

Abstract

27 Inter-individual cognitive factors have been shown to be related to the changes in affect
28 evaluations during continuous high-intensity exercise in adolescents, but the role of cognitive
29 factors on affect during high-intensity interval exercise (HIIE) is currently unknown. This study
30 evaluated the influence of personality traits (behavioural activation system; BAS and
31 behavioural inhibition system; BIS) and self-efficacy on affect, enjoyment and perceived
32 exertion during HIIE in adolescents. Participants (N=30; 15 boys; mean age= 12.2 ± 0.4 years;
33 moderate to vigorous physical activity levels per day = 33 ± 12 min) were median split into
34 low vs. high BAS/BIS and self-efficacy groups. All participants performed HIIE consisting of
35 8 x 1-min work-intervals at 85% of peak power separated by 75 seconds recovery. Affect,
36 enjoyment, and rating of perceived exertion (RPE) were recorded 5 min before HIIE, near the
37 end of the HIIE work intervals, and 20 min after HIIE. The high BAS/low BIS group elicited
38 greater affect and enjoyment compared to low BAS/high BIS group during work-intervals 5 to
39 8 (all $P < 0.039$, all $ES > 0.59$) and after HIIE for post-enjoyment (all $P < 0.038$, all $ES > 0.95$).
40 Affect and enjoyment were greater in high compared to low self-efficacy group during work-
41 intervals 5 to 8 (all $P < 0.048$, all $ES > 0.62$). The BAS/BIS groups elicited similar RPE (all
42 $P > 0.10$), but RPE was lower in high than low self-efficacy group at work-intervals 5 to 8 (all
43 $P < 0.037$, $ES > 0.98$). Individual differences in personality and self-efficacy may influence the
44 affective, enjoyment and RPE responses during HIIE in adolescents.

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46 **Key Words:** feeling states, personality characteristic, perceived capability, interval exercise,
47 youth.

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51 **Lay summary**

52 This study aimed to evaluate the role of personality characteristics and self-efficacy on
53 perceptual responses (pleasure/displeasure and enjoyment) during HIIE in youth. Individual
54 differences in personality characteristics and self-efficacy may decrease or increase the
55 likelihood that a person will experience pleasurable feelings and enjoyment to HIIE in youth.

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76 **Introduction**

77 High-intensity interval exercise (HIIE, exercise performed above the ventilatory threshold
78 (VT)) has been shown to be a viable exercise protocol for enhancing cardiorespiratory fitness
79 and cardiometabolic health in adolescents (Bond et al., 2017; Costigan et al., 2015). Recent
80 studies in youth have shown that a commonly used HIIE protocol (i.e. 8 x 1-min work interval
81 separated by 75 s recovery) performed at intensity below 100% of peak power or maximal
82 aerobic speed elicited positive affect responses (Malik et al., 2018a; 2019), suggesting that the
83 recovery interval incorporated into HIIE may be preserving the further decline in affect
84 responses. This finding contrasts with the expected pattern of negative affect responses
85 (unpleasant feelings) during high-intensity exercise in youth as predicted by the dual mode
86 theory (DMT), which is based on continuous high-intensity exercise and an incremental test to
87 exhaustion (Benjamin et al., 2012; Stych & Parfitt, 2011). Therefore, the adoption and
88 implementation of HIIE protocol as a health strategy is promising in youth.

89 Despite the aforementioned HIIE protocol generating pleasurable feelings in youth,
90 Malik and colleagues (2018a; 2019) indicated that the decline in affect (i.e. less pleasurable
91 feelings) during HIIE is related to physiological factors such as heart rate (HR) and brain
92 oxygenation responses). According to the DMT (Ekkekakis et al., 2005), the predominance of
93 interoceptive/physiological cues (e.g. increased HR) or cognitive/psychological cues (e.g. self-
94 efficacy) during high-intensity exercise is related to unpleasant and pleasant feelings,
95 respectively. Furthermore, the interaction of an individual's cognitive and physiological factors
96 could also influence perceptions that either maintain or enhance the positive affective response
97 during exercise at a given intensity (Rose & Parfitt, 2007). While previous research has
98 evaluated the relationship between affect responses and physiological responses during HIIE
99 in youth (Malik et al., 2018a; 2018b; 2019), data on cognitive factors during HIIE have yet to
100 be explored.

101 The DMT postulates that cognitive factors are unique to the individual and are likely to
102 be influenced by self-efficacy, personality traits and goal achievement (Ekkekakis, 2003).
103 Research has investigated personality traits and self-efficacy as the cognitive factors that
104 underlie affective responses to exercise in adolescents and adults (McAuley & Courneya, 1992;
105 Schneider & Graham, 2009). Regarding personality traits, Carver and White (1994) proposed
106 that behavioural activation system (BAS, approach motivation) individuals are sensitive to the
107 stimuli that are typically associated with a sense of reward and positive feelings (e.g.
108 pleasurable and happiness), whereas behavioural inhibition system (BIS, avoidance
109 motivation) individuals are sensitive to the stimuli that are typically associated with a sense of
110 punishment and negative feelings (e.g. frustration and sadness). A previous study in adolescent
111 boys and girls (aged 14.8 ± 0.46 years) revealed that the BAS group experienced greater
112 enjoyment and pleasurable feelings compared to the BIS group during continuous moderate-
113 and high-intensity exercise (Schneider and Graham, 2009). This finding indicates the role of
114 an individual's personality on affect responses, but this observation was made during
115 continuous exercise where high-intensity exercise was perceived as unpleasant. It is currently
116 unknown whether affect and enjoyment responses during HIIE is related to individual's BIS
117 and BAS in youth.

118 With regard to self-efficacy (i.e. confidence to perform the exercise task), a review of
119 research in adolescents has indicated self-efficacy as a prominent personal determinant to
120 engage with PA behaviour (Van der Horst et al., 2007). Bandura (1986) argued that there is a
121 link between affective responses and the subsequent formation of individual self-efficacy (i.e.
122 pleasurable feelings may reflect high confidence level and unpleasant feelings may reflect low
123 confidence level). Previous studies in adults have consistently reported that individuals with
124 high self-efficacy exhibit more positive affect and a lower rating of perceived exertion (RPE)
125 compared to low self-efficacy individuals during exercise (Focht, 2013; McAuley & Courneya,

126 1992; Tate et al., 1995). These authors revealed that the differences between low vs. high self-
127 efficacy individuals were increasingly evident at more demanding work intensities (e.g. above
128 70% of predicted maximal heart rate). However, these observations were limited to incremental
129 exercise to exhaustion and continuous exercise in adults, which is untypical of youth patterns
130 of activity and exercise (Barkley, Epstein, & Roemmich, 2009).

131 Given the above, the extent to which affect responses differ according to personality
132 and self-efficacy factors during HIIE has not yet been examined in youth. Therefore, the
133 purpose of the present study was to evaluate the influence of personality (BIS/BAS) and self-
134 efficacy on the affect, enjoyment and RPE responses to a commonly used HIIE protocol in
135 adolescent boys and girls. We hypothesised that individuals with high BAS, low BIS, and high
136 self-efficacy would perceive HIIE to be more pleasurable and enjoyable, and less exertional
137 compared to individuals with low BAS, high BIS and low-efficacy.

138 **Methods**

139 **Participants**

140 The data in the current study were obtained by combining data across two published
141 studies that have examined the perceptual responses to HIIE in adolescents (Malik et al., 2018b;
142 2019). Information related to the inclusion and exclusion criteria and recruitment of the
143 participants is explained in the original studies. Data on individual personality and self-efficacy
144 in response to affect, enjoyment and RPE during HIIE were not reported in these previous
145 studies. The present study resulted in the sample size of 30 participants (11 to 13-years-old, 15
146 boys). Using a repeated measure analysis of variance (ANOVA) statistical test in G*Power
147 (3.0.10), a sample size of 26 participants to detect a moderate effect using a power of 0.8, an
148 alpha of 0.05 and an effect size (F) of 0.25 was indicated. The sample size reflects related
149 research in youth (Malik et al., 2019). All the participants were unfamiliar with HIIE. Written
150 assent from the participants and written informed consent from the parent/guardian were

151 obtained. Information about participants' health status was obtained before the commencement
152 of exercise using a standard health screening form for children. All participants free of any
153 musculoskeletal injury and health problems. The study procedures were approved by the
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155 **Experimental overview**

156 The present study was a combination of two studies which involved four experimental
157 visits. However, the current study only reports data from the HIIE protocol performed at 85%
158 peak power. Consequently, only data from two visits were taken into consideration for the
159 present study. The first visit was to measure anthropometric variables, determine
160 cardiorespiratory health status and familiarise participants with the measurement scales.
161 Participants also were asked to complete a BIS) and BAS scales which consist of 20 items
162 (Carver & White, 1994) in the first visit. This was followed by another visit involving a cycling
163 HIIE protocol. All exercise tests were performed using an electronically braked cycle
164 ergometer (Lode Corival Pediatric, Groningen, The Netherlands).

165 **Anthropometric and physical activity measures.** Stature and body mass were
166 quantified to the nearest 0.01 m and 0.1 kg using standard procedures. Body mass index (BMI)
167 was calculated as body mass (kg) divided by stature (m) squared. Age and sex specific BMI
168 cut-points for overweight and obesity status were determined (Cole et al., 2000). Percentage
169 body fat was estimated using triceps and subscapular skinfolds to the nearest 0.2 mm
170 (Harpenden callipers, Holtain Ltd, Crymych, UK) according to sex and maturation specific
171 equations (Slaughter et al., 1988). Cardiometabolic health status was determined based on age
172 and sex specific aerobic fitness cut-offs (Adegboye et al., 2011). Following completion of the
173 HIIE protocol, participants wore an accelerometer (GENEActiv, GENE, UK) on their non-
174 dominant wrist for seven days. The accelerometer was set to record at 100 Hz. Participants'
175 data were used if they had recorded ≥ 10 hours/day of wear time for at least three week days

176 and one weekend day (Riddoch et al., 2007). Data were analysed at 1 s epoch intervals to
177 establish time spent in moderate and vigorous intensity physical activity using validated cut-
178 points (Phillips et al., 2013).

179 **Cardiorespiratory fitness.** Participants were familiarised to exercise on the cycle
180 ergometer before completing a ramp test to establish maximal oxygen uptake ($\dot{V}O_{2\max}$) and the
181 VT (Barker et al., 2011; Sansum et al., 2019). The highest value from a ramp test represents a
182 true $\dot{V}O_{2\max}$ in ~ 90% of cases as reported by Sansum et al., (2019). Participants began a warm-
183 up of unloaded cycling for 3 min, followed by 15 W increments every 1 min until volitional
184 exhaustion, before a 5 min cool down at 25 W. Participants cycling at a constant cadence
185 between 75-85 rpm with exhaustion was defined as a drop in cadence below 60 rpm for 5
186 consecutive seconds despite strong verbal encouragement. Peak power was taken as the highest
187 power output achieved at the end of the ramp test.

188 **HIIE protocol.** Participants completed the HIIE protocol consisting of a 3 min warm-
189 up at 20 W followed by 8 x 1 min work intervals performed at 85% of the peak power
190 determined from the ramp test, interspersed with 75 s active recovery at 20 W. A 2 min cool
191 down at 20 W was provided at the end of the protocol. Participants were instructed to maintain
192 a cadence between 75-85 rpm throughout the exercise condition.

193 **Experimental measures**

194 **Gas exchange and heart rate.** Expired gas exchange and ventilation variables during
195 the cardiorespiratory fitness test and HIIE protocol were measured using a calibrated metabolic
196 cart (Cortex Metalyzer III B, Leipzig, Germany). HR responses were recorded continuously
197 using a telemetry system (Polar Electro, Kempele, Finland). Both gas exchange and HR data
198 were subsequently averaged over 10 s intervals. The VT was determined from the incremental
199 test data using the ventilatory equivalents for carbon dioxide production ($\dot{V}CO_2$) and $\dot{V}O_2$
200 (Beaver, Lamarra, & Wasserman, 1981). $\dot{V}O_{2\max}$ was determined as the highest 10 s average in

201 $\dot{V}O_2$ elicited either during the incremental or supramaximal test. Maximal HR (HR_{max}) was
202 taken as the highest HR achieved during the ramp test. A cut-off point of $\geq 90\%$ HR_{max} was
203 used as the criterion for compliance to the HIIE protocol (Malik et al., 2017; Taylor et al.,
204 2015).

205 **Affective responses.** Affective valence (pleasure/displeasure) was measured using the
206 feeling scale (FS; Hardy & Rejeski, 1989) according to previous work in adolescents
207 (Benjamin et al., 2012; Malik et al., 2018a). Participants were asked to rate how they currently
208 feel on an 11-point bipolar scale ranging from "Very Good" (+5) to "Very Bad" (-5). Van
209 Landuyt et al. (2000) report that FS exhibited convergent validity with the Affect Grid (Russell
210 et al., 1989).

211 Activation levels were measured using the felt arousal scale (FAS; Svebak &
212 Murgatroyd, 1985). The FAS is a single-item measure of perceived activation, with participants
213 asked to rate themselves on a 6-point scale ranging from 1 'low arousal' to 6 'high arousal'.
214 Van Landuyt et al. (2000) report that FS and FAS exhibited correlations ranging from 0.41 to
215 0.59 and 0.47 to 0.65, respectively, with the Affect Grid (Russell, Weiss, & Mendelsohn, 1989),
216 indicative of convergent validity with similar established measures. Affective responses were
217 also assessed from the perspective of the circumplex model (Russell et al., 1989), using a
218 combination of FS and FAS.

219 **Perceived enjoyment.** Participants rated their enjoyment during the exercise
220 conditions on a 7-point exercise enjoyment scale (EES; Stanley & Cumming, 2010).
221 Participants respond to the statement: "Use the following scale to indicate how much you are
222 enjoying this exercise session" via a 7-point Likert item from 1 (not at all) to 7 (extremely).
223 EES exhibited correlations ranging from 0.41 to 0.49 with FS, indicative of convergent validity
224 with similar established measures (Stanley et al., 2009). Post-exercise enjoyment was measured
225 using the modified physical activity enjoyment scale (PACES), which is validated for use in

226 adolescents (Motl et al., 2001). The PACES includes 16 items that are rated on a 5-point bipolar
227 scale (score 1 = “strongly disagree” to score 5 = “strongly agree”). The score for each item was
228 summed to calculate a total enjoyment score for each exercise protocol, resulting a possible
229 range of scores from 16 through to 80 with a higher score representing greater enjoyment.

230 **Rating of perceived exertion.** RPE was assessed using the validated 0–10 Pictorial
231 Children’s OMNI scale (Robertson et al., 2000). Participants responded to the statement “How
232 tired does your body feel during exercise” via a 0-10 point Likert item ranging from 0 (not tired
233 at all) to 10 (very, very tired).

234 **Measurement time points.** The measurements scales (i.e. FS, EES, RPE and PACES)
235 were administered before (i.e. 5-min before and warm-up), 20 s before the end of the HIIE
236 work and recovery intervals, and after (i.e. immediately after and 20-min after) HIIE. The FS
237 and RPE were also obtained at the end of every stage during the incremental test to exhaustion
238 to familiarize the participants with the scale. The same verbal instructions for using all the
239 scales were given to all participants before undertaking the exercise protocols by the same
240 researcher. No verbal encouragement was given to the participants during the HIIE protocol.

241 **Exercise Task Self-Efficacy.** Participants’ confidence in their ability to repeat the HIIE
242 protocol they had just completed was assessed at 20-min post-exercise using a 5-item measure.
243 Each question anchored the stem “How confident are you that you can” following the item
244 “perform one/two/three/four/five bout(s) of exercise a week for the next 4 weeks that is just
245 like the one you completed today?” Participants responded to each item on a 100-point
246 percentage scale with 10 percent increments that ranged from 0% (not at all confident) to 100%
247 (completely confident). The five item scores were averaged and used as the self-efficacy score.
248 The format for this scale was consistent with Bandura, (1997) and a previous study that
249 examined the influence of affective responses to HIIE in adults (Jung et al., 2014). Based on

250 the Cronbach's alpha test, the internal consistencies for the self-efficacy scale in this study were
251 excellent ($\alpha= 0.93$). Self-efficacy questionnaire was administered by the same researcher.

252 **Behavioural activation and behavioural inhibition.** Participants' personality
253 characteristics were measured during the first visit using the BIS and BAS scales which consist
254 of 20 items (Carver & White, 1994). This scale has been successfully used and validated for
255 use in adolescents (Cooper et al., 2007; Schneider & Graham, 2009). Items are scored on a
256 four-point Likert-type scale. The BIS consists of a single subscale measuring the anticipation
257 of punishment, whereas the BAS consists of three subscales measuring drive, fun seeking, and
258 reward responsiveness. In order to focus on different aspects of incentive sensitivity of BAS as
259 proposed by Carver and White (1994), the reward responsiveness subscale was used to
260 represent the BAS group. This is because previous work in youth has shown that feelings of
261 reward facilitated elevated enjoyment levels after HIIE (Malik et al., 2017). The total score for
262 BAS and BIS were averaged for each item and used as the BAS and BIS score. The internal
263 consistencies for the BIS and BAS scale in this study were excellent ($\alpha= 0.80$ and $\alpha= 0.86$,
264 respectively). The BIS/BAS questionnaire was administered by the same researcher.

265 **Statistical analyses**

266 All statistical analyses were conducted using SPSS (24.0; IBM Corporation, Armonk,
267 NY, USA). Descriptive characteristics (mean \pm standard deviation) and cardiorespiratory data
268 between boys and girls were analysed using independent samples t-tests. The BAS/BIS and
269 self-efficacy variables were transformed into dichotomous variables using a median split to
270 form high and low groups for the total of 30 participants: low (n = 14) and high (n = 16) BAS;
271 low (n = 17) and high (n = 13) BIS; and low (n = 15) and high (n = 15) self-efficacy). This
272 median split was conducted after all the participants completed the HIIE protocol. The mean
273 difference between each grouping was analysed using independent samples t-test for self-
274 efficacy and BIS/BAS. Data were analysed using a mixed model analysis of variance

275 (ANOVA) to examine group differences (low BAS vs. high BAS; low BIS vs. high BIS; low
276 self-efficacy vs. high self-efficacy) in affect, enjoyment, and RPE over time during HIIE (the
277 work and recovery intervals) and the incremental test (min 1, VT, VT+1 min, end). The
278 exclusion of sex into the ANOVA model was due to the insufficient numbers between boys
279 and girls across the group following the median split. In the event of significant effects ($P <$
280 0.05), follow-up Bonferroni post hoc tests were conducted to examine the location of mean
281 differences. The magnitude of mean differences was interpreted using effect size (ES)
282 calculated using Cohen's d (Cohen, 1988), where an ES of 0.20 was considered to be a small
283 change between means, and 0.50 and 0.80 interpreted as a moderate and large change,
284 respectively.

285 **Results**

286 The participants' descriptive characteristics are presented in Table 1. A total of 26 participants
287 (12 boys) were deemed to have a low level of aerobic fitness indicative of increased
288 cardiometabolic risk. Also, three out of 30 participants were categorised as overweight and the
289 remainder were normal weight. Three boys and one girl achieved the recommended guideline
290 of 60 min of daily MVPA.

291 HIIE cardiorespiratory data for boys and girls are presented in Table 2. Based on the
292 VT representing $\sim 50\%$ VO_{2max} in our sample the prescribed HIIE protocol was performed at
293 an intensity that exceeded the VT for work-intervals 1 to 8 (i.e. 71% to 78% $\dot{V}O_{2max}$). There
294 were significant increases in HR across consecutive work intervals in all BIS/BAS and self-
295 efficacy groups ($P < 0.01$), but there was no condition by interval number interaction (all
296 $P > 0.28$) or main effect of condition ($P > 0.31$). A total of 27 participants (14 girls) reached the
297 cut-off point of $\geq 90\%$ HR_{max} , which occurred during work intervals 4 to 8. Also, there was no
298 significant difference in VO_{2max} and MVPA levels between the BIS/BAS and high/low self-

299 efficacy groups (all $P>0.51$ and $P>0.37$, respectively). All participants completed the HIIE
300 protocol and no adverse events were observed.

301 **BIS/BAS with affective responses.** The BAS and BIS exhibited an average of $2.7 \pm$
302 1.1 (minimum to maximum= 1.86 to 3.71) and 2.8 ± 0.5 (1.9 to 3.7) of FS score, respectively.
303 For the incremental test, FS showed a significant group by time interaction effect for BIS
304 ($P=0.025$) and BAS ($P=0.031$). FS was significantly higher in the high BAS compared to low
305 BAS group at VT+1 min and end of incremental test (all $P<0.021$, ES= 0.49 and 0.46 ,
306 respectively). FS was also significantly higher during low the BIS than high BIS group at VT+1
307 min and end (all $P<0.029$, ES= 0.49 and 0.45 , respectively). FS remained negative at the end of
308 incremental test in low BAS in 14 participants (100%; FS= -1.5 ± 0.8), high BAS in 12
309 participants (75%; FS= -1.0 ± 1.3), low BIS in 13 participants (76%; FS= -1.1 ± 1.3) and high
310 BIS in 13 participants (100%; FS= -1.6 ± 0.9).

311 The affective responses during HIIE when separated for BIS/BAS groups are illustrated
312 in Figure 1A. FS showed a significant group by interval number interaction effect for BIS
313 ($P=0.028$) and BAS ($P=0.039$). FS was significantly higher in high compared to low BAS at
314 work intervals 4 to 8 (all $P<0.039$, ES= 0.59 to 1.73) and recovery intervals 4 to 7 (all $P<0.031$,
315 ES= 0.50 to 1.56 , respectively). FS was also significantly higher during low BIS than high BIS
316 during work intervals 4 to 8 (all $P<0.012$, ES= 0.99 to 1.68) and recovery intervals 4 to 7 (all
317 $P<0.032$, ES= 1.11 to 1.48). FS remained positive at work-interval 8 in low BAS in 11
318 participants (78%; FS= 0.8 ± 0.7), high BAS in 16 participants (100%; FS= 2.1 ± 1.3), low BIS
319 in 16 participants (94%; FS= 2.0 ± 1.3) and high BIS in 11 participants (84%; FS= 0.12 ± 0.9).

320 FAS did not reveal any significant group by interval number interaction for BAS
321 ($P=0.41$) and BIS ($P=0.26$) or a main group effect for BAS ($P=0.21$) and BIS ($P=0.28$).
322 Affective responses (valence and activation) during the work intervals for HIIE protocols when
323 separated for BIS/BAS were plotted onto a circumplex model (Figure 3 A, B, C and D). There

324 was a shift from the unactivated/pleasant to the activated/pleasant quadrant for all BIS/BAS
325 groups.

326 **BIS/BAS with enjoyment responses.** The enjoyment responses during HIIE when
327 separated for BIS/BAS groups are illustrated in Figure 1B. EES showed a significant group by
328 interval number interaction effect for BAS ($P=0.01$) and BIS ($P=0.039$). EES was significantly
329 higher in high compared to low BAS at work-intervals 5 to 8 and recovery-intervals 5 to 7 (all
330 $P<0.015$; ES=1.21 to 1.66 and ES=1.15 to 1.16, respectively). EES was also significantly
331 higher in low compared to high BIS at work-intervals 6 to 8 and recovery-intervals 6 to 7 (all
332 $P<0.035$; ES=1.31 to 1.86 and ES=1.18 to 1.20, respectively).

333 PACES showed a significant main group effect in BAS ($P=0.02$) and BIS ($P=0.038$).
334 PACES was significantly higher in high than low BAS immediately after (75 ± 3 vs. 72 ± 2 ,
335 ES=1.19) and 20 min after HIIE (77 ± 2 vs. 74 ± 2 , ES=1.50). PACES was also significantly
336 higher in low than high BIS immediately after (74 ± 4 vs. 71 ± 2 , ES=0.95) and 20-min after
337 HIIE (75 ± 2 vs. 73 ± 2 , ES=1.00).

338 **BAS/BIS with RPE** The RPE responses during HIIE when separated for BIS/BAS
339 groups are represented in Figure 1A. RPE did not reveal any significant group by interval
340 number interaction for BAS ($P=0.31$) and BIS ($P=0.36$) or a main group effect for BAS
341 ($P=0.14$) and BIS ($P=0.10$).

342 **Self-efficacy with affective responses.** For the incremental test, FS showed a
343 significant group by time interaction effect for self-efficacy ($P=0.03$). FS was significantly
344 higher in the high than low self-efficacy group at VT+1 min and end (all $P<0.043$, ES= 0.45
345 and 0.50, respectively). FS remained negative at the end of the incremental test in the low self-
346 efficacy group in 15 participants (100%; FS= -1.6 ± 1.1) and high self-efficacy in 11
347 participants (73%; FS= -1.1 ± 0.9).

348 The affective responses during the HIIE when separated for low vs. high self-efficacy
349 groups are illustrated in Figure 1A. FS exhibited a significant group by interval number
350 interaction effect in self-efficacy ($P=0.024$). FS was significantly higher in high than low self-
351 efficacy group during work-intervals 5 to 8 (all $P<0.26$, ES= 0.88 to 1.06) and recovery-
352 intervals 5 and 7 (all $P<0.042$, ES= 0.79 to 0.73). FS remained positive at work-interval 8 in
353 the high-efficacy group in 15 participants (100%; 1.7 ± 1.3) and low-efficacy group in 12
354 participants (80%; 0.8 ± 0.7).

355 FAS did not reveal any significant group by interval number interaction effect in self-
356 efficacy ($P=0.39$) Affective responses (valence and activation) during the work intervals for
357 HIIE protocols, when separated for self-efficacy groups, were plotted onto a circumplex model
358 (Figure 3 E and F). There was a shift from the unactivated/pleasant to the activated/pleasant
359 quadrant for all self-efficacy groups.

360 **Self-efficacy with enjoyment responses.** The enjoyment responses during the HIIE
361 when separated for self-efficacy groups are illustrated in Figure 1B. EES exhibited a significant
362 group by interval number interaction effect in self-efficacy ($P=0.031$). EES was significantly
363 higher in the high than low self-efficacy group at work-intervals 5 to 8 (all $P<0.044$, ES=0.62
364 to 0.99) and at recovery-intervals 5 to 7 (all $P<0.048$, ES=0.53 to 0.89). There was no condition
365 by time interaction ($P=0.58$) or effect of group ($P=0.62$), but there was a main effect of time
366 ($P<0.01$) for PACES. PACES was significantly higher 20-min after compared to immediately
367 after HIIE (high-efficacy, 76 ± 2 vs. 74 ± 3 , $P=0.02$, ES=0.67; low-efficacy, 76 ± 3 vs. 73 ± 2 ,
368 $P=0.002$, ES=1.18).

369 **Self-efficacy with RPE.** The affective responses during HIIE when separated for low
370 vs. high self-efficacy are illustrated in Figure 1A. RPE exhibited a significant group by interval
371 number interaction effect in self-efficacy ($P=0.018$). RPE was significantly higher in high

372 compared to low self-efficacy groups during work-intervals 5 to 8 (all $P < 0.037$, $ES = 0.98$ to
373 1.43).

374 **Discussion**

375 The aim of this investigation was to examine the role of personality characteristics (BAS/BAS)
376 and self efficacy on affect, enjoyment and RPE responses during a commonly used HIIE
377 protocol in adolescents. The key findings are: 1) the high BAS/low BIS groups experienced
378 greater positive affect and enjoyment responses at the mid-point to the end of HIIE compared
379 to the low BAS/high BIS groups; 2) the high BAS/low BIS groups also experienced greater
380 post-enjoyment (immediately after and 20-min after) compared to low BAS/high BIS groups;
381 and 3) the high self-efficacy group elicited greater positive affect and enjoyment accompanied
382 by lower RPE at the mid-point to the end of HIIE compared to low self-efficacy group.

383 In the present study, we observed greater positive affect and enjoyment levels in high
384 BAS/low BIS groups than the low BAS/high BIS groups during the last five HIIE work
385 intervals. These findings suggest that personality traits (i.e. BAS/BIS) may have dependent
386 effects near the end of HIIE bout. We reason that the increase in HR responses during HIIE in
387 the current study is likely to account for the difference in BAS/BIS groups. According to the
388 DMT (Ekkekakis, 2003), an individual's interpretation of physiological cues (e.g. pain due to
389 the intensified physiological strain such as increased in HR) to manifest in an expression of
390 pleasant and unpleasant feelings could be influenced by individual's personality characteristics
391 in the zone of response variability (i.e. exercise above the VT, termed as high-intensity).
392 Indeed, Ekkekakis et al. (2005a) argued that the presence of stable inter-individuals traits (e.g.
393 personality traits) can influence the intensity of exercise a person is predisposed to tolerate or
394 select. We therefore suggest that variation in personality traits (i.e. BAS/BIS) and stimulated
395 challenge by the physiological strain (i.e. increased in HR) during HIIE may improve or reduce
396 the likelihood that an individual will experience positive affect and enjoyment in youth.

397 In the present study, the greater positive affect and enjoyment responses in the high
398 BAS compared to low BAS groups may be due to the greater sensitivity to reward, which led
399 participants to perceive the challenge of HIIE as positive reinforcement, as proposed by Gray's
400 personality theory (1993). By contrast, a greater sensitivity to punishment and threat cues may
401 have caused high BIS individuals to perceive the challenge of HIIE as a negative reinforcement,
402 resulting in less pleasurable and enjoyment responses compared to low BIS individuals. In
403 contrast to our data, Schneider and Graham (2009) stated that only BIS and not BAS influences
404 affect during continuous high-intensity exercise in youth. Differences in type of exercise
405 (continuous vs interval) may be an important contributing factor to these inconsistent results.
406 Furthermore, the high BAS group in the Schneider and Graham (2009) study experienced
407 negative affect during continuous high-intensity exercise, whereas the majority of our
408 participants (above 78%), regardless of personality characteristics, evoked positive affect at the
409 end of the HIIE bout. This observation highlights that the recovery interval built into HIIE may
410 have reduced the challenge posed by the HIIE protocol compared to continuous exercise, thus
411 making HIIE a less threatening condition. This is in line with the previous studies (Jung et al.,
412 2014; Malik et al., 2018a), which predicts that a pleasurable feeling can occur during rest
413 periods due to the withdrawal of the stress generated stimulus during the work intervals.

414 The present study also found greater pleasurable and enjoyment feelings in the high
415 self-efficacy group compared to the low-efficacy group during HIIE. Our result is in
416 accordance with a previously reported study in adults, which suggested that high self-efficacy
417 individuals tend to report greater positive affect compared to low-efficacy individuals when
418 exercise is performed at high-intensity exercise (i.e. above 70% of predicted maximal HR)
419 during a graded exercise test (McAuley & Courneya, 1992). According to Bandura (1997),
420 high self-efficacy individuals are more likely to engage in challenging tasks and are more
421 resistant to stressful or aversive stimuli compared to individuals with low-efficacy. This may

422 explain the differences in affect and enjoyment responses between the low and high self-
423 efficacy groups during HIIE in our study. These observations, however, were only evident after
424 work interval 5, suggesting that the challenging or stressful stimuli during HIIE is only
425 perceived after about half of the total work performed. We reason that low intensity exercise
426 performed during recovery periods could potentially improve confidence levels even with the
427 low-efficacy group by reducing the aversive and stressful stimuli (i.e. intensified sensory body
428 cues) found after about half of the total work is performed. It should also be noted that similar
429 enjoyment was observed following HIIE in both the low and high efficacy groups. In light of
430 enjoyment findings from the study by Malik et al. (2017), it is possible that the participants
431 interpreted the HIIE as a mastery experience (e.g. it gives me a strong feeling of success)
432 regardless of levels of confidence. Indeed, Bandura's (Bandura, 1997) theoretical framework
433 support that mastery experiences as one of the primary sources to develop individual's beliefs
434 about their efficacy apart from vicarious experience and social persuasion.

435 In this study, we found similar RPE regardless of personality characteristics, but high
436 self-efficacy groups elicited lower RPE compared to low self-efficacy groups. This indicates
437 that self-efficacy and personality traits have an independent effect on RPE during HIIE in
438 adolescents. We speculate that this is because self-efficacy is more associated with judgment
439 of one's capabilities or confidence to execute a demanding task, while BIS/BAS is associated
440 with the judgment of one's feelings regarding the exercise task. Indeed, RPE reflects the
441 conscious sensation of how hard, heavy, and strenuous the physical task is (Pageaux, 2016).
442 Furthermore, previous studies in adults and youths have consistently shown that personality
443 traits do not influence RPE during continuous exercise regardless of intensity (Coquart et al.,
444 2012; Schneider & Graham, 2009). With regards to self-efficacy, previous studies have shown
445 that lower RPE during exercise is linked with higher self-efficacy after exercise in youth
446 (Pender et al., 2002; Robbins et al., 2004), which supports our observations. However, these

447 studies (Pender et al., 2002; Robbins et al., 2004) were limited to continuous moderate-intensity
448 exercise (e.g. 60% $\text{VO}_{2\text{max}}$) and no observations were made regarding affect and enjoyment. In
449 this study, the high-efficacy group reported lower RPE accompanied by greater pleasurable
450 and enjoyment feelings compared to the low-efficacy group, which supports previous work in
451 adults during incremental exercise (McAuley & Courneya, 1992). Our data therefore supports
452 the proposition that self-efficacy may influence what (i.e. RPE) and how (i.e. affect) individuals
453 feel during HIIE in youth.

454 In the present study, we observed that at the end of incremental test to exhaustion in
455 BIS/BAS and self-efficacy groups, 78% and 73% of participants, respectively, experienced
456 negative affect responses compared to 75% and 80% of participants who experienced positive
457 affect at the end of HIIE bout. These observations strengthen previous work on adolescents
458 that indicates this HIIE protocol performed below 100% maximal effort does not elicit
459 prominent unpleasant feelings (Malik et al., 2018a), as argued by others (Biddle & Batterham,
460 2015; Hardcastle et al., 2014). According to Kahneman et al., (1993) the peak (positive vs.
461 negative) and end affect are the most important stimulus that provide overall interpretation of
462 an exercise session (Parfitt & Hughes, 2009; Hargreaves & Stych, 2013) to predict future
463 adherence (Rhodes & Kates 2015). Furthermore, HIIE elicited affect experienced to the
464 boundary of the activated pleasant feelings on the circumplex model in all groups (see Figure
465 3) due to similar arousal (measured by FAS score). Therefore, our findings reinforce the
466 feasibility of HIIE to preserve pleasurable feelings during exercise in adolescents with different
467 personality characteristics and levels of self-efficacy.

468 **Practical implications**

469 An important implication of this present study is that individual differences in personality traits
470 and self-efficacy may need to be considered when prescribing HIIE interventions in youth. We
471 observed that low BAS/high BIS groups elicited lower positive affect responses at the mid-

472 point to the end of the HIIE bout compared to high BAS/low BIS groups. Therefore, strategies
473 could be adopted by educators or coaches when targeting high BIS and low self-efficacy
474 individuals with HIIE interventions. For instance, low repetitions of HIIE may be applicable for
475 individual with low self-efficacy and high BIS individuals to promote future exercise behaviour
476 in youth. Also, an attentional dissociation strategy (e.g. diverting attention away from the
477 aversive stimuli by listening to self-selected music) could be used to help build positive
478 perceptions of feelings (e.g. affect and enjoyment) and perceived ability towards the exercise.
479 Indeed, Stork et al. (2015) showed that listening to self-selected music improved affect and
480 enjoyment responses during sprint interval training in adults, although this has yet to be
481 examined in youth. Verbal encouragement or persuasion technique towards the exerciser
482 during HIIE could also boost self-efficacy to facilitate more enjoyment and positive affect
483 during exercise.

484 **Limitation and future directions**

485 This study is limited to the single work intensity used to prescribed HIIE. Previous work has
486 shown that the relationship between perceptual responses (e.g. affect and RPE) and cognitive
487 factors (e.g. BIS/BAS and self-efficacy) may vary in magnitude as a function of exercise
488 intensity (Hall, Ekkekakis, & Petruzzello, 2005). However, this is the first study that provides
489 insight into the influence of cognitive factors on perceptual responses during HIIE in youth.
490 Another important limitation is that the HIIE protocol comprised cycling performed in a
491 laboratory setting. Therefore, the findings may not apply to other exercise modalities (e.g.
492 running) and limit the representations of a participant's real world affective response to
493 exercise. Despite this limitation, the HIIE protocol adopted shows similar findings to recent
494 work in adolescents examining affect responses during HIIE running (Malik et al., 2018a).
495 Another important limitation is that the HIIE was performed in a laboratory setting, which may
496 reduce the ecological validity of the affect experienced during HIIE. A research design in a

497 laboratory setting (e.g. lack of auditory, visual and social interaction) was required, so as to
498 ensure accurate comparison of perceptual responses (i.e. affect, enjoyment and RPE) during
499 HIIE. However, future studies may consider expanding the scope of the present investigation
500 to school-based HIIE with long-term monitoring of adherence and dropout patterns.

501

502 **Conclusions**

503 In conclusion, our study further expands the understanding of the influence of cognitive factors
504 on temporal changes in affect, enjoyment and perceived exertion during HIIE in adolescents.
505 The present study showed that individual differences in personality and self-efficacy may
506 decrease or increase the likelihood that a person will experience positive affective and
507 enjoyment response to HIIE. Our findings provide advancement to the DMT by showing that
508 cognitive factors are related to the changes in the affect responses during HIIE in youth, but
509 are also dependent on the HIIE work interval. The present study extends the previous finding
510 showing that HIIE does not generate prominent feeling of displeasure (Malik et al., 2018a)
511 despite differences in personality and self-efficacy.

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Table 2 Cardiorespiratory responses to HIIE

	Mean \pm SD			
	Boys	Girls	P-value	ES
Average HR (bpm)	155 \pm 8	158 \pm 6	0.13	0.46
Average % HRmax	81 \pm 4	83 \pm 3	0.06	0.85
Peak HR (bpm)	180 \pm 4	182 \pm 5	0.92	0.44
Peak %HRmax	94 \pm 4	96 \pm 3	0.16	0.57
Average $\dot{V}O_2$ (L \cdot min ⁻¹)	0.98 \pm 0.11	0.96 \pm 0.13	0.72	0.17
Average $\dot{V}O_2$ (% $\dot{V}O_{2max}$)	60 \pm 6	61 \pm 8	0.70	0.14
Peak $\dot{V}O_2$ (L \cdot min ⁻¹)	1.26 \pm 0.11	1.20 \pm 0.12	0.11	0.52
Peak $\dot{V}O_2$ (% $\dot{V}O_{2max}$)	79 \pm 10	76 \pm 8	0.41	0.33

Values are reported as mean \pm standard deviation. Abbreviations: HR, heart rate; HR_{max}, maximal heart rate; $\dot{V}O_2$, oxygen uptake; $\dot{V}O_{2max}$, maximal oxygen uptake; % $\dot{V}O_{2max}$, percentage of maximal oxygen uptake; VT, ventilatory gas exchange.

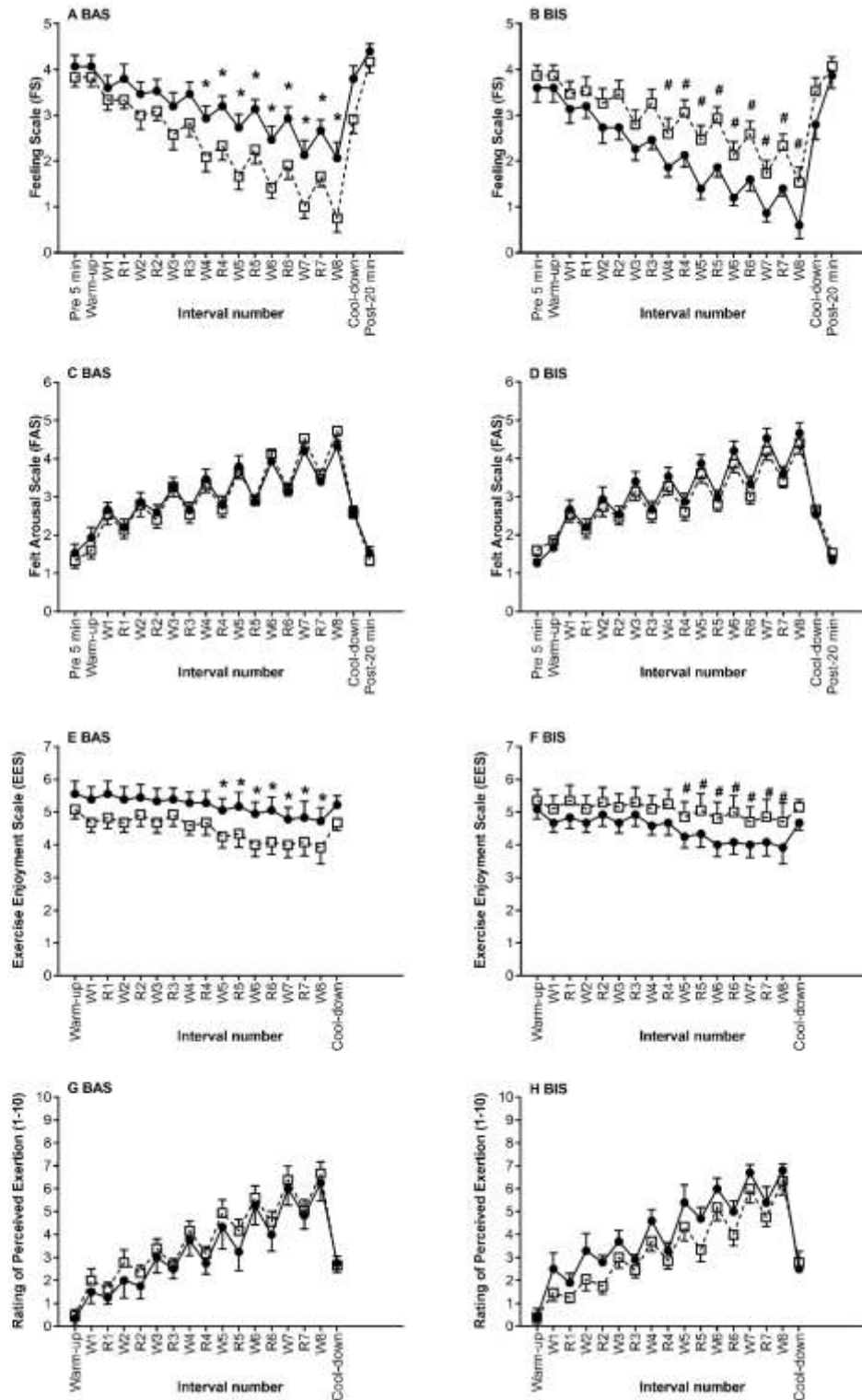


Figure 1. Feeling scale for behavioural activation (BAS) (A) and behavioural inhibition (BIS) (B), Felt arousal scale for BAS (C) and BIS (D), exercise enjoyment scale for BAS (E) and BIS (F), and rating of perceived exertion for BAS (G) and BIS (H) during the interval and recovery phases of the HIIE for the high (●) and low (□). Where, W= work interval and R= recovery

interval. *Significant difference between high and low BAS ($P<0.05$). #Significant difference between high and low BIS ($P<0.05$). Error bars are presented as SD. See text for details.

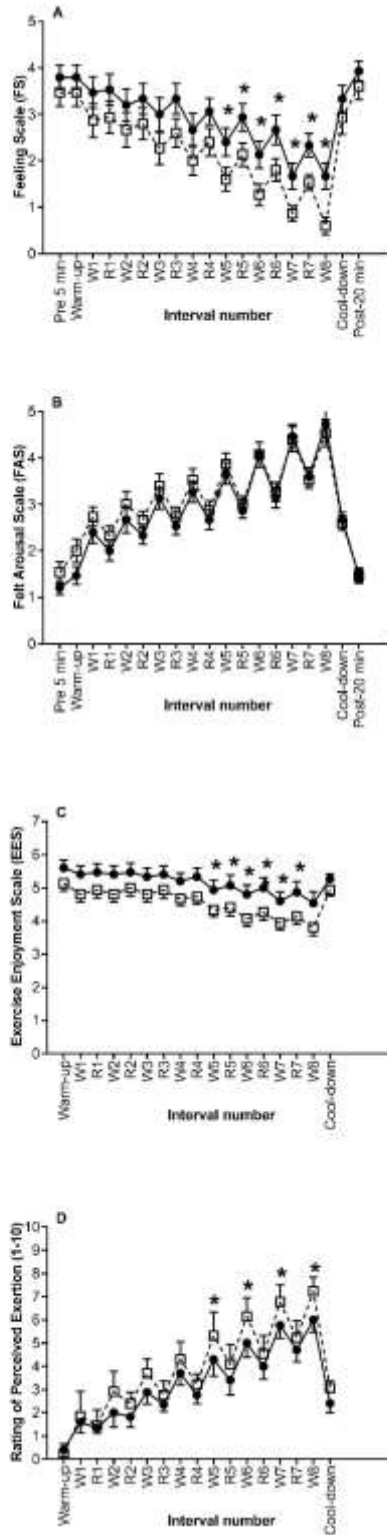


Figure 2. Feeling scale (A), felt arousal scale (B), exercise enjoyment scale (C) and rating of perceived exertion (D) during the interval and recovery phases of HIIE for high-efficacy (●) and low-efficacy (□). Where, W= work interval and R= recovery interval. *Significant difference between high and low self-efficacy ($P < 0.05$). Error bars are presented as SD. See text for details.

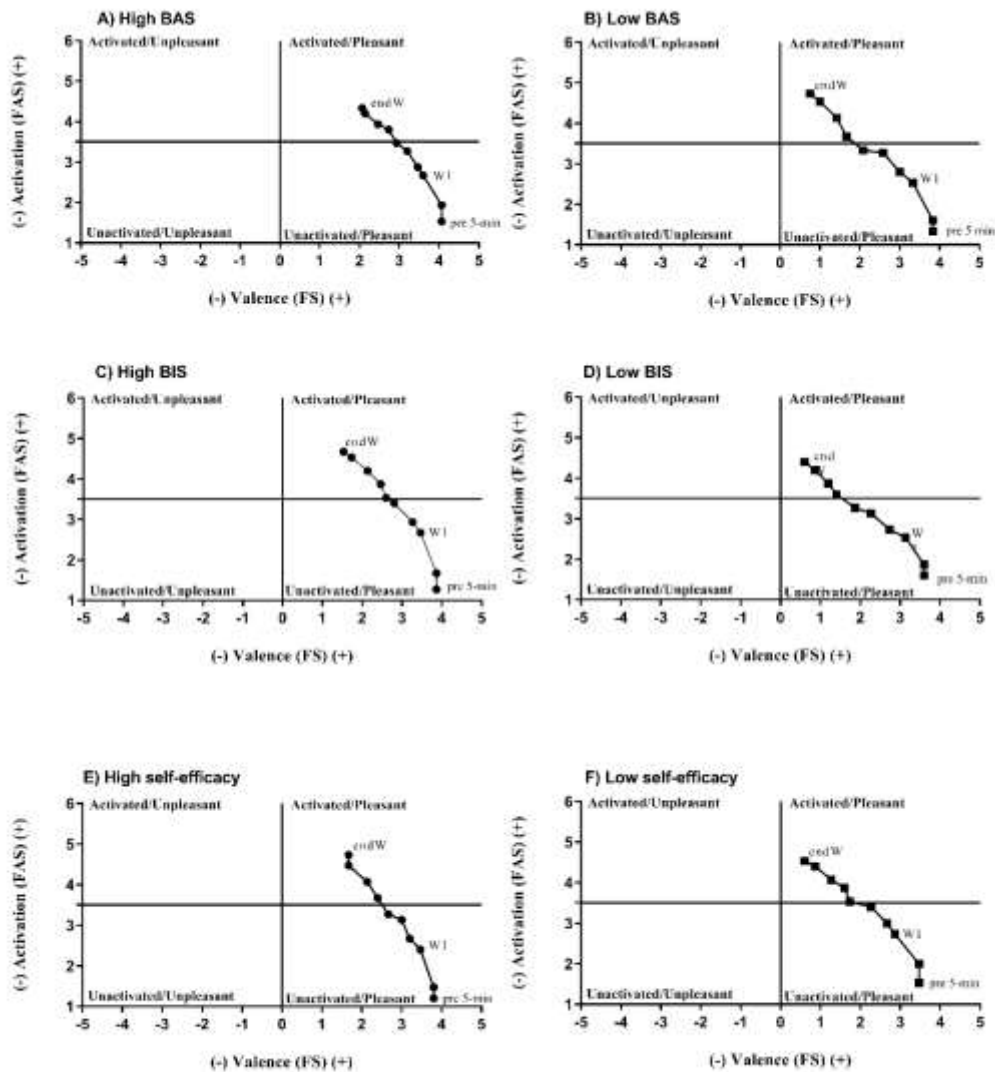


Figure 3. Valence (FS) and activation (FAS) during the work interval of high BAS (A), low BAS (B), high BIS (C), low BIS (D), high self-efficacy (E), and low self-efficacy (D) plotted onto the circumplex model. Where, W= work interval and endW= work interval 8 in HIIE. See text for details.