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Sylvain Laborde
Deutsche Sporthochschule Köln

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Trait emotional intelligence in sports: A protective role against stress through heart rate variability? ☆

Sylvain Laborde [a,b,*], Anne Brüll [b], Julian Weber [b], Lena Sophie Anders [b]

[a] UFR STAPS, EA 4260, University of Caen, France
[b] German Sport University, Institute of Psychology, Cologne, Germany

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ABSTRACT

Emotional intelligence (EI) has received very scant attention from researchers in the sport domain to date, yet emotions are key to sport performance. Therefore, the aim of this study was to explore the influence of trait EI in athletes when they have to face the stress of competition. Thirty male handball players (M_{Age} = 22.5 years; SD = 1.7) were exposed to a competition-like stressor in the laboratory consisting of 20 min of negative imagery coupled with the sound of a crowd hissing. Their trait EI was measured with the Trait Emotional Intelligence Questionnaire, and a mental stress indicator, the low-frequency/high-frequency (LF/HF) ratio, was calculated from their heart rate variability. A repeated measures analysis of variance showed a significant Time of Measurement × Trait EI interaction, $F(1, 28) = 6.036$, $p = .020$, $\eta_p^2 = .18$, indicating that high trait EI athletes experienced a lower increase of stress compared to their low trait EI counterparts. Through its influence on the LF/HF ratio, trait EI may help athletes cope better with stress.

1. Introduction

1.1. Emotional intelligence in sports

The influence of emotions in sports is crucial to performance: although sports can be practiced for fun and enjoyment (Sit & Lindner, 2005), athletes also experience anxiety and stress when they try to reach a high performance (e.g., Mellalieu, Neil, Hanton, & Fletcher, 2009). The pressure and the subsequent stress and emotions experienced by athletes are more intense when highly valued goals are at stake (Lazarus, 2000). Yet despite the importance of emotions in sports, the role of emotional intelligence (EI) in this context has received only scant attention from researchers (for recent considerations of the role of EI in sports, see, for example, Stough, Clements, Wallish, & Downey, 2009). In particular, the measurement of EI needs to be clarified in sports (Lane, Meyer, et al., 2009), and there is a need for empirical studies.

In the sport context, EI is important for both coaches and athletes. For coaches, it has been positively associated with coaching efficacy (Thelwell, Lane, Weston, & Greenlees, 2008), more specifically for motivation efficacy and character building. For athletes, higher EI has been linked to higher performance in team sports, such as cricket (Crombie, Lombard, & Noakes, 2009), hockey (Perlini & Halverson, 2006), and baseball (Zizzi, Deaner, & Hirschhorn, 2003). According to Zizzi and colleagues (2003), an athlete must recognize one's emotions, as well as teammates' and opponents' emotions, in order to perform well in team sports. Moreover, at the individual level higher EI was found to be positively related to the use of psychological skills, such as imagery and self-talk (Lane, Thelwell, Lowther, & Devonport, 2009).

One of the promising aspects of EI in sports seems to be its effect on stress when under pressure. Facing stress and anxiety is commonplace for athletes, whatever their age (Reeves, Nicholls, & McKenna, 2009), gender (Kaiseler, Polman, & Nicholls, 2009), or expertise level (Mellalieu et al., 2009). Therefore, athletes must cope appropriately with stress if they are to perform at the highest levels (Haney & Long, 1995). Regarding the link between EI and coping with stress in athletes, it has been suggested that EI is positively associated with precompetitive emotions that optimize performance (Lane et al., 2010) and with less precompetitive anxiety (Lu, Li, Hsu, & Williams, 2010). Recently, trait emotional intelligence (trait EI; Petrides, 2009) has been found to be related to task-oriented coping in both French and Chinese table tennis players, for different stressful situations (Laborde, You, Dosseville, & Salinas, in press). However, the underlying mechanisms of the relationship between EI and coping with stress in sports remain unclear. This study examined how EI influences an athlete's reaction to stress.

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* Corresponding author at: UFR STAPS, EA 4260, University of Caen, France.
E-mail address: sylvain.laborde@yahoo.fr (S. Laborde).

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1.2. Trait emotional intelligence and stress

This study focuses on trait EI, which is a constellation of emotional self-perceptions situated at the lower levels of personality hierarchies (Petrides, Pita, & Kokkinaki, 2007). Trait EI is assessed by a self-report measure. One criticism of this kind of measure is that it can be biased by social desirability, that is, by participants responding in what they think is a socially desirable way, which leads to weak predictive power. In self-report evaluations concerning traits, when a great social value is placed on a trait, the participant "may try to conceal undesirable behavior and highlight desirable behavior" (Connelly & Ones, 2010, p. 1095). However, trait EI has been shown to have strong links with behavioral components (Petrides, 2009; and for recent work about trait EI and EEG see Mikolajczak, Bodarwé, Laloyaux, Hansenne, & Nelis, 2010), particularly in the response to stress. The TEIQue was found to have incremental validity over the Big-5 in predicting coping (Petrides, Perez-Gonzalez, & Furnham, 2007). Petrides (2009) has suggested that one of the four factors (i.e., well-being, self-control, emotionality, and sociability) of trait EI seems closely linked with the response to stress: self-control. In particular, this factor influences the way people control their emotions, withstand pressure, and regulate stress.

Trait EI has been found to play a role in how efficiently people cope with stress (Mikolajczak & Luminet, 2008; Mikolajczak, Menil, & Luminet, 2007). In addition to being related to subjective measures of stress in these studies, trait EI has also been found to be related to biological measures, such as cortisol response (Mikolajczak, Roy, Luminet, Fillee, & de Timary, 2007). These relationships with real physical measures, more than self-report measures, give a stronger foundation to the trait EI construct. Research should continue to explore biological correlates of trait EI in stress conditions, such as with heart rate variability (HRV), which has been used in many studies as a stress indicator (e.g., Demaree & Everhart, 2004). Moreover, HRV is not only a stress indicator but also an indicator of cognitive processing, according to the theory of the neurovisceral integration (Thayer, Hansen, Saus-Rose, & Johnsen, 2009), and this biological connection could constitute an interesting addition to the trait EI construct.

To the best of our knowledge, so far only one study has linked EI to HRV (Craig et al., 2009). In this study, the Brain Resource Inventory for Emotional Intelligence Factors (BRIEF; Kemp et al., 2005) was used to assess EI, and no relationship was found with HRV. The present study addressed this question based on another EI framework, trait EI.

1.3. HRV and stress

HRV corresponds to the variability of R–R intervals (i.e., intervals between consecutive R peaks; Niskanen, Tarvainen, Ranta-Aho, & Karjalainen, 2004). It assesses the sympathetic–vagal balance of an organism (Malik, 1996). Thus HRV could be an appropriate noninvasive indicator of stress: According to the physiological stress model, stress often comes with an increase of sympathetic tone, caused by an increased catecholamine level (Axelrod, 1984), and a reduction of vagal tone (Watkins, Grossman, Krishnan, & Sherwood, 1998). One of the main parameters calculated from HRV is the low-frequency/high-frequency (LF/HF) ratio, obtained by frequency analysis. The LF/HF ratio, which represents the balance between the sympathetic and the parasympathetic system (Malik, 1996), has been shown to be an indicator of mental stress (Kristalboneh, Raifel, Froom, & Ribak, 1995) and will be used here as evidence of stress.

1.4. Objective of the study

The aim of this study was twofold: first, to examine the relevance of the EI construct in sports, and more specifically its role in coping with stress; and second, to extend the trait EI framework to an objective biological measure of stress, HRV. The purpose of this study was therefore to analyze the influence of trait EI on the change of an indicator of mental stress, the LF/HF ratio, when an athlete is exposed to a competition-like stressor. Due to its supposed protective effect against stress, higher trait EI will predict a lower increase of the sympathetic system and a lower decrease of the parasympathetic system during exposure to a stressor, which will be reflected in a lower increase in the LF/HF ratio. More particularly, we expected a stronger role of the self-control factor in this relationship, due to its influence on the ability to withstand pressure.

2. Method

2.1. Participants

The study involved 30 male handball players (M_{Age} = 22.5 years; SD = 1.7) who volunteered for the study. Informed consent was obtained and this study involving stress exposure was accepted by the Ethics Committee of the German Sport University of Cologne.

2.2. Instruments

Participants' trait EI was measured with the German adaptation (Freudenthaler, Neubauer, Gabler, Scherl, & Rindermann, 2008) of the Trait Emotional Intelligence Questionnaire (TEIQue, Petrides, 2009). Validity evidence can be found for the TEIQue for many languages (e.g., Petrides et al., 2010). The long form contains 153 items, which the participants had to rate from 1 (*completely disagree*) to 7 (*completely agree*). From this questionnaire, it is possible to obtain a global trait EI score and a score on four factors (see Section 1.2). Sample items are "I'm usually able to express my emotions when I want to" and "I often find it difficult to show my affection to those close to me".

2.3. Material

A Nexus 4 device was used to measure HR with three chest electrodes, with the software Biotrace. The interbeat interval data was then exported to the software Kubios, so we could obtain comprehensive HRV data with time and frequency domain analyses. Frequency parameters were computed through fast Fourier transform.

2.4. Protocol

For the day of the session, participants were told to follow their usual sleeping routine, not to train the day before, and not to consume caffeine or tobacco. These procedures were followed so that the physiological system would be in an undisturbed state and were used in previous studies where heart rate variability was measured (Nakahara, Furuya, Francis, & Kinoshita, 2010). Participants were welcomed to the laboratory, and then the experimenter explained how the session would be organized. As a cover story, participants were told that they would participate in an experiment about concentration. A cover story is often used in emotion research (e.g., Reifen Tagar, Federico, & Halperin, in press), in order not to make the emotion manipulation salient to the participants. They were invited to sit on a chair, and three cardiac electrodes were placed on their chest. After they had sat quietly for 5 min, a baseline reading was taken for 3 min. Afterward they were exposed to a competition-like stressor (i.e., they had to listen to a pre-recorded negative imagery script together with the sound of a crowd hissing, with sentences like "Your opponents don't lack anything" and "Motivation is leaving you") for 20 min.[1]

[1] The audio file is available from the first author upon request, as well as the negative imagery text.

The volume was 75 dBA, which represents a good compromise between stimulation and hearing safety (Alessio & Hutchinson, 1991). This stressor was chosen because on the one hand crowd noise has been found to foster anxiety in sport participants (Balmer et al., 2007), and on the other hand because negative imagery has been shown to provoke performance deterioration (Woolfolk, Parrish, & Murphy, 1985). The negative imagery was aimed at stimulating the negative self-talk that an athlete can experience before a competition and contained propositions aimed at decreasing self-esteem and self-confidence in a sport context. During stressor exposure, participants were given the instruction to stay as focused as possible, as if they were about to start a competition. Just after stressor exposure, HR was recorded for 3 min. To maintain coherence with the cover story, their concentration was assessed before and after the experiment with the concentration grid (Harris & Harris, 1984), a 10 × 10 square with 100 numbers (i.e., from 1 to 100), and the participants were given 2 min to fill in as many numbers as possible, in order from 1 to 100.

2.5. Data analysis

We focus here on the LF/HF ratio, one of the variables that can be computed from the HRV analysis. For the reader to get an overview of the experiment, however, we present a correlation matrix with all time and frequency parameters crossed with TEIQue factors in Table 1.

To look for time and trait EI effects, we computed a repeated measures analysis of variance (ANOVA) with time as a within-subject factor (two measures: at baseline, T1, and at post-manipulation, T2, corresponding to a 3-min measurement after the experimental task and before taking part in the concentration grid) and trait EI (two categories: above and below the mean, named respectively high trait EI and low trait EI) as a between-subjects factor; and taking the LF/HF ratio as a dependent variable. Finally, the effect of trait EI factors on HRV baseline and HRV change (computed by subtracting T1 from T2) was checked through regression analyses.

3. Results

3.1. TEIQue descriptive statistics

The descriptive values from the TEIQue are reported here for the global score and the four main factors: trait EI (M = 4.99; SD = 0.35; α = 0.88); well-being (M = 5.56; SD = 0.50; α = 0.78); self-control (M = 4.79; SD = 0.56; α = 0.79); emotionality (M = 4.88; SD = 0.57; α = 0.78); and sociability (M = 5.06; SD = 0.51; α = 0.84). The trait EI mean scores for the high trait EI group (M = 5.28; SD = 0.19) and for the low trait EI group (M = 4.71; SD = 0.21) were respectively 0.56 SD above and 0.47 below the trait EI mean score of a German-speaking population (M = 4.96; SD = 0.57) (Freudenthaler et al., 2008).

Table 1
Correlations between trait emotional intelligence (EI) and heart rate variability (HRV) parameters (change between baseline and after stressor).

	Well-being	Self-control	Emotionality	Sociability	Trait EI
RMSSD (ms)	.23	.22	.20	.49**	.40*
pNN50 (%)	.17	.19	.14	.39*	.31
SDNN index (ms)	0	0	.05	.25	.28
LF_{nu}	.12	−.05	−.26	−.39*	−.22
HF_{nu}	.24	.08	−.11	.25	.14
LF_{nu}	−.03	−.09	−.17	−.37*	−.24
HF_{nu}	.18	.23	.03	.28	.24
LF/HF ratio	−.28	−.47**	−.43*	−.06	−.47**

Note: RMSSD: the root mean square of the sum of the squared differences between adjacent normal RR intervals; pNN50: percentage of differences between adjacent normal RR intervals more than 50 ms; SDNN: standard deviation of all RR intervals; LF: low frequency; HF: high frequency; LF/HF: ratio between the low-and high-frequency band; nu: normalized units.
* $p < .05$.
** $p < .01$.

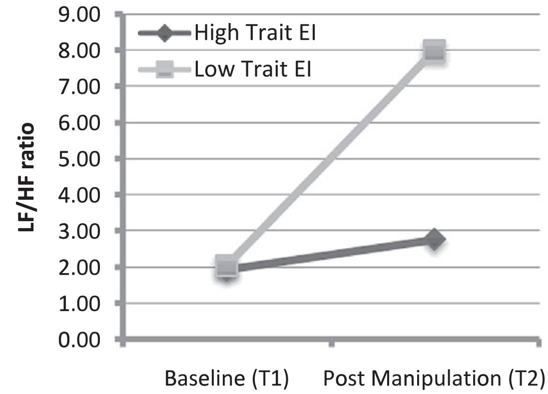

Fig. 1. Change of the low-frequency/high-frequency (LF/HR) ratio during a stressful task for high and low trait emotional intelligence (EI) participants.

The repeated measures ANOVA (see Fig. 1) indicated a significant main effect of time, $F(1, 28) = 10.692$, $p = .003$, $\eta_p^2 = .28$, and a significant Time × Trait EI interaction, $F(1, 28) = 6.036$, $p = .020$, $\eta_p^2 = .18$.

To understand further the influence of trait EI on HRV, we conducted regression analyses on HRV baseline and on HRV change. First, neither trait EI ($\beta = -.10$, $p > .05$) nor a model including the four EI factors ($R^2_{adj} = .03$, $p > .05$) was found to predict HRV at baseline. However, one of the four factors, well-being, was found to predict the LF/HF ratio at baseline individually and significantly ($R^2_{adj} = .16$, $\beta = -.44$, $p = .016$). Second, regarding HRV change, the overall model with the four factors significantly predicted the LF/HF ratio ($R^2_{adj} = .26$, $p = .02$). Emotionality was also found to be a significant predictor ($\beta = -.44$, $p = .034$), while there was a tendency for self-control ($\beta = -.32$, $p = .09$).

4. Discussion

The aim of this paper was twofold: to show evidence for the validity of trait EI in a sport context when athletes are facing stress, and to extend the trait EI construct to HRV. Regarding our experimental task, we found a main effect of time, which means that there was a significant increase of the LF/HF ratio for all participants during the emotional manipulation. This increase represents a dominance of the sympathetic system over the parasympathetic one. Therefore, according to the physiological model of stress (Axelrod, 1984; Watkins et al., 1998), we can say that the task was stressful for the participants.

The interaction effect suggested to us that the increase of LF/HF ratio was higher for low trait EI participants, indicating that they were more stressed by the task than high trait EI participants. We address this finding in detail below.

At baseline, no relationship was found between trait EI or a model including the four factors and the LF/HF ratio. Only well-being was found to predict negatively the LF/HF ratio, which means that the higher the well-being, the less stressed is the individual. This is in line with a previous study where HRV was found to predict subjective well-being through emotion regulation (Geisler, Vennewald, Kubiak, & Weber, 2010).

Regarding the LF/HR ratio change during the stressful task, it was found to be linked negatively with trait EI and a model including the four factors (with 26% of the variance explained). But in contrast to the cortisol study (Mikolajczak, Roy, et al., 2007), not all factors had the same influence in this relationship. In particular, the change of the LF/HF ratio during the stressful task was linked negatively with emotionality and with self-control, although it was only a tendency for the latter ($p = .09$). Emotionality is linked to being clear about one's own and others' feelings, and self-control to emotion and stress management. In theory, the self-control factor should have a stronger role in physiological regulation during a stressful event. The nature of the task should have an influence, and we will come back to this point later.

Regarding the relationship observed between trait EI and HRV, we attribute it not to differences in baseline, as in the cortisol relationship (Mikolajczak, Roy, et al., 2007), but to the change of HRV parameters during stressor exposure. Trait EI might influence HRV through stressor appraisal during stressor exposure. Actually, individuals with higher trait EI may appraise the stressor more as a challenge than as a threat (Mikolajczak & Luminet, 2008) and may use more adaptive coping strategies (Mikolajczak, Menil, et al., 2007). At the biological level, the change of HRV sympathetic parameters can be compared to the change of cortisol, as they originate from systems that work in parallel under stress, the sympathetic–adrenomedullary system and the hypothalamic–pituitary–adrenocortical axis (Mikolajczak, Roy, et al., 2007). Therefore, when a person is facing stress, the role trait EI plays with HRV sympathetic parameters is then similar to that it plays with the release of cortisol: The higher the trait EI, the lower the increase of these parameters. Finally, our findings differed from those of Craig and colleagues (2009). In their study, no relationship between EI and HRV was found. This can be explained by the difference in EI measurement (they used the BRIEF), and constitutes an additional argument for the validity of the trait EI construct, linked with a behavioral component.

Regarding the sport context, this study shed light on a specific aspect of trait EI: its role in protecting against stress, through an influence on HRV. This might be because high trait EI athletes appraise the competition as a challenge rather than as a threat. This would be in line with previous studies indicating that EI fosters emotions before a game that optimize performance (Lane et al., 2010) and decrease precompetitive anxiety (Lu et al., 2010). This latter finding would be a claim for a difference in HRV baselines of low and high trait EI participants. However, we did not find such a baseline difference in our study, perhaps because we used a different type of task. In the study of Lu et al. (2010), the participants filled out an EI questionnaire just before a real competition, where highly valued goals were at stake, whereas in our study we used a laboratory task with no really important goals at stake. Further studies should check these findings, evaluating the influence of athletes' trait EI directly on the field, where they face the pressure of real competition.

This study has some limitations. First, only men were involved, and it could be interesting to study the TEIQue/HRV relationship during acute stress in women. Regarding this point, a decrease in the vagal component has been found in response to stress for both men and women (Dishman et al., 2000). Second, the stressor used was specific to the participants' expertise domain, and it should be of interest to see how they would react to a nonspecific stressor in another context. Third, it should also be worth studying the trait EI and HRV relationship in the context of acute versus chronic stress. Finally, the question of causality must arise: How can we be sure that it is trait EI that influences the autonomous system, and not the other way around? It is possible that there is reciprocal action: Models such as Cloninger's (2008) Temperament and Character Inventory postulate some biological basis to personality. In this study, it would mean that the change of the sympathetic and parasympathetic systems when exposed to stress might influence trait EI.

5. Conclusions

This study provides interesting insight about the role of trait EI in the sport context, when an athlete is facing stress, and brings additional physiological evidence to the trait EI construct with HRV, explaining how it might contribute to emotional regulation. Withstanding pressure is the key for athletes to reach a high level of performance, and if trait EI has an influence on the reaction to stress, athletes might be interested in whether it is possible to change EI, which may in turn influence the way they physically react to a stressor. This point has been recently studied (Nelis, Quoidbach, Mikolajczak, & Hansenne, 2009) and deserves attention from researchers in the future. From an applied point of view, it would be interesting to help athletes with low trait EI work on appraisal in order to influence the sympathetic system, and to teach them coping strategies adapted to the context (Mikolajczak & Luminet, 2008). We can also think about HRV biofeedback, to train them to decrease the sympathetic reaction under stress (Siepmann, Aykac, Unterdörfer, Petrowski, & Mueck-Weymann, 2008).

Finally, this study may help shed light on the findings of other studies dealing with trait EI and stress: For example, on the one hand, trait EI has recently been found to predict better academic performance during an exam, a real-world stressful task (Laborde, Dosseville, & Scelles, 2010); on the other hand, HRV is supposed to influence cognition (Thayer et al., 2009). Therefore, the influence of trait EI on cognition through action on the autonomous system during a stressful event might be an exciting topic for further research.

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