

**Mental Toughness in Sport: Motivational Antecedents and Associations with
Performance and Psychological Health**

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1 Abstract

2 We argue that basic psychological needs theory (BPNT) offers impetus to the value of mental
3 toughness as a mechanism for optimizing human functioning. We hypothesized that
4 psychological needs satisfaction (thwarting) would be associated with higher (lower) levels
5 of mental toughness, positive affect, and performance, and lower (higher) levels of negative
6 affect. We also expected that mental toughness would be associated with higher levels of
7 positive affect and performance, and lower levels of negative affect. Further, we predicted
8 that coaching environments would be related to mental toughness indirectly through
9 psychological needs, and that psychological needs would indirectly relate with performance
10 and affect through mental toughness. Adolescent cross-country runners (136 male and 85
11 female, $M_{\text{age}} = 14.36$) completed questionnaires pertaining to BPNT variables, mental
12 toughness, and affect. Race times were also collected. Our findings supported our
13 hypotheses. We concluded that BPNT is generative in understanding some of the antecedents
14 and consequences of mental toughness and is a novel framework useful for understanding
15 mental toughness.

16
17 Keywords: Autonomy, Positive Youth Development, Coach Environments, Human
18 Functioning,

19

20 Mental Toughness in Sport: Motivational Antecedents and Associations with Performance
21 and Psychological Health

22 Mental toughness is a term that is often used to describe a collection of psychological
23 characteristics thought to be central to high performance (Butt, Weinberg, & Culp, 2010;
24 Jones, Hanton, & Connaughton, 2002). Over the last decade, researchers have expended
25 considerable efforts in attempting to define and conceptualize mental toughness. As such,
26 there have been recent advancements in understanding this concept. To progress this research
27 field further, there is a need to investigate the positioning of mental toughness within a
28 nomological network of relations that includes variables from established theories within the
29 broad field of psychological enquiry. One such theory proposed in the literature as being
30 connected to mental toughness (Gucciardi & Mallett, 2010) is self-determination theory
31 (SDT; Deci & Ryan, 2002). Drawing on theory such as SDT would expand the boundaries of
32 mental toughness research and provide new perspectives in understanding the development
33 and consequences of this concept. The present investigation is a step toward this direction as
34 it aims to examine how mental toughness is linked to motivational variables encompassed by
35 self-determination theory, as well as psychological health, and objective sport performance.

36 **Mental Toughness in Sport**

37 Gucciardi, Hanton, Gordon, Mallett, and Temby (in press) recently defined mental
38 toughness as a personal capacity to produce consistently high levels of subjective (e.g.,
39 personal goal achievement) or objective (e.g., race times) performance despite everyday
40 challenges and stressors as well as significant adversities. This capacity has been discussed as
41 a collection of personal characteristics including attributes such as self-confidence, optimistic
42 thinking, and buoyancy, leading to a general consensus that mental toughness is a
43 multidimensional concept (Butt et al., 2010; Jones et al., 2002). In testing this assumption
44 regarding the dimensionality of mental toughness, Gucciardi et al. (in press) found that there

45 was considerable empirical overlap among such personal characteristics and that a
46 multidimensional construct was limited in terms of discriminant validity. As a result, they
47 proposed and found support for a direct, unidimensional model of mental toughness. They
48 found excellent model fit and good-to-excellent factor loadings for the unidimensional model
49 across three performance groups (i.e., sport, academia, business), as well as strong
50 correlations with theoretically related properties (i.e., perceived stress, performance, goal
51 attainment, thriving). Such evidence highlighted that the personal characteristics reported in
52 previous studies aimed at conceptualizing mental toughness are not readily distinguishable by
53 individuals in performance contexts and therefore called into question the
54 multidimensionality of this concept. Gucciardi et al.'s (in press) work provides a foundation
55 upon which to consider further lines of enquiry that would position mental toughness
56 alongside variables from other theoretical frameworks and help identify associated predictors
57 and outcomes of the concept.

58 **Linking Mental Toughness with SDT**

59 Although we focus on the links between mental toughness and SDT in this paper, we
60 acknowledge that other theories of motivation (e.g., self-efficacy theory; Bandura, 1977;
61 achievement goal theory; Elliot & McGregor, 2001) are potentially useful for understanding
62 consistently high performance. For example, in line with self-efficacy theory, the degree to
63 which individuals perceive their actions as efficacious will determine how much effort they
64 expend and for how long they persist on tasks (Bandura, 1977). Similarly, findings from
65 achievement goal theory (e.g., Puente-Diaz, 2012) suggest that effortful and persistent actions
66 are determined by how individuals define (i.e., absolute, intra-individual, or normative) and
67 valance (i.e., positive or negative) notions of competence. These motivational theories
68 evidence strong links with behaviors implicit in Gucciardi et al.'s (in press) definition and,
69 hence, are potentially useful in understanding mental toughness. Despite motivational

70 theories such as these holding currency for understanding mental toughness, we focus on
71 SDT in the current study because of previous proposed links between this particular theory
72 and mental toughness (e.g., Gucciardi & Mallett, 2010), as well as to open debate about the
73 theoretical underpinnings of mental toughness and its development – an avenue researchers
74 have largely neglected in previous research.

75 Self-determination theory is comprised of five mini-theories, one of which is
76 particularly apt for the present study, namely basic psychological needs theory (BPNT, Deci
77 & Ryan, 2002). In line with BPNT, the optimization of human functioning is contingent on
78 the degree to which individuals perceive the satisfaction of three fundamental psychological
79 needs: autonomy (the belief that one's actions are self-chosen), competence (the belief that
80 one can bring about desired outcomes), and relatedness (the belief that one is meaningfully
81 connected with a wider social network).

82 We propose that mental toughness is connected to notions that underscore BPNT as it
83 too concerns the optimization of human functioning in performance contexts. In addition,
84 researchers have shown that BPNT variables are predictive of behaviors or characteristics
85 consistent with the definitional and conceptual properties of mental toughness. For example,
86 there is evidence to support associations between psychological needs satisfaction and
87 persistence (e.g., Pelletier, Fortier, Vallerand, & Brière, 2001), effort (e.g., Boiché, Sarrazin,
88 Grouzet, Pelletier, & Chanal, 2008), concentration (e.g., Standage, Duda, & Ntoumanis,
89 2003), adaptive coping (e.g., Smith, Ntoumanis, Duda, & Vansteenkiste, 2011), and
90 challenging-seeking (e.g., Standage et al., 2003).

91 Other principles detailed in BPNT are also useful for interpreting mental toughness.
92 In particular, within BPNT, psychological needs satisfaction is dependent on the degree to
93 which autonomy, competence, and relatedness are supported by social environments. Social
94 environments that nurture all three psychological needs are termed autonomy-supportive

95 (despite the title, autonomy-supportive environments support all three psychological needs),
96 whereas those that thwart psychological needs are termed controlling (Bartholomew,
97 Ntoumanis, & Thøgersen-Ntoumani, 2009; Deci & Ryan, 2000). Su and Reeves (2011), in
98 their meta-analysis of the extant literature, identified autonomy-supportive environments as
99 being characterized by the offering of choice (within boundaries), the acknowledgement of
100 feelings or perspectives, the use of non-controlling actions and feedback, the provision of
101 meaningful rationales, and the nurturing of individuals' inner motivational resources (e.g.,
102 curiosity, enjoyment, belonging). In comparison, controlling environments are characterized
103 by the manipulative use of rewards, negative conditional regard, intimidation, and excessive
104 personal control (Bartholomew, Ntoumanis, & Thøgersen-Ntoumani, 2010).

105 In line with previous findings (Bartholomew, Ntoumanis, Ryan, Bosch, & Thøgersen-
106 Ntoumani, 2011) and recent speculations in the literature (Gucciardi & Mallett, 2010), we
107 propose that the provision of autonomy-supportive environments may lead to the facilitation
108 of mental toughness, whereas controlling environments may lead to the forestallment of
109 mental toughness. Elucidating these suggestions further, previous findings show that factors
110 believed to be responsible for the development of mental toughness share the characteristics
111 of autonomy-supportive environments. In particular, researchers (e.g., Connaughton, Wadey,
112 Hanton, & Jones, 2008; Gucciardi, Gordon, Dimmock, & Mallett, 2009) have suggested that
113 mental toughness development is contingent on athletes being afforded opportunities to
114 explore and engage in tasks volitionally (e.g., self-directed learning), perceiving themselves
115 as competent and feeling challenged during learning (e.g., being able to demonstrate skill
116 mastery, engage in competitive challenges), and feeling respected, cared for, and needed by
117 those around them (e.g., positive social support, a sense of belonging). In line with BPNT,
118 autonomy-supportive environments are key to the optimization of human functioning because

119 of how they nurture psychological needs satisfaction, suggesting an indirect association
120 between social environments and functioning through psychological needs satisfaction.

121 As architects of athletes' experiences, coaches are pivotal in the provision of the
122 social environments that may either foster (i.e., autonomy-supportive) or forestall (i.e.,
123 controlling) mental toughness. Although not explicitly focused on BPNT principles,
124 Gucciardi et al. (2009) proposed that coaches who exhibit behaviors consistent with the
125 notion of autonomy-supportive environments (e.g., encourage athlete input, challenge
126 learning, promote mastery, create non-hostile social environments) were more likely to
127 facilitate mental toughness. Gucciardi et al. (2009) also found that coaches who engage in
128 behaviors consistent with notions of controlling environments (e.g., emphasize ego
129 involvement) are likely to thwart mental toughness development. As articulated above, it is
130 likely that coaching environments are associated with mental toughness indirectly depending
131 on the degree to which such environments nurture individuals' psychological needs.

132 **Linking BPNT to Adaptive Outcomes through Mental Toughness**

133 Researchers have shown that athletic performance (e.g., Gillet, Vallerand, Amoura, &
134 Baldes, 2010), as well as positive and negative affect (e.g., Aide, Duda, & Ntoumanis, 2008)
135 are contingent on the satisfaction of psychological needs that result from the provision of
136 autonomy-supportive environments. Findings from related fields of psychological enquiry
137 provides evidence demonstrating that better athletic performances, higher levels of positive
138 affect, and lower levels of negative affect are associated with the personal characteristics
139 consistent with mental toughness conceptualizations (e.g., self-belief, Caprara, Steca,
140 Gerbino, Paciello, & Vecchio, 2006; success mindset, Elliot & McGregor, 2001; emotional
141 awareness and regulation, Salami, 2011). Further, preliminary research has supported
142 theoretically expected relations between mental toughness and performance (Bell, Hardy, &
143 Beattie, 2013; Gucciardi et al., in press), positive affect, and negative affect (Gucciardi et al.,

144 in press). Given the plausible links and preliminary evidence of relations between mental
145 toughness and BPNT variables, performance, and both positive and negative affect, we
146 contest a nomological network of relations that details the antecedents and outcomes of
147 mental toughness. In particular, we propose that BPNT variables facilitate mental toughness
148 that, in turn, results in adaptive athlete outcomes.

149 The aim of the current study was to explore 1) how motivational variables detailed in
150 BPNT relate to adolescent athletes' mental toughness levels; and 2) the associations between
151 both motivation variables and mental toughness and adaptive outcomes (i.e., performance
152 and positive and negative affect). We were also interested in exploring the indirect relations
153 between coaching environments and mental toughness through psychological needs, as well
154 as the indirect relations between psychological needs and adaptive outcomes through mental
155 toughness. Adolescence was considered because it is a stage of development most commonly
156 associated with interpersonal differences in mental toughness and, therefore, arguably the
157 most pertinent age group to investigate questions of substantive interest (Bell et al., 2013).

158 In line with previous research on BPNT, we predicted that athletes who reported
159 higher levels of autonomy support from their coaches would perceive higher levels of
160 psychological needs satisfaction and lower levels of psychological needs thwarting (*H1a*). In
161 contrast, higher levels of perceived coach control was expected to be associated with lower
162 levels of psychological needs satisfaction and higher levels of psychological needs thwarting
163 (*H1b*). Further, athletes who perceived higher levels of psychological needs satisfaction
164 would report higher levels of positive affect, lower levels of negative affect, and faster race
165 times (*H2a*), whilst greater psychological needs thwarting would be associated with lower
166 levels of positive affect, higher levels of negative affect, and slower race times (*H2b*).

167 Based on the arguments articulated above pertaining to how BPNT variables inform
168 an understanding of mental toughness, we predicted that athletes who perceived higher levels

169 of psychological needs satisfaction would report higher levels of mental toughness (*H3a*) and
170 athletes who perceived higher levels of psychological needs thwarting would report lower
171 levels of mental toughness (*H3b*). We also predicted that, based on preliminary findings (Bell
172 et al., 2013; Gucciardi et al., in press) athletes who reported higher levels of mental toughness
173 would also report higher levels of positive affect, lower levels of negative affect, and quicker
174 race times compared to adolescent athletes who reported lower levels of mental toughness
175 (*H4*). These hypothesized direct relations can be illustrated in Figure 1. Finally we made
176 several predictions pertaining to indirect relations. We predicted that autonomy-supportive
177 coaching environments would be positively (*H5a*) and controlling environments would be
178 negatively (*H5b*) related with mental toughness through psychological needs satisfaction.
179 Conversely, we expected that autonomy-supportive coaching environments would be
180 negatively (*H5c*) and controlling environments would be positively (*H5d*) related with mental
181 toughness through psychological needs thwarting. We also expected that psychological needs
182 satisfaction would be positively (*H6a*) and psychological needs thwarting would be
183 negatively (*H6b*) associated with positive affect through mental toughness, whilst
184 psychological needs satisfaction would be negatively (*H6c*) and psychological needs
185 thwarting would be positively (*H6d*) associated with negative affect and race times through
186 mental toughness.

187 **Method**

188 **Participants**

189 Participants were 136 male ($M_{\text{age}} = 14.39$, $SD = 1.44$) and 85 female ($M_{\text{age}} = 14.29$,
190 $SD = 1.53$) cross-country runners recruited from high schools in Australia ($N = 221$). On
191 average, participants had been competing in inter-school cross-country events for 4.47 years
192 ($SD = 2.57$) and trained 2.10 hours per week ($SD = 1.63$).

193 **Measures**

194 **Demographics.** Participants' age, gender, years competing in cross-country, and
195 number of training hours per week were garnered using single item measures.

196 **Mental Toughness Index (MTI).** The MTI (Gucciardi et al., in press) is an eight-
197 item direct measure of mental toughness (e.g., "I am able to regulate my focus when
198 performing tasks"). Each question represents one of the eight facets of mental toughness
199 proposed in Gucciardi et al.'s (2011) synthesis of the literature. Participants respond to each
200 item on a 7-point scale (1 = *false, 100% of the time* and 7 *true, 100% of the time*). The scale
201 has received psychometric support with samples of university students, athletes, and
202 employees, and theoretically consistent relations with performance, stress, and psychological
203 health (Gucciardi et al., in press).

204 **Sport Climate Questionnaire – Short Form (SCQ-SF).** The SCQ-SF is a sport-
205 adaption of the Learning Climate Questionnaire (Williams & Deci, 1996), which measures
206 athletes' perceptions of coach autonomy support (e.g., "I feel that my coach provides me with
207 choices and options"). Participants respond to the 6-item questionnaire using a scale ranging
208 from 1 (*strongly disagree*) to 7 (*strongly agree*). The SCQ-SF has been validated in sport
209 samples (e.g., Hagger, Chatzisarantis, Culverhouse, & Biddle, 2003).

210 **Basic Needs Satisfaction in Sport Scale (BNSSS).** The BNSSS (Ng, Lonsdale, &
211 Hodge, 2011) measures athletes' perceptions of competence (e.g., "I am skilled at my sport"),
212 relatedness (e.g., "I show concern for others in my sport"), and autonomy. Ng et al.'s (2011)
213 measure separates autonomy into three categories, namely volition (e.g., "I feel I participate
214 in my sport willingly"), choice (e.g., "In my sport, I get opportunities to make choices"), and
215 internal perceived locus of causality (e.g., "In my sport, I feel I am pursuing goals that are my
216 own"). Participants respond on a scale ranging from 1 (*not at all true*) to 7 (*very true*).
217 Psychometric analyses showed the 20-item measure to have satisfactory internal consistency

218 scores and model fit, and good nomological validity and test-retest reliability (Ng et al.,
219 2011).

220 **Psychological Needs Thwarting Scale (PNTS).** The PNTS (Bartholomew,
221 Ntoumanis, Ryan, & Thogersen-Ntoumani, 2011) is a 12-item measure of athletes'
222 perceptions of psychological needs thwarting. This measure includes statements pertaining to
223 the thwarting of autonomy (e.g., "I feel pushed to behave in certain ways"), competence (e.g.,
224 "There are situations where I am made to feel inadequate"), and relatedness (e.g., "I feel
225 rejected by those around me"), and requires participants to respond on a seven-point scale (1
226 = *strongly disagree* and 7 = *strongly agree*). Analyses have revealed support for the three-
227 factor model and internal consistency (Bartholomew et al., 2011).

228 **Controlling Coach Behaviors Scale (CCBS).** The CCBS (Bartholomew et al., 2010)
229 includes 15 items pertaining to athletes' perceptions of their coaches' behaviors. The scale is
230 comprised of four factors: controlling use of rewards (e.g., "my coach only rewards/praises
231 me to make me train harder"), negative conditional regard (e.g., "my coach pays me less
232 attention if I have displeased him/her"), intimidation (e.g., "my coach threatens to punish me
233 to keep me in line during training"), and excessive personal control (e.g., "my coach tries to
234 control what I do during my free time"). Responses are rated on a 7-point scale from 1
235 (*strongly disagree*) to 7 (*strongly agree*). Statistical analyses have revealed sound content and
236 factorial validity for the measure, as well as internal consistency and invariance across gender
237 and sport type (Bartholomew et al., 2010).

238 **Psychological health.** Positive affect was measured using the Mental Health
239 Continuum Short Form (MHC-SF, Keyes, 2005). This 14-item questionnaire requires
240 individuals to indicate the degree to which they have experienced certain thoughts and
241 feelings over the past month on a 6-point scale (1 = *never* and 6 = *every day*). Questions are
242 categorized into three factors, emotional (e.g., "happy"), psychological (e.g., "that your life

243 has a sense of direction or meaning to it”), and social (e.g., “that people are basically good”).
244 High internal consistency scores and evidence of discriminatory validity support the use of
245 the MHC-SF (Keyes, 2005).

246 The 21-item Depression Anxiety Stress Scale (DASS-21) was employed to measure
247 negative affect (Lovibond & Lovibond, 1995). The DASS-21 measures depression (e.g., “I
248 felt down-hearted and blue”), anxiety (e.g., “I felt I was close to panic”), and stress (e.g., “I
249 found it difficult to relax”), and requires individuals to respond on a 4-point scale (0 = *did not*
250 *apply to me*, 1 = *applied to me to some degree, or some of the time*, 2 = *applied to me a*
251 *considerable degree, or a good part of time*, and 3 = *applied to me very much, or most of the*
252 *time*). The DASS-21 has been shown to have strong factor loadings, discriminator validity,
253 and internal consistency (Antony, Bieling, Cox, Enns, & Swinson, 1998).

254 **Performance.** Race times over varying distances (depending on age and gender) were
255 collected during the end-of-season championship and served as a measure of performance.
256 This event was selected because of the high attendance of athletes and because mental
257 toughness is thought to be most pertinent during pressure-filled performances such as end-of-
258 season championships (Bell et al., 2013). Race times were standardized to account for
259 differences in race distance across age and gender (e.g., 15 year old boys ran 4 km, 15 year
260 old girls ran 3 km). A higher race time equated to poorer performance.

261 **Procedure**

262 Following university ethics approval, school staff (i.e., principals and/or sport
263 directors) were approached and informed about the aims and procedures of the research.
264 Information sheets and written consent forms were then distributed to parents/guardians and
265 adolescent athletes during training sessions. Once parent/guardian and participant written
266 consent was received, participants were asked to complete a booklet that included the
267 abovementioned questionnaires. Participants completed the questionnaires roughly one

268 month before the end-of-season inter-school championship. The demographic questions
269 appeared first in all booklets and the remaining questionnaires were randomly counter-
270 balanced. Race times were recorded during the championship event by race organizers.

271 **Data Analysis**

272 Path analysis with a Bayesian estimator was applied in Mplus 7.11 (Muthén &
273 Muthén, 1998-2012) to examine the hypothesized model depicted in Figure 1 (for general
274 examples and descriptions of Bayesian analysis see, van de Schoot et al., in press; Zyphur &
275 Oswald, in press) including both direct and indirect pathways (see, Yuan & MacKinnon,
276 2009). Bayesian analysis is an approach that has garnered the interests of sport and exercise
277 psychology researchers in recent years (Doran & Gaudreau, 2014; Jackson, Gucciardi, &
278 Dimmock, 2014). This approach leverages off theory and previous research to form a *prior*
279 *distribution* – a combination of the specific magnitude and variability of effect sizes. Prior
280 distributions are then incorporated into the analysis to determine the probability of a
281 hypothesized model, given the data (Muthén & Asparouhov, 2012). Prior distributions can
282 range from non-informative, where no prior knowledge is asserted about the magnitude or
283 variance of the parameter, to highly informative, where the distribution is constrained by very
284 precise parameter estimates. These prior distributions are combined with new data to form
285 the *posterior distribution* – an updated understanding of the prior distribution in light of the
286 given data. In totality, all available evidence – prior and current – is considered in the process
287 of Bayesian analysis. Additionally, Bayesian analysis does not depend on asymptotic (large-
288 sample) theory and, as such, provides more accurate estimates of parameters and model fit
289 than frequentist approaches when sample size is small. Another benefit of Bayesian analysis
290 over traditional approaches is that it is more flexible when handling complex models, as the
291 use of prior knowledge incorporates additional information into the analysis that help identify

292 parameter solutions that otherwise might not be achieved by using a frequentist approach
293 (Asparouhov & Muthén, 2012, July 18).

294 We used both empirical evidence and theoretical knowledge to guide the specification
295 of priors in our analysis. First, prior knowledge regarding the relations between coaching
296 climate and psychological needs, and psychological needs and psychological health were
297 guided by empirical evidence (Bartholomew et al., 2011). We utilized Bartholomew et al.'s
298 findings because of the similarity between the aims, sample, and measures of their study and
299 ours. For similar reasons, we utilized Gucciardi et al.'s (in press) findings to inform the
300 selection of priors for the relations between mental toughness and both positive and negative
301 affect. The empirically informed priors and their respective variances can be seen in Table 1.

302 Although the effects of both BPNT variables (Gillet et al., 2010) and mental
303 toughness (Bell et al., 2013; Gucciardi et al., in press) on performance have been examined in
304 previous research, it is difficult and often inappropriate to guide priors when exploring
305 unrelated performances (e.g., mean performances in closed sports are not equivalent to mean
306 performances in endurance sports). Hence, drawing on statistical recommendations (Muthén
307 & Asparouhov, 2012; Zyphur & Oswald, in press) and theoretical expectations, the priors for
308 the effects of psychological needs satisfaction/thwarting on mental toughness were set with a
309 mean of $-.40$ and a variance of $.03$, meaning that 95% of the loadings should fall between $-.06$
310 and $-.74$. These means and variances were selected to reflect the expected direction of
311 relations between mental toughness and race times (i.e., inverse relations), as informed by
312 past research, whilst limiting constraints on the strength between these associations (for
313 further details about the use and selection of theoretically informed priors see, Zyphur &
314 Oswald, in press). As the use of different priors can influence the relations between variables
315 (Zyphur & Oswald, in press), we conducted a sensitivity analysis by comparing the
316 hypothesized model (i.e., informed by empirical and theoretical priors) with two other

317 models; one with the same mean parameters but with variances around the expected
318 parameter estimates set to be highly precise, and another with low precision for the variance
319 of the parameter distribution (see Table 1).

320 Model convergence is an important consideration for valid estimation and inference
321 with Bayesian modeling. Bayesian analysis employs a sophisticated estimation process
322 known as Markov Chain Monte Carlo (MCMC) whereby the prior distribution is specified
323 and through an iterative process an accurate representation of the posterior distribution is
324 approximated from representative samples of parameter values from the entire posterior
325 distribution (for detailed discussions about MCMC methods and application, see Chen, Shao,
326 & Ibrahim, 2000; Gamerman & Lopes, 2006). At least two MCMC estimation "chains" are
327 run in parallel, each using different starting values for model parameters to ensure the
328 iterative process provides an opportunity to monitor convergence (Muthén & Asparouhov,
329 2012). Two diagnostic tools can be created from these chains: (i) the potential scale reduction
330 (PSR) factor, which takes into account the overall parameter variability both within and
331 between the chains; and (ii) trace plots, which graphically represent the fluctuation in
332 parameter values as the MCMC estimator iterates toward the solution. A PSR value of ≤ 1.1
333 provides evidence in support of convergence to the true posterior distribution, as it suggests
334 that parameter variability could not be appreciably reduced with further iterations
335 (Asparouhov & Muthén, 2010, September 29). Visual inspection of trace plots should
336 indicate that the multiple independent chains have all stabilized to essentially the same
337 distribution (Asparouhov & Muthén, 2010, September 29).

338 Model fit is subsequently assessed using posterior predictive checking (for more
339 detail, see Lynch & Western, 2004). This method compares the probability of the observed
340 data against that of the generated posterior distribution of parameters, while taking into
341 account variability in the parameters. Specifically, the posterior predictive p (PPP) value

367 Table 1) demonstrated sound fit indices. In light of these results, and in keeping with prior
368 findings, we focus our discussions on the hypothesized model (i.e., Model A).

369 Bayesian estimates and 95% CIs for the associations between the study variables for
370 all three models are summarized in Table 1. Theoretically consistent relations were evidenced
371 between social environments and psychological needs. In particular, autonomy-supportive
372 environments were positively associated with psychological needs satisfaction and negatively
373 associated with psychological needs thwarting. Further, controlling environments were
374 positively associated with psychological needs thwarting and negatively related with
375 psychological needs satisfaction. Psychological needs were also strongly associated with
376 mental toughness, as well as positive and negative affect, and performance. Specifically,
377 psychological needs satisfaction was positively associated with mental toughness and
378 positive affect, and negatively associated with negative affect and race times. Further,
379 psychological needs thwarting was positively associated with negative affect and race times,
380 and negatively associated with mental toughness and positive affect. Finally, mental
381 toughness was strongly associated with positive and negative affect, and race times as
382 hypothesized. Specifically, mental toughness was positively related to positive affect and
383 negatively associated with negative affect and race times.

384 Psychological needs satisfaction mediated the relation between autonomy-supportive
385 environments and mental toughness, as well as the relations between controlling
386 environments and mental toughness. Similarly, psychological needs thwarting mediated the
387 relations between autonomy-supportive environments and mental toughness, as well as
388 controlling environments and mental toughness. Further, mental toughness mediated the
389 relations between psychological needs satisfaction and positive and negative affect, and
390 performance, as well as psychological needs thwarting and positive and negative affect, and
391 performance (Table 3).

Discussion

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Guided by basic psychological needs theory (Deci & Ryan, 2002), mental toughness is a concept that can be positioned within a nomological network of relations that provides an insight into its motivation antecedents and relations with performance and psychological outcomes. The aims of the current study were to explore 1) how motivational variables detailed in BPNT relate to adolescent athletes' mental toughness levels and 2) the associations between both motivation variables and mental toughness and adaptive outcomes (i.e., performance and positive and negative affect). We were also interested in exploring how coaching environments and mental toughness were indirectly related through psychological needs, as well as how psychological needs and adaptive outcomes were indirectly associated through mental toughness.

In the first instance, all direct relations between the coaching climate and psychological needs (*H1a-b*), and between psychological needs and outcome variables (*H2a-b*) were supported. These findings compliment previous research that has identified associations between social environments and psychological needs, and between psychological needs and outcome variables (Deci & Ryan, 2000; Ntoumanis, 2012). Beyond these results, the major substantive findings of our study pertain to the direct and indirect associations involving mental toughness, which highlight a nomological network within which this concept can be understood. To our knowledge, this study is the first to show that psychological needs satisfaction is positively, whilst psychological needs thwarting is inversely associated with mental toughness (*H3a-b*). Arguably, to produce consistently higher levels of performance despite obstacles faced – that is, to demonstrate greater levels of mental toughness – individuals need to not only expend a great deal of cognitive and behavioral effort, but also maintain this effort over time. In line with BPNT, the quality and quantity of cognitive and behavior effort available to individuals is contingent on the degree

417 to which psychological needs are satisfied (Deci & Ryan, 2000). That is, psychological needs
418 satisfaction promotes perceptions of personal control, self-efficacy, and self-value that result
419 in the maintenance of high levels of effort. In comparison, psychological needs thwarting
420 inhibits individuals' sense of personal control, efficaciousness, and importance, resulting in a
421 reduction or forfeiting of effort – behaviors that reflect lower levels of mental toughness.

422 We also found that mental toughness levels were positively associated with positive
423 affect and inversely associated with negative affect and race times (*H4*). These relations are
424 consistent with preliminary evidence in sport (Bell et al., 2013; Gucciardi et al., in press).
425 Further, these data provide additional support for Gucciardi et al.'s (in press) definition of
426 mental toughness (i.e., that higher levels of mental toughness are representative of better
427 performances) and helps shore up the conceptual foundations of this concept by highlighting
428 meaningful associations. However, there are numerous avenues that researchers need to
429 consider before firmer conclusions can be drawn about the adaptive potential of mental
430 toughness. A recommendation previously presented in the literature (Andersen, 2011)
431 concerns the perceptions and actions of injured athletes who are more mentally tough. It is
432 possible that such individuals would jeopardize their recovery by ignoring feelings of pain and
433 not adhere to rehabilitation recommendations in order to pursue competition goals, meaning
434 that mental toughness is maladaptive in particular contexts. Researchers could investigate
435 such contexts to further explore whether or not mental toughness is solely adaptive or also
436 relates to maladaptive outcomes.

437 We also found support for the expected indirect association between coaching
438 environments and mental toughness through psychological needs (*H5a-d*). These findings are
439 consistent with a body of previous research which has shown environmental supports and
440 outcome variables to be indirectly related through psychological needs (e.g., Bartholomew,
441 Ntoumanis, Ryan, Bosch, et al., 2011). However, our findings are unique as they are, to our

442 knowledge, the first to identify associations between BPNT variables and mental toughness.
443 Our findings extend on previous research by Gucciardi et al. (2009) who reported that
444 different coaching styles can foster or forestall mental toughness development. We agree with
445 Gucciardi et al.'s (2009) conclusions, but also extend them by contesting that the degree to
446 which coaching environments nurture psychological needs is one mechanism through which
447 coaches may contribute to mental toughness development.

448 A final substantive finding of our study was the indirect relations between
449 psychological needs and adaptive outcomes through mental toughness (*H6a-d*). Above we
450 proposed that psychological needs satisfaction promoted continuous, high effort because of
451 an increased sense of personal control, efficaciousness, and self-value, and that this was
452 reflective of mental toughness. We extended this line of thinking by suggesting that higher
453 levels of continuous effort are more likely to result in individuals feeling as though they are
454 mastering new skill, goal achievement, and a sense of productivity and, as such is likely to
455 enhance perceptions of positive affect. The opposite could be said of individuals who expend
456 little effort on tasks because their psychological needs are thwarted. That is, less effort is
457 likely to result in stagnation, underachievement, and reduced productivity and, as such, is
458 likely to produce greater levels of negative affect.

459 Some shortcomings of the current study offer possible avenues for future research.
460 The first notable limitation was the use of a cross-sectional methodology. The use of
461 longitudinal methods in subsequent studies would allow researchers to monitor changes in
462 social environments, psychological needs, mental toughness, and markers of human
463 functioning (e.g., positive affect, performance). Another possible methodological avenue to
464 overcome the cross-sectional limitation of the current study would be to conduct an
465 experimental trial where coaches are exposed to a training program aimed at fostering more
466 autonomy-supportive and less controlling interpersonal styles. Athletes' perceptions of

467 coaching behaviors, psychological needs satisfaction, and mental toughness could then be
468 monitored at the end of the intervention and at follow-ups to determine the causal effects of
469 BPNT variables on mental toughness. A second limitation of the current study was the sole
470 emphasis on coaching environments. Coaching environments were selected in the current
471 study because of their prevalence in previous mental toughness literature (e.g., Connaughton
472 et al., 2008; Gucciardi et al., 2009), but also because coaches often form strong relationships
473 with adolescents as they emancipate from their primary caregivers (Jowett & Timson-
474 Katchis, 2005). Nevertheless, parents and peers are two other groups identified as playing a
475 meaningful role in the provision of autonomy-supportive or controlling environments (Su &
476 Reeve, 2011), as well as mental toughness development (e.g., Connaughton et al., 2008).
477 Researchers could explore how other social agents contribute to psychological needs, mental
478 toughness, and associated outcomes. A third limitation of this study concerns the manner in
479 which prior distributions in the Bayesian analysis were informed. Specifically, a single
480 source informed the selection of some priors, whereas others were theoretically informed. We
481 acknowledge that ideally these priors would have been informed by point and variance
482 estimates of effect sizes obtained from meta-analyses and that it is impossible to account for
483 variability across contexts with such sparse prior knowledge. In line with changing trends in
484 statistical enquiry and the growing interests in Bayesian approaches in particular, we suggest
485 that researchers continue to add to the pool of available data on topics such as mental
486 toughness in order to allow substantiated conclusions to be formed. Finally, as alluded to in
487 the introduction of this paper, SDT is but one lens through which to consider mental
488 toughness and its development. Other theories such as self-efficacy theory (Bandura, 1977)
489 and achievement goal theory (Elliot & McGregor, 2001) may be useful for understanding
490 mental toughness and its development and should be considered in subsequent research.

491 Taken together, our findings represent several meaningful contributions for
492 understanding mental toughness. They provide new insight into how motivational variables
493 proposed by BPNT are linked to mental toughness and highlight a conceptual model that
494 helps researchers to understand some of the antecedents and consequence of mental
495 toughness. Conceptually, we believe findings such as those reported in this study advances
496 mental toughness research by directing it into a new wave of enquiry. Further exploration
497 along these lines is required to offer a more comprehensive understanding of the positioning
498 of mental toughness amongst other psychological concepts and its value in supporting
499 optimal human functioning.

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Table 1

Comparison of Unstandardised Weights of Parameter Estimates of Bayesian Estimates using Different Priors, including Prior Means and Variances of Hypothesized Model

	Hypothesized Model	Model A	Model B	Model C
Model Fit				
PPP (95% CI)		.43 [-25.00, 29.47]	.43 [-25.06, 29.37]	.43 [-25.19, 29.84]
Parameters	Prior Mean (Variance)	μ [95% PPI]	μ [95% PPI]	μ [95% PPI]
AS → NS	.46 (.03)	.45 [.18, .74]*	.46 [.40, .52]*	.43 [-.07, .95]
AS → NT	-.22 (.01)	-.24 [-.42, -.05]*	-.22 [-.28, -.16]*	-.32 [-.81, .17]
CO → NS	-.07 (.001)	-.07 [-.13, -.01]*	-.07 [-.13, -.01]*	-.08 [-.78, .69]
CO → NT	.50 (.03)	.50 [.18, .81]*	.50 [.44, .56]*	.50 [-.24, 1.25]
NS → MT	.40 (.03)	.43 [.14, .72]*	.40 [.34, .46]*	.47 [-.02, .96]
NS → PA	.66 (.03)	.48 [.18, .79]*	.65 [.59, .71]*	.30 [-.34, .95]
NS → NA	-.16 (.005)	-.15 [-.28, -.02]*	-.15 [-.21, -.09]*	-.12 [-.78, .44]
NS → RT	-.40 (.03)	-.39 [-.72, -.05]*	-.40 [-.46, -.34]*	-.35 [-1.20, .46]
NT → MT	-.40 (.03)	-.37 [-.70, -.05]*	-.40 [-.46, -.34]*	-.31 [-.99, .39]
NT → PA	-.10 (.001)	-.10 [-.17, -.04]*	-.10 [-.17, -.04]*	-.18 [-.88, .52]
NT → NA	.24 (.01)	.22 [.04, .41]*	.24 [.18, .30]*	.14 [-.43, .85]
NT → RT	.40 (.03)	.38 [.05, .72]*	.40 [.34, .46]*	-.29 [-.51, 1.13]
MT → PA	.57 (.03)	.39 [.09, .69]*	.56 [.50, .62]*	.21 [-.45, .90]
MT → NA	-.18 (.005)	-.18 [-.31, -.05]*	-.18 [-.24, -.12]*	-.20 [-.81, .40]
MT → RT	-.40 (.03)	-.39 [-.72, -.05]*	-.40 [-.46, -.34]*	-.35 [-1.22, .48]

Note. Model A = originally hypothesized model; Model B = variance around the expected parameter estimates of original model was set to be highly precise (i.e., .001 or a 95% limit of $\pm .06$ around the mean); Model C = variance around the expected parameter estimates of original model was specific with low precision (i.e., .20 or a 95% limit of $\pm .87$ around the mean). AS = autonomy support; CO = controlling; NS = needs satisfaction; NT = needs thwarting; MT = mental toughness; PA = positive affect; NA = negative affect; RT = race times.

*CI did not encompass zero

Table 2

Descriptive Statistics, Reliability Scores, and Correlations for all Study Variables

Variables	<i>M</i> (<i>SD</i>)	Skew.	Kurt.	1	2	3	4	5	6	7	8	9	10
1 Age	14.36 (1.47)			-									
2 Years	4.47 (2.57)			0.22**	-								
3 Hrs/wk	2.10 (1.63)			0.02	0.08	-							
4 AS	5.27 (1.16)	-.74	.61	0.27**	0.12	0.16*	(.88)						
5 CO	2.22 (0.92)	.77	.31	-0.15*	0.01	0.05	-0.32**	(.88)					
6 NS	5.53 (0.80)	-.60	.39	0.07	0.03	0.20**	0.53**	-0.26**	(.89)				
7 NT	2.57 (1.05)	.53	-.21	-0.23**	-0.07	-0.05	-0.52**	0.58**	-0.40**	(.88)			
8 MT	5.48 (0.78)	-.63	1.00	0.06	-0.01	0.18**	0.31**	-0.24**	0.59**	-0.38**	(.79)		
9 PA	4.97 (0.74)	-1.34	2.59	0.05	0.05	0.05	0.33**	-0.13	0.46**	-0.34**	0.40**	(.90)	
10 NA	0.53 (0.41)	1.18	1.36	-0.30**	-0.07	-0.06	-0.23**	0.25**	-0.29**	0.43**	-0.37**	-0.38**	(.84)
11 Race time	0.00 (0.98) [†]	.71	.26	-0.02	-0.21**	-0.22**	-0.16*	-0.04	-0.22**	0.43**	-0.21**	0.02	0.08

Note. Skew = Skewtosis; Kurt = Kurtosis Years = years competing in cross-country; Hrs/wk = hours per week spent training in cross-country; AS = autonomy-supportive environments; CO = controlling coaching environments; NS = psychological needs satisfaction; NT = psychological needs thwarting; MT = mental toughness; PA = positive affect; NA = negative affect; Race time = performance times standardized across age, gender, and distance run; internal reliability estimates (Cronbach's alpha) provided on the diagonal in parentheses.

* $p < .05$. ** $p < .01$. [†] Z-scores, race time standardized across age, gender, and distance run.

Table 3

Unstandardized Weights of Parameter Estimates for Indirect Effects of Variables in Model A

Mediation variable	Estimate (SE)	95% PPI
Indirect path		
Needs satisfaction		
Autonomy-supportive → Mental toughness	0.18 (.03)	[0.04, 0.41]*
Controlling → Mental toughness	-0.03 (.02)	[-0.07, -0.01]*
Needs thwarting		
Autonomy-supportive → Mental toughness	0.08 (.02)	[0.01, 0.22]*
Controlling → Mental toughness	-0.17 (.02)	[-0.42, -0.02]*
Mental toughness		
Need satisfaction → Race time	-0.16 (.04)	[-0.39, -0.01]*
Need thwarting → Race time	0.13 (.02)	[0.01, 0.37]*
Need satisfaction → Negative affect	-0.07 (.02)	[-0.17, -0.01]*
Need thwarting → Negative affect	0.06 (.01)	[0.01, 0.16]*
Needs satisfaction → Positive affect	0.16 (.03)	[0.02, 0.38]*
Needs thwarting → Positive affect	-0.13 (.01)	[-0.34, -0.01]*

Note. SE = standard error, PPI = posterior probability interval.

*CI did not encompass zero.

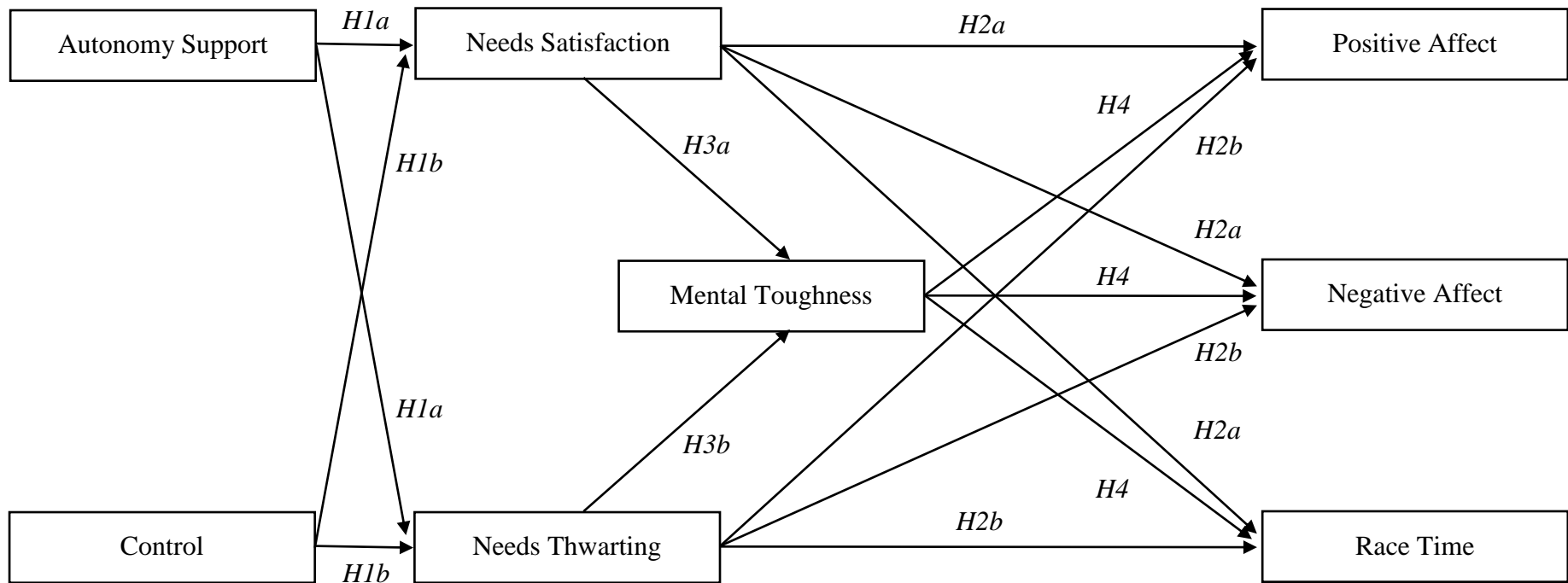


Figure 1. Hypothesized direct relations between coaching environments, psychological needs, mental toughness, performance, positive affect, and negative affect.