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Research paper

Sleep and the heart: Interoceptive differences linked to poor experiential sleep quality in anxiety and depression

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ABSTRACT

Interoception is the sense through which internal bodily changes are signalled and perceived. Individual differences in interoception are linked to emotional style and vulnerability to affective disorders. Here we test how experiential sleep quality relates to dimensions of interoceptive ability. 180 adults (42 'non-clinical' individuals, 138 patients accessing mental health services) rated their quality of sleep before performing tests of cardiac interoception. Poor sleep quality was associated with lower measures of interoceptive performance accuracy, and higher self-report measures of interoceptive sensibility in individuals with diagnoses of depression and/or anxiety. Additionally, poor sleep quality was associated with impaired metacognitive interoceptive awareness in patients with diagnoses of depression (alone or with anxiety). Thus, poor sleep quality, a common early expression of psychological disorder, impacts cardiac interoceptive ability and experience across diagnoses. Sleep disruption can contribute to the expression of affective psychopathology through effects on perceptual and interpretative dimensions of bodily awareness.

1. Introduction

Interoception refers to the sensing of visceral signals from the inner body and contrasts with exteroceptive senses (including touch, vision, hearing, smell) and with proprioceptive signals about the spatial location of body parts from joints, tendons and muscles (Cameron, 2001; Craig, 2002; Sherrington, 1948). The measurement of interoception has focused on quantifying individual differences in interoceptive sensitivity, most frequently assessed using tests of how well a person can perceive their heart beating at rest, perhaps as heartbeats are discrete and easily measurable (Wiens, Mezzacappa, & Katkin, 2000). Two tests dominate: the 'heartbeat tracking' task in which participants report the number of heartbeats they feel over a predetermined time interval (accuracy reflects how close this reported number is to actual recorded number of heartbeats; Schandry, 1981), and of 'heartbeat discrimination' in which participants judge whether external signals (for example, auditory tones) are cued to be synchronous or asynchronous to their own heartbeat (Brener & Kluvitse, 1988; Katkin, Reed, & Deroo, 1983; Whitehead, Drescher, Heiman, & Blackwell, 1977).

Self-report indices of interoception ('interoceptive sensibility') include questionnaires probing subjective sensitivity to specific bodily changes, and confidence ratings of interoceptive task performance. Such experiential measures frequently diverge from the objective measures of interoceptive accuracy. Recently, a dimensional model, supported by empirical data, was proposed for the conceptualization of psychological aspects of interoception along dimensions of interoceptive accuracy, interoceptive sensibility, and interoceptive awareness (Garfinkel et al., 2015Garfinkel, Seth, Barrett, Suzuki, & Critchley, 2015). Here, interoceptive awareness describes the metacognitive correspondence between self-report and performance measures: i.e. how well interoceptive sensibility matches interoceptive accuracy (Garfinkel & Critchley, 2013; Garfinkel et al., 2015). Importantly, dissociation between these interoceptive dimensions demonstrate that individuals do not necessarily have good insight into their interoceptive ability, and is very relevant to understanding anxiety in terms of interoceptive prediction error (Garfinkel et al., 2016, 2015; Paulus & Stein, 2006).

Interoception is influenced by the dynamic state of physiological

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arousal (we become aware of heartbeats when running or scared) or hunger (Herbert et al., 2012), and by attention-dependent processes including self-observation (Ainley, Maister, Brokfeld, Farmer, & Tsakiris, 2013; Ainley, Tajadura-Jiménez, Fotopoulou, & Tsakiris, 2012). Here, we explore the proposition that poor experiential sleep quality may be associated with poor interoception, impairing interoceptive accuracy. Interoceptive information contributes to the regulation of sleep-wake cycles: Sleep arises from the interaction between a homeostatic process dependent on sleep propensity and a sleep-independent circadian process (Borbély, 1982). Correspondingly, poor quality sleep may perturb the processing of viscerosensory information, including cardiovascular signals. Normal sleep is accompanied by predictable changes in bodily physiology: a decrease in blood pressure and heart rate is observed when an individual progresses from wakefulness to non-rapid eye movement (NREM) sleep. Increases in blood pressure and heart rate periodically occur during NREM sleep. During REM sleep, blood pressure and heart rate are comparable to wakefulness (Calandra-Buonaura, Provini, Guaraldi, Plazzi, & Cortelli, 2016). Additionally, sleepiness reduces physiological arousal, including heart rate (Bonnet & Arand, 2005Corcoran, 1964), particularly in the absence of a requirement for effort to remain awake (Corcoran, 1964).

Sleep problems are an early indicator of psychological disorder and they are bi-directionally associated with depression and anxiety (Gregory et al., 2005, 2011; Harshaw, 2015; Jansson-Frojmark & Lindblom, 2008; Shanahan, Copeland, Angold, Bondy, & Costello, 2014). Poor sleep quality can have distinct effects on interoception for individuals with different mental health diagnoses. Reduced interoceptive accuracy is reported in individuals with depression (Furman, Waugh, Bhattacharjee, Thompson, & Gotlib, 2013) and suicidality (Forrest, Smith, White, & Joiner, 2015), while enhanced interoceptive accuracy is often linked to the expression of panic disorder, panic attacks, and other anxiety disorders (Ehlers & Breuer, 1992; Richards, Cooper, & Winkelman, 2003; Van Der Does, Antony, Ehlers, & Barsky, 2000). There may be a vicious cycle where, for example in depression, interoceptive dysfunction causes errors in the interpretation of somatic signals necessary for normal sleep, thereby contributing to sleep disturbance and further interoceptive deficits (Harshaw, 2015).

Poor sleep is linked to specific deficits in cognitive functioning and emotional information processing (Fulda & Schulz, 2001; Gobin, Banks, Fins, & Tartar, 2015; Soffer-Dudek, Sadeh, Dahl, & Rosenblat-Stein, 2011), yet there is currently no published research that explores whether experiential sleep quality is associated with disturbances in interoception. In addition, there is no published research that explores differential effects of sleep quality on interoception for individuals with different mental health diagnoses. The current study aimed to explore associations between experiential sleep quality and distinct dimensions of interoception, measured as performance accuracy, self-report sensibility or as metacognitive awareness in people with and without mental health diagnoses. Interoception is influenced by physiological states, such as hunger (Herbert et al., 2012). We therefore hypothesised that experiential sleep quality would similarly predict interoceptive accuracy, sensibility and metacognitive awareness. Given the reported alteration of performance on interoceptive tasks in clinical populations (Forrest et al., 2015; Furman et al., 2013), and associations between sleep problems and mental health difficulties (Harshaw, 2015; Shanahan et al., 2014), we further hypothesised that the presence of specific clinical diagnoses would enhance the impact of poor sleep in interoception. Specifically, our hypotheses were that (1) perceived poor sleep quality would predict impaired interoceptive accuracy (that is, impaired performance on behavioural tests of interoception), with this negative effect enhanced for individuals with mental health diagnoses, (2) perceived poor sleep quality would predict elevated interoceptive sensibility (that is, self-report ratings about their interoceptive performance), particularly for individuals with mental health diagnoses, and (3) perceived poor sleep quality would predict reduced interoceptive awareness (that is, a reduced correspondence between interoceptive accuracy and confidence ratings), with a greater discrepancy between accuracy and confidence for individuals with mental health diagnoses.

2. Method

2.1. Participants

A total of 180 participants were recruited to the study. Participants with no mental health diagnosis were recruited through advertisements placed around the university, inviting healthy volunteers to take part in the study. Forty-two participants with no history of mental health diagnoses were recruited to the study, including 8 males (19%) and 34 females (81%), with a mean age of 28.2 years (range 18–65). Thirty participants (71%) had received either an undergraduate or postgraduate degree.

Participants with current or previous mental health diagnoses (n = 138) were referred to the study by psychiatrists and clinical psychologists from the Assessment and Treatment Services (secondary care), or were self-referred to the study and recruited through advertisements placed within primary care and community settings. The study team were informed of participant diagnoses at the time of referral, and the Electronic Care Plan Approach (eCPA) patient notes were referred to for a subset of participants to verify their diagnosis. eCPA notes are systematically updated by the clinical care team, and are an electronic record of the patient's care notes, including details such as patient diagnosis, care plan, assessments, and any associated documents, notes or letters for that patient. Where there was a discrepancy between patient self-report and clinical notes, the diagnosis as detailed in the clinical notes was used. This diagnosis was based on either International Classification of Diseases (ICD) or Diagnostic and Statistical Manual (DSM) criteria, depending on the preference of the psychiatrist. The sample of clinical participants included 43 males (31.2%), 92 females (66.7%), 1 other (0.7%), and 2 undisclosed (1.4%), with a mean age of 34.21 (range 18–64), and with 53 participants (38.9%) educated at either undergraduate or postgraduate degree level. Primary diagnoses included: major depression n = 44 (33%), anxiety n = 24 (25%), mixed anxiety and depressive disorder n = 18 (13%), psychosis n = 11 (8%), bipolar disorder n = 10 (7%), personality disorder n = 8 (6%), obsessive compulsive disorder n = 7 (5%), eating disorder n = 5 (4%), posttraumatic stress disorder n = 3 (2%), autistic spectrum disorder n = 2 (1%), attention deficit hyperactivity disorder n = 1 (1%), and dissociative disorder n = 2 (1%). Due to low numbers of participants with some diagnoses, diagnosis groups with less than 15 participants were excluded for the interoception analyses. As such, 133 participants remained for the interoception analyses, including healthy controls, and participants with depression, anxiety, and mixed anxiety and depressive disorder. However, analyses that did not require groupings by diagnosis (including the principal component analysis) used the full sample of participants. Participants with a significant history of cognitive impairment or an additional neurological condition, and participants with alcohol intake on the day of testing, were excluded from the study.

2.2. Measures

Demographic questionnaire. Background information was collected from participants, including age, gender, BMI, education level, working status, medication use, and exercise uptake.

PiBTsburgh Sleep Quality Index (Buysse et al., 1989Buysse, Reynolds, Monk, Berman, & Kupfer, 1989). The Pittsburgh Sleep Quality Index (PSQI) is a 19-item self-rated measure of sleep quality and disturbances, with subscales of experiential sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. Each subscale was scored from 0 to 3, with higher scores indicating poorer sleep quality.

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