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The effect of psychological stress and relaxation on interoceptive accuracy: Implications for symptom perception☆

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Abstract

Objectives: The goals of the current study were to investigate: (i) how the manipulation of psychophysiological state (stress vs. relaxation) would influence heartbeat detection performance in a laboratory environment and (ii) whether interoceptive accuracy had a relationship with symptom reporting. **Method:** Forty participants (20 males) performed a stressor (a demanding mental arithmetic task) and a relaxation exercise during two counterbalanced sessions, both of which included baseline (control) conditions. Performance of both tasks was interspersed with a heartbeat detection task, i.e., a two-choice Whitehead paradigm. Data were collected from subjective mood scales as well as the electrocardiogram. **Results:** Both stress and relaxation conditions had the anticipated influence on subjective mood. There was no effect of stress or relaxation on heartbeat detection accuracy for male participants. However, the heartbeat detection accuracy of female participants showed a significant decline during the stressor condition. There was evidence that lower mean heart rate tended to improve heartbeat detection performance. A regression analysis revealed that two traits from the Body Perception Questionnaire (autonomic reactivity and body awareness) predicted heartbeat detection accuracy but not in the expected direction. **Conclusions:** The study provided evidence of a gender-specific decrement of heartbeat detection accuracy due to a laboratory stressor. However, the relevance of this finding for health psychology may be limited, as interoceptive accuracy had no significant relationship with symptom reporting.

Keywords: Stress; Interoception; Heartbeat detection; Symptom perception

Introduction

Interoception describes the perception of symptoms and sensations that originate within the body [1,2]. Interoceptive perception of internal change functions as the first stage in the process of symptom detection [3,4]. Interoceptive accuracy (IA) is also relevant for specific clinical conditions, i.e., there is evidence that IA is higher for sufferers of anxiety disorders and panic attacks [5,6].

Laboratory-based assessment of IA typically involves the subjective appraisal of ongoing physiological activity, e.g., sensitivity to temporal characteristics of heart rate [7]. A number of standard protocols have been developed and refined for the measurement of heartbeat detection accuracy [8–10], e.g., the Whitehead procedure [7], which requires participants to discriminate between synchronous ("true") and asynchronous ("false") feedback of the heartbeat, presented aurally as a series of tones [11,12].

With respect to symptom perception within a health context, it has been argued that high IA is associated with hypersensitivity to bodily sensations and a tendency to overreport physical symptoms [13,14]. The evidence to support this hypothesis is mixed. A study by Aronson et al [15] found no association between IA using the Whitehead procedure and scores on the Somatosensory Amplification Scale (SSAS) [16], i.e., the SSAS is associated with hypochondrias and increased symptom reporting. A recent neuropsychological study conducted by Critchley et al [17]

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reported a positive association between: (a) activity in the right anterior insula and IA on the Whitehead task, (b) IA and the size of the right anterior insula (i.e., local gray matter volume) and (c) local gray matter volume in the right anterior insula and a subjective measure of body awareness [18]. This study pointed to a degree of convergence between neurological and subjective traits associated with interoception but provided no evidence for any direct association between subjective body awareness and IA.

If IA is indirectly associated with symptom overreporting via a personality trait or neurological substrate, this relationship may be complicated by the influence of transient changes at the autonomic level. Increased sympathetic activation due to physical manipulation or psychological variables may moderate interoceptive perception by acting directly on the autonomic system. For example, increased stroke volume due to a physical manipulation (a tilt-table) tends to increase the accuracy of heartbeat perception [19,20]. The influence of transient psychological factors such as anxiety and emotional activation has been explored via a number of correlational studies [17,21–24], which demonstrated that increased emotional activation and subjective changes in negative affect/anxiety may improve IA.

It is postulated that physiological reactivity to everyday anxiety or stress may influence the process of symptom perception by acting directly on interoceptive awareness. Anxiety and negative affect have distinct autonomic concomitants [25], which may raise IA and provoke the tendency towards overreporting or symptom amplification previously noted by Barsky and Borus [26] and Pennebaker [14]. If proven, this causal chain could potentially beget a vicious spiral wherein anxiety provokes increased IA, which amplifies symptom detection and severity, and subsequently raises the level of anxiety experienced by the individual.

The purpose of the current study is to test this hypothesis by prospectively manipulating levels of anxiety in a laboratory environment and assessing any subsequent effects on heartbeat perception accuracy. The study will also investigate any possible correlational relationships between IA, individual traits and symptom reporting.

Methods

Participants

Forty participants completed the experiment: 20 males (mean age=25.3 years, S.D.=6.3) and 20 females (mean age=25.8 years, S.D.=4.9). Participants were excluded from the study if they were taking any medication at the time of the experiment or if there was any evidence for (a) stress-related illness (e.g., peptic ulcer, hypertension), (b) psychological illness (e.g., depression, high anxiety), or (c) cardiovascular illness (e.g., cardiac arrhythmia). All participants received a financial reward for taking part in the study.

Independent variables

A laboratory stressor based upon the mental arithmetic task used by Brod [27] was used during the stress condition. Initially, participants received a three-digit number presented on a computer screen (e.g., 517), which they were instructed to summate (e.g., 5+1+7=13) and then add this sum to the original number (e.g., 13+517=530) and verbally report the answer when the "Answer Now" screen appeared 6 s later. The three digits of the new total must then be added together (e.g., 5+3+0=8) and added to the total (e.g., 530+8=538). This cycle was repeated for a duration of 3 min.

For the relaxation condition, participants were taught a simple Yogic breathing technique. Participants were instructed to mentally count during inhalation and exhalation and to progressively extend the duration of inhalation and exhalation over the 3-min duration of the task, i.e., from a count of three during the first minute to a count of five during the final minute.

Apparatus

The electrocardiogram (ECG) was monitored via three electrodes connected to a MP150 BIOPAC system running AcKnowledge 3.8 (BIOPAC Systems, Goleta, CA, USA) at a sample rate of 1000 Hz, with high and low bandpass filters were set at 0.5–35 Hz, respectively. Vinyl electrodes were positioned on the seventh intercostal space on the right and left side of the body to measure heart activity. A common ground electrode was placed on the hip on the right side of the body. Participants received aural feedback of each R peak in the ECG trace via a triggering algorithm in the AcKnowledge software, which produced a tone that was presented binaurally via headphones. A time delay facility within the AcKnowledge software allowed tones to be presented at delays of either 200 and 500 ms from actual R peak. A second computer was used during the stressor condition that ran a slideshow (using Microsoft PowerPoint; Microsoft Corporation, Redmond, WA, USA) to prompt the participant to provide answers during the mental arithmetic task.

Heartbeat detection task

Participants listened to 10 consecutive tones (i.e., heart beats) during each heartbeat detection trial. At the end of each series of 10 tones, they were prompted to indicate in writing whether they believed the series represented their actual heart rate or not. Half of the series were presented as synchronous tones (200-ms delay) and the other half were presented as asynchronous tones (500-ms delay) [12], providing a 1:1 ratio of "targets" and "non-targets."

Dependent variables

Performance on the heartbeat detection task was assessed using a parametric measure of sensitivity (d') based on signal detection theory [28].