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Flexibility as the key for somatic health: From mind wandering to perseverative cognition

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ABSTRACT

Mind wandering (MW) has been defined as the brain's default mode of operation. It is a common experience, however, that this process can become maladaptive, and take the form of repetitive thoughts. We aimed to compare the cardiac and cognitive correlates of perseverative cognition (PC) and MW. Seventy-three healthy participants were engaged in two recall interviews designed to draw their attention to a neutral and a personally relevant negative episode. After each interview, participants performed a 20-min tracking task with thought probe while the electrocardiogram was continuously recorded. Perseverative cognition was associated with higher levels of cognitive inflexibility (slower reaction times, highest intrusiveness, efforts to inhibit), autonomic rigidity (low heart rate variability), and mood worsening compared to being focused on task or MW. Results suggest that MW fails to serve its adaptive function, and turns into a risk factor for health whenever it becomes a rigid and inflexible pattern (PC).

1. Introduction

Mind wandering (MW), a drifting away from an activity toward unrelated inner thoughts and feelings, has been defined as the default mode of operation of our brain (Mason et al., 2007). Given the time that humans dedicate to this activity, it has been suggested that mind wandering is associated with an evolutionary advantage. Several adaptive functions have been proposed, for example, mind wandering might be useful to maintain an optimal level of arousal, or to integrate past, present and future experiences into a coherent frame (e.g., Baars, 2010). In contrast with this view, a series of recent studies showed an association between episodes of MW and negative mood (e.g., Killingsworth & Gilbert, 2010; Smallwood, Fitzgerald, Miles, & Phillips, 2009), dysphoria (e.g., Carriere, Cheyne, & Smilek, 2008; Smallwood, O'Connor, Sudberry, & Obonsawin, 2007), slowed response time (RT), increases in heart rate (HR) and skin conductance (e.g., Smallwood, Davies et al., 2004; Smallwood, O'Connor, Sudberry, Haskell, & Ballantyne, 2004), and enhancement of the blink reflex (Smilek, Carriere, & Cheyne, 2010). Given the pervasiveness of this cognitive process in our lives (46.9% of the samples in Killingsworth & Gilbert, 2010) and the adaptive role conferred to it, it seems implausible that MW has the effect of making people vulnerable in terms of physiological reactivity and mood worsening, both recognized risk factors for health.

Aside from the recent literature on MW, there is a wider series of more clinically oriented studies focused on rumination and worry (i.e., perseverative cognition, PC) that suggest the role of these processes in the onset and maintenance of psychopathology (Aldao, Nolen-Hoeksema, & Schweizer, 2010), and highlight their consequences on somatic health (reviewed in Verkuil, Brosschot, Gebhardt, & Thayer, 2010). In fact, both rumination and worry have been associated with a number of established risk factors for health, such as prolonged activation of the endocrine and immune systems (reviewed in Denson, Spanovic, & Miller, 2009), diminished HR variability (HRV) and baroreflex sensitivity (e.g., Ottaviani & Shapiro, 2011; Ottaviani, Shapiro, Davydov, Goldstein, & Mills, 2009), increases in 24-h blood pressure (e.g., Hogan & Linden, 2004; Ottaviani, Shapiro, & Fitzgerald, 2011), and decreases in HRV during the day (e.g., Pieper, Brosschot, van der Leeden, & Thayer, 2010) and the subsequent night (Brosschot, Van Dijk, & Thayer, 2007). Worry and rumination seem therefore to act as pathophysiological mechanisms with a negative impact on the cardiovascular system (reviewed in Gerin et al., 2012) and health in general (reviewed in Brosschot, 2010).

The ability to adaptively let our mind wander without ruminating or worrying is critical to mental health. However, in spite of the large amount of work on PC on the one hand and MW on the other, the literature on these topics is largely separate. The present study attempts to integrate these concepts, driven by the conviction that this separation led to implausible results and interpretations.

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According to a dimensional view of psychopathology, we assume that MW is not in itself a maladaptive process, but it fails to serve its function and turns into a risk factor for health whenever it becomes rigid and inflexible, that is, when it takes the form of PC (*mind wandering-perseverative cognition continuum hypothesis*). The rationale for this hypothesis derives from recent evidence that MW involves control processes during easy tasks (Levinson, Smallwood, & Davidson, 2012), and facilitates creative problem solving (Baird et al., 2012), both important sources of cognitive flexibility. On the other hand, there are studies showing that the tendency to experience PC is associated with reductions in objectively assessed cognitive flexibility (Davis & Nolen-Hoeksema, 2000). Similarly, findings on the dimensionality of rumination and worry suggested that it lies on a severity continuum, with more experienced intrusiveness and more efforts to inhibit these processes associated with their more severe, pathological forms (e.g., Ruscio & Borkovec, 2004; Watkins, 2004).

To our knowledge, this is the first study to compare the cardiac and cognitive correlates of MW and PC. The rationale for collapsing ruminative and worrisome thoughts into one category derives from previous studies showing different content but no differences between these two processes on appraisals and strategies (Watkins, Moulds, & Mackintosh, 2005). To our knowledge, no study has directly compared the physiological outcomes of rumination and worry. Separate studies, however, showed a common autonomic signature, that is diminished HRV in both rumination (e.g., Ottaviani et al., 2009; Ottaviani & Shapiro, 2011) and worry (e.g., Brosschot et al., 2007; Delgado et al., 2009; Pieper et al., 2010). Indeed, some of the most prominent approaches include rumination and worry under the umbrella term of perseverative cognition (reviewed in Brosschot, Verkuil, & Thayer, 2010) or repetitive thoughts (reviewed in Watkins, 2008).

Our first hypothesis was to find higher cognitive rigidity (slower reaction times, higher intrusiveness, and efforts to inhibit) during PC compared to MW. In line with Friedman and Thayer's model of anxiety (Friedman & Thayer, 1998), we also expected that an increase in cognitive inflexibility would be associated with higher levels of autonomic rigidity assessed by HRV, an established risk factor for health (Thayer, Yamamoto, & Brosschot, 2010). Thus, we hypothesized that PC would be characterized by lower HRV compared to MW. Our third hypothesis was to find greater mood worsening in PC compared to MW.

2. Methods

2.1. Participants

The sample was composed of University students who received credit for participation: 31 men (mean age 25.2 (4.4) years) and 42 women (mean age 23.4 (4.6) years). Individuals were invited to participate in a study on "the psychophysiological correlates of attention" and were not informed about the true aims of the study. Before debriefing them, we asked participants what they thought was the real purpose of the study, and their answers suggested that they believed it was a study on sustained attention. All subjects were Caucasian. Exclusionary criteria, assessed during a pre-screening structured interview, were: a diagnosis of psychiatric disorders (current and/or past), diagnosis of hypertension or heart disease, any other disease or use of drugs/medications that might affect cardiovascular function, obesity (body mass index > 32 kg/m^2), 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 Department of Psychology, Sapienza University of Rome Ethics Committee.

2.2. Procedure

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. Participants were engaged in two 5-min recall interviews; after each interview, they performed a 20-min tracking task with a thought probe. The first interview required them to verbally describe a well-known route (i.e., the itinerary from the building where the experiment took place to Rome central station) and had the aim to account for the degree of sympathetic arousal associated with vocalization (e.g., Girdler, Turner, Sherwood, & Light, 1990). To increase the likelihood of episodes of PC, the second interview 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/worry. Given the long term effects of emotional recall on mood and psychophysiological measures (e.g., Ottaviani et al., 2011), the neutral recall always preceded the affect recall. Psychophysiological data were recorded throughout the session. At the end of the tasks, participants completed personality questionnaires and were then debriefed.

2.3. Tracking task with thought probe

Before the beginning of the task, the experimenter made sure that participants understood what kind of thoughts belonged to mind wandering, rumination, and worry by first providing definitions derived from the literature and then asking for examples. Rumination was defined as "Passively and repetitively focusing on one or more stressful events that occurred in the past, and on the circumstances surrounding this event ("It's all my fault", "Why do I always react this way?"; Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008)". Worry was defined as "A chain of thoughts, images, and negative feelings that are hard to control about a situation whose outcome is uncertain and may be bad ("What if they have an accident?", "What if I fail?"; Borkovec, Robinson, Pruzinsky, & Dupree, 1983)". Mind wandering was defined as "A shift of attention from a primary task to simply follow the flow of thoughts. It takes the form of mental images, awareness of the body, inner speech, etc. (Smallwood & Schooler, 2006)".

The task was developed using Superlab 4 software (Credus Corporation). To increase the likelihood of episodes of MW and make the task automatic, the level of difficulty was very low. Participants were asked to keep the cursor inside a white circle in motion on a black screen and press the left mouse button as fast as possible each time the circle turned red. The duration of the red circle (target) was 1500 ms: if participants did not respond within that time limit, the circle disappeared and the task continued. For each target, accuracy and RT were recorded. At different time intervals, probes interrupted the task to inquire about subjects' thoughts. The thought probe method used in this study was adapted from Stawarczyk, Majerus, and Maj (2011). Eight blocks were administered, each of them immediately followed by the thought probe. Duration of each block was 35, 45, 55, or 65 s, and two blocks of each length were randomly presented. A minimum of one and a maximum of three targets were presented during each block, but the stimuli presented just before the thought probe were always non-targets. The probability of the target stimulus was 11%. We had a total of 16 thought-probes per subject (8 during each tracking task). For each probe, participants were asked to characterize the ongoing conscious experience they had just prior to the probe, among the following: (a) focused on the task, (b) distracted by external stimuli (noise, etc.), (c) MW, (d) worrying about a future event, and (e) ruminating about a past stressful event. Whenever subjects reported not being focused on the task or distracted by external stimuli, they were asked how much they experienced the thought as intrusive and how much they were trying to suppress it (from 1 = not at all to 5 = very much). Afterwards, they specified the main supposed function of the thought ("Why was your attention there?"): (a) facilitate task performance, (b) solve a personal problem, (c) make you feel better, (d) keep you aroused, (e) keep your anxiety under control, (f) plan something, and (g) do not know. The average time of a typical probe episode, including completion of the ratings, was 76.4 (43.3) s.

2.4. Mood ratings

At the beginning of the tracking task (baseline) and after each probe, participants were asked to rate their current levels of feeling Sad, Happy, Bored, Optimistic, Tired, Stressed, Anxious, and Angry on separate visual analogue 100-point scales. For each mood, change scores (task value minus initial baseline value) were computed by subtracting the initial baseline from task values.

2.5. Psychophysiological assessment

The electrocardiogram (ECG) was continuously monitored (Monitoring, Adatec s.r.l., Italy) with a standard electrode configuration. The signal was digitized at 1000 Hz. Each epoch was manually checked and corrected for artifacts. As the root mean square successive difference (RMSSD) has been demonstrated to be a reliable parameter for assessing vagus-mediated HRV from very short (down to 10 s) ECG recordings (e.g., Nussinovitch et al., 2011), HR and RMSSD were obtained for the 30-s epochs preceding each probe using HRV Analysis Software (Niskanen, Tarvainen, Ranta-Aho, & Karjalainen, 2004). Even if this epoch size is significantly larger than the bin size typically used in the mind-wandering literature, our choice was necessitated by our interest in HRV as a risk factor for health. In fact, a prospective study by Dekker et al. (1997) showed a strong association between 15-to 30-s HRV and death from all causes.

2.6. Questionnaires

Participants completed a series of socio-demographic, lifestyle (nicotine, alcohol, and caffeine consumption, International Physical Activity Questionnaire (IPAQ;