International Journal of Psychophysiology xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

International Journal of Psychophysiology

journal homepage: www.elsevier.com/locate/ijpsycho

Heart rate variability mediates the link between rumination and depressive symptoms: A longitudinal study

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ARTICLE INFO

Keywords:
Rumination
Depressive symptoms
Heart rate variability
Longitudinal
Mediation

ABSTRACT

Ruminative thinking about negative feelings has been prospectively associated with increases in depressive symptoms and heightened risk for new onsets of major depression. One putative pathophysiological mechanism underlying this link might be represented by autonomic nervous system dysfunction. The objective of this longitudinal study was to evaluate the interplay between rumination, autonomic function (as revealed by heart rate variability (HRV) analysis), and depressive symptoms in healthy young subjects, over a three-year period. Rumination and depressive symptoms were evaluated in twenty-two women and twenty men at three assessment points (Time 0, 1 and 2) by the score on the Ruminative Response Scale, and the Center for Epidemiological Studies Depression Scale, respectively. Vagally-mediated HRV was assessed in a laboratory session (Time 0) and in two ambulatory sessions at Time 1 and Time 2 (~13 and 34 months after Time 0, respectively). Ruminative thinking was found to be (i) a stable trait characteristic, (ii) more prevalent in women than men, and (iii) positively correlated with depressive symptoms. Moreover, resting HRV was negatively correlated with both rumination and depressive symptoms. Finally, HRV at Time 1 mediated the relationship between rumination at Time 0 and depressive symptoms at Time 2. We conclude that autonomic dysfunction, specifically low vagal tone, may be prospectively implicated in the generation of depressive symptoms in a non-clinical setting.

1. Introduction

Rumination is defined as a form of responding to psychological distress, which "*involves repetitive thoughts associated with symptoms, causes, and consequences of one's negative feelings*" (Nolen-Hoeksema et al., 2008). Over the past two decades, the role of ruminative thought processes in the development, persistence and recurrence of depressed mood has clearly emerged (Nolan et al., 1998; Nolen-Hoeksema and Davis, 1999; Nolen-Hoeksema et al., 1999; Nolen-Hoeksema et al., 2008; Smith and Alloy, 2009). Furthermore, there is evidence that high levels of rumination are associated with less therapeutic responsiveness to both antidepressant and cognitive-behavioral interventions (Ciesla and Roberts, 2002; Schmaling et al., 2002). Although less prevalent, ruminative thinking is also present in healthy, non-clinical individuals and has been consistently reported to be more common in women compared to men (Johnson and Whisman, 2013), thus possibly explaining sex differences in prevalence rates of psychological disorders, particularly depression (Nolen-Hoeksema, 2012). Rumination is thought to negatively impact individuals through the activation of negative thoughts and memories, thereby exacerbating the impact of depressed mood on a person's thinking and increasing the likelihood that individuals will make depressogenic inferences in regard to their current circumstances (Nolen-Hoeksema, 2014).

At a physiological level, a series of studies have associated rumination with a reduced variability in the periods between consecutive heart beats (heart rate variability; HRV), a measure of the dynamic interplay between parasympathetic (vagal) and sympathetic influences on sinoatrial node activity (Task Force, 1996). Notably, a recent meta-analysis suggests that reduced HRV may be a consequence of rumination (Ottaviani et al., 2016). Indeed, when individuals are experimentally induced to ruminate in the lab (Ottaviani and Shapiro, 2011; Ottaviani et al., 2009) or spontaneously ruminate in daily life (Ottaviani et al., 2015; Ottaviani et al., 2014; Ottaviani and Shapiro, 2011), their HRV is reduced as if they were facing an actual stressor (Perseverative Cognition Hypothesis (Brosschot et al., 2006)), and this pattern emerges early during childhood (Ottaviani et al., 2017). An

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http://dx.doi.org/10.1016/j.ijpsycho.2017.11.002
Received 26 July 2017; Received in revised form 25 October 2017; Accepted 3 November 2017

alternative explanation of the inverse relationship between HRV and rumination takes into consideration tonic HRV instead of its phasic responses to rumination. High resting HRV has been associated with effective self-regulation as well as adaptive and flexible responses to meet various environmental challenges (Thayer and Lane, 2000, 2009). When tonic HRV is considered, it seems that low HRV may represent a cause rather than the consequence of rumination. Within this context, greater resting-state HRV was found to predict more successful inhibition of unwanted memories (Gillie et al., 2015). Indeed, low tonic HRV has been associated both with rumination (Willams et al., 2017) and depression (Kemp et al., 2010). Moreover, resting HRV has been found to be a significant predictor of treatment response and remission from major depressive disorder (MDD) (Chambers and Allen, 2002; Jain et al., 2014), and HRV biofeedback seems a promising tool for the treatment of MDD (Karavidas et al., 2007). Such complex intercorrelations are made even more complicated by the fact that depression and rumination are twice as common in women than in men, despite the fact that women have a higher resting HRV (Koenig and Thayer, 2016).

Notably, the above mentioned studies are somewhat limited by the fact that specific associations between HRV, rumination and depression were tested cross-sectionally and/or mostly focused on phasic HRV response to a stressor. On the other hand, to the best of our knowledge, studies that longitudinally examined the relationship between rumination and resting-state HRV in the context of depressive symptomatology are scarce. For example, the role of rumination as a mediator of the relationship between HRV and depressive symptoms has been recently investigated in a multi-wave study (Stange et al., 2017b). Results suggest that perseverative cognition moderates (exacerbates) the inverse association between vagal withdrawal during a sad film and symptoms of depression across a 12-week time span. Moreover, in a large community study where depression was considered as predictor, women with a history of past MDD exhibited higher levels of rumination and lower levels of HRV (Woody et al., 2014). Clearly, further exploration of longitudinal changes over time are needed to disentangle the complex relationships between resting-state HRV, rumination and depression.

Therefore, the main aim of the present study was to test several plausible prospective models of the specific interplay between rumination, resting-state HRV, and depressive symptoms in a non-clinical population over a time span of almost three years. We hypothesized that HRV would represent either a predictor or a mediator of depressive changes over the course of years, but we also explored the possibility that depressive symptom levels would influence subsequent rumination – HRV interplays. In line with existing studies, we also hypothesized higher levels of rumination and depressive symptoms as well as higher resting HRV in women compared to men.

2. Methods

2.1. Sample and participants

University students and employees were invited to participate in a longitudinal study on “what happens in your body when your mind wanders”. Of the 73 subjects who agreed to participate to the laboratory session, 23 did not complete the follow-up session at Time 1 and 8 did not complete the follow-up at Time 2. Non-completers did not differ from those who completed the follow-ups for any variable of the study. The final sample was composed of 22 women (mean age = 23.7 ± 1.1 years) and 20 men (mean age = 23.0 ± 1.0 years). All participants were Caucasian. Exclusion criteria, which were assessed during a pre-screening questionnaire, were as follows: Self-reported current or past diagnosis of psychiatric disorder or serious medical illness, use of medications that may affect cardiovascular function, obesity, menopause, use of oral contraceptives during the previous 6 months, and pregnancy or childbirth within the last 12 months. The protocol was approved by the Bioethical Committee of the Santa Lucia Foundation, Rome, Italy.

2.2. Procedure

The study consisted of three phases: a laboratory session at Time 0 and two identical ambulatory sessions at Time 1 and Time 2. Participants were consented at the beginning of each session.

2.2.1. Time 0 laboratory session

Participants were informed of the following restrictions: no caffeine, alcohol, nicotine, or strenuous exercise for 2 h prior to the appointment. The experiment took place in a quiet, well-lit room. After reading and signing the informed consent form, ECG electrodes were attached to the subject and the heart rate was recorded continuously for 20 min while participants were seated comfortably during undisturbed resting conditions and invited to leaf through a neutral magazine (vanilla baseline (Jennings et al., 1992)). At the beginning of the baseline period, the experimenter left the room. All participants then engaged in two easy 20-min computerized tracking tasks interspersed by two recall interviews (a perseverative cognition induction and a control neutral condition). The preservative cognition induction required participants to talk about a personal event that occurred in the past or will occur in the future and “when thinking about it” elicited stress. The control condition required participants to verbally describe a well-known route. The current study focuses on the resting baseline period as the effects of the experimental manipulation have been reported elsewhere (Ottaviani and Couyoumdjian, 2013). The 20-min duration of the baseline period was chosen to make it comparable with the duration of the two tracking tasks.

Lastly, participants completed a series of socio-demographic (age, sex, years of education), lifestyle (nicotine and alcohol consumption, and physical activity assessed by the International Physical Activity Questionnaire (IPAQ) (Craig et al., 2003)), and dispositional scales, including the Center for Epidemiological Studies Depression Scale (CES-D) (Radloff, 1977), and the Ruminative Response Scale (RRS) (Nolen-Hoeksema and Morrow, 1991).

2.2.2. Time 1 and Time 2 ambulatory sessions

The average time between Time 0 and Time 1 sessions was 12.8 ± 0.4 months. At Time 1, subjects were instructed to wear a heart rate device for 24 h. The ambulatory session also included an ecological momentary assessment by the use of electronic diaries, but results relative to the moment-to-moment relationship among physiological, thought, and mood data have been described elsewhere and will not be considered here (Ottaviani et al., 2015). After removing the device, participants completed the CES-D and RRS questionnaires. The Time 2 session was identical to Time 1 session. The average time between Time 1 and Time 2 sessions was 20.7 ± 0.4 months, and the average time between Time 0 and Time 2 sessions was 33.5 ± 0.5 months. At the end of each session, participants were compensated for their time.

Discrepancies in the settings and acquisition time of HRV assessment across the three time points are due to the fact that the present study is based on a secondary analysis of data obtained from a larger study examining physiological and mood concomitants of perseverative cognition and mind wandering in the lab and in daily life (Ottaviani and Couyoumdjian, 2013; Ottaviani et al., 2015; Ottaviani et al., 2013).

2.3. Questionnaires

The CES-D is a 20-item self-report scale designed to measure depressive symptomatology during the past week in the general population (e.g., I felt that everything I did was an effort; I thought my life had been a failure; I felt that I could not shake off the blues, even with the help from family or friends) (Radloff, 1977). The validity of the CES-D has been repeatedly confirmed, although some specific items are