Physiology & Behavior 139 (2015) 532–540

Contents lists available at ScienceDirect

Physiology & Behavior

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

The contribution of coping-related variables and heart rate variability to visual search performance under pressure

Sylvain Laborde [a,b], Franziska Lautenbach [a], Mark S. Allen [c]

[a] German Sport University Cologne, Institute of Psychology, Germany
[b] University of Caen, France
[c] University of Wollongong, School of Psychology, Australia

HIGHLIGHTS

- High-frequency heart rate variability (HF-HRV) reflects emotion regulation.
- Trait and state coping-related variables are linked to HF-HRV.
- HF-HRV does not play a role in visual search performance under pressure.

ARTICLE INFO

Article history:
Received 10 July 2014
Received in revised form 24 November 2014
Accepted 2 December 2014
Available online 3 December 2014

Keywords:
Emotional intelligence
Coping
Vagal tone
Stress
Emotion regulation
Concentration grid exercise

ABSTRACT

Visual search performance under pressure is explored within the predictions of the neurovisceral integration model. The experimental aims of this study were: 1) to investigate the contribution of coping-related variables to baseline, task, and reactivity (task − baseline) high-frequency heart rate variability (HF-HRV), and 2) to investigate the contribution of coping-related variables and HF-HRV to visual search performance under pressure. Participants ($n = 96$) completed self-report measures of coping-related variables (emotional intelligence, coping style, perceived stress intensity, perceived control of stress, coping effectiveness, challenge and threat, and attention strategy) and HF-HRV was measured during a visual search task under pressure. The data show that baseline HF-HRV was predicted by a trait coping-related variable, task HF-HRV was predicted by a combination of trait and state coping-related variables, and reactivity HF-HRV was predicted by a state coping-related variable. Visual search performance was predicted by coping-related variables but not by HF-HRV.

1. Introduction

The ability for individuals to quickly identify relevant cues in the environment—in case of threat—played a critical evolutionary role. Nowadays, this ability is particularly valuable to athletes, who have to act and make decisions extremely fast under pressure, using relevant visual cues in their environment [53,69]. We consider here pressure according to the definition of Baumeister [2]: "any factor or combination of factors that increases the importance of performing well on a particular occasion". The pressure of the situation [33] and the mental effort required to perform the visual search (e.g., [60]) are likely to influence the physiological state of the organism, and the physiological state of the organism, in turn, is likely to influence pressure appraisal and mental effort making necessary the need to use effective coping responses. In this study we considered the association between pressure, mental effort linked to visual search performance, and coping behaviours as they relate to one physiological marker: heart rate variability (HRV). HRV is a measure of the continuous interplay between the sympathetic and parasympathetic influences on heart rate [4] and serves as an index of effective emotional and cognitive functioning [63]. Our study addressed particularly these last two characteristics to further our understanding of visual search performance under pressure. Effective emotional functioning reflects an effective way of coping with stressful situations. However, to date, no studies have addressed the question of how high-frequency HRV (HF-HRV) is related to self-reported coping-related variables, in other words, how conscious appraisals of coping processes are related to the bodily processes involved in coping. The first aim of our study was to address this deficiency. Moreover, the relationship between HF-HRV and cognitive functioning is known to be specific to executive function, but so far no studies have investigated the role of HF-HRV concerning the entrance stage of cognition, namely, visual search. Addressing this deficiency was the second aim of our study. Hence, we sought to address both research gaps, using a holistic approach that takes into account both subjective (i.e., trait and state coping variables) and objective

E-mail address: sylvain.laborde@yahoo.fr (S. Laborde).

http://dx.doi.org/10.1016/j.physbeh.2014.12.003
0031-9384/

(i.e., HRV as a physiological measure) variables to better understand visual search performance under pressure.

1.1. Heart rate variability

1.1.1. Neurovisceral integration model

The neurovisceral integration model [63] appears particularly suited to give sense to the variables under assessment in this experiment. This model postulates that the activity of the parasympathetic nervous system, which is reflected in the high-frequency component of HRV (HF-HRV), is positively associated with an optimal functioning of a broad range of regulatory functions serving goal-directed behaviours—particularly at the cognitive and emotional level. This relationship is achieved through the common structures at stake for cardiac regulation and for cognitive regulation, through a structural and functional network connecting the heart to the prefrontal cortex, mainly through the vagus [63]. Importantly, this model postulates an important functional role of both trait and state HRV [61,65]. Little is known about the respective implications of either (see [11,49]) and our aim here is to clarify their associations with both coping behaviour and visual search performance under pressure.

1.1.2. Trait and state HRV

Pressure often leads to stress [33,42] and this requires coping efforts to alleviate its negative consequences. In line with the argumentation of Thayer and colleagues [61,65]—that both trait and state HF-HRV are connected to coping responses—there is a need to differentiate the (potential) different nature of HRV indicators in relation to trait and state coping variables. The capacity model approach [10] recommends moving beyond the mere resting state as a single indicator to consider instead the reactivity to the (emotional) task. The authors argue that individual differences "are best thought of as interactions between the emotional demands of specific situations and the emotion-regulatory abilities individuals bring to those situations" ([10], p. 198). One of the hypotheses derived from this approach is that individual differences will show stronger relationships with criterion variables if measured during emotional challenges, rather than during "resting" tasks, because greater measurement error can occur during baseline measurements. Given these recommendations and based on the theoretical proposals of Thayer and Lane [65], we looked at HF-HRV at three levels[1]: 1) parasympathetic activity as a prerequisite for coping behaviour (baseline HF-HRV); 2) parasympathetic activity as an outcome of the coping behaviour (task HF-HRV); 3) parasympathetic activity as a process that accompanies coping behaviour (HF-HRV reactivity, task – baseline). In the following, we review the findings linking these different HF-HRV levels to the way people consciously appraise their coping processes, namely, by considering trait and state coping-related variables.

1.2. Trait coping-related variables and HRV

Regarding trait coping-related variables, we considered two different aspects, first the traditional coping styles, and then an individual difference that has been related to coping processes at the trait level: trait emotional intelligence.

1.2.1. Coping styles and HRV

There is limited and somewhat inconsistent past research into associations between trait coping-related variables and HRV. For example, people using repression (a cognitive avoidant processing style) as a coping mechanism have been found to record lower parasympathetic activity under stress [14,50]. Unfortunately, the repressive coping construct suffers from an unclear conceptualization [18] and this makes the connection to the autonomic nervous system somewhat difficult to interpret [28]. Other investigations—using more standard measures of coping—have reported conflicting findings. In one experiment, an association was identified between the expression of negative emotions and vagal tone (which usually corresponds to HF-HRV) but this was found to differ relative to the age of participants [54]. Specifically, a positive association was found in men aged between 31 and 50 years, and a negative association was found in men aged between 18 and 30 years. It remains unclear why age would factor in as a moderator of this relationship. More recently, in a non-clinical sample of young adults, reported coping style (problem-focused, social-supportive, and avoidance-focused) was found to be unrelated to HRV [39]. Taken together, there is little clear evidence to support a link between coping style and HRV.

1.2.2. Trait emotional intelligence and HRV

Also belonging to our definition of trait coping-related variables, trait emotional intelligence (EI)—a constellation of emotional self-perceptions situated at the lower levels of personality [52]—encompasses coping and emotion regulation within its conceptualisation. New studies have demonstrated that trait EI is related to task-oriented coping [34] and physiological stress responses that include cortisol secretion [32,41] and HRV [30]. In particular, in the study by Laborde et al. [30], participants were instructed to remain as focused as possible (as if they were about to start a sport competition) during which the sound of a negative crowd response was being played. The authors found that a higher trait EI was associated with a greater activation of the parasympathetic nervous system during the pressure manipulation, as illustrated by the root mean square of the square differences between adjacent normal RR intervals (RMSSD). They concluded that trait EI has a protective influence on the reaction to stress as illustrated with its links to HRV reactivity. The experiment did not identify an association between trait EI and baseline HRV [30]. These initial findings suggest that trait EI has a greater connection to parasympathetic activity processes (HRV reactivity) than to parasympathetic activity at rest (HRV).

1.3. State coping-related variables

1.3.1. State coping-related variables and HRV

More is known about the relationship between HRV and coping responses to stressful stimuli. Investigations can be separated into those considering the tonic level of HRV (referring to the current HRV level, named baseline and task HF-HRV in this study) and those considering the phasic level of HRV (referring to HRV reactivity, named reactivity HF-HRV in this study, representing the change between baseline and task HF-HRV). At the tonic level of HRV, vagal tone activity (referred to in this study as HF-HRV) has been found to correlate positively with engagement coping strategies and negatively with disengagement coping strategies [16,68]. Investigations have also found that people with higher resting HRV are more stress tolerant and resilient in the face of environmental changes [21] and this might reflect a greater use of more effective coping strategies.

At the phasic level of HRV—focusing on vagal withdrawal (the decrease of parasympathetic activity)—the research findings are more inconsistent. On the one hand, there is evidence that individuals reacting to angry faces with disengagement record (subsequently) a higher vagal withdrawal [57], and the authors suggest that a stronger decrease of HF-HRV might indicate a better adjustment to stressful situations, which is in line with the findings of other studies [70]. On the other hand, a separate body of research has found that effective emotion regulation is associated with increases in parasympathetic activity [8,35,49]. It is important to note the associations of both tonic and phasic HRV to emotion regulation—a higher tonic HF-HRV (a higher level of parasympathetic activity) relates positively to effective emotion regulation [1] but for HF-HRV reactivity, either a strong decrease

[1] We acknowledge that the parasympathetic activity is usually considered as a marker of effective emotion regulation, and not only of coping [1]. However, due to the focus on coping in this paper we refer only to HF-HRV as being linked to coping responses. According to Gross and Thompson [20], coping differs from emotion regulation by its focus on negative emotions.