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Running head: Emotion and HRV

Motivational state and personality in relation to emotion, stress, and HRV responses to aerobic exercise

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ABSTRACT

This study examined emotion, stress, and performance during aerobic exercise performed in the telic and paratelic states, in relation to telic and paratelic dominance. The study tested the misfit effect and is the first to examine heart rate variability (HRV) responses to exercise in relation to both personality and motivational state. Based on their Paratelic Dominance Scale scores, participants identified as telic dominant (TD) and paratelic dominant (PD) completed ramp tests following telic and paratelic state manipulations (repeated measures). In each condition, participants watched 'serious' (telic) or 'playful' (paratelic) videos for 10 min, then performed a ramp test on a cycle ergometer whilst continuing to watch the videos throughout the entire protocol. Motivational state (telic/paratelic), HRV, emotion, and stress levels were measured at baseline, pre, post, and 15 min post-ramp test. Time to exhaustion was measured as an index of performance. Limited support was obtained for the misfit effect as interactions between state and dominance were not revealed for any of the variables with the exception of low frequent (*LF*) and the low frequent/high frequent ratio (*LF/HF* % normalized), which can be interpreted as indicating that both groups were more relaxed in their preferred state condition. Regardless, findings offer useful insight into methodological considerations for similar studies, such as consideration of the moderating effects of exercise characteristics. Our findings also confirm a number of reversal theory (Apter, 1982) proposals including the concept of dominance as an individual difference factor, with varying characteristics of different dominances, based on physiological response variables. We recommend continued research into the misfit effect with larger samples, and designs that accommodate the methodological considerations raised by the present results.

Keywords: **Reversal theory; HRV; Emotion; Stress; State manipulation**

Introduction

Exercise can have a positive influence on physical and psychological well-being (Yeung, 1996), thus influences on emotion and stress in exercise have been widely investigated (e.g., Ekkekekis, Hargreaves, & Parfitt, 2013; Hall, Ekkekakis, & Petruzzello, 2007; Rudolph & McAuley, 1998). However, evidence suggests that emotion and stress responses differ among individuals, and personality and/or exercise mode can impact on these responses (e.g., Legrand & Thatcher, 2011; Van Landuyt, Ekkekakis, Hall, & Petruzzello, 2000). Aiming to understand these effects, various studies have investigated links between personality, emotion and exercise and autonomic nervous system activity (ANS; e.g., Bosquet, Gamelin, & Berthoin, 2007; Buchheit & Gindre, 2006; Dishman et al., 2000; Friedman, 2007; Iwanaga, Kobayashi, & Kawasaki, 2005; Sakuragi, Sugiyama, & Takeuchi, 2002; Schweiger, Wittling, Genzel, & Block, 1998). More specifically, heart rate variability (HRV) has been used in various studies as a non-invasive measure of cardiac autonomic activity (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology [TFESC; NASPE], 1996). In this strategy, variations between the RR intervals of the electrocardiogram (ECG) signal are examined to determine HRV measures. Two widely used HRV analyses are the ‘time domain analysis’ method and the ‘frequency domain analysis’ method, with the latter being used widely for short-term recordings (TFESC; NASPE, 1996).

The frequency domain analysis, also referred to as ‘spectral analysis’, examines three frequency regions or bands: (i) 0.00–0.03 Hz; a very low frequency

(VLF) band, (ii) 0.03–0.15 Hz; a low frequency (LF) band, and (iii) 0.15 Hz or above; a high frequency (HF) band (TFESC; NASPE, 1996).

VLF is associated with vagal activity, rennin-angiotensin activity, thermoregulatory control, and peripheral chemoreflex activity (Leicht, Sinclair, & Spinks, 2008). The LF component is associated with parasympathetic nervous system (PNS) and sympathetic nervous system (SNS) activity (Pagani et al., 1986); i.e., when sympathetic activity is stimulated, the LF component increases. The HF component, in contrast, is associated with vagal activity (Martinmaki, Rusko, Kooistra, Kettunen, & Saalasti, 2006). The LF/HF ratio is used as a marker of sympathetic modulation and/or sympatho-vagal balance of HRV (TFESC; NASPE, 1996). Power component measures are expressed in absolute values (ms^2). However, the relative value for LF and HF in proportion to the total power minus the VLF is expressed as a normalized unit (n.u.) and is used to show the controlled and balanced behaviour of ANS for LF and HF. Normalization also minimizes the effects of LF and HF components on the change in total power.

The relationship between HRV and trait anxiety has been widely studied (e.g., Carpeggiani et al., 2005; Dishman et al., 2000; Friedman, 2007; Friedman & Thayer, 1998). The majority of studies have found that lower HRV is associated with greater anxiety or perceived emotional stress, including samples of patients with clinical anxiety, acute myocardial infarction, and healthy individuals. From a state or situational perspective, studies have investigated the relationship between HRV and changes in mood induced by manipulating states (e.g., Iwanaga et al., 2005; Sakuragi et al., 2002; Sakuragi & Sugiyama, 2005). In Iwanaga et al.'s study participants listened to sedative, excitative, or no music, which had varying effects on HRV. Both sedative and no music induced high relaxation and low tension, which resulted in an increase in the LF component and the LF/HF ratio, and a higher HF component when listening to sedative music, reflecting parasympathetic nerve system (PNS) activity and lower stress. Mood was manipulated using comedy and tragedy video stimuli by Sakuragi et al. (2002). Although these induced different mood states (more positive and negative, respectively), the LF/HF ratio and HF component of HRV decreased in response to both. Thus HRV might not reflect qualitative changes in mood states but instead only reflect changes in intensity of emotional arousal.

The effects of exercise on HRV have been widely studied (e.g., Buchheit & Gindre, 2006; Parekh & Lee, 2005; Saboul, Pialoux, & Hautier, 2013; Weinstein, Deuster, & Kop, 2007), as during exercise the ANS affects cardiovascular function regulation (Maciel, Gallo, Martin Neto, Lima Filho, & Martins, 1986). In endurance exercise, an initial vagal withdrawal is followed by an increase in sympathetic activation as the intensity of exercise increases (Iellamo, 2001). The vagal reactivation occurs post-exercise, followed by attenuation of sympathetic outflow (Perini et al., 1989), with a decrease in HF and/or an increase in LF/HF ratio for 10-15 min post exercise (Kamath, Fallen, & McKelvie, 1991; Takahashi, Okada, Saitoh, Hayano, & Miyamoto, 2000). In addition, vagal-related HRV indices [i.e., the root-mean-square difference of successive normal RR intervals (RMSSD)], the percentage of successive RR differences greater than 50 ms (pNN50), HF and HF/(LF + HF) have been shown to be related to cardiorespiratory fitness, indicated by a positive correlation between $\dot{V}O_2$ max and vagal-related HRV indices, whereas heart rate recovery was related to training load (Buchheit & Gindre, 2006).

A useful theoretical framework, which has previously been employed to explore emotional and physiological responses to exercise, is offered by reversal theory (e.g., Bindarwish & Tenenbaum, 2006; Males & Kerr, 1996; Thatcher, Reeves,

& Dorling, 2003). Reversal theory (Apter, 1982) proposes that how we interpret our experiences is dependent on our current motivational state. There are 8 motivational states in total, organised into 4 pairs of bipolar opposites: telic-paratelic, negativist-conformist, mastery-sympathy, and autic-alloic states; only the first pair is described here in line with the study's focus. The states in each pair are mutually exclusive, thus cannot be experienced simultaneously, but we can reverse between the opposite states in each pair. Each pair of states is characterised by a distinct underpinning motivational focus, for instance, the focus of the telic-paratelic state pair is on means and ends. In the telic (or serious) state, the individual is focused on achieving goals and on the future consequences of current experience, whereas in the paratelic (or playful) state, the individual is focused on the value of current experiences for their own sake, lacks regard for future consequences and has a need for spontaneity. Thus, high arousal is preferred in the paratelic state and low arousal is preferred in the telic state, with positive emotions resulting from a match between preferred and felt arousal and negative emotions from mismatched felt and preferred arousal levels. The theory proposes that the emotions experienced in the telic state are relaxation (positive) and anxiety (negative) and in the paratelic state are excitement (positive) and boredom (negative). Experienced arousal discrepancies and associated negative emotions also result in stress, termed tension stress, with attempts to reduce this stress inducing further stress, known as effort stress. Tension and effort stress can both emanate from internal and external sources.

Whilst an individual will experience both states from each pair at different times, they do have a preference for spending time in one of these states, referred to as motivational dominance, and research has demonstrated differences in preferred sport and exercise activities in relation to dominance. Telic dominant individuals prefer and participate more frequently in endurance sports (e.g., cycling), involving repetitive and more predictable movement, whereas paratelic dominant individuals prefer and participate in explosive sports (e.g., basketball) that involve intermittent, less predictable activity (Cogan & Brown, 1999; Kerr, 1991; Kerr & Svebak, 1989; Kuroda et al., 2011).

Early work by Svebak (1990) identified that individuals participating in their non-preferred exercise (e.g., paratelic dominant individuals performing endurance sport) reported unpleasant emotions, a phenomenon subsequently labelled the “misfit effect” by Spicer and Lyons (1997). Recent studies (e.g., Kuroda et al., 2011; Thatcher, Kuroda, Legrand, & Thatcher, 2011) have revealed initial support for this effect in exercise contexts. Kuroda et al. (2011) examined the misfit effect when telic and paratelic dominant individuals performed isokinetic leg extensions in both the telic and paratelic states and showed that individuals tended to perform better when metamotivational dominance and state were congruent, although this effect was not statistically significant. However, emotion and stress responses were not measured in the study. Using a cycle ergometer task, Thatcher et al. (2011) observed that telic dominant individuals were more stressed when exercising in a paratelic state and paratelic dominant individuals were more stressed when performing exercise in a telic state. However, this study did not examine emotion or performance outcome.

To date, therefore, evidence indicates associations between personality, exercise, mood state, and HRV response, but research has yet to examine these variables simultaneously. We propose that reversal theory offers a framework that brings together these different variables, allowing for such an investigation. Although there have been various psychophysiological studies using reversal theory (e.g., Gerkovich, Cook, Hoffman, & O’Connell, 1998; Martin, Kuiper, Olinger, & Dobbin, 1987; Svebak et al., 1993), revealing differences in psychophysiological responses in relation to dominance, the present study is the first to incorporate HRV, and therefore makes a novel contribution to this literature. The overall aim of this study was to examine emotion, stress, and performance during aerobic exercise performed in the telic and paratelic states, in relation to telic and paratelic dominance. Thus the study offers a test of the misfit effect and is the first to examine HRV in relation to both personality and motivational state in an exercise context. The hypotheses for the present study were that during aerobic exercise: (1) paratelic dominant individuals will report more stress and more negative emotions when exercising in the telic compared to the paratelic state, and vice versa for telic dominant individuals; (2) paratelic dominant individuals will perform better when exercising in the telic compared to the paratelic state, and vice versa for telic dominant individuals; (3) HRV measures will reflect higher stress in paratelic dominant individuals when exercising in the telic compared to the paratelic state, and vice versa for telic dominant individuals.

Method

Participants

Participants were recruited via verbal approach to undergraduate sport and exercise science students, and via email to the wider university population. Written informed consent was obtained from each participant prior to participation in the study, which was approved by the University ethics committee, and all procedures conformed to the Declaration of Helsinki (World Medical Association, 2013). The initial participant pool included 232 participants, ranging from 18 to 65 years (*M* = 21.0, *SD* = 5.3). Participants signed informed consent forms, completed a paratelic dominance measure (the PDS – see below) and provided demographic information.

From this total participant pool, two groups, each incorporating 10 participants were identified – one group involving telic dominant individuals (TD; PDS scores; *M* = 5.10, *SD* = 2.81) and the other paratelic dominant individuals (PD; PDS scores; *M* = 23.45, *SD* = 1.09) – and recruited to the study. There were 4 male and 6 female participants in the TD group, ranging from 18 to 31 years (*M* = 24.3, *SD* = 4.3), with a mean frequency of *M* = 3.75 (*SD* = 1.57) exercise sessions per week, and there were 5 male and 5 female participants in the PD group, ranging 18-38 years (*M* = 21.4, *SD* = 6.0), with a mean frequency of *M* = 3.40 (*SD* = 1.91) exercise sessions per week.

Measures

Paratelic Dominance Scale (PDS; Cook & Gerkovich, 1993). There are 30 items in the PDS, which are grouped into three theoretically-based subscales: playfulness, spontaneous, and arousal seeking. Each subscale is represented by 10 items within a true/false answer format. Responses are scored with 0 = telic option and 1 = paratelic option, resulting in a scoring range of 0-30 (0 being extremely telic and 30 being extremely paratelic).

Telic State Measure (TSM; Svebak & Murgatroyd, 1985). There are five items in the TSM to determine whether a person is in a telic or paratelic state at that specific moment, and their associated arousal and levels of effort. The five items are: serious-playful, planning-spontaneous, felt arousal (low-high), preferred arousal (low-high), and effort invested in the task (low-high). A six point rating scale with these defining adjectives at each end is used for each item. Low scores (1-3) for the serious-playful and planning-spontaneous items indicate a telic state, and high scores (4-6) indicate a paratelic state. Previous research has used only selected items from the TSM (e.g., Perkins, Wilson, & Kerr, 2001). Similarly, only the first four items (i.e., serious-playful, planning-spontaneous, felt arousal and preferred arousal) were used in this study.

Tension and Effort Stress Inventory (TESI; Svebak, 1993). There are 20 items in the TESI to measure tension stress, effort stress, pleasant emotions, and unpleasant emotions. The first four items on the TESI ask respondents to estimate: (1) the degree of pressure, stress, challenge, or demand they are exposed to in their current situation from internal and external sources (tension stress), and (2) their investment of effort in trying to cope with external situational factors (external effort stress) and their own body (internal effort stress).

The next section includes a list of 16 emotions (8 pleasant emotions: relaxation, excitement, placidity, provocativeness, pride, modesty, gratitude, and virtue, and 8 unpleasant emotions: anxiety, boredom, anger, sullenness, humiliation, shame, resentment, and guilt). The rating scale ranges from 1-7 (1 being 'not at all' and 7 being 'very much') for each item, with respondents indicating the degree to which they are experiencing each emotion. The first four items, which measure stress, and the first four emotion items (relaxation, anxiety, excitement, and boredom) were used in this study, as in previous research (e.g., Perkins et al., 2001). These emotions are the most relevant to the telic and paratelic states (Apter, 1982). The TSM and modified TESI measure can be found in the Appendix.

Procedures

The 20 selected participants attended the human performance laboratory on three separate occasions, with all visits scheduled at the same time of day. The first session was used for familiarisation to the equipment and procedures. During this visit participants' height and body mass were recorded before being seated comfortably on the cycle ergometer (Lode, Groningen, the Netherlands). Saddle height was recorded, as was handle bar height and distance from the participant's chest whilst seated. The following two visits were completed in counter-balanced order between participants, and involved state manipulation into either the telic or paratelic state via video stimuli, as in previous studies (Kuroda et al., 2011; Thatcher et al., 2011).

Participants completed the first TSM and TESI and an ECG was recorded prior to the metamotivational state manipulation (baseline). Participants' metamotivational states were manipulated via video stimuli, projected onto a 1.3 m × 1.5 m screen, for 10 minutes. A comedy video was used to induce the paratelic state (PS), and a serious documentary video was used to induce the telic state (TS). After 10 min of state manipulation, participants completed the second TSM and TESI measures and their HR was recorded (pre-exercise) before completing the performance trial.

Participants then performed aerobic exercise in the form of a ramped cycle ergometer test. The ramp increased by 30 W/min after 2 min of no resistance (0 W), until the participant reached exhaustion. During the test, participants watched the video stimulus; therefore, unlike a typical ramped test, there was no encouragement from the experimenter. Oxygen consumption was measured throughout the ramped test, as is the standard protocol for this test, but these data are not reported here. Following the ramped test, the TSM and TESI were completed, constituting post-exercise measures. After a 5 min cool down at 0-25 W, participants rested whilst seated for 10 min. ECG data were collected for the last 5 min of this rest period, after which participants completed the TSM and the TESI 15 min post-exercise.

Raw ECG data were edited and HRV analyses were performed using HRV Module for Chart v1 for Windows (ADInstruments, Castle Hill, Australia). QRS complexes were identified as follows: normal, ectopic or artefact. A configurable R wave threshold detector identified every heartbeat automatically. Normal-to-normal RR intervals were calculated for HRV. Ectopic beats were replaced using linear interpolation of the previous and succeeding normal intervals for the analysis. For the time domain analysis, the mean NN interval, RMSDD, and pNN50 were computed. The nonparametric method, Spectrum of intervals, where RR intervals are re-sampled and interpolated at intervals equal to the average period, was used to determine the frequency domain (Leicht, Sinclair, & Spinks, 2008). The Fast Fourier Transform of 1024 point to overlapping segments of the resampled RR data with a Hanning window for minimal spectral leakage was applied to calculate each power spectrum, which was computed for 5 min. For the frequency domain analysis, the data were quantified into the power spectral density of the VLF, LF, and HF.

Data Analysis

Three-way repeated measures ANOVAs (dominance * state * time) were applied to the TESI and TSM items. For TESI and TSM items, the state factor had two levels (telic: TS, paratelic: PS), as did the dominance factor (telic dominant: TD, paratelic dominant: PD) and the time factor had four levels (baseline, pre-exercise, post-exercise, 15 min post-exercise).

HRV data were used to examine changes in SNS and PNS in both conditions for both groups. Dominance (TD/PD) and state (telic/paratelic) had two levels, and time (baseline, pre- and post-exercise) had three levels. Alpha was set at 0.05.

Time to exhaustion was employed to examine performance differences between groups and between conditions using a repeated measures mixed design with two levels of the within-subject factor, state (TS, PS) and two levels of the between-subject factor, dominance (TD, PD).

For all dependent variables (i.e., TSM, TESI, HRV, time to exhaustion [min]), where significant interactions were revealed by the ANOVAs, contrasts were further analyzed with t-tests to identify specific differences between individual means. Bonferroni adjustment for the number of pairwise comparisons was employed. Greenhouse-Geisser ε corrections were used when the sphericity assumption was violated. Due to the volume of data, although all effects are reported in Tables 3 and 6, only significant effects are discussed below, excluding time related effects as these are expected in a dynamic context such as exercise and were not central to testing the study's hypotheses. Although not providing direct tests of the study's hypotheses, any main effects of state and dominance revealed do nevertheless offer supporting evidence for reversal theory constructs, hence, where significant, these are highlighted below.

Results

Motivational Dominance, State and Arousal

The PD group scored significantly higher than the TD group on total PDS score ($t(18) = -19.268$, $p < 0.001$), thus supporting group allocation.

INSERT TABLE 1 HERE

Effects of State Manipulation and Exercise on TSM reported Motivational State

Serious-Playful

There were significant main effects of dominance and state on the serious-playful item of the TSM (dominance: partial $\eta^2 = 0.571$; state: partial $\eta^2 = 0.523$; Table 3). Overall, the PD group was more playful than the TD group ($t(158) = -6.412$, $p < 0.001$; PD $M = 3.49$, $SD = 1.36$, TD $M = 2.30$, $SD = 0.95$) and both groups were more playful in the PS condition than the TS condition ($t(79) = -4.586$, $p < 0.001$; PS $M = 3.23$, $SD = 1.44$, TS $M = 2.56$, $SD = 1.08$).

Planning-spontaneous

There was a significant main effect of dominance on the planning-spontaneous item of the TSM (partial $\eta^2 = 0.759$; Table 3). The TD group was more planning oriented than the PD group ($t(158) = -16.76$, $p < 0.001$; TD $M = 1.81$, $SD = 0.81$, PD $M = 4.39$, $SD = 1.11$).

Effects of state manipulation and exercise on TSM reported arousal

Felt arousal

There was a significant main effect of state on felt arousal (partial $\eta^2 = 0.227$; Table 3). Participants reported higher felt arousal in the TS condition than the PS condition ($t(79) = 2.18$, $p = 0.032$; TS $M = 3.33$, $SD = 1.35$, PS $M = 3.06$, $SD = 1.41$).

Preferred arousal

There were no significant state or dominance main effects or interactions for preferred arousal.

INSERT TABLE 2

INSERT TABLE 3

Effects of state manipulation and exercise on TESI reported emotion and stress responses

Relaxation

There was a significant main effect of dominance on relaxation (partial $\eta^2 = 0.216$; Table 3). Overall the PD group was more relaxed than the TD group ($t(158) = -2.631$, $p = 0.009$; PD $M = 4.29$, $SD = 1.77$, TD $M = 3.60$, $SD = 1.53$).

Anxiety, Excitement and Boredom

There were no significant state or dominance main effects or interactions for anxiety, excitement or boredom.

Stress

There were no significant state or dominance main effects or interactions for any of the stress measures.

Effects of state manipulation and state dominance on performance (time to exhaustion)

There were no significant effects upon time to exhaustion (dominance: $F(1, 18) = 0.375$, $p = 0.548$; partial $\eta^2 = 0.020$; state: $F(1, 18) = 0.345$, $p = 0.564$; partial $\eta^2 = 0.019$; state * dominance: $F(1, 18) = 2.282$, $p = 0.148$; partial $\eta^2 = 0.113$).

INSERT TABLE 4 HERE

INSERT TABLE 5 HERE

INSERT TABLE 6 HERE

Cardiac Data

Heart Rate

For mean HR, the main effect of dominance was significant (partial $\eta^2 = 0.297$; Table 5). Mean HR (bpm) was higher in the PD group than the TD group ($t(118) = -3.889$, $p < 0.001$; TD $M = 74$, $SD = 13$, PD $M = 84$, $SD = 14$).

Heart Rate Variability

Descriptive data for all HRV variables are presented in Tables 4 and 5 with a summary of all *F* ratios for the three-way repeated measures ANOVAs in Table 6.

RMSSD

There was a significant main effect of dominance on RMSSD (dominance: partial $\eta^2 = 0.285$; Table 6) resulting from higher RMSSD in the TD than the PD group ($t(118) = 4.435$, $p < 0.001$; TD $M = 53.14$, $SD = 31.15$, PD $M = 31.81$, $SD = 20.46$).

HF

There was a significant main effect of dominance upon HF (dominance: partial $\eta^2 = 0.215$; Table 6), as HF (ms^2) was higher in the TD group than the PD group ($t(118) = 3.703$, $p < 0.001$; TD $M = 1224.88$, $SD = 1319.47$, PD $M = 511.19$, $SD = 698.39$).

HF: nu

There was a significant dominance effect (partial $\eta^2 = 0.243$). The TD group had significantly higher HF: nu than the PD group (TD $M = 32.45$, $SD = 14.89$; PD $M = 22.97$, $SD = 13.62$).

HF %

There were no significant state or dominance main effects or interactions for *HF %*.

LF %

There were significant state * dominance and state * time * dominance interactions (with partial $\eta^2 = 0.396$; and partial $\eta^2 = 0.264$, respectively) on LF % (Table 6). LF % was higher in the TS condition than the PS condition for the TD group ($t(29) = 2.078$, $p = 0.047$; TS $M = 83.44$, $SD = 42.78$, PS $M = 71.19$, $SD = 32.94$), but for the PD group, the value was higher in the PS condition than the TS condition ($t(29) = -2.357$, $p = 0.025$; TS $M = 65.48$, $SD = 35.60$, PS $M = 81.48$, $SD = 53.26$).

In the TD group, LF % decreased from baseline to pre-exercise in the PS condition only ($t(9) = 2.693$, $p = 0.025$), but decreases from baseline to 15 min post-exercise (TS: $t(9) = 6.925$, $p < 0.001$; PS: $t(9) = 9.831$, $p < 0.001$) and pre to 15 min post-exercise (TS: $t(9) = 3.876$, $p = 0.004$; PS: $t(9) = 3.636$, $p = 0.004$) were observed in both state conditions (Table 6, Figure 1).

For the PD group, LF % decreased from baseline to pre-exercise ($t(9) = 3.913$, $p = 0.004$) and post-exercise ($t(9) = 10.174$, $p < 0.001$) and from pre to post-exercise ($t(9) = 3.659$, $p = 0.005$) in the TS condition. In the PS condition, there were decreases from baseline to post-exercise ($t(9) = 4.932$, $p < 0.001$) and from pre to post-exercise ($t(9) = 2.916$, $p = 0.017$; Table 6, Figure 1).

INSERT FIGURE 1 HERE

LF/HF %.

There were significant state * dominance (partial $\eta^2 = 0.200$) and state * time * dominance interactions (partial $\eta^2 = 0.189$) for the LF/HF % (Table 6, Figure 2).

LF/HF % was higher in the TS condition than the PS condition for the TD group ($t(29) = 2.275$, $p = 0.030$; TS $M = 250.33$, $SD = 357.18$, PS $M = 162.19$, $SD = 170.38$). There were significant increases from baseline to 15 min post-exercise (TS, $t(9) = -2.734$, $p = 0.23$; PS, $t(9) = -2.409$, $p = 0.039$) and from pre to 15 min post-exercise (TS, $t(9) = -2.791$, $p = 0.021$; PS, $t(9) = -2.394$, $p = 0.040$) in both conditions for the TD group (Table 3). For the PD group there was a significant decrease from baseline to pre-exercise ($t(9) = 3.851$, $p = 0.004$) and a significant increase from pre to 15 min post-exercise ($t(9) = -3.017$, $p = 0.015$) in the TS condition (Table 6).

Discussion

The purpose of this study was to examine emotion, stress, and performance during aerobic exercise performed in the telic and paratelic states, in relation to telic and paratelic dominance. In doing so, we tested the misfit effect in an exercise context. The first hypothesis stated that paratelic dominant individuals will report more stress and more negative emotions during aerobic exercise in the telic state compared to the paratelic state, and vice versa for telic dominant individuals. This hypothesis was not supported, as the anticipated metamotivational state by dominance interactions were not observed. The exercise test required participants to exercise to volitional fatigue and it is possible that compared to exercise at lower intensities, contextual and motivational factors exert a limited influence on the individual's responses. This effect has been described in the dual-mode theory (Ekkekakis & Acevedo, 2006) and has been demonstrated in previous reversal theory studies (e.g., Legrand, Bertucci, & Thatcher, 2009). Although not fundamental to testing the study's hypotheses, Table 6 reports increases over time in all measures of perceived stress. These increases support the suggestion that this was a challenging test for participants and psychologically stressful as it required them to work to volitional fatigue. Therefore the exercise may have overridden many of the potential effects of state manipulation on the performance and psychological measures. The exception was felt arousal, which was significantly higher when participants exercised in the telic state. Given the wording of this item on the TSM (see Appendix) this appears to be in line with previous findings by Thatcher, Kuroda, Thatcher, and Legrand (2010) that Rating of Perceived Exertion and HR (reflecting greater work-related arousal) were both elevated at the later stages of aerobic treadmill exercise performed in a self-reported, but not manipulated, telic state. Future studies could, nevertheless, consider exercise intensity as a potential moderating variable when exploring the misfit effect.

Our second hypothesis stated that paratelic dominant individuals will perform better when exercising in the telic compared to the paratelic state, and vice versa for telic dominant individuals. This hypothesis was not supported by the study's findings, as there were no significant effects for the performance measure, time to exhaustion. Unlike the present study, previous research has identified performance differences when physical tasks were carried out in different motivational states. For instance, the paratelic state has resulted in better performance on motor tasks, such as archery (a telic activity; Kerr et al., 1997), explosive activities, such as grip strength (a paratelic activity; Perkins, Wilson, & Kerr, 2001), and high-risk activities, such as rock climbing (a paratelic activity; Howard et al., 2002). However, no studies have examined performance during an endurance exercise task to volitional fatigue when performed in different states. The lack of any dominance by state interaction in relation to performance could be due to a lack of sensitivity in the performance measure. While the ramp test is regularly used in exercise physiology laboratories to establish aerobic capacity, the motivational state of the individual may not be sufficient to override physiological limitations to test performance.

Our final hypothesis stated that cardiac measures will reflect higher stress in paratelic dominant individuals when exercising in the telic state than when exercising in the paratelic state, and vice versa for telic dominant individuals. This hypothesis was supported by (time-dependent) state by dominance interaction effects on LF % and LF/HF %. Although there were significant dominance effects on HR, RMSSD, HF, and HF:nu, these measures did not appear to be affected by the state manipulation.

In relation to dominance, overall, the telic dominant group had a lower HR than the paratelic dominant group, which is possibly linked to telic dominant individuals' preference for endurance activities and to their training status (Svebak & Kerr, 1989), as one physiological response to training in these activities is a lower resting HR and faster recovery of HR post-exercise.

A dominance main effect was also observed for mean RMSSD, HF, and HF:nu, with higher values observed in the telic dominant group than in the paratelic dominant group. The lower RMSSD reflects the increase in SNS activity, along with inhibition in PNS activities, and the lower HF component reflects a decrease in PNS activity, which is commonly observed when an individual feels anxious. Thayer et al.

(1996) compared HRV in anxiety disorder patients and non-anxious individuals and observed a lower HF component in the group of anxiety disorder patients. Therefore, in the present study, the telic dominant individuals, who spend more time in a serious state and prefer low arousal (Apter, 1982), would be expected to have a lower HF component than the paratelic dominant individuals. However, as Table 6 indicates, the telic dominant group had a higher RMSSD and HF component than the paratelic dominant group at baseline and pre-exercise indicating that they were less anxious in the test environment. This could reflect a greater habituation of the telic dominant group due to their preference for endurance activity (Kerr & Svebak, 1989; Kuroda et al., 2011).

Supporting the hypothesised misfit effect, state by dominance interactions were observed for LF % and LF/HF %. Higher values for both LF % and LF/HF % were seen in both groups in their preferred state indicating a possible increase in sympathetic activity. In support of this the increase in LF/HF is something that has previously been reported in response to a stress related task (Rantanen, Laukka, Lehtihalmes, & Seppanen, 2010). While the overall increase in LF/HF % during exercise was expected, the higher values in the participants' preferred state was not expected as this would suggest higher levels of anxiety, something that was not supported by the TESI's anxiety and stress items. This increase in LF % and LF/HF %, despite no increase in reported anxiety and stress, is in agreement with Iwanaga et al. (2005) who asked participants to listen to sedative, excitative, or no music. Both sedative and no music induced high relaxation and low tension and were associated with an increase in the LF component and the LF/HF ratio. Furthermore, Houle and Billman (1999) concluded that the LF component of HRV results from an interaction of the sympathetic and parasympathetic nervous systems and, as such, does not accurately reflect changes in sympathetic activity. Thus while the current data would suggest that the participants experienced greater sympathetic drive while exercising in their preferred state it appears that there may be a complex interaction between sympathetic drive and vagal withdrawal during and immediately following exercise, which is influenced by state by dominance interactions.

In sum, the present study provides limited support for the misfit effect (Spicer & Lyons, 1997), as the anticipated state by dominance interactions were only evident in a limited number of cardiac variables, i.e. LF % and LF/HF %. Nevertheless the study also offers some observations of note. First, as in previous research (Kuroda et al., 2011; Thatcher et al., 2011), video stimuli were successfully used to induce the telic and paratelic states in participants. Thus suggesting that external stimuli can be employed to induce specific motivational states; future studies could attempt to replicate this effect across other pairs of metamotivational states. Second, findings add further support for the concept of dominance as an individual difference factor, as differences were evident in these two groups in relation to some HRV measures, although only in one psychological variable. Unlike previous findings (Kerr et al., 2006) there were differences in relaxation between the two dominance groups. Overall, the paratelic dominance group was more relaxed than the telic dominance group, which matches their motivational profile. Third, the present study lends support for the reversal theory proposal that dominance groups are not only distinguished by their motivational orientations and psychological responses to different stimuli, but also by their physiological responses, in this case, HRV. Fourth, future research could explore the moderating effects of exercise intensity and mode (e.g., explosive or endurance) to determine if a psychologically based phenomenon such as the misfit effect is superceded by physiological cues during certain exercise modes and intensities, as the dual mode theory would suggest. We propose, in conclusion, that although our study found limited support for the misfit effect, it would be premature to cast doubt on the integrity of the effect. The effect is consistent with reversal theory propositions and the increasing evidence that supports these propositions (including the present study) suggests that further inquiry into this effect with larger samples is warranted.

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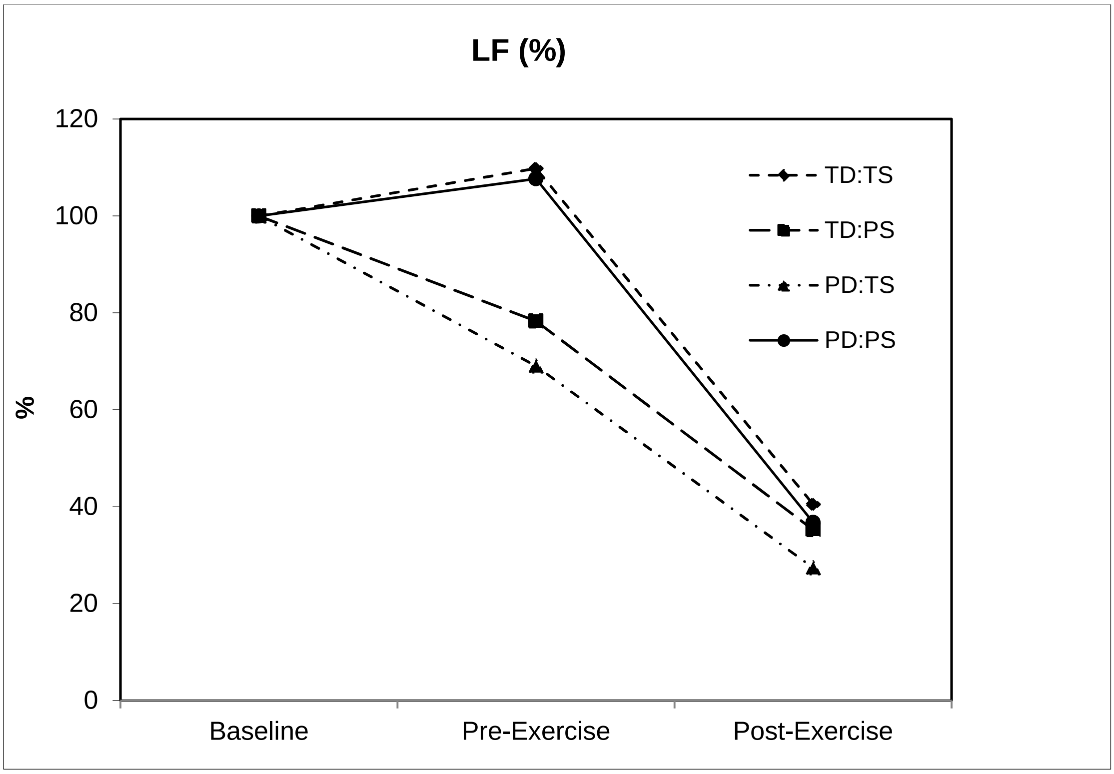

Figure 1: LF % for telic (TD) and paratelic (PD) dominance groups in the telic (TS) and paratelic (PS) state conditions at baseline, pre-, and post-exercise. Values are presented as group mean ± SEM.

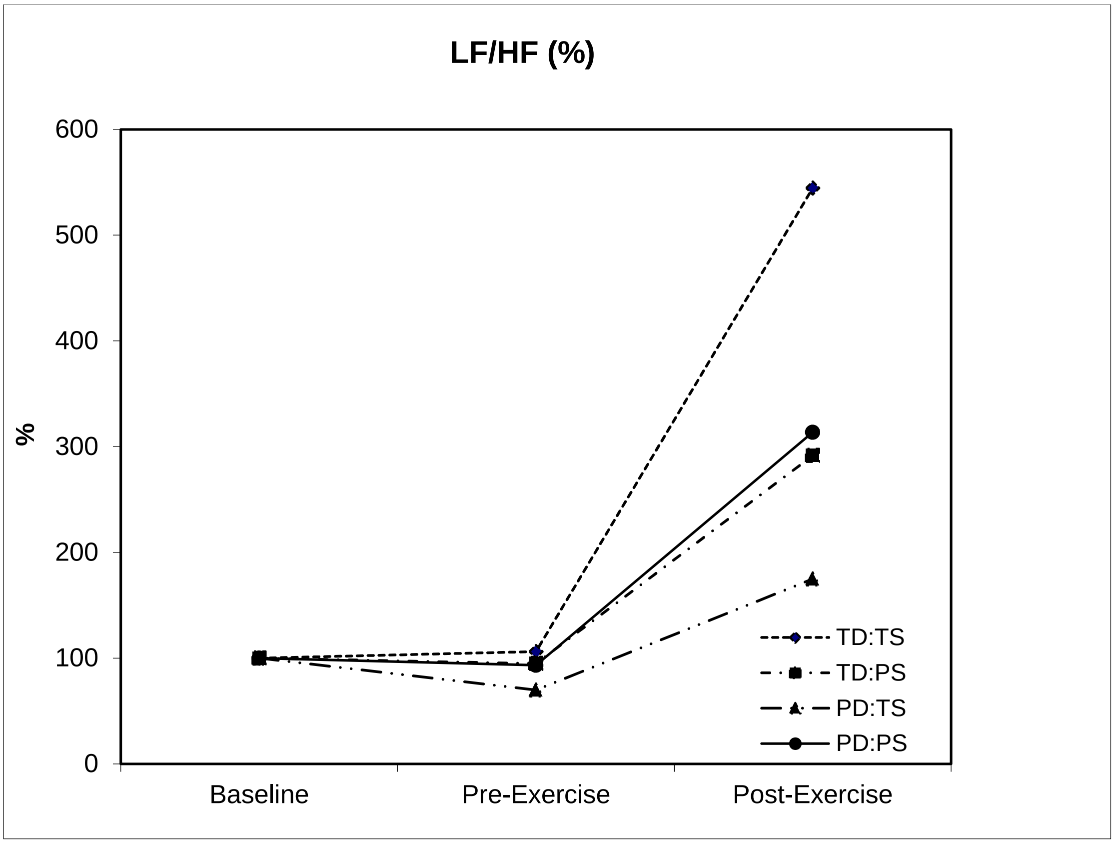

Figure 2: LF/HF % for telic (TD) and paratelic (PD) dominance groups in the telic (TS) and paratelic (PS) state conditions at baseline, pre-, and post-exercise. Values are presented as group mean ± SEM.

Table 1: TSM scores for telic and paratelic dominance groups at baseline (base), pre-, post-, and 15 min post-exercise in the telic and paratelic state conditions.

TD group

	TS manipulation								**PS manipulation**							
	Base		Pre-		Post-		15 min Post-		Base		Pre-		Post-		15 min Post-	
TSM	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Serious-playful	2.5	0.53	1.8	0.79	1.7	0.95	2.2	0.63	2.4	0.7	3.4	0.7	2.1	1.2	2.3	1.06
Planning-spontaneous	2	1.05	1.7	0.67	1.7	0.67	1.7	0.48	2.2	1.32	1.9	0.88	1.8	0.63	1.5	0.53
Felt arousal	2.9	0.99	3.4	0.84	5.2	0.63	2.2	0.79	2.5	1.35	3	0.47	4.9	0.57	1.8	0.63
Preferred arousal	3.6	1.35	4.1	0.74	4.5	1.18	2.7	1.06	3.2	1.23	3.8	1.14	4.4	1.43	2.8	1.14

PD group

	TS manipulation								**PS manipulation**							
	Base		Pre-		Post-		15 min Post-		Base		Pre-		Post-		15 min Post-	
TSM	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Serious-playful	3.8	1.03	2.7	0.48	2.2	0.79	3.6	1.17	4.4	1.35	5	0.94	2.8	1.48	3.4	1.17
Planning-spontaneous	4.5	1.18	4.3	1.25	4.2	1.03	4.5	1.27	4.6	1.07	4.7	0.95	4.1	1.1	4.2	1.23
Felt arousal	3	1.25	2.8	0.79	4.7	1.06	2.4	0.97	2.1	0.74	3.1	1.29	4.5	1.08	2.6	1.35
Preferred arousal	4.1	1.6	3.9	1.52	4.4	1.58	3.1	1.66	3.8	1.48	4.3	1.49	4.6	1.51	3.2	1.62

Table 2: TESI scores for the telic and paratelic dominance groups at baseline (base), pre-, post-, and 15 min post-exercise in the telic and paratelic state conditions.

TD group

	TS manipulation								**PS manipulation**							
	Base		Pre-		Post-		15 min Post-		Base		Pre-		Post-		15 min Post-	
TESI	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Relaxation	4.2	1.23	3.8	1.23	2.2	1.23	4.5	1.43	3.9	1.37	3.2	1.48	2.3	1.34	4.7	1.06
Anxiety	3	1.7	2.9	1.29	3	1.83	1.8	0.79	3.1	1.37	2.9	0.88	2.3	1.34	2.2	1.32
Excitement	3.3	1.25	2	0.82	3.3	1.77	2	0.94	2.8	1.23	2.4	0.52	3.4	1.17	1.7	0.82
Boredom	1.8	1.03	2.5	2.01	1.8	1.62	2.5	2.01	2.2	1.75	1.4	0.84	1.2	0.42	1.9	1.66
External tension stress	2.3	0.95	3.1	1.73	4.1	1.85	1.9	0.99	2.1	1.52	2.8	1.4	4.1	1.45	2	1.33
Internal tension stress	2.9	1.52	3.3	1.25	5	1.33	2.6	1.26	2.5	1.18	3	0.94	4.7	1.42	2.2	0.92
External effort stress	2.1	0.99	2.3	0.95	3.5	1.84	2.1	1.1	2.2	1.62	2.5	0.85	4.1	1.6	1.9	1.2
Internal effort stress	3.1	1.6	3.3	1.42	5.2	1.03	2.2	1.14	2.4	1.17	2.6	0.7	5.4	0.97	2.1	1.2

PD group

	TS manipulation								**PS manipulation**							
	Base		Pre-		Post-		15 min Post-		Base		Pre-		Post-		15 min Post-	
TESI	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Relaxation	5.5	0.97	4	1.41	1.9	0.57	5.4	1.26	5.4	1.17	4.7	1.16	2.3	1.34	5.1	1.37
Anxiety	2.2	0.92	2.5	1.27	1.9	1.29	1.8	1.03	2.1	1.2	2.1	1.1	2.1	1.6	1.8	0.92
Excitement	3.2	1.55	2.7	1.95	3.2	1.62	2.1	0.88	3.1	1.2	3.4	1.43	3	1.33	2.3	0.95
Boredom	1.3	0.48	2.9	1.6	1.2	0.42	2.7	1.83	2.3	1.7	2.2	1.4	1.6	0.52	3.4	1.58
External tension stress	2.1	0.99	2.5	1.27	3.5	1.78	1.8	0.63	2.1	1.2	2.1	0.99	3.3	1.57	1.9	0.88
Internal tension stress	2.5	1.72	2.3	0.95	5.2	0.79	2.2	1.03	2.5	1.27	2.5	1.18	5.3	1.06	2.6	1.17
External effort stress	2.5	1.43	2.2	1.14	3.8	2.49	2.2	1.4	2.4	1.35	2.1	1.1	3.4	2.07	2.2	1.55
Internal effort stress	2.8	1.87	2.6	1.26	5.3	1.42	2.5	1.51	2.5	1.51	2.3	1.42	4.8	1.55	2.5	1.43

Table 3: Summary of *F* ratios for three-way repeated measures ANOVAs on dominance (TD/PD), state (TS/PS) and time (baseline, pre-, and post-exercise) for TSM and TESI variables; * $p < 0.05$.

Variable	dominance	state	state*dominance	time	time*dominance	state*time	state*time*dominance
TSM	(df = 1, 18)	(df = 1, 18)	(df = 1, 18)	(df = 3, 54)	(df = 3, 54)	(df = 3, 54)	(df = 3, 54)
Serious-playful	23.94*	19.74*	1.19	9.52*	1.83	18.06*	1.31
Planning-spontaneous	56.72*	0.12	0.03	3.57*	0.90	1.18	0.16
Felt arousal	0.14	5.30*	0.97	51.63*	1.68	1.27	1.30
Preferred arousal	0.35	0.04	0.49	15.54*	0.49	1.20	0.65
TESI							
Relaxation	4.95*	0.006	1.31	37.79*	2.47	0.39	1.49
Anxiety	2.33	0.09	0.003	4.63*	0.89	0.54	1.24
Excitement	0.46	0.03	0.29	11.94*	2.15	1.82	0.45
Boredom	0.36	0.08	3.64	11.48*	3.06	4.90*	0.46
External tension stress	0.84	0.36	0.004	22.35*	0.92	0.52	0.11
Internal tension stress	0.21	0.30	2.67	36.67*	1.37	0.11	0.13
External effort stress	0.001	0.01	1.64	15.61*	0.55	0.21	1.79
Internal effort stress	0.10	3.14	0.02	40.03*	0.74	0.80	0.98

Table 4: HR and HRV variables in the TD group at baseline (base), pre- and 15 min post-exercise in the telic and paratelic state conditions.

	TS manipulation						**PS manipulation**					
	Base		Pre-		15 min post-		Base		Pre-		15 min post-	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Mean HR (bpm)	68	10	69	9	88	9	68	9	65	9	88	9
Mean NN (ms)	897	134	889.7	121	684	65.9	899.98	141	936	151	685.9	69.2
SDNN (ms)	85.2	31	84.04	32.3	42.26	17.4	88.65	29.2	72.8	20.7	45.11	25.8
RMSSD	65.16	30.5	68.26	30.4	25.9	18.1	67.14	29.4	60.2	22.3	32.24	28.6
NN50	20.45	12.8	19.88	13.8	2.62	4.06	26.68	12.9	24.3	14.8	6.51	8.06
VLF [DC-0.04Hz] (ms^2)	3572	3473	3430	2857	742.6	577	3831.88	2255	1958	1213	1023	1068
LF [0.04-0.15Hz] (ms^2)	2278	1826	2306	1850	887.9	846	2620.37	2475	1869	1602	861.4	728
HF [0.15-0.4Hz] (ms^2)	1687	1399	1925	1772	280.3	321	1562.93	1461	1318	931	576.8	914
LF: nu	53.55	13.8	52.39	11.4	73.59	14.3	59.26	10.9	55.2	17.5	67.82	20.4
HF: nu	40.42	13.5	40.67	10.3	16.59	7.89	35.36	10.3	39.9	16.2	21.83	10.6
LF/HF	1.58	0.87	1.49	0.92	6.14	4.13	1.87	0.78	1.74	1	4.78	4.54
LF (%)	100	0	109.8	45.1	40.5	27.2	100	0	78.3	25.5	35.26	20.8
HF (%)	100	0	121.3	77.7	17.5	17.7	100	0	106	60.6	28.02	27
LF/HF (%)	100	0	106.3	46.5	544.7	514	100	0	95	48.3	291.6	252

Table 5: HR and HRV variables in the PD group at baseline (base), pre- and 15 min post-exercise for the telic and paratelic state conditions.

	Telic state manipulation						**Paratelic state manipulation**					
	Base		Pre-		15 min post-		Base		Pre-		15 min post-	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Mean HR (bpm)	79	10	77	9	99	10	78	11	75	11	98	11
Mean NN (ms)	768.7	84.7	786	84.2	612.5	61.7	783.53	99.2	817	109	619.1	67
SDNN (ms)	63.66	21.9	54.36	16.9	32.6	10.7	68.46	28.1	63.8	19.7	33.3	15.7
RMSSD	35.72	16.1	36.16	17.6	15.56	10.7	41.52	22.2	40.5	19.6	21.42	23.3
NN50	15.01	12.9	16.25	15	1.03	2.2	17.13	15	20.7	15.5	3.5	6.54
VLF [DC-0.04Hz] (ms^2)	2027	1499	1109	652	637.5	466	2412.03	2071	2053	1726	544.3	466
LF [0.04-0.15Hz] (ms^2)	1770	1325	1087	761	321.2	298	2326.4	3749	1414	736	416.2	405
HF [0.15-0.4Hz] (ms^2)	594.7	512	657.2	615	102	164	833.68	1218	719	659	160.4	308
LF: nu	73.36	14.2	62.99	18.8	71.25	17.7	71.36	14.1	68.7	16.7	69.93	24.1
HF: nu	23.14	12.4	31.08	16.5	15.22	8.83	24.06	12.4	27.4	15.2	16.9	11.1
LF/HF	5	4.2	4.22	4.92	7.44	7.05	4.54	3.58	4.21	3.72	8.47	8.52
LF (%)	100	0	69.05	25	27.41	22.6	100	0	108	64.3	36.77	40.5
HF (%)	100	0	106.6	51.6	20.71	23.9	100	0	117	65	32.43	52
LF/HF (%)	100	0	69.9	24.7	174.9	106	100	0	93.3	39	313.6	472

Table 6: Summary of *F* ratios for three-way repeated measures ANOVAs on dominance (TD/PD), state (TS/PS) and time (baseline, pre-, and post-exercise) for HR and HRV variables; * $p < 0.05$.

Variable	dominance	state	state*dominance	time	time*dominance	state*time	state*time*dominance
	(df = 1, 18)	(df = 1, 18)	(df = 1, 18)	(df = 2, 36)	(df = 2, 36)	(df = 2, 36)	(df = 2, 36)
Mean HR (bpm)	7.60*	1.46	0.02	81.01*	0.07	1.69	0.23
Mean NN (ms)	8.00*	1.87	0.00	55.84*	0.85	2.75	0.40
SDNN (ms)	4.37	0.28	1.13	42.22*	0.78	0.54	3.18
RMSSD	7.18*	0.68	0.64	27.94*	2.33	1.31	0.83
NN50	1.49	2.89	0.16	38.15*	0.76	0.08	0.21
VLF [DC-0.04Hz] (ms^2)	3.75	0.05	2.52	16.73*	1.23	0.41	2.58
LF [0.04-0.15Hz] (ms^2)	1.20	0.50	0.82	9.13*	0.17	1.12	0.47
HF [0.15-0.4Hz] (ms^2)	4.93*	0.01	0.82	12.77*	1.60	2.20	2.16
LF: nu	4.14	0.11	0.00	4.06*	2.42	1.33	0.90
HF: nu	5.78*	0.03	0.00	23.06*	2.35	2.48	1.67
LF/HF	4.16	0.00	0.09	14.21*	0.07	0.02	0.69
LF (%)	0.40	0.21	11.79*	36.87*	0.08	0.06	6.45*
HF (%)	0.01	0.26	0.65	33.15*	0.03	0.63	0.62
LF/HF (%)	1.85	0.26	4.49*	11.68*	1.43	0.43	4.19*

Appendix

Telic State Measure (TSM)

Please rate your feelings at this moment in terms of the four following rating scales. Do this by circling a number.

1. Estimate here how playful or serious you feel.

Serious |_____|_____|_____|_____|_____| Playful
1 2 3 4 5 6

2. Estimate here how far you would prefer to plan ahead or to be spontaneous.

Preferred planned |_____|_____|_____|_____|_____| Preferred spontaneous
1 2 3 4 5 6

3. Estimate here how aroused ("worked up") you actually feel.

Low Arousal |_____|_____|_____|_____|_____| High arousal
(not at all "worked up") 1 2 3 4 5 6 (extremely "worked up")

4. Estimate here the level of arousal how "worked up" you would like to feel.

Preferred low |_____|_____|_____|_____|_____| Preferred high
1 2 3 4 5 6

5. Estimate here how much effort you invested in the task.

Low effort |_____|_____|_____|_____|_____| High effort
1 2 3 4 5 6

1. By "*serious*" here is meant the feeling that you are pursuing (or at least thinking about) some essential goal. For example, the goal may be to achieve something in the future which you believe to be important, or it may be to overcome some real danger or threat in the present.
   By "*playful*" is meant the feeling that you are doing what you are doing for its own sake. In this case your activity is felt to be enjoyable in itself and not to require any further justification. Any goal which there might be is really an excuse for the behavior.
2. By "*planning ahead*" is meant trying to organize your behavior in such a way that it leads effectively to some goal in the (perhaps distance) future, and being aware of the future consequences of your present actions.
   By "*spontaneous*" is meant that your actions are undertaken on impulse, with little regard for future consequences. Note that this scale asks for your *preference* at the time in question, rather than your ability to plan or be spontaneous.
3. By "*arousal*" here is meant how "worked up" you feel. You might experience high arousal in one of a variety of ways, for example as excitement or anxiety or anger. Low arousal might also be experienced by you in one of a number of different ways, for example as relaxation or boredom or calmness.
4. "*Arousal*" has the same meaning for this scale as for the previous one, but now the emphasis is on the level of arousal you *want* rather than the level of arousal which you are actually experiencing.

Modified Tension Effort Stress Inventory (TESI)

Please give your answers by circling the appropriate figures.

A. Estimate the degree of pressure, stress, challenge, or demand that you are exposed to in the current situation as due to:

No pressure Very much

External factors: 1 - 2 - 3 - 4 - 5 - 6 - 7
Your own body: 1 - 2 - 3 - 4 - 5 - 6 - 7

B. Estimate the degree of effort that you put up in the current situation to cope with pressure etc. from:

No effort Very much

External factors: 1 - 2 - 3 - 4 - 5 - 6 - 7
Your own body: 1 - 2 - 3 - 4 - 5 - 6 - 7

C. Estimate here the degree to which you experience the following moods or emotions in the current situation:

Not at all Very much
Relaxation: 1 - 2 - 3 - 4 - 5 - 6 - 7

Anxiety: 1 - 2 - 3 - 4 - 5 - 6 - 7

Excitement: 1 - 2 - 3 - 4 - 5 - 6 - 7

Boredom: 1 - 2 - 3 - 4 - 5 - 6 - 7