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Effects of explicit and implicit perseverative cognition on cardiac recovery after cognitive stress

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ABSTRACT

Slow cardiovascular (CV) recovery after stress is a predictor of adverse CV outcomes. Perseverative cognition (PC) about stress has been hypothesized to co-determine slow recovery. In the present study, it was investigated whether two types of trait PC, i.e. trait worry and trait rumination, predicted delayed cardiac recovery after a cognitive stressor. Furthermore, it was examined whether explicit state PC (i.e. negative intrusive thoughts) or implicit state PC (i.e. automatic vigilance) additionally predicted delayed cardiac recovery.

Fifty-nine participants performed a stressful task, which consisted of an unsolvable synonym task. After a 6-minute recovery period, participants reported on their level of negative intrusive thoughts (i.e. explicit state PC), and performed a lexical decision task (LDT) to measure automatic vigilance for task-related information (i.e. implicit state PC). Cardiac activity was continuously measured using heart rate (HR) and heart rate variability (HRV). Trait worry and rumination were measured by the Penn State Worry Questionnaire (PSWQ) and the Ruminative Response Scale (RRS), respectively.

The results showed that high trait worriers had a slower HR recovery from the cognitive stressor compared to low trait worriers. They also showed delayed HRV recovery, but only when the tendency to dwell upon one's negative mood (the 'brooding' subscale of the RRS) was low. Slow HR recovery was associated with high levels of negative intrusive thoughts and with automatic vigilance, but in the unexpected direction for the latter. These results provide evidence that delayed cardiac recovery is associated with trait as well as state PC, and suggest that brooding attenuates the HRV suppressing effect of high trait worry.

1. Introduction

A large body of research has made clear that stressful events can have profound effects on the pathogenesis of cardiovascular diseases (e.g., Rozanski et al., 1999; Black and Garbutt, 2002; Pickering, 2001; Krantz and McCeney, 2002; Rosengren et al., 2004). The investigation of how stressful events can affect cardiovascular health has for a long period focused on adverse cardiovascular activity *during* these stressful events, while in more recent years the insight has grown that stress-related cardiovascular activity that is *prolonged* beyond the presence of these stressors might be much more detrimental (McEwen, 1998; Pieper and Brosschot, 2005; Schwartz et al., 2003). Delayed heart rate recovery has indeed been found to be predictive of coronary events (Pitsavos, 2004), heightened levels of carotid atherosclerosis (Heponiemi, 2007; Jae et al., 2008) and even all-cause mortality (Cole, 2000; Nishime et al., 2000). In addition, delayed blood pressure recovery predicted hypertension 3 and 5 years later (Stewart and France, 2001; Borghi et al., 1986, respectively). Clearly, it is important to elucidate the psychological, that is, cognitive-emotional, factors that contribute to this delayed cardiovascular recovery.

It has been suggested that stressful events are associated with delayed cardiovascular recovery particularly because these events evoke negative, worrisome thoughts (Brosschot et al., 2006). According to the perseverative cognition (PC) hypothesis (Brosschot et al., 2006), worry and rumination extend the mental representation of a stressful event beyond its actual presence and this is suggested to delay cardiovascular recovery after this event. Perseverative cognition (PC) is defined as "the repeated or chronic activation of the cognitive representation of one or more psychological stressors" (cited from: Brosschot et al., 2006, p 114). This definition of PC is quite broad and as such, previous studies have focused on different operationalizations of PC when testing the PC hypothesis. First, PC can be measured as a trait or personality characteristic – some people are more prone to worry or ruminate than others – or as a state, that is, measuring the actual experience of negative repetitive thoughts during an experiment or in daily life. Trait and state worry appear only marginally related (Verkuil et al., 2007). The second aspect is the content of the stressor that is represented. Whereas 'worry' refers to PC about future stressors, 'depressive rumination' refers to PC about one's current sad mood,

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while 'angry rumination' refers to PC about anger provocations. Third, all previous studies have focused on explicit forms of PC whereas it is likely that implicit forms of PC exist. Below we will discuss to what extent these different operationalizations of PC have yielded supportive evidence for the PC hypothesis.

Several studies have suggested that high trait ruminators recover more slowly from stressful events (Gerin et al., 2006; Roger and Jamieson, 1988; Key et al., 2008). However, these studies measured trait anger rumination (Gerin et al., 2006) and trait depressive rumination (Key et al., 2008; Roger and Jamieson, 1988) and not trait worry, that is, *anxious* PC. Both trait worry and trait depressive rumination are important risk factors for the onset and maintenance of mood and anxiety disorders (Nolen-Hoeksema, 1991; Borkovec et al., 1998) which are in turn important risk factors for the development of cardiovascular diseases (CVD) (Kawachi et al., 1994; Wulsin et al., 1999). For example, worry is one of the central features of Generalized Anxiety Disorder (GAD) and rumination plays an important role in Major Depressive Disorder (MDD). At least two study have shown that trait worry directly predicts cardiovascular health problems, that is myocardial infarction (Kubzansky et al., 1997) and the long term cardiovascular effects of a major stressful event ('9/11'; Holman et al., 2008). Although depressive rumination and anxious worry are related forms of PC, they possess some characteristics that distinguish them. For example, Watkins et al. (2005) found that worrisome thoughts are rated as more upsetting and disturbing than ruminative thoughts. This would imply that worrisome thoughts, which are typically measured with the Penn State Worry Questionnaire (PSWQ; Meyer et al., 1990), might have stronger cardiac effects than ruminative thoughts. On the contrary, depressive rumination, as typically measured by the items of the Ruminative Response Scale (RRS; Treynor et al., 2003) might have somewhat less forthright physiological effects. This idea seems to be supported by empirical evidence. On the basis of their review of the physiological effects of PC, Brosschot et al. (2006) concluded that trait worry, as measured with the PSWQ is a the better predictor of delayed physiological recovery than trait rumination, as measured with the RRS. Moreover, worrisome thoughts were reported to continue for a greater number of years than rumination (Watkins et al., 2005), implying that worrying may cause longer 'wear and tear' on the body (cf: McEwen, 2003). In the present study, we addressed this issue and expected trait worry (measured by the PSWQ) to be the stronger predictor of delayed cardiac recovery than trait rumination (measured by the RRS).

State worry has also been suggested to be implicated in slow CV recovery after stressful events (Brosschot et al., 2006). It has been shown that during experimentally induced worry as well as during worry in daily life cardiovascular activity is increased (Lyonfields et al., 1995; Thayer et al., 1996; Verkuil et al., 2009; Pieper et al., 2007). Worry has also been shown to mediate the effects of daily stressors on prolonged cardiac activity during waking and sleeping (Brosschot et al., 2007). Yet, direct evidence that delayed cardiovascular recovery after a stressful event is due to perseverative cognition is still scarce, as most experimental studies have only found an association between delayed recovery and trait PC, and not, or not consistently, between state PC measured after or during the recovery period (Glynn et al., 2002; Key et al., 2008; Gerin et al., 2006). This may be due to several limitations of these latter studies. Firstly, these studies used anger provocation or emotional recall tasks as stressors, after which explicit state worry might just be less likely. For example, only 31% of the participants in a study by Glynn reported anger related thoughts after an anger recall task. The present study aimed to use a more general stressor, i.e. performance on an unsolvable cognitive task within an evaluative context. Such tasks have been previously shown to be experienced as physiologically and psychologically stressful (Brosschot et al., 1992; Weidner et al., 1989). Accordingly, in the present study we tested whether state PC concerning a previous stressor is associated with slowed cardiac recovery and adds to a model wherein slowed cardiac recovery is predicted by trait PC.

A second limitation of these previous studies pertains to the nature of state PC. Gerin et al. found that although delayed cardiovascular recovery after recalling an anger provoking event was predicted by trait angry rumination (Gerin et al., 2006; Glynn et al., 2002), this was not due to state rumination, as measured by thought sampling. However, in a more recent study Key et al. (2008) did find an effect of state rumination on cardiovascular recovery, but this was – unexpectedly – only true for people *low* in trait rumination (Key et al., 2008). As a possible explanation for this finding the authors suggested that perseverative cognition in frequent ruminators occurs largely implicit, without conscious awareness, and would therefore be difficult to report. Thus, delayed cardiac recovery after stressful events might not or not only be caused by explicit PC, but also by implicit or *unconscious* PC related to these events. It is not unlikely that implicit PC exists. In the last decades it has become clear that a large part of our information processing in daily life occurs relatively implicit and without reflective conscious awareness (Bargh and Chartrand, 1999; Bargh and Ferguson, 2000). Thus, there is reason to expect that stressful events not only give rise to explicit PC, but also to implicit PC. One example of implicit PC is 'automatic vigilance' for stressor related information. Automatic vigilance can be regarded as the increased sensitivity of the attentional system for task or stressor related information. This occurs for example after failure on a task (Rothermund, 2003; Smith et al., 2000). To date, no study has directly addressed the possibility that this type of PC causes prolonged stress-related physiological activity. Automatic vigilance or other forms of implicit or unconscious cognitive processing, such as after subliminal emotional stimulation, have not been tested for their physiological effects with the exception of relatively subtle effects on brain activity (Morris et al., 1999), startle reflex (Ruiz-Padial and Vila, 2007) and skin conductance (Öhman and Mineka, 2001).

Finally, the role of mood in recovery from stressors remains unclear. It seems common sense that state negative mood is associated with cardiac activity. However, in several ambulatory (Brosschot et al., 2007) and laboratory studies (Verkuil et al., 2009; Key et al., 2008) state mood was measured and was found to be unrelated to heightened or prolonged cardiovascular activity. In other studies of PC and recovery this was not tested, although effects of trait hostility on slowed blood pressure recovery have been reported (Anderson et al., 2005). Therefore, in the present study we also investigated the effects of state anxiety and state sadness.

Summarizing, this study tested the hypothesis that slowed cardiac recovery after a stressor is predicted by high trait PC, especially trait worry, and by explicit and implicit state PC (negative intrusive thoughts and automatic vigilance) and negative affect. To test this, we used an unsolvable cognitive task, which consisted of an intelligence test of which the participants were made to believe that it predicted future career success, thereby creating an evaluative environment. This task has been previously used to evoke automatic vigilance (Koole et al., 1999).

2. Materials and methods

2.1. Participants

Fifty-nine undergraduate students from Leiden University participated in this study (mean age = 22.4 years, SD = 3.66; 12 males, 47 females). The sample was predominantly Caucasian (80%); 12% identified themselves as Black, 5% as Hispanic and 3% as Asian. They received € 4.50 or course-credits for their participation. This study was approved by our Institutional Review Board. All subjects provided written informed consent.

2.2. Instruments

2.2.1. Cardiac activity

HR and HRV were continuously measured, in a non-invasive manner, with the Polar s810i wristwatch and the Polar Wearlink 31 belt band,