stress and trait anxiety on task performance to be assessed separately. In line with ACT it was predicted that individuals with high trait anxiety would show greater distraction (i.e. a larger oddball effect) than less anxious individuals. Finally as trait anxiety has been found to predict the effect of manipulations of psychological stress (e.g. Hoskin, Hunter, & Woodruff, 2014) trait anxiety was also regressed against the impact of the stress manipulation on the size of the oddball effect. It was predicted that any effect of the stress manipulation would be greater in individuals reporting high trait anxiety.

2. Method: Experiment 1

2.1. Participants

Fifty-three participants were recruited for the experiment. Two participants withdrew due to discomfort with the stress manipulation and a further two participants were excluded due to poor performance and equipment malfunction respectively. This left 49 participants (27 female, mean age 27, $\sigma = 7.79$) whose data was analysed. Participants reporting either a current psychiatric diagnosis or hearing difficulties were excluded from the study. All participants had normal or corrected-to-normal vision. The study received ethical approval from the University of Sheffield Medical School Research Ethics Committee.

2.2. Task design

Participants were required to respond to a monaural speech stimulus by pressing the arrow button on a laptop that corresponded to the ear in which the sound had been played (Fig. 1). Each speech stimulus lasted 250 ms and participants had 800 ms from stimulus onset to make a response. The inter-trial interval was 450 ms, giving an overall trial length of 1250 ms. Responses made within 150 ms of stimulus onset were treated as errors. The speech stimuli comprised of 4 common one-syllable words, spoken in a neutral male voice (Supplementary Table 1). These words were presented in an oddball pattern, such that the majority of trials involved the same word (the standard) being presented, while the 3 remaining speech sounds acted as deviant stimuli by appearing only on occasional trials (Fig. 2).

The arrangement of trials within the experiment was similar to that described in Hoskin, Hunter, and Woodruff (in press). Trials were presented in 'blocks,' with each of the four speech stimuli acting as the standard stimulus in 2 blocks. There were therefore 8 blocks arranged in this manner. The balanced use of each stimulus in both the standard and deviant positions ensured that any differences between the speech sounds did not systematically contribute to the oddball effect.

Each block included 76 oddball trials alongside 6 presentations of audio-visual stimuli. Each audio-visual stimulus was presented for 2500 ms. Every block began with the presentation of one audio-visual stimulus with the remaining 5 stimuli arranged in a pseudo-random pattern within the block such that between 8 and 20 oddball trials separated each presentation of an audio-visual stimulus (Fig. 2). In half the blocks (herein referred to as 'stress blocks') the audio-visual stimulus involved the presentation of an aversive image alongside speech relevant to the content of the image. In the remaining (non-stress) blocks neutral images were presented alongside content-relevant speech. Participants were made aware of the valence of the images that would appear in the upcoming block, with the purpose of evoking psychological stress as regards the threat of the appearance of unpleasant content during the stress blocks only.

Block presentation was arranged so that each pair of blocks that employed the same standard stimulus was presented in succession. Each of these pairs contained one stress block and one non-stress block. The arrangement of blocks in this manner therefore minimised the number of times the identity of the standard stimulus changed during the paradigm, while allowing stress and non-stress blocks to alternate. Across participants the position of the 4 pairs of blocks were randomised using a 4x4 Latin square formation to ensure that each pair of blocks using a particular standard stimuli appeared (across participants) in each position (first to fourth) an equal number of times. Half the participants started with a stress block, and the other half started with a non-stress block.

Twelve deviant trials were presented within each block (probability of occurrence 16%) with each of the three different deviant stimuli being presented 4 times. Trial position was pseudo-randomised such that (1) each block started with at least 5 consecutive standard trials, (2) at least

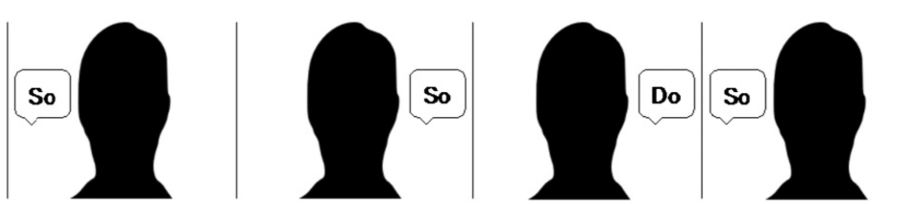

Fig. 1. The speech oddball task. Participants had 800 ms to respond as to which side of the head a speech sound was presented.