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The tendency to ruminate and the dynamics of heart rate recovery after an ordinary, mildly stressful performance situation

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ABSTRACT

Prospective studies indicated that heart rate recovery from mildly stressful laboratory tasks can predict cardiovascular health years later. This is only reasonable if patterns of cardiac recovery in the laboratory are closely related to the way individuals typically recover from ordinary psychological demands occurring repeatedly in their everyday lives. The tendency to ruminate as a trait may be indicative of such habitual response patterns. The special attributes of the present study were that it was evaluated whether cardiac correlates of trait rumination may go beyond specific rumination-provoking situations by studying cardiac recovery after an ordinary, mildly stressful performance situation, and that the immediate dynamics of cardiac recovery were analysed by using high temporal resolution data, which allow to reliably uncover subtle effects after only mild stressors. Higher levels of the tendency to ruminate as a trait were associated with more prolonged increased heart rates after task performance. The results demonstrate that cardiac correlates of a (moderately) high disposition to ruminate can be observed even after ordinary minor stressors of the kind that frequently occur in an individual's daily life, and, thus, broaden the relevance of the construct, the effects of which are obviously not restricted to rare, specific situations.

1. Introduction

The present study is concerned with the potential link between an individual's tendency to ruminate and sustained cardiac activity after ordinary stressors, which is relevant, because extended cardiac activity after stressors indicates prolongation of the stress response and, thus, impairment of the body's natural recovery process (Brosschot, 2010; Brosschot, Gerin, & Thayer, 2006). It has been suggested, therefore, that psychological influences on recovery from stress may play a role in cardiovascular health (Brosschot et al., 2006; Larsen & Christenfeld, 2011). Several prospective studies indicated that heart rate recovery from mildly stressful laboratory tasks over the course of several minutes can predict cardiovascular health years later (Heponiemi et al., 2007; Stewart, Janicki, & Kamarck, 2006). As responses to acute stress in the laboratory are of course not of clinical importance in themselves, these associations are only reasonable, if they are closely related to the way that individuals typically recover from their ordinary psychological demands which repeatedly occur in their everyday lives. Accumulation of maladaptive responses over several years may eventually have pathophysiological significance (Chida & Hamer, 2008). The tendency to ruminate may be an important personality trait generally predisposing to prolonged cardiac activation after stressful situations and, hence, may represent an important connecting link in this context.

Rumination is characterized by a typically unintentional, persistent focus on the internal emotional state and the circumstances surrounding it, and is linked with increased associative thinking along similar lines (Koster, DeLissnyder, Derakshan, & DeRaedt, 2011; Nolen-Hoeksema, 1991). Rumination as a trait has been related to deficits in elementary inhibitory processes regulating emotion processing. More specifically, the tendency to ruminate seems to be based on the tendency to not disengage attention from negative self-generated thoughts once it is captured (Koster et al., 2011; Whitmer & Gotlib, 2013).

Extended research demonstrated that the continued mental representation of stressors beyond their actual presence causes delayed recovery of cardiovascular variables as indexed by a slower return to baseline (Brosschot, 2010). This has been shown in several studies in which rumination was explicitly experimentally induced or conditions strongly promoting rumination were used such as harassment, extremely difficult tasks, or unexpected negative performance feedback (e.g., Key, Campbell, Bacon, & Gerin, 2008; Ottaviani, Shapiro, &

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Fitzgerald, 2011; Papousek, Paechter, & Lackner, 2011; Papousek et al., 2010; Radstaak, Geurts, Brosschot, Cillessen, & Kompier, 2011), and in momentary assessment studies as a correlate of self-reported state rumination (e.g., Pieper, Brosschot, van der Leeden, & Thayer, 2010). In connection with rumination as a trait, too, mainly conditions provoking high amounts of rumination (such as anger provocation or very difficult or unresolvable tasks) have been studied (e.g., Gentzler, Wheat, Palmer, & Burwell, 2013; Gerin, Davidson, Christenfeld, Goyal, & Schwartz, 2006, Johnson, Lavoie, Bacon, Carlson, & Campbell, 2012; Key et al., 2008; Suchday, Carter, Ewart, Larkin, & Desiderato, 2004; Verkuil, Brosschot, deBeurs, & Thayer, 2009).

The special attributes of the present study that distinguish it from previous research are, firstly, that it aimed at adding to the relevant literature by evaluating whether cardiac correlates of trait rumination may go beyond such specific rumination-provoking situations. To this end, cardiac recovery was studied after an ordinary, mildly stressful performance situation of the kind that frequently occurs in everyday life. Secondly, the immediate dynamics of cardiac recovery after termination of the stressor were analysed by using high temporal resolution data, which allow to reliably uncover subtle effects after only mild stressors. Several studies demonstrated that in the context of mildly stressful events the high-resolution time-course of transient changes of cardiac activity can supply relevant information on influences of psychological factors that are not available from the commonly used coarse average values (e.g., Lackner, Batzel, Roessler, Hinghofer-Szalkay, & Papousek, 2014; Lackner et al., 2013; Papousek et al., 2014).

The analysis of cardiac (heart rate) changes was prefered over blood pressure, because the mean arterial blood pressure is the primary regulated variable during stressful conditions and, thus, there is not much variation depending on psychological characteristics in blood pressure recovery after mild stressors (Goswami et al., 2010; Lackner et al., 2014). Its temporal characteristics, too (variations of blood pressure much slower and less accentuated than those of heart rate) renders the analysis of heart rate changes more useful in this context. Transient cardiac changes reliably reflect also subtle influences of psychological factors (e.g., Lackner et al., 2014).

Students were exposed to a performance situation the psychological characteristics of which resembled those of situations that were common in their everyday educational lives. No additional measures were taken to provoke particularly high amounts of perseverative cognition (such as harassment, unexpected feedback or unsolvable tasks), in order to observe the natural responses of individuals with lower and higher levels of trait rumination. Trait rumination was assessed by a standard questionnaire (RSQ, Nolen-Hoeksema & Morrow, 1991), which supplies two rumination scales: Whereas "symptom-focused" rumination primarily captures thinking about the later implications of one's symptoms and seems to be more relevant in major disturbances, "self-focused" rumination more closely refers to the maintenance of ongoing cognitive or emotional states, may also be relevant to the short-lived responses after ordinary, mildly stressful situations, is not specifically linked to sadness and depression (Krieger, Altenstein, Baettig, Doerig, & Holtforth, 2013), and should, therefore, better fit the background and experimental condition of the present study. We expected that higher levels of trait rumination, particularly its "self-focused" facet, would be associated with a more sustained increased heart rate after termination of the stressor.

2. Material and methods

2.1. Participants

The sample comprised 72 undergraduate university students (half of them male, half female; all Caucasian) aged between 19 and 33 years ($M = 23.4$, $SD = 3.3$). No participant reported using drugs or medication that may alter cardiovascular activity, and none had cardiovascular problems or psychological disorders according to self-report. The study was approved by the local ethics committee. Participants gave their written consent to participate.

2.2. Rumination

The self-focused rumination subscale (7 items, rated on a four-point Likert scale, $\alpha = 0.72$; sample item: "When I feel sad or depressed, I go away by myself and think about why I feel this way") and the symptom-focused rumination subscale (8 items, $\alpha = 0.69$; "When I feel sad or depressed, I think I won't be able to do my job/work because I feel so badly") of the German version of the Response Styles Questionnaire were used to assess the tendency to ruminate as a trait (RSQ-D; Kuehner, Huffziger, & Nolen-Hoeksema, 2007; original version by Nolen-Hoeksema & Morrow, 1991).

2.3. Stressor

Standardised mental arithmetic items were used (Düker & Lienert, 2001). A total of 60 items were presented on the computer screen. Six items each were presented on a screen page, which changed automatically after 30 s elapsed (total duration 5 min). The participants were instructed to work as fast and exactly as possible and to speak aloud the results of the calculations, which would be recorded by the experimenter. By requiring verbal responses a mild social-evaluative element was added to the cognitive stressor, which elicits greater heart rate increases during the performance of the task than when only covert responses are required (Lackner et al., 2014).

2.4. Rating scales

The participants retrospectively rated the difficulty of the task (17-point rating scale ranging from "not difficult at all" to "extremely difficult"), and the amount to which they were thinking about the calculations during the break afterwards (from 1, very little to 17, very much).

2.5. Heart rate recording and quantification

Continuous monitoring of heart rate (3-lead electrocardiography using Ag-AgCl electrodes placed at thoracic regions, sampling rate = 1 kHz) was carried out with the Task Force Monitor® (TFM®; CNSystems, Graz, Austria). Interbeat intervals were derived using QRS complex detection based on Hilbert transformation (Harke, Schlögl, Anderer, & Pfurtscheller, 1999; Nygards & Sörnmo, 1983), and were used for calculating the average heart rate for the baseline recording and the recordings during task performance. For the analysis of the dynamics of heart rate changes after task performance (recovery), interbeat intervals were resampled at 4 Hz using piecewise cubic spline interpolation. Heart rate time series during the last 10 s of task performance and one minute following termination of the task were segmented in 5-s intervals. This observation period was chosen, because after typical laboratory stress tasks with an additional psychological stress component such as harassment or social-evaluative stress, heart rate typically recovers within about 30 to 60 s after termination of the task (Brosschot et al., 2014; Goswami et al., 2010). Values for these fourteen 5-s intervals (in bpm) were used in the statistical analysis.

2.6. Procedure

After arriving at the laboratory, demographic variables, height and weight were obtained, and the participants were seated in an acoustically shielded examination room. They were instructed for the task (including some practice trials), and electrodes were attached. A 5 min baseline recording (sitting quietly) was followed by the mental arithmetic task (5 min) and the recovery period (2.5 min). Additionally, a purely physical task was applied: Participants were instructed to squeeze a handgrip as hard as possible. 3-s active intervals were