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In the zone: An exploration of personal characteristics underlying affective responses to heavy exercise

Leighton Jones¹, Jasmin C. Hutchinson², Elizabeth M. Mullin³

¹ Academy of Sport and Physical Activity, Sheffield Hallam University, UK

² Department of Exercise Science and Sport Studies, Springfield College, USA

³ Department of Physical Education and Health Education, Springfield College, USA

Corresponding author:

Dr Leighton Jones. A212 Collegiate Hall, Collegiate Campus, Sheffield Hallam University. Sheffield. S10 2BP. UK. leighton.jones@shu.ac.uk

"As accepted for publication in *Journal of Sport & Exercise Psychology*, ©Human Kinetics"

Abstract

1 Positive affective responses to exercise have been linked with longer term adherence. The
2 Dual-Mode Model indicates that affective responses during heavy exercise (between the
3 ventilatory threshold and the respiratory compensation point) are subject to interindividual
4 variability (*zone of response variability*). Participants ($N = 48$) completed measures to assess
5 personal characteristics prior to a graded exercise test (GXT). Responses to the Feeling Scale
6 were recorded during the GXT and subsequently used to group participants as either Negative
7 Responders or Neutral/Positive Responders to heavy exercise. Discriminant Function
8 Analysis was applied and a significant weighted linear composite predicted affective
9 response. Preference for exercise intensity and sex were significant predictors ($p = .003$).
10 Negative Responders had lower Preference scores and were more likely to be men. The
11 combination of these two variables successfully predicted group membership 71% of the
12 time. Individual differences appear relevant when examining affective responses to heavy
13 exercise.
14

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16 **Keywords:** Personality, physical activity, pleasure, sensation seeking, preference

1 reasons for the variable affective response during heavy exercise, but Ekkekakis (2003)
2 proposed that the interplay of cognitive appraisal and interoceptive cues drives such
3 variability. A greater understanding of what is driving these interindividual differences in
4 affective responses to exercise may help practitioners to personalise exercise prescriptions and
5 therefore deliver exercise experiences that are more consistently pleasurable, and in turn,
6 more sustainable.

7 In a study seeking to further understand the cognitive factors influencing affective
8 responses at an exercise intensity proximal to T_{vent} , Rose and Parfitt (2010) adopted a
9 qualitative approach using a ‘think aloud’ procedure. Thematic analysis revealed concepts
10 relating to pre-exercise affective state, perceptions of ability, immediate and anticipated
11 outcomes, attentional focus, and perceptions of control as salient in determining affective
12 response. This approach afforded the researchers a rich insight into participants’ cognitions
13 but limited the researchers’ capacity to account for the role of traits in determining affective
14 responses at this exercise intensity. Jones, Karageorghis, Lane, and Bishop (2017) examined
15 dominant attentional style and motivation as predictors of affective responses to group
16 exercise and results revealed that individuals with a dominant associative attentional focus
17 and self-determined motivation derived the greatest pleasure from sessions. However, their
18 study did not examine responses in relation to T_{vent} and it is unknown how influential these
19 specific individual factors are in determining affective responses in the zone of response
20 variability. There are a number of traits that are likely determinants of affective responses
21 during exercise. Previous research has indicated that these might include preference for, and
22 tolerance of, exercise (Ekkekakis, Hall, & Petruzzello, 2005), and traits from classic
23 personality theories (e.g., extraversion, and sensation seeking; Ekkekakis, Hargreaves, &
24 Parfitt, 2013; Zuckerman, 1983). However, few studies have sought to address these traits in
25 direct relation to the tenets of the DMM.

1 Hall, Petruzzello, Ekkekakis, Miller, and Bixby (2014) discussed how individual
2 differences could play a role in exercise testing and prescription, but noted that these
3 differences have been understudied in this context. Hall et al. examined preference for, and
4 tolerance of, exercise intensity across a range of exercise testing protocols. Preference for
5 exercise intensity is described as the “predisposition to select a particular level of exercise
6 intensity when given the opportunity” and tolerance is “a trait that influences one’s ability to
7 continue exercising at an imposed level of intensity beyond the point at which the activity
8 becomes uncomfortable or unpleasant” (Ekkekakis et al., 2013; p.354). Preference has been
9 shown to be a relevant factor in self-selecting exercise intensity (Smith, Eston, Tempest,
10 Norton, & Parfitt, 2015). Further, Hall et al.’s (2014) findings that preference and tolerance
11 were positively correlated with performance in exercise tests indicated these characteristics
12 are relevant for exercise testing and prescription. However, their study did not explore the
13 relationship between preference, tolerance, and affective responses to exercise. Among the
14 scant previous work exploring the relationship between preference and tolerance, and in-task
15 affective responses was Ekkekakis et al.’s (2005) study where they found that preference and
16 tolerance were significantly correlated with Feeling Scales scores above T_{vent} . Ekkekakis et al.
17 also examined the ability of the PRETIE-Q scales to predict affective responses to bouts of
18 physical activity at different levels of intensity using hierarchical multiple regression
19 analyses. The Preference and Tolerance scales both accounted for significant portions of the
20 variance in affective valence when exercise intensity was at T_{vent} , while only the Tolerance
21 scale accounted for significant portions of the variance when the intensity exceeded T_{vent} .
22 Neither scale was significantly related to affective responses below T_{vent} . It appears that
23 preference and tolerance are relevant variables in the context of affective response during
24 moderate to vigorous exercise and warrant additional research attention. The previous work
25 done by Ekkekakis et al. involved young physically active participants; therefore, more

1 attention should be given to examining these relationships in older and less active populations
2 (Ekkekakis et al., 2005).

3 Outside of physical activity contexts, personality traits have been associated with
4 affective experience in day-to-day life (e.g., Larsen & Ketelaar, 1989). The Big Five
5 personality model (extraversion, neuroticism, openness, agreeableness, and
6 conscientiousness) was proposed as a generalizable model to examine psychological and
7 behavioural outcomes (De Raad, 2000), and has been the subject of voluminous empirical
8 work. In their seminal work, Costa and McCrae (1980) demonstrated that extraversion related
9 strongly to positive affect and neuroticism to negative affect. Further work has identified a
10 link between conscientiousness and trait positive affect (Watson, David, & Suls, 1999), and
11 this link has since been extended by Lochbaum and Lutz (2005) who found higher
12 conscientiousness was associated with greater enjoyment of a step aerobics class. The
13 influence of personality on exercise has been subject to extensive research (Rhodes & Smith,
14 2006; Rhodes & Pfaeffli, 2012) but early work in the area led to a number of inconsistent
15 findings (see Hall et al., 2014). More recent meta-analyses have sought to clarify the role of
16 personality in exercise and health contexts (Wilson & Dishman, 2015). Conceptually, it has
17 been proposed that extraverts seek out strong sensory stimuli (Eysenck, Nias, & Cox., 1982),
18 and that physical activity might fulfil a drive for stimulation. Neuroticism is related to
19 heightened autonomic responsiveness to intense stimuli and individuals with high neuroticism
20 tend to be predisposed to negative affect (Gray, 1991); this could account for negative affect
21 during exercise if the increased physiological arousal is perceived negatively (Wilson &
22 Dishman, 2015). Individuals with a greater degree of openness are receptive to new
23 experiences and different types of physical activity, and a recent analysis by Wilson and
24 Dishman (2015) revealed a correlation between openness and physical activity. It has been
25 proposed that conscientious people might have more effective self-regulation (Ingledeu,

1 Markland, & Sheppard, 2004); a greater capacity to regulate feelings when interoceptive cues
2 are challenging the maintenance of positive emotions (i.e., above T_{vent}) would be beneficial
3 for maintaining a pleasant exercise experience.

4 There is evidence that high levels of extraversion and conscientiousness and low
5 levels of neuroticism relate to high levels of physical activity among younger adults (Rhodes
6 & Smith, 2006). Further, high levels of extraversion, openness, conscientiousness, or low
7 levels of neuroticism in older adults results in greater energy expenditure at peak walking
8 pace (Terracciano et al., 2013). However, there does not appear to be a relationship between
9 agreeableness and physical activity (Wilson & Dishman, 2015). There is a pattern between
10 personality dimensions and physical-activity levels that appears relatively consistent across
11 age groups, culture, gender, and activity modes (Rhodes & Pfaeffli, 2012). While the
12 evidence linking personality and behaviour has developed, there has been less focus on the
13 role that personality can play in how people *feel* during exercise. Beyond the Big Five
14 dimensions, Schneider and Graham (2009) found that behavioural inhibition was correlated
15 with decreases in pleasure during “hard” intensity exercise (average of work rate at T_{vent} and
16 VO_{2peak}). However, the “hard” exercise intensity employed in the Schneider and Graham
17 (2009) study makes inference to the DMM difficult as this average work load might have
18 been above or below RCP depending upon an individual’s fitness; if above RCP this would
19 have likely led to a sharp decline in pleasure, but if below, would have led to a more variable
20 response.

21 The links expounded in previous work between the Big Five dimensions and the
22 amount of physical activity done might, in part, be a consequence of how individuals *feel*
23 during exercise (i.e., they undertake more exercise because it feels good). An examination of
24 whether individuals with certain personality traits respond more favourably during physical
25 exercise appears warranted and could help to understand the drivers behind the relationships

1 between personality traits and physical activity behaviour.

2 Sensation seeking has been proposed as a distinct trait and has been linked to high-risk
3 sport participation (e.g., Jack & Ronan, 1998), but its role in exercise is less well understood.
4 Zuckerman (1994) defined sensation seeking as “the seeking of varied, novel, complex, and
5 intense sensations and experiences and the willingness to take physical, social, legal, and
6 financial risks for the sake of such experiences” (p.27). Hedonic allostasis theory (Koob & Le
7 Moal, 1997) conceptualises certain behaviours (e.g., sensation seeking, compulsive exercise)
8 as a response to hypoactivity in dopamine systems (Dishman & Holmes, 2012). The
9 behaviors (i.e., physical activity) are engaged in to restore normal hedonic tone, and recent
10 evidence has shown that sensation seeking might be more strongly characterised by the
11 intensity of an experience, rather than the novelty (Minkwitz et al., 2016). The findings of
12 Minkwitz et al. (2016) indicated that individuals with high sensation seeking scores expended
13 more energy during everyday activities, and the intensity element of sensation seeking was
14 significant in this relationship. The preference for experiences of greater intensity alludes to
15 more positive affective response to such activities and the results of Minkwitz et al. (2016)
16 could suggest that sensation seeking is a relevant variable in understanding affective
17 responses in an exercise context where the intensity of the experience can vary greatly.

18 In his proposal for the DMM, Ekkekakis (2003) highlighted a void in the literature
19 pertaining to personality and affective responses to exercise, stating that this “is partly due to
20 the fact that the standard measures of relevant personality traits (e.g., extraversion, sensation
21 seeking, behavioural activation/inhibition, etc.) emphasise social behaviour over responses to
22 somatosensory stimuli...Nevertheless, individual differences are likely to play an important
23 role” (p. 221). The purpose of this study was to explore the extent to which a range of
24 personal characteristics influence affective responses in the zone of response variability (i.e.,
25 exercise intensity between T_{vent} and RCP) as identified in the DMM. This includes

1 characteristics pertaining to social behaviour (cognitive) and responses to somatosensory
2 stimuli (interoceptive). Given the exploratory nature of the study and the scant previous work
3 examining the role of personality variables in determining affective responses at specific
4 exercise intensities, we tentatively hypothesised that individuals who experience a decline in
5 pleasure during heavy exercise will: report a lower preference for, and tolerance of, exercise
6 intensity (H_1); lower scores on the personality dimensions of extraversion, openness,
7 conscientiousness, and higher on neuroticism (H_2); score lower on the sensation seeking scale
8 (H_3).

9 **Methods**

10 The experimental approach was approved by ethics committees at the host institutions in England
11 and the USA. All aspects of the study conform to the Helsinki Declaration on Human Rights
12 (2013).

13 **Participants**

14 Participants were recruited to this multisite study from England and the USA.
15 Advertisements for participants were placed at two institutions and recruitment relied upon a
16 snowball sampling strategy. Participants were eligible for inclusion if they were free from
17 cardiorespiratory disease and had no other health contraindications; participation did not
18 require a certain level of physical fitness or BMI and the upper and lower age limit was 64
19 years and 18 years, respectively. No significant mean differences (all $ps > .05$) were found in
20 age, BMI, and VO_{2peak} between the two sites (Table 1). Experimental participants were aged
21 between 18-50 years ($M_{age} = 30.33$, $SD = 7.54$) and included 21 women and 27 men. The
22 physical fitness of the participants ranged from unfit to highly trained (self-reported) which
23 was evident in the range of VO_{2peak} data recorded (Range 21.68–66.01ml/kg/min; $M =$
24 45.68, $SD = 9.35$). BMI ranged from 18.4–43.82 kg/m² ($M = 25.3$, $SD = 4.4$). Descriptive
25 statistics for the demographics variables are presented in Table 1, broken down by gender and

1 by testing site. The sample included participants from a wide range of ethnicities and
2 sociocultural backgrounds.

3 **Measures**

4 **Before Exercise. *Preference for, and Tolerance of, the Intensity of Exercise***
5 ***Questionnaire (PRETIE-Q; Ekkekakis, Hall, & Petruzzello, 2005).*** Participants completed
6 the PRETIE-Q to identify preferred intensity of exercise and tolerance of exercise intensity.
7 The questionnaire comprises 16 items with a response scale ranging from 1 (*I totally*
8 *disagree*) to 5 (*I totally agree*). Items to identify preference for exercise intensity included
9 “I’d rather go slow during my workout, even if that means taking more time” and “When I
10 exercise, I usually prefer a slow, steady pace”. Items to identify tolerance of exercise intensity
11 included “When my muscles start burning during exercise, I usually ease off some” and
12 “Feeling tired during exercise is my signal to slow down or stop”. Cronbach’s alpha levels of
13 0.84 for the Preference scale and 0.80 for the Tolerance scale represent satisfactory internal
14 consistency (Hall et al., 2014). In the current study, Cronbach’s alpha was .84 for the
15 Preference scale and .75 for the Tolerance scale.

16 ***International Personality Item Pool (IPIP - Inventory based on Costa and McCrae’s***
17 ***[1992] NEO-PI-R Domains).*** Public domain scales from the IPIP (Goldberg et al., 2006)
18 were used to measure the Big Five dimensions of personality (extraversion, openness,
19 conscientiousness, agreeableness, neuroticism). The public domain scales have been shown to
20 correlate highly with the commercial scales of the NEO Five-Factor Inventory (Costa &
21 McCrae, 1992) and have strong evidence to support their validity (Goldberg et al., 2006;
22 Ingledew & Markland, 2008). The 50-item questionnaire included 10 items for each of the
23 five subscales and a response scale of 1 (*very inaccurate*) to 5 (*very accurate*) was used for
24 each item. Items were phrased as statements (e.g., “Am interested in people”; “Keep in the
25 background”) and participants were required to respond by indicating the extent to which the

1 statement was accurate. Cronbach's alpha for the IPIP in the current study ranged from .76
2 (Conscientiousness) to .91 (Extraversion), and therefore was considered to have adequate
3 internal consistency.

4 **Sensation Seeking Scale-V (SS-V; Zuckerman, Eysenck, & Eysenck, 1978).** The SS-
5 V was administered to assess the participant's need for varied, novel, intense, and complex
6 sensations and experiences. The scale comprises 40 items that require a forced-choice
7 between two statements. Participants are instructed to indicate "which of the choices most
8 describes your likes or the way you feel", and the overall score for the 40 items represents a
9 general sensation seeking score. Internal consistency coefficients for the subscales within the
10 SS-V ranged from 0.67 – 0.84 (Zuckerman, 1979). In the current study, Kuder Richardson
11 KR-20 coefficient was calculated as .83 for the general sensation seeking score.

12 **During Exercise. The Feeling Scale (FS; Hardy & Rejeski, 1989).** In-task affective
13 valence was assessed using Hardy and Rejeski's (1989) 11-point Feeling Scale which has a
14 single-item response scale ranging from +5 (*very good*) to -5 (*very bad*). The scale has
15 demonstrated satisfactory validity (Hardy & Rejeski, 1989).

16 **Procedure**

17 Participants attended a single testing session during which they completed the
18 questionnaires prior to exercise. Participants were familiarised with the in-task measures and
19 then began a treadmill protocol designed to elicit maximal capacities (a continuous ramp test
20 based on the Bruce Protocol [Will & Walter, 1999]). The protocol maintained the 3 min stage
21 markers of the Bruce Protocol (e.g., 12% gradient and 2.5mph at min 6, 14% gradient and 3.4
22 mph at min 9), but the gradient and treadmill belt velocity increased gradually every 15s
23 rather than steeply every 3 min. Participants were asked to respond to the FS 10s prior to the
24 end of each 1-min of the protocol, and were asked to exercise until volitional exhaustion. The
25 use of a facemask to collect expired gases prohibited a verbal rating, therefore participants

1 pointed to a number on the scales, which were held directly in front of them whenever
2 responses were required. After each response, a researcher repeated the participant's selection
3 aloud to ensure accuracy; the participant confirmed the number non-verbally with a nod or
4 'thumbs up' gesture.

5 Breath-by-breath data were collected throughout the exercise protocol using gas
6 analysers (Ultima, Medical Graphics [UK]; Sensor Medics 2900, Sensor Medics Corp
7 [USA]). These data were analysed independently by two members of the research team who
8 identified the ventilatory threshold (T_{vent}) and respiratory compensation point (RCP). Analysis
9 was conducted using Winbreak software (Ekkekakis, Lind, Hall, & Petruzzello, 2008) and
10 was based on the three-method procedure described by Gaskill et al. (2001) for T_{vent} , and a
11 slightly modified version of Beaver, Wasserman, and Whipp's (1986) procedure for RCP,
12 based upon the relationship between minute ventilation and carbon dioxide output (see
13 Ekkekakis et al., 2008). In instances where the identification of T_{vent} and RCP differed
14 between the members of the research team ($n = 2$), data were referred to an independent,
15 accredited physiologist to decide upon the threshold points.

16 **Data Analysis**

17 A change in FS score (ΔFS) during heavy exercise (i.e., zone of response variability)
18 was calculated for each participant by subtracting the FS score reported immediately prior to
19 reaching RCP from the FS score reported during the minute in which T_{vent} was reached.
20 Participants were then divided into two groups based on this score: Negative Responders ($n =$
21 28), among whom change in FS score ranged from -3 to -1, and Neutral/Positive Responders
22 ($n = 20$), among whom the change in FS ranged from 0 to +2. Neutral responders were
23 grouped with positive responders owing to the assumption that maintaining or increasing
24 pleasure at this exercise intensity is beneficial compared to a decline in pleasure with regards
25 to future exercise adherence.

1 Responder Group was used as the dependent variable in a series of Predictive
2 Discriminant Function Analyses (PDA). The purpose of Discriminant Analysis (DA) is to
3 predict group membership from a series of continuous predictor models. DA can be used to
4 test a prediction hypothesis (PDA) or as a multivariate post hoc to a significant one-way or
5 factorial MANOVA (Descriptive Discriminant Analysis) to describe the nature of the
6 differences between groups (Barton, Yeatts, Henson, & Martin, 2016; Warner, 2013). Like
7 Multiple Regression, DA develops an optimal weighted linear composite or function from a
8 set of continuous predictors for the purposes of prediction. However, in DA the purpose is to
9 develop one or more optimal functions (depending on the number of groups and/or predictors)
10 which optimize between groups variance and minimize within groups variance (Warner,
11 2013).

12 In the first model, personal factors including Tolerance, Preference, Extraversion,
13 Agreeableness, Conscientiousness, Neuroticism, Openness, and Sensation Seeking, were
14 identified as predictor variables. Alpha was set at .05. An arbitrary cut-off point to evaluate
15 structure and standardized coefficients was set at 0.5 (Warner, 2013). A classification table
16 was requested to more fully examine the extent of the discrimination by the weighted linear
17 composite. All data were analysed using SPSS version 23.

18 After reviewing the model, predictors that did not contribute substantially to the model
19 were removed. A second model was developed to assess how the remaining personal factors
20 as well as key demographics (age, sex, BMI, and VO₂peak), predicted group membership.
21 Sex was dummy coded (men = 0, women = 1). A final model was developed with only
22 substantially contributing predictors.

23 **Results**

24 Descriptive statistics for the predictor variables are presented in Table 2 and
25 intercorrelations of the predictors is depicted in Table 3. Prior to beginning the inferential

1 analysis, data were screened for normality, skewness, and other basic assumptions. No major
2 deviations from skewness or normality were detected. No outliers were found in the data
3 beyond 3.29 standard deviations of the mean (Warner, 2013).

4 Basic assumptions of the PDA were reviewed. The Box M test was non-significant (p
5 $> .05$), suggesting the assumption of homogeneity of variance/covariance was met. A single
6 weighted linear composite was generated as a result of the PDA. The weighted linear
7 composite was statistically significant, $\Lambda = 0.679$, $\chi^2(8) = 16.27$, $p = .039$. The resulting
8 moderate eigenvalue and large squared canonical correlation (R_c^2) were .473 and .321,
9 respectively. A review of the structure coefficients identified that only Preference (-.642) had
10 a structure coefficient greater than the identified cut-off value of 0.5, suggesting it is the only
11 predictor which substantially correlated to the outcome of the predictive function. Scores on
12 the Preference scale explained 41.2% of the variance in the composite. This finding is further
13 supported when reviewing univariate one-way ANOVAs, where the two groups significantly
14 differed only on Preference when using a Bonferonni correction ($\alpha = .05/8 = .006$), among the
15 eight predictor variables, $\Lambda = .837$, $F(1, 46) = 8.977$, $p = .004$ (mean data are presented in
16 Table 1).

17 A standardized weighted linear composite was developed to predict group
18 membership. When examining the standardized coefficients (analogous to the standardized
19 slopes or betas in regression; Barton et al., 2016), Preference (-1.023) was the only slope
20 above the cut off value. Participants predicted to be in the Negative Responder group reported
21 lower scores on the Preference scale. While Sensation Seeking (.496) and Conscientiousness
22 (.477) approached the cut off value, the corresponding structure coefficients were weak (.175
23 and .257, respectively). All other measured trait variables only weakly influenced the
24 predicted scores. A summary of the structure and standardized coefficients is presented in
25 Table 3. The weighted linear composite accurately predicted group membership for 70.8% (n

1 = 34) of participants in the current study. More specifically, membership for 64.3% ($n = 18$)
2 of Negative Responders and 80% ($n = 16$) of Neutral/Positive Responders was predicted
3 correctly. The classification table is presented in Table 5.

4 In a second model, Preference was retained as a predictor, while age, sex, BMI, and
5 VO_2peak were added as predictors to the model. The weighted linear composite was
6 significant, $\Lambda = .741$, $\chi^2(5) = 13.047$, $p = .023$, $R_c^2 = .259$. When reviewing the standardized
7 slopes in the second model, Preference (.611) and sex (.816) were substantial contributors to
8 predicting group membership such that members of the predicted Negative Responder group
9 had lower Preference scores and were more likely to be male. Only Preference and sex
10 substantially correlated with the function in Model 2 (.747 and .657, respectively). Structure
11 and standardized coefficients are presented in Table 4. Overall, 68.8% ($n = 35$) of participants
12 were correctly classified by the weighted linear composite, where 67.9% ($n = 19$) of Negative
13 Responders and 70% ($n = 14$) of Neutral/Positive Responders were correctly classified.
14 Classification results are presented in Table 5.

15 A final model was run with only Preference and sex as the critical predictors of group
16 membership. The weighted linear composite was significant, $\Lambda = .769$, $\chi^2(2) = 11.821$, $p =$
17 $.003$, $R_c^2 = .231$. Preference and sex substantially contributed to the prediction of group
18 membership (.714 and .599 standardized coefficients, respectively) and correlated with the
19 weighted linear composite (.806 and .709 structure coefficients, respective). 70.8% ($n = 34$) of
20 participants were classified correctly by the resulting function, where 67.9% ($n = 19$) of
21 Negative Responders and 75% ($n = 15$) of Neutral/Positive Responders were classified
22 correctly. Model 3 coefficients are presented in Table 4 and classification results for are
23 presented in Table 5.

24 Discussion

25 The purpose of this study was to explore the influence of a range of personal

1 characteristics on affective responses to exercise in the zone of response variability (i.e.,
2 exercise intensity between T_{vent} and RCP). Participants were grouped as either Negative
3 Responders or Neutral/Positive Responders based upon the trajectory of affective valence (i.e.
4 ΔFS) between T_{vent} and RCP. Negative responders had lower scores on the PRETIE-Q
5 Preference subscale, and were more likely to be male.

6 **Preference for Exercise Intensity**

7 The lower PRETIE-Q Preference scores observed in Negative Responders are in line
8 with theoretical predictions. In previous work, both the Preference and Tolerance subscale of
9 the PRETIE-Q accounted for significant portions of the variance in affective valence at T_{vent} ,
10 and the Tolerance scale accounted for significant portions of the variance when the intensity
11 exceeded T_{vent} (Ekkekakis et al., 2005). In the present study, Preference was a substantial
12 predictor of group membership based on affective response to exercise in the zone of response
13 variability but Tolerance was not, therefore H_1 is partially accepted. Our findings pertaining to
14 Preference demonstrate the importance of considering preferred exercise intensity when
15 prescribing exercise in order to optimize affective response, and in turn, adherence. Exercise
16 is often prescribed based on intensity zones (e.g., by personal trainers or training plans) but
17 these prescriptions do not account for individual affective responses to different exercise
18 intensities. For example, high-intensity interval training (HIIT) receives notable media
19 coverage and endorsement as it is portrayed as a time efficient way for individuals to garner
20 physiological benefits from exercise (e.g., Gillen & Gibala, 2014). However, exercise at such
21 intensities might not be suitable for all individuals and a negative affective response to high
22 intensity exercise could lead to poor adherence (Oliveira, Slama, Deslandes, Furtado, &
23 Santos, 2013; Saaniloki et al., 2015). ACSM exercise prescription guidelines (2018) identify
24 moderate intensity exercise as 46-63% VO_2max and vigorous intensity as 64-<91% VO_2max .
25 The mean % VO_2peak recorded at T_{vent} and RCP in the present study were $61.9 \pm 10.1\%$ and

1 91.7±6.5% VO_2 peak, respectively. This offers additional support that the present data are of
2 relevance to exercise professionals as the intensity examined is within the ranges of moderate
3 and vigorous intensity exercise that are currently part of the PA guidelines worldwide.

4 Affect is viewed within behavioral economics as one of the major factors driving
5 human decision-making. Put simply, humans tend to repeat what makes them feel better and
6 avoid what makes them feel worse (Ekkekakis & Dafermos, 2012). Preliminary findings in
7 exercise psychology show that affective responses to exercise predict subsequent exercise
8 behaviour (e.g., Williams et al, 2012; Rhodes, Fiala, & Connor, 2009). Therefore, using
9 preference for exercise intensity to tailor exercise prescriptions to optimize the subjective
10 experience of exercise may be a promising way to improve exercise adherence. The
11 preference scale of the PRETIE-Q could be used to develop a protocol for screening
12 individuals who might be predisposed to negative affective response during heavy exercise
13 (i.e., above T_{vent} but below RCP). In practice, the questionnaire could be administered prior to
14 the commencement of an exercise program and if an individual reported a score >30
15 (according to present data; Table 2) the practitioner could be more confident that an
16 individual would respond to heavy exercise in a neutral or positive manner. If an individual
17 reports a score <30, then the practitioner could consider programming exercise at intensities
18 below T_{vent} as the individual will likely respond negatively to exercise intensities above T_{vent} ,
19 which will in turn impact upon adherence.

20 Present results also lend support to the implementation of affect-regulated exercise,
21 which has been cited as a viable way in which to minimise feelings of displeasure during
22 exercise (Parfitt, Alrumh, & Rowlands, 2012). Recent evidence has demonstrated that
23 exercising at an intensity that feels ‘good’ leads to a meaningful intensity for cardiovascular
24 benefits (Schneider & Schmalbach, 2015) across active (Hutchinson et al., 2018) and
25 sedentary populations (Hamlyn-Williams, Tempest, Coombs, & Parfitt, 2015). Affect-

1 regulated exercise offers an easily implementable way for individuals to regulate their
2 exercise intensity per their individual preference while ensuring a pleasant experience.

3 The findings for Tolerance are inconsistent with previous reports (Ekkekakis et al.,
4 2005; Tempest & Parfitt, 2016) and this might be a consequence of the limited amount of
5 time spent working above T_{vent} . In the present study, participants spent an average of
6 3.18 ± 1.13 min working at intensities between T_{vent} and RCP, whereas previous work has
7 employed a continuous workload protocol (e.g., 15min [Ekkekakis et al., 2005]). The short
8 period of time might have been insufficient to capture the unique contribution of tolerance of
9 exercise intensity.

10 **Big Five Personality Factors and Sensation Seeking**

11 Research on personality and exercise behaviour has largely focused on the relationship
12 with volume of physical activity, as well as long-term health outcomes. Minimal attention has
13 been paid to the role that personality can play in how people *experience* exercise, despite
14 accumulating evidence that the pleasure or displeasure experienced during exercise can
15 influence subsequent physical activity (e.g., Hagberg et al., 2009; Williams et al., 2012). In
16 the present study, personality dimensions from the Big Five factor structure and Sensation
17 Seeking did not effectively discriminate between the two affective response groups, thus H_2
18 and H_3 are not accepted.

19 To our knowledge, there is no previous work to draw upon regarding the relationship
20 between personality factors and affective experiences during exercise at varying workloads.
21 In one of the few studies to investigate the influence of personality on the subjective
22 experience of exercise, Lochbaum and Lutz (2005) observed that participants who reported
23 greater enjoyment of a step-aerobics exercise session were more conscientious and less
24 neurotic. There is also consistent evidence that conscientiousness is positively related to
25 general positive affect in non-exercise contexts (DeNeve & Cooper, 1998) and is associated

1 with greater self-reported PA (Rhodes & Smith, 2006). In the present study,
2 Conscientiousness (.477) approached the standardized coefficient cut off value of 0.5,
3 although the corresponding structure coefficient (.257) indicated it was a relatively weak
4 predictor of group membership.

5 It is somewhat surprising that extraversion did not differ between the two affective
6 response groups given the extensive body of literature linking extraversion with positive
7 affect (e.g., Watson & Clark, 1992). Indeed, the experience of positive emotions is considered
8 to be a facet of extraversion (Costa & McCrae, 1992). Future investigations might benefit
9 from studying the lower-order facets of personality, which often show differential
10 relationships with performance criteria. For example, conscientiousness has been
11 characterized as having both proactive (e.g., need for achievement, self-discipline) and
12 inhibitive (e.g., cautiousness, self-control) aspects which may differentially influence health
13 and exercise behavior (O'Connor, Conner, Jones, McMillan, & Ferguson, 2009). With respect
14 to the affective experience of exercise, the lower-order extraversion facets of *positive*
15 *affectivity*, and *activity* seem particularly worthy of investigation (Rhodes, Courneya, &
16 Jones, 2002).

17 Our hypothesis pertaining to sensation seeking (H_3) was based on findings that suggest
18 high sensation seekers expend more energy during everyday tasks (Minkwitz et al., 2016),
19 and sensation seekers seek out "intense sensations". In light of our null findings, it is possible
20 that the intensity of sensations experienced between T_{vent} and RCP were not high enough to
21 satisfy high sensation seekers. Alternatively, the task itself may have been unappealing to
22 high sensation seekers. Sensation seeking is highly correlated with impulsivity and involves
23 pursuit of targeted rather than merely general stimulation (Arnett, 1994). Moreover, sensation
24 seekers express a greater need for autonomy (Zuckerman, 1994) which is largely absent in the
25 context of a constrained laboratory task.

1 The weak contribution of personality variables (the Big Five and Sensation Seeking)
2 suggests that accounting for such social cognitive variables is of limited utility when seeking
3 to understand and predict affective responses to heavy exercise. It appears that measures
4 including greater acknowledgement of interoceptive sensations are more effective at
5 accounting for affective responses during heavy exercise. The dual-mode model (Ekekkakis,
6 2003) postulates that there is interplay between social cognitive factors and interoceptive cues
7 in the zone of response variability; the present results indicate that the interplay is dominated
8 by an individual's interpretation of those interoceptive cues (manifest in an expression of
9 preference for exercise intensity), and it is that which predominates affective responses during
10 heavy exercise. The capacity of broad personality dimensions (extraversion, neuroticism,
11 openness, agreeableness, conscientiousness, and sensation seeking) to help researchers and
12 practitioners individualise exercise programs appears limited.

13 **Sex and affective response**

14 Relevant demographics (age, sex, BMI, and VO_{2peak}) were added to the model with
15 the aim of enhancing the practical application of the findings. The significant contribution of
16 sex indicates that practitioners could consider this alongside preference for exercise intensity
17 when designing exercise programmes. There is scant work examining sex differences in
18 affective responses to exercise, with studies typically including one sex (e.g., Ekekkakis et al.,
19 2010; Jones et al., 2017) or not exploring differences between their participants (e.g., Kwan &
20 Bryan, 2010; Schneider & Schmalbach, 2015; Sheppard & Parfitt, 2008). This preliminary
21 finding could indicate that future investigations examining different affective responses to
22 exercise between the sexes could be fruitful and offers further options in the personalisation
23 of exercise programs.

24 In non-exercise settings, men and women have been found to differ in the use of
25 emotion regulation strategies. Men use suppression, which involves attempts to hide, inhibit

1 or reduce emotion-expressive behavior more often than women (Gross & John, 2003). This
2 pattern of gender differences is often explained in terms of social norms (Smieja, Mrozowicz,
3 & Kobylińska, 2011), but there is accumulating evidence of sex-related structural differences
4 in the prefrontal cortex that are “meaningfully related to affective individual differences,
5 including emotion-regulation strategies, expression and experience” (Welborn et al., 2009,
6 p.334). A review of functional neuroimaging studies supports the notion that men and women
7 use different strategies to down-regulate negative emotions, and that these strategies might be
8 mediated by different neural circuitry (Whittle, Yücel, Yap, & Allen, 2011).

9 **Limitations and Future Research**

10 Affective responses were recorded during a GXT to account for the entire range of
11 exercise intensities and to anchor responses around relevant respiratory markers. This
12 laboratory-based exercise test is not representative of a typical exercise session or setting,
13 therefore different modes of exercise and environments may yield different results.

14 Future work could include investigations of whether there are other personal
15 characteristics that might explain affective response to exercise in the zone of response
16 variability. This could lead to greater understanding of how individual difference factors
17 influence affective responses to exercise, which may in turn hold meaningful implications for
18 exercise prescription and adherence. The characteristics presented here represent an initial
19 exploration, but there are likely other salient characteristics such as BIS/BAS (Schneider &
20 Graham, 2009), and perceived evaluative threat (Focht & Hausenblas, 2004) that will likely
21 provide additional understanding of individual affective responses during heavy exercise.

22 A seemingly promising avenue for future research is the role of hereditary influences
23 on individual differences in exercise-related affect. Initial evidence of the genetic contribution
24 to the affective response to exercise has been offered by Schutte, Nederend, Hudziak, Bartels,
25 and de Geus (2017). Schutte et al. report that genetic factors explained 15% of the individual

1 differences in FS responses during a cycle ergometer test. Moreover, significant correlations
2 were observed between affective responses during exercise and regular voluntary exercise
3 behaviour ($r = .15-.21$).

4 **Conclusions**

5 This study offers an initial exploration of personal characteristics underlying affective
6 responses to heavy exercise (i.e., in the zone of response variability within the dual-mode
7 model; Ekkekakis, 2003). Findings suggest that individuals in the current study could be
8 correctly classified as either Negative Responders or Neutral/Positive Responders 71% of the
9 time by measuring preference of exercise intensity and accounting for sex. Preference for
10 exercise intensity was the strongest predictor among these measures. Individuals who
11 experience no change or a positive change in pleasure (Neutral/Positive Responders) reported
12 higher preferred exercise intensity and were more likely to be female than individuals who
13 experienced a decline in pleasure (Negative Responders) during heavy exercise. Researchers
14 and practitioners might seek to account for the role of individual differences when examining
15 affective responses and when designing exercise programs for clients. While the reasons for
16 non-adherence to exercise are multifarious and complex, negative affective responses to
17 heavy exercise might play a role. Through more accurate predictions of how an individual
18 will feel during exercise, we can seek to make the exercise experience more consistently
19 pleasurable.

20 **Acknowledgements**

21 The authors would like to acknowledge the contribution of _____, _____, _____, and _____
22 for their assistance with data collection at _____. We would also like to
23 acknowledge the reviewers for their insight and assistance with the manuscript.

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- 21

1 Table 1

2 *Descriptive Statistics for Demographic Variables*

	Total (<i>N</i> = 48)		Male (<i>n</i> = 27)		Female (<i>n</i> = 21)		Independent Groups <i>t</i> -test (<i>df</i> = 46)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>t</i>	<i>p</i>
Age ^a	30.3	7.5	29.4	8.1	31.5	6.8	-0.97	.34
BMI ^b	25.3	4.4	25.8	2.9	24.8	5.8	0.72	.47
VO ₂ peak ^c	45.7	9.4	49.9	7.2	40.2	9.1	4.15	.00

	England (<i>N</i> = 21)		USA (<i>N</i> = 27)		<i>t</i>	<i>p</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
Age ^a	31.0	3.9	29.8	9.5	0.63 ^d	.53
BMI ^b	25.0	2.9	25.7	5.4	-0.56	.50
VO ₂ peak ^c	46.4	7.6	45.1	10.6	0.49	.63

3 *Note.* ^ayears; ^bkg/m²; ^cml/kg/min; ^d*df* = 36.4 due to adjustment for heterogeneity of variances

1 Table 2
 2 *Descriptive Statistics for Predictor Variables*

Variables	All (<i>N</i> = 48)		Negative Responders (<i>n</i> = 28)		Positive/Neutral Responders (<i>n</i> = 20)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Tolerance	27.7	4.6	28.1	5.1	27.2	3.9
Preference*	28.1	5.5	26.2	5.1	30.8	3.1
Extraversion	33.2	8.1	33.3	7.8	33.9	8.1
Agreeableness	40.4	6.3	39.5	7.2	41.7	4.7
Conscientiousness	38.3	6.1	39.1	5.7	37.0	6.6
Neuroticism	33.5	7.1	33.3	7.5	33.7	6.7
Openness	37.1	5.3	36.4	5.4	38.1	5.2
Sensation Seeking	19.9	6.6	20.5	6.2	19.0	7.2
Age	30.3	7.5	31.1	8.4	29.3	6.2
Male ^{a*}	27.0	56.3	20.0	71.4	7.0	35.0
Female ^{a*}	21.0	75.0	8.0	28.6	13.0	65.0
BMI	25.3	4.4	25.5	3.8	25.2	5.3
VO ₂ peak	45.7	9.4	46.0	9.1	45.2	9.9

3 *Note.* ^a Sex is reported in *n*/%; *Significantly different (all *ps* < .05) between groups.

4

1 Table 3

2 *Intercorrelations of the Personal Predictor Variables (N = 48)*

	1	2	3	4	5	6	7	8
1. Tolerance	--	.363*	.045	.005	.228	.213	.042	.164
2. Preference		--	.047	.250	.043	.298*	.019	.071
3. Extraversion			--	.402**	-.165	-.003	.299*	.206
4. Agreeableness				--	.087	.081	.250	-.150
5. Conscientiousness					--	.157	.008	-.350*
6. Neuroticism						--	.003	-.114
7. Openness							--	.117
8. Sensation Seeking								--

3 *Note. * $p < .05$, $p < .01$*

4

1 Table 4

2 *Summary of Structure Coefficients and Standardized Coefficients from the Predictive*3 *Discriminant Function Analyses*

	Structure Coefficient	Standardized Coefficient
Model 1		
Tolerance	-.642	0.402
Preference	.257	-1.023*
Extraversion	-.246	0.035
Agreeableness	-.228	0.027
Conscientiousness	.175	0.477
Neuroticism	.143	0.163
Openness	-.402	-0.402
Sensation Seeking	.496	0.496
Model 2		
Preference	.747	0.611*
Sex	.657	0.816*
Age	-.199	-0.216
VO ₂ Peak	-.077	0.360
BMI	-.052	0.145
Model 3		
Preference	.806*	0.714*
Sex	.709*	0.599*

4 *Note.* *Above the cut-off value (.5) identified by Warner (2013)

5

1 Table 5

2 *Predicted Classification of Positive and Negative Responders*

		<u>Predicted Group Membership</u>	
		Negative Responders	Neutral/Positive Responders
Model 1 ^a			
Original	Negative Responders	64.3 (18)	35.7 (10)
	Neutral/Positive Responder	20.0 (4)	80.0 (16)
Model 2 ^b			
Original	Negative Responders	67.9 (19)	32.1 (9)
	Neutral/Positive Responder	30.0 (6)	70.0 (14)
Model 3 ^c			
Original	Negative Responders	67.9 (19)	32.1 (9)
	Neutral/Positive Responder	25.0 (5)	75.0 (15)

3 *Note.* Reported in % (*n*); ^a70.8% of participants were correctly classified; ^b68.8% of cases
4 were correctly classified; ^c70.8% of participants were correctly classified.

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