



The effect of arousal on auditory threat detection and the relationship to auditory hallucinations



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ABSTRACT

Background and objectives: A recent model of a subtype of auditory verbal hallucinations (AVHs) has proposed such experiences may result from increased arousal altering auditory threat perception.

Methods: This study considered this theory using undergraduate students who undertook a new experimental paradigm, the Auditory Threat Discrimination Task (ATDT). This examined the effects of arousal on auditory threat perception (Study 1), and its relation to hallucination-proneness (Study 2).

Results: Study 1 ($n = 66$) found evidence that the high, as compared to low-arousal condition, was associated with a higher level of accurate and false threat detection (as measured by both number of hits and false-alarms). Study 2 addressed some methodological limitations of Study 1 and also found that the high as compared to low-arousal condition, was associated with a higher level of threat detection. Study 2 also found that high hallucination prone participants ($n = 20$) reported a higher level of perceived threat (as measured by both number of hits and false-alarms), compared to low hallucination prone participants ($n = 20$).

Limitations: Overall limitations of the work included use of a non-clinical group. Also the increased arousal induced by the experiment was modest and may not fully represent the processes in operation in clinical participants.

Conclusions: These findings provide some initial evidence that auditory threat detection increases under conditions of arousal, and are consistent with the proposal that some AVHs may result from hypervigilance to auditory threat.

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Introduction

Auditory verbal hallucinations (AVHs), the experience of hearing a voice in the absence of a corresponding external stimulus, can be distressing and disabling to those who experience them (Chadwick & Birchwood, 1994). Attempts to understand the phenomena from a psychological perspective consider that they are internally-generated experiences misattributed as an externally-generated voice (Waters et al., 2012). Bentall (1990) proposed individuals

attribute internal events to an external source owing to a bias in meta-cognitive processes involved in monitoring the source of information. Source monitoring judgments will be influenced by the nature and quality of the stimulus material as well as being influenced by top-down processes, like perceptual expectations that shape the incoming information (Aleman, 2003). Vercammen and Aleman (2010), provide support for this hypothesis as they showed that people higher in hallucinatory predisposition were more likely to report hearing a word that fitted the sentence context even when it was not presented.

Recently, Dodgson and Gordon (2009) proposed that heightened threat detection, specifically in the auditory modality, may play a role in the etiology of some AVHs. They posit that in conditions of high arousal, individuals adopt a vigilant attentional style aimed at identifying immediate physical or social threat. Although

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this hypervigilance to auditory threat may advantageously increase the detection of actual threats, it may also lead to reporting threat that is not actually there (false-alarms). Such false alarms may involve non-threatening auditory stimuli being misidentified as threatening and experienced as an AVH. For example, a person walking down the street may report hearing derogatory comments being made about them, involving, for example, their sexuality, which they perceive as a threat. When examined in detail this person may have actually either correctly heard a word such as “gay” being mentioned in a conversation by other people (although not targeted at the individual), or have heard a closely related word such as “pay” that the person heard as “gay”.

Unlike some models of AVHs (Waters et al., 2012) Dodgson and Gordon indicate that some voice-like experiences result from a mishearing, or misinterpreting of real external sounds, and therefore that not all AVHs are necessarily the result of external misattributions of internally generated experience. This type of AVH has been termed a hypervigilance AVH (hAVH). At the heart of their model is the proposal that the accuracy of auditory threat detection is mediated by anxious arousal. The hAVH model emphasizes that in times of high psychological arousal such as stress, shame or fear, high vigilance is valuable in helping to identify potential threats to the individual. However, a limitation of this model is that the impact of arousal on auditory threat detection remains poorly understood (Harvey, Watkins, Mansell, & Shafran, 2004). An improved understanding of this would hence aid the development of the hAVH model.

One way to conceptualize the impact of arousal on threat detection is through Error Management Theory (EMT, Hasleton & Buss, 2000). EMT states that when there is a differential cost for two types of errors (particularly between false-alarms and misses), over time cognitive processes will become biased towards making errors that are less costly. For example, missing aggressive intentions is likely to be more costly than the cost of false-alarms (e.g., of over-inferring aggressiveness) at least in the short term. The application of EMT to auditory threat discrimination leads to the proposal that under conditions of heightened arousal and threat, individuals may adopt a cognitive style of being better safe than sorry so as to avoid missing the presence of real threat (Dudley & Over, 2003), with the consequence of increasing the chance of false-alarms (erroneously perceiving the presence of threat), which may come to be experienced as a hAVH. However, this proposal has yet to be empirically examined.

The ideal conceptual and empirical framework to test this is signal detection theory (SDT). SDT describes the underlying cognitive mechanisms of decision accuracy in conditions of uncertainty (Wickens, 2002). On an SDT test, there are four possible responses; hit (correct detection of threat signal), miss (incorrectly identifying threat signal as non-threatening), false-alarm (incorrectly identifying non-threat stimuli as threatening), and correct rejection (correct detection of non-threat). Hence, the SDT framework maps closely on to the processes described by Dodgson and Gordon (2009). Previous studies with non-clinical participants have demonstrated that those high in predisposition to voice hearing report more false alarm responses (hearing a word that is not there) than people low in predisposition (Barkus, Stirling, Hopkins, McKie & Lewis, 2007; Bentall & Slade, 1985; Rankin & O'Carroll, 1995). The same pattern has been shown with clinical participants (Bentall & Slade, 1985). However, these previous studies have not specifically investigated threat detection or the impact of increased arousal on decision-making in the auditory domain. In two linked studies we first aimed to use the SDT paradigm to investigate the effect of arousal on detection of threat, in the auditory domain, hypothesizing that when in a state of increased arousal participants would notice more real threat (increased hits) but also make more false-alarm errors.

In a second study we considered the impact of increased arousal on auditory threat detection in groups of people high or low in predisposition to AVHs.

Study one

Method

Participants

Participants were undergraduate students recruited from a United Kingdom University. A total of 66 students (50 female, mean age of 20 years, $SD = 2.50$, range 18–25) took part in the study. The inclusion criteria were that participants had English as their first language, had no identified difficulties with hearing, were not currently taking psychiatric medication or accessing services for mental health difficulties, and had no self-reported past history of mental health problems.

Measures and procedure

A new experimental task, the Auditory Threat Discrimination Task (ATDT), was developed for this study. The ATDT task mimics a condition in which individuals scan their auditory environment for threat. Participants respond ‘yes’ to the presence of a threat word and ‘no’ to the presence of a non-threat word. This was done using a computer administered auditory discrimination task delivered via the stimulus presentation platform SuperLab (Cedrus, 2008), and consisted of an auditory stimulus train delivered via headphones.

The auditory stimulus lasted 8 min and consisted of two simultaneously presented strands: a continuous background noise track; and word stimuli. The background noise track was an amalgam of generated white noise and indiscriminate mumbling, created using ChatterBlocker™ (2004) and was presented at 70 dB. The word stimuli were embedded at pre-determined auditory threshold (65 dB) within the white noise/mumbling track. These volumes were pre-calibrated via piloting so that two thirds of stimuli elicited a response, enabling the measurement of meaningful change in discrimination across mood conditions. In total 36 words were presented (18 threat words and 18 non-threat words). The task was split into 8-s blocks, with one word presented in each block. In 60% of these blocks the stimulus word was presented in the first second. The words presented were developed from those employed by Waller, Watkins, Shuck, and McManus (1996) and supplemented by words from the ANEW database (Bradley & Lang, 1999; examples of threat words include: hurt, worthless, kill). The presentation order of the word stimuli was randomly determined for each trial.

Participants listened to the ATDT via headphones and were cued to attend for an auditory stimulus through the sounding of a pure tone beep that preceded the word stimulus at a randomly spaced interval. Participants pressed one of two buttons on a computer mouse. A 2-min practice trial of the ATDT allowed participants to rehearse the required responses. Piloting was conducted to ensure robust development of the ATDT. Briefly, piloting established the comprehensibility and threat valence of the word stimuli; and perceptual threshold volume of auditory stimuli. In piloting ($n = 10$) correct identification was above 66% of presentations.

In order to control for order effects, participants were allocated (sequentially) to one of two experimental groups. In the first group participants first underwent anxious arousal induction using an 8-min clip of the Blair Witch Project film (Myrick & Sanchez, 1999). The clip is set at night and involves the protagonists' reactions to noises from the woods outside their tent. The characters try to make sense of what they are hearing, but become increasingly distressed and afraid. In piloting, this material was found to

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