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5 Prior self-control exertion and perceptions of pain during a physically demanding task

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26   Abstract

27   **Objectives**

28   Exertion of self-control has been associated with impaired performance on subsequent

29   physical tasks also requiring self-control, but it remains unknown why this occurs. This

30   study, therefore, explored whether a) prior self-control exertion reduces subsequent

31   persistence on a physically demanding task, and b) whether any observed performance

32   decrements could be explained by changes in perceptions of pain.

33   **Method**

34   In a within-subject design, sixty-three individuals completed an easy (congruent)

35   Stroop task or a difficult (incongruent) Stroop task that required self-control. Participants

36   were then required to remain in a physically demanding posture (i.e., a 'wall-sit') until

37   voluntary exhaustion and their perception of pain was recorded during the task.

38   **Results**

39   When participants completed the difficult Stroop task, they quit the wall-sit sooner.

40   This decrement in performance was explained by greater perceptions of pain at the beginning

41   of the wall-sit.

42   **Conclusions**

43   Perceptions of pain may, therefore, be an important attentional mechanism explaining

44   why self-control use interferes with subsequent persistence during physically effortful tasks.

45   *Keywords:* self-regulation, ego depletion, pain tolerance, physical performance

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50   Prior self-control exertion and perceptions of pain during a physically demanding task

51   Self-control has been defined as the process of volitionally controlling and overriding

52   predominant, habitual tendencies in order to achieve a specific goal (Baumeister, Vohs, &

53   Tice, 2007). This process enables individuals to initiate or inhibit particular responses, attend

54   to stimuli, and engage in purposeful, effortful, and goal-directed behaviors (Baumeister,

55   Heatherton, & Tice, 1994). The capacity to exert self-control can differ between individuals

56   (i.e., trait self-control), as well as within individuals across situations (i.e., state self-control;

57   Tangney, Baumeister, & Boone, 2004). Regarding the latter, meta-analytic evidence has

58   shown that, following the exertion of self-control on one task, individuals typically have an

59   impaired ability to self-regulate when performing a subsequent second task, even if this task

60   is drawn from a different domain (Hagger, Wood, Stiff, & Chatzisarantis, 2010). Some

61   researchers, however, have questioned the existence of this depletion effect and suggested

62   that it is not a real phenomenon (Carter, Kofler, Forster, & McCullough, 2015).

63   Despite the controversies within the literature, considerable research has demonstrated

64   that self-control use can lead to impaired performance on subsequent physical tasks also

65   requiring self-control. One task that has been frequently employed to explore this effect is

66   squeezing an isometric handgrip for as long as possible (e.g., Muraven, Tice, & Baumeister,

67   1998; Muraven & Shmueli, 2006; Tice, Baumeister, Shmueli, & Muraven, 2007). Although

68   this task requires muscular endurance, overcoming fatigue or pain and overriding the urge to

69   quit are acts of self-control and mental persistence (Muraven et al., 1998). Following the

70   completion of a task requiring self-control (incongruent Stroop task), individuals persisted

71   less at squeezing an isometric handgrip, compared to when they completed a task requiring

72   no self-control (congruent Stroop task; Bray, Graham, Martin Ginis, & Hicks, 2011; Bray,

73   Martin Ginis, Hicks, & Woodgate, 2008). This is substantively interesting because one could

74   assume that the underlying self-control mechanisms involved in overriding learned responses

75   in the Stroop task are different to those required to overcome pain and persist in the handgrip

76   task. Despite these differences, employment of the former type of self-control still effects the

77   latter, suggesting the same mechanism is responsible for a large variety of self-control tasks

78   (Baumeister et al., 2007). Indeed, psychometric and neurological evidence points to

79   considerable overlap between the inability to attend to difficult cognitive tasks (e.g.,

80   incongruent Stroop tasks) and the inability to resist strong impulses (e.g., pain avoidance;

81   Duckworth & Kern, 2011; Steinberg, 2008).

82   Callisthenic measures of physical action have also been employed so that assumptions

83   concerning more complex human performance can be formulated. For instance, following a

84   cognitively demanding task, competitive athletes performed significantly worse on a sit-up

85   task compared to when they completed a cognitively simple task (Dorris, Power, & Kenefick,

86   2012). The ability for self-control exertion to reduce subsequent physical endurance

87   performance has been substantiated during cycling tasks (e.g., Boat, Taylor, & Hulston, 2017;

88   Englert & Wolff, 2015; Martin Ginis & Bray, 2011; Wagstaff, 2014). Clearly, self-control

89   seems to be crucial in order to be able to achieve high levels of physical performance that

90   require prolonged effort. What is unknown and, therefore, the focus of the present study is

91   *why* self-control is diminished following prior use. Understanding the causal explanations

92   would provide a more complete model of self-control.

93   A number of theories have been proposed to explain self-regulatory failures following

94   previous exertion of self-control. Some researchers have suggested that self-control is a

95   limited resource; therefore, prior acts of self-control can lead to a temporary loss of self-

96   control strength in subsequent acts (Baumeister, Bratslavsky, Muraven, & Tice 1998). This

97   hypothesis has come under severe criticism (e.g., Kurzban, 2010; Lange & Eggert, 2014). An

98   alternative perspective is the *shifting priorities model of self-control,* which is centred on

99   motivational and attentional processes (Inzlicht & Schmeichel. 2016; Milyavskaya &

100   Inzlicht, 2017). Self-control fades as a result of a subjective valuation process, whereby distal

101   and proximal goal choices are continuously assessed (Berkman, Livingston, Kahn, &

102   Inzlicht, 2015). Following the use of self-control, attention and motivation shifts to the extent

103   that the value of exerting further self-control in pursuit of the distal goal diminishes, while the

104   value of conceding to the tempting proximal goal is increased (De Witte Huberts, Evers, & de

105   Ridder, 2014; Kool & Botvinick, 2014). Ultimately, self-control represents a decision to exert

106   effort to resist a tempting proximal goal in favour of a distal goal (Milyavskaya & Inzlicht,

107   2017).

108   Many of the physical or athletic tasks that have been utilized previously are

109   unpleasant and induce considerable levels of discomfort and pain (e.g., Boat et al., 2017;

110   Bray et al., 2008; 2011; Dorris et al., 2012; Englert & Wolff, 2015). A fundamental function

111   of pain is to disturb and galvanize attention (Eccleston & Crombez, 1999). This provides an

112   opportunity to use participants' perceptions of pain during physical tasks as an indicator of

113   attentional shift concordant with the 'shifting priorities' perspective. We propose that self-

114   control exertion leads to an attentional shift towards perceptions of pain during subsequent

115   endurance tasks. This leads to increasing focus on the proximal goal (quitting or reducing

116   effort to relieve the pain), relative to the distal goal (persisting on the task to maximize

117   performance), resulting in reduced performance. In other words, perceptions of pain may

118   explain why self-control exertion interferes with subsequent performance on a physical task.

119   Individuals with higher levels of trait self-control persisted longer when required to submerge

120   their hand in painfully cold water for as long as possible, compared to those participants with

121   lower levels of trait self-control (Schmeichel & Zell, 2007). However, this does not explain

122   why a bout of self-control use reduces subsequent physical performance.

123   Extending the literature described above, the aims of the current research were to

124   determine whether exerting self-control a) reduces performance and b) increases perceptions

125   of pain during a subsequent, unrelated physical task that required self-control. In addition, we

126   investigated whether any observed performance decrements as a result of self-control

127   exertion could be explained (i.e., mediated) by an individual's perceptions of pain. In the

128   present experiment, our self-control manipulation was a congruent versus incongruent Stroop

129   task performed for four minutes. Previous research has shown this task to require self-control

130   (McEwan, Martin Ginis, & Bray, 2013) and the same length of time has been used previously

131   (e.g., Gailliot et al., 2007). To measure physical performance we used a 'wall-sit', which

132   entails leaning with one's back against a wall with hips and knees bent at 90 degrees. This

133   procedure is increasingly painful and requires participants to resist the temptation to alleviate

134   the pain by quitting the task, and instead to invest sustained effort to persist as long as

135   possible.

136   Based on the broad self-control literature (e.g., Bray et al., 2011; Dorris et al., 2012;

137   Englert & Wolff, 2015; Inzlicht & Schmeichel, 2016) it was hypothesized that engaging in a

138   cognitively demanding task previously shown to require self-control (i.e., an incongruent

139   Stroop task) would result in poorer performance (hypothesis 1) and increased perceptions of

140   pain (hypothesis 2) in a subsequent wall-sit task, compared to a cognitively simple task (i.e.,

141   a congruent Stroop task). In addition, we expected that perceptions of pain would mediate the

142   effects of the self-control manipulation on wall-sit performance (hypothesis 3). Recent

143   evidence suggests that cognitive and performance disruption associated with self-control may

144   be time-dependent (Boat et al., 2017; Englert & Wolff, 2015), therefore, we examined

145   potential mediating effects at different points during the endurance task. This would enable

146   investigation of whether shifts in pain early or late in the endurance task drive any reductions

147   in performance.

148   **Methods**

149   **Participants**

150   A power calculation (G*Power version 3.1; Faul, Erdfelder, Lang, & Buchner, 2009)

151   with power = .80 and α = .05, indicated a minimum sample size of $N = 52$ would be sufficient

152   to detect a medium effect size (.40), which is typical of previous self-control studies. Our

153   sample consisted of 63 participants (21 male, 42 female) aged 18-34 years old (M age = 22

154   years, $SD = 3$ years). The participants spent, on average, four days $(SD = 2$ days) per week

155   exercising, and 56 participants reported that they had completed a wall-sit previously.

156   Following approval from a university ethics committee, each participant signed an

157   informed consent form after the study was explained in full and it was clarified that

158   involvement was anonymous and voluntary. Furthermore, all participants were healthy, as

159   assessed by a university approved general health questionnaire.

160   **Protocol**

161   Each participant took part in two experimental sessions. Given previous evidence

162   (e.g., Englert & Rummel, 2016; Tangney et al., 2004) and the nature of the wall-sit

163   experimental task, participants first completed questionnaires to control for the influence of

164   daily stress and physical fatigue (see measures section). Participants were then familiarized

165   with the wall-sit procedure. Subjects were directed to stand with his/her back against a wall,

166   feet shoulder width apart and knees and hips flexed at a 90 degree angle, with his/her hands

167   resting against the wall. Specific exercise instructions were scripted so that they remained

168   constant for each participant. Participants practiced the wall-sit once to ensure that they were

169   familiar with and understood what was required, but they were not asked to persist at the task.

170   Participants were then administered a computerized version of the Stroop task. Color

171   words were presented on a screen and participants were required to read aloud the color of

172   the print ink and ignore the text of each word presented. However, when participants

173   encounter a word presented in red ink, they are required to override the general instructions

174   and read aloud the printed word. In the self-control condition, the print ink colour and printed

175   text were mismatched. For example, if the word 'yellow' was printed in green, the correct

176   verbal response would be green. However, if the word 'orange' was presented in red ink, the

177   correct verbal response would be orange. In the non-self-control condition, the words were

178   matched (e.g., the word 'yellow' was printed in yellow ink, 'red' was printed in red ink).

179   Previous studies have repeatedly demonstrated that the incongruent version of the Stroop task

180   is cognitively challenging and requires self-control because individuals have to volitionally

181   override their primary impulse of naming the word instead of the font colour (e.g., Englert &

182   Wolff, 2015; McEwan et al., 2013). Participants sat in a quiet room and were instructed to

183   respond as accurately as possible. The Stroop task was four minutes in duration and words

184   were presented on the screen at 1,500 ms intervals. Prior to the actual test, participants

185   completed a practice session lasting 30 seconds to acquaint with the task. Following the

186   experimental manipulation of self-control, participants completed a manipulation check

187   which assessed their perceived mental exertion during the Stroop task (see measures section).

188   Participants then performed the wall-sit. Subjects were instructed to hold the position

189   for as long as possible, until exhaustion. Throughout the wall-sit, participants' perception of

190   pain was recorded (see measures section). In sum, participants completed two seated wall-sits

191   under two experimental conditions: prior self-control and no self-control. Sessions were

192   counterbalanced and separated by 24 hours.

193   **Measures**

194   **Daily stress.** Daily stress was assessed using the seven stem questions from the Daily

195   Inventory of Stressful Events Questionnaire (Almeida, Wethington, & Kessler, 2002).

196   Participants were instructed to indicate whether any of a number of stressful events had

197   occurred today by circling either 'yes' or 'no' (e.g., "An argument or disagreement with

198   someone"). The item scores have demonstrated acceptable internal consistency and predictive

199   validity in previous research (Almeida et al., 2002).

200   **Perceptions of physical fatigue.** Physical fatigue was measured using two items from

201   the fatigue subscale from the Profile of Mood States (McNair, Lorr, & Droppleman, 1992;

202   i.e., "I feel physically worn out" and "I feel physically exhausted"). Participants were

203   instructed to consider the degree to which they were currently experiencing the items on a

204   five-point scale anchored by 1 (*not at all true*) to 5 (*very true*). These items were selected

205   based on high factor loadings in previous research and acceptable reliability (e.g., Beedie,

206   Terry, & Lane, 2000).

207   **Mental exertion.** Participants rated their mental exertion during the Stroop task using

208   Borg's single-item CR-10 scale (Borg, 1998; 0 = *extremely weak*; 10 = *absolute maximum*).

209   This single item measure has been shown to be a valid measure in previous research (e.g.

210   McEwan et al., 2013).

211   **Perceptions of pain.** Participants' current pain perception was measured using the

212   short-form McGill pain questionnaire (SF-MPQ; Melzack, 1987), which consists of three

213   subscales. First, participants reported the degree to which they were currently experiencing

214   various sensations on a four-point scale anchored by 0 (*none*) to 3 (*severe*). Four items each

215   from the sensory ("Throbbing", "hot-burning", "cramping", "aching") and affective ("Tiring-

216   exhausting", "sickening", "fearful", "punishing-cruel") subscales were used. The investigator

217   presented the participants with a printed copy of each item and they were instructed to

218   verbally communicate their answer. Next, participants completed the Visual Analog scale

219   from the SF-MPQ; a 10-centimeter line, where one end represented no pain and the other end

220   represented the worst pain. Participants were asked to make a mark on the line that

221   represented his/her current pain intensity. The SF-MPQ has been used previously in studies

222   of pain as a relatively quick assessment tool to examine pain levels during physical activities

223   (e.g., Osborne & Gatt, 2010), and has demonstrated acceptable reliability and predictive

224   validity in previous research (Wright, Asmundson, & McCreary, 2001).

225   Participants completed a subscale of pain measurement at 15 second intervals for the

226   entire duration of the wall-sit task. For instance, participants completed the four items from

227   the sensory subscale after 10 seconds, the four items from the affective subscale after 25

228   seconds, and the VAS after 40 seconds. This same order was subsequently repeated

229   throughout the wall-sit. Intervals of 15 seconds were employed to allow participants enough

230   time to answer the items from each subscale and a period of rest before the following

231   subscale was presented.

232   **Task performance.** Performance was assessed using the time (in seconds)

233   participants stopped the wall-sit task.

234   **Results**

235   **Preliminary Analysis**

236   The Statistical Package for Social Sciences (SPSS; Version 22.0) was used for all

237   statistical analyses. Table 1 displays descriptive statistics for each variable across each

238   experimental condition. The Cronbach alpha coefficients for the Daily Inventory of Stressful

239   Events Questionnaire and physical fatigue subscale ranged between .62 - .76 across the two

240   trials. Paired samples *t*-tests revealed that participants did not differ in their levels of daily

241   stress $t(61) = -.88$, $p = .24$, $r = .01$, or ratings of physical fatigue $t(61) = - .34$, $p = .74$, $r = .04$,

242   across experimental conditions. Neither stress ($r = .22$, $p = .08$; $r = .12$, $p = .33$) nor fatigue (r

243    $= -.13$, $p = .31$; $r = -.11$, $p = .33$) were correlated with wall sit-performance in either

244   experimental condition. Based on these results, it was not necessary to control for stress or

245   fatigue in the main analysis. The manipulation check revealed that participants reported

246   higher mental exertion following the incongruent Stroop task ($M = 5.15$, $SE = 0.23$)

247   compared to the congruent Stroop task ($M = 1.33$, $SE = .15$), $t(61) = 16.68$, $p < .001$ $r = .90$.

248   **Primary Analyses**

249   A mixed one-way ANOVA was conducted to evaluate the impact of exerting self-

250   control on wall sit performance (within-subjects; hypothesis 1) as well as examine order

251   effects (between-subjects) on performance. Variances and covariance's were homogenous

252   across all trials (Levene's and Box's test $p > .05$). The results revealed that there was a

253   significant main effect for experimental trial on wall sit performance ($F(1,60) = 7.62$, $p = .01$,

254    $r = .78$). Participants gave up quicker in the self-control experimental condition ($M = 130.20$,

255    $SE = 8.98$), compared to the non-self-control condition ($M = 147.07$, $SE = 9.31$). There was

256   no significant main effect of order on performance ($F(1,60) = .14$, $p = .71$, $r = .28$) or

257   interaction effect between experimental trial and order ($F(1,60) = 1.92$, $p = .17$, $r = .05$),

258   indicating that there were no order effects.

259   Within-subjects (i.e., two treatments) multivariate analysis of variance (MANOVA)

260   with noncommensurate dependent variables (sensory, affective and VAS pain measures) was

261   used to test the effect of experimental condition on participants' perception of pain during the

262   wall-sit task (hypothesis 2). Although our protocol required participants to complete multiple

263   measures of sensory, affective, and VAS subscales, 57% of participants did not complete

264   more than two complete set of measures before they quit the task. To maintain the maximum

265   sample size, we therefore conducted separate MANOVAs on all participants' first and final

266   set of pain scores before quitting the task only. Variances and covariances were homogeneous

267   across trials (all Levene's tests and Box's tests $p > .05$).

268   At the beginning of the wall-sit, differences in pain across the experimental conditions

269   were bordering on conventional levels of statistical significance and a moderate effect size

270   was observed: $F(3, 58) = 2.44$, $p = .07$, $\eta^2 = .11$. Follow-up univariate tests indicated that

271   VAS scores at the beginning of the wall-sit task were significantly higher following the self-

272   control experimental condition ($M = 3.83$, $SE = .24$) compared the non-self-control condition

273   ($M = 3.37$, $SE = .21$), $F(1,60) = 6.23$, $p = .02$, $\eta^2 = .09$). Experimental condition had no

274   effect on sensory scores ($F(1,60) = 1.68$, $p = .20$, $\eta^2 = .03$) or affective scores ($F(1,60) =$

275   2.70, $p = .11$, $\eta^2 = .04$).

276   Eighteen participants did not complete a second set of pain scores before quitting and

277   we did not consider it appropriate to re-use their first pain scores as their final pain scores.

278   Therefore, a second MANOVA was conducted on results from the remaining 45 participants.

279   Results revealed significant differences in final pain scores before quitting across

280   experimental conditions and a large effect size: $F(3, 42) = 2.77$, $p = .05$, $\eta^2 = .17$. Follow-up

281   univariate tests revealed that VAS scores at the end of the wall-sit task were significantly

282   higher following the self-control experimental condition ($M = 6.68$, $SE = .32$), compared to

283   the non-self-control condition ($M = 6.19$, $SE = .36$), $F(1,44) = 8.38$, $p = .01$, , $\eta^2 = .16$). No

284   differences were found for sensory scores ($F(1,44) = .71$, $p = .40$, $\eta^2 = .02$) or affective

285   scores ($F(1,44) = .12$, $p = .73$, $\eta^2 = .00$) across experimental conditions.

286   Within-subject mediation analysis (Judd, Kenny, & McClelland, 2001) using the

287   MEMORE macro (Montoya & Hayes; 2016) was employed to test whether the VAS pain

288   scores mediated the observed differences in wall-sit performance time (hypothesis 3).

289   MEMORE has been specifically developed for cases in which the experimental manipulation

290   varies within participants, as in our study. It provides estimates of total, direct, and indirect

291   effects and produces confidence intervals for inference about the indirect effect using

292   bootstrapping techniques. Five thousand bootstrap samples were used in the present study.

293   Only the VAS pain scores were explored because these appeared to be driving the

294   differences in perceptions of pain across experimental conditions. Results for VAS scores at

295   the beginning of the wall sit (i.e., after 40s) revealed a significant total effect of experimental

296   condition on wall sit performance ($b = -17.20$, 95% CI (-29.71, -4.68), $p = .01$). Direct effects

297   were non-significant ($b = -10.68$, 95% CI (-22.88, 1.52), $p = .09$), however, indirect effects

298   were significant ($b = -6.52$, 95% CI (-14.56, -.92), $p = .01$), suggesting that pain in the early

299   stages of the wall-sit task fully explained differences in performance across experimental

300   conditions.

301   The mediation analysis was repeated with participants' final VAS pain scores before

302   quitting the task as the mediating variable. Results indicated a non-significant total effect of

303   experimental condition on wall sit performance (b = -13.62, 95% CI (-27.81, .56), p = .06). In

304   addition, non-significant direct (b = -13.95, 95% CI (-29.80, 1.91), p = .08) and indirect (b

305   = .32, 95% CI (-7.49, 9.16), p = .06) effects were observed. Therefore, pain at the end of the

306   wall-sit task did not explain differences in performance across experimental conditions.

307   **Discussion**

308   The present study explored the effects of exerting self-control on a subsequent

309   physical task requiring self-control and whether any observed performance decrements could

310   be explained by an individual's perceptions of pain. Consonant with our predictions,

311   participants quit a physically demanding 'wall-sit' task faster when they had exerted self-

312   control in a prior task, relative to when they did not. This effect was attributable to

313   participants' elevated perceptions of pain during the early stages of the wall-sit. The findings

314   provide new evidence that perceptions of pain may explain why the use of self-control

315   interferes with subsequent performance on a physically demanding task.

316   In accordance with previous research (e.g., Bray et al., 2008; 2011; Dorris et al.,

317   2012; Englert & Wolff, 2015; McEwan et al., 2013; Wagstaff, 2014), exertion of self-control

318   significantly reduced subsequent performance in a physical task, in this case persistence at a

319   wall-sit. Participants gave up quicker following a difficult cognitive task, compared to when

320   they completed a simple cognitive task. The results provide yet more evidence that when

321   participants are required to perform two consecutive acts of self-control, diminished

322   performance on the second task ensues (Hagger et al., 2010). Recent evidence has questioned

323   the existence and replicability of the depletion effect (Hagger et al., 2016) and suggested that

324   it is not a real phenomenon (Carter et al., 2015). However, by employing a within-subjects

325   design individual differences in performance on the self-control tasks are controlled for. Such

326   designs may improve the replicability of the depletion effect, as opposed to traditional

327   between-participant designs typically employed (Cunningham & Baumeister, 2016;

328   Schweizer & Furley, 2016).

329   The most significant contribution to knowledge of the present study is the

330   demonstration that exertion of self-control led to elevated perceptions of pain during the

331   physical task. Indeed, the mediation analysis evidenced that perceptions of pain in the early

332   stages of the wall-sit task explained the performance decrements. These findings align well

333   with the shifting priorities model of self-control (Inzlicht & Schmeichel, 2016). Self-control

334   use quickly brought about a state of elevated distress and attentional priorities shifted towards

335   the pain relatively early in the wall-sit task (Elkins-Brown, Teper, & Inzlicht, 2016; Inzlicht,

336   Schmeichel, & Macrae, 2014). This aversive state has been proposed to encourage

337   individuals to consciously attend to the presence of task goal conflict (Baumeister & Bargh,

338   2014), and encourage alleviation of the distressing state (Inzlicht & Legault, 2014).

339   Consequently, motivational priorities shift towards an increased focus on the proximal goal

340   (quitting to relieve the pain), relative to the distal goal (demonstrating high levels of

341   persistence on the task), resulting in disengagement from the task relatively earlier (Inzlicht

342   & Schmeichel, 2016).

343   It is important to highlight that the VAS scores appeared to be driving the observed

344   differences in perceptions of pain, compared to the sensory and affective pain scores. This

345   suggests that the pain mechanism responsible for reduced persistence is general, rather than

346   any specific affective or sensory component of pain. In particular, scores of affective pain

347   remained low throughout the wall-sit exercise; therefore, this pain component may not be

348   salient during prolonged postural endurance tasks. Alternatively, the VAS is a highly

349   responsive outcome measurement for monitoring changes in pain (Chaffee, Yakuboff, &

350   Tanabe, 2011), whereas the sensory and affective scales are only 4-point scales and maybe

351   less sensitive. It is possible that the different measurement scales explain the pattern of

352   findings associated with different pain constructs.

353   From a sporting perspective, this study unearths a potentially critical explanation for

354   intra-individual variation in performance. Although the Stroop task is a well-established self-

355   control task (Englert & Wolff, 2015) and the wall-sit requires muscular endurance, they are

356   not sport specific. This finding, therefore, requires replication with sport specific tasks which

357   require self-control. If shown to be replicable, efforts are required to counteract the effect of

358   self-control use and heightened perceptions of pain. Promisingly, regular practice exerting

359   self-control can improve an individual's ability to perform future acts of self-control (Allom,

360   Mullan, & Hagger, 2016). Squeezing a handgrip twice a day for as long as possible over a

361   two week period improved individuals' self-control performance in subsequent self-control

362   acts (Bray, Graham, & Saville, 2015). Performing relaxation and mindfulness techniques can

363   also attenuate self-control reductions (Friese, Messner, & Schaffner, 2012; Tyler & Burns,

364   2008) and perhaps offer more applicable solutions to reducing the impact of self-control use.

365   **Limitations**

366   Despite yielding important findings, there are some study limitations worth noting.

367   Numerous steps to eliminate any potential problems associated with bias were taken; for

368   instance, the experimenter read the instructions for all tasks from a pre-prepared text to

369   reduce the variability in the delivery of the instructions (Dorris et al., 2012). However, a

370   blind-researcher protocol was not employed; therefore, the possibility of experimenter bias

371   impacting the results of this study cannot be ruled out. Furthermore, performance on the

372   initial self-control task was not assessed. Although manipulation checks in the current study

373   confirmed our self-control manipulation, the identification of a decline in performance on the

374   Stroop task in future similar studies would be a useful measure of depletion and evaluating an

375   individual's level of exertion (Lee, Chatzisarantis, & Hagger, 2016). Additionally,

376   participants' mood was not assessed following the Stroop task designed to manipulate self-

377   control. It could be argued that overriding a well-learned behavior (i.e., reading the ink color

378   not the word) could be associated with negative emotional states (Tice & Bratslavsky, 2000).

379   Therefore, it is possible that mood differences may well have been responsible for the current

380   pattern of results. However, previous research has repeatedly shown that self-control

381   manipulation does not affect mood (e.g., Englert & Bertrams, 2012; Muraven et al., 1998).

382   Although the findings of the current study are consistent with the shifting priorities

383   model from an attentional perspective, we did not measure the motivational mechanisms of

384   this model. Future research should make efforts to explore whether the exertion of self-

385   control leads to a reduction in motivation during subsequent tasks (Inzlicht & Schmeichel,

386   2012). In the same way as the VAS was employed to measure pain in the present study,

387   momentary measures of task importance may be taken. This may provide more precise

388   measures of motivational shifts, rather than assessing motivation before or after the task,

389   which is typical in self-control research. Explicit measures of proximal goal focus (how much

390   does the participant want to avoid the pain?) relative to distal goal focus (how much does the

391   participant want to continue persisting?) may also provide interesting insight into shifting

392   priorities.

393   **Conclusion**

394   The present study provides further evidence that initial self-control exertion reduces

395   performance on a physical task. Furthermore, the results make an important contribution to

396   the self-control literature by highlighting that perceptions of pain may be a critical attentional

397   mechanism explaining why self-control exertion interferes with subsequent persistence

398   during physically effortful tasks.

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572   Table 1

573   *Descriptive Statistics for all Variables*

Variable	Experimental condition			
	Self-control		Non-self-control	
	M	*SD*	*M*	*SD*
Mental exertion	5.15	1.83	1.33	1.17
Physical fatigue	2.02	.86	2.05	.89
Daily stress	6.45	1.05	6.58	.86
Wall-sit performance time (seconds)	130.16	70.01	147.31	73.01
Sensory pain scores				
-Start of wall-sit task	.83	.57	.73	.55
-End of wall-sit task	2.21	.58	2.15	.65
Affective pain scores				
-Start of wall-sit task	.50	.48	.40	.40
-End of wall-sit task	.97	.59	.94	.61
VAS pain scores				
-Start of wall-sit task	3.83	1.88	3.37	1.67
-End of wall-sit task	6.68	2.13	6.19	2.40

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