

## **The effect of ego depletion on challenge and threat evaluations during a potentially stressful public speaking task**

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1 **The effect of ego depletion on challenge and threat evaluations during a potentially**  
2 **stressful public speaking task**  
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4 Word count: 3745  
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**Abstract**

10 **Background:** It has been well established that challenge and threat evaluations affect the  
11 performance of potentially stressful tasks, however, the factors that influence these evaluations  
12 have rarely been examined. **Objective:** This study examined the effects of ego depletion on  
13 challenge and threat evaluations during a public speaking task. **Method:** 262 participants (150  
14 males, 112 females;  $M_{\text{age}} = 20.5$ ,  $SD = 4.3$ ) were randomly assigned to either an ego depletion  
15 or control group. Participants then completed self-report measures of trait self-control. The ego  
16 depletion group performed a written transcription task requiring self-control, while the control  
17 group transcribed the text normally. Before the public speaking task, participant's challenge  
18 and threat evaluations and subjective ratings of performance were assessed via self-report  
19 items. **Results:** The results of independent  $t$ -tests supported the effectiveness of the self-control  
20 manipulation. There were no significant differences between the ego depletion and control  
21 groups in terms of challenge and threat evaluations or subjective performance. Additional  
22 correlation analyses revealed that trait measures of self-control were significantly and  
23 negatively related to challenge and threat evaluations and subjective performance. **Conclusion:**  
24 Findings suggest that ego depletion might not influence appraisals of potentially stressful tasks,  
25 and thus add to recent evidence questioning the ego-depletion phenomenon.

26 **Keywords:** self-control, stress, cognitive appraisal, demand/resource evaluations, self-  
27 regulation, strength model

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29 Abstract word count: 203

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**Introduction**

37 *Self-regulation and control*

38           The ability to control behaviour enables individuals to achieve important goals such as  
39 maintaining health, controlling impulses, inhibiting unwanted thoughts, and regulating social  
40 behaviour (Muaraven, Colins, & Neinhaus, 2002; Heatherton & Wagner, 2011; Richeson &  
41 Shelton, 2003). Individuals who are better able to self-regulate their behaviour are less likely  
42 to develop contemporary societal problems such as alcoholism, obesity, and addiction  
43 compared to individuals who are less able to self-regulate (Quinn & Fromme, 2010; Vohs &  
44 Heatherton, 2000; Ferguson & Bargh, 2004). Despite every individual having the capacity to  
45 self-regulate, many behavioural, social, and health problems still occur, in part, due to lapses  
46 in self-control (Baumeister & Heatherton, 1996; Vohs & Baumesiter, 2004). Currently, there  
47 is a lack of understanding regarding both the circumstances and the mechanisms associated  
48 with these lapses in self-control. As such, gaining an insight into how people regulate and  
49 control their behaviour and emotions is important. This study will aid understanding by  
50 examining how reductions in self-control influence cognitive appraisals (i.e., challenge and  
51 threat) before a potentially stressful public speaking task.

52           Self-regulation has been heavily researched within areas such as personality, social and  
53 cognitive psychology, sociology, neuroscience, medicine, and many more (Nigg, 2017). Self-  
54 regulation involves various adaptive complex processes and systems, with overlaps in their  
55 function, measurement, and terminology (Nigg, 2017; McAuley, Chen, Goos, Schachar, &  
56 Crosbie, 2010). It is important to note that the terms self-regulation and self-control appear to  
57 be used interchangeably across numerous domains due to discrepancies in how to label, define,  
58 and measure the construct of self-control (Duckworth & Kern, 2011; Lurquin & Miyake, 2017).  
59 For clarity, we offer a definition of both self-regulation and self-control.

60           Self-regulation refers to the intrinsic processes that aide psychological and  
61 physiological adaptation. Self-regulation encompasses top-down and bottom-up processes that

62 alter emotion, behaviour, and cognition in order to achieve explicit or implicit goals, including  
63 deliberate as well as reactive/automatized processes (Nigg, 2017; Calkins & Fox, 2002).  
64 Generally, it is agreed that self-control refers to the capacity to resist or inhibit a dominant  
65 response, and therefore refers to the ability to override and adjust behaviour, thoughts, and  
66 emotions (Bandura, 1989; Metcalfe & Mischel, 1999; Vohs & Baumeister, 2004). Furthermore,  
67 research suggests that self-control focuses on the effort individuals exert to promote desirable  
68 responses and inhibit undesirable responses (Duckworth & Kern, 2011; Fujita, 2011). In a  
69 broad sense, self-control has also been referred to as voluntary behaviour and cognition,  
70 effectively top-down aspects of self-regulation (Avital-Cohen & Tsal, 2016; Nigg, 2017).

### 71 *Self-control theory and research*

72 One of the most cited theoretical frameworks associated with self-control is the strength  
73 model (Baumeister & Heatherton, 1996). The model states that self-control is vulnerable to  
74 deterioration over time due to repeated exertion. It is argued that self-control is a finite resource  
75 that can be depleted, and consequently this reduction in self-control resources decreases the  
76 capacity to regulate behaviour during subsequent tasks. The depletion of this limited resource  
77 is termed 'ego depletion' (Baumeister & Heatherton, 1996). Research has examined the effect  
78 of ego-depletion on performance, with a meta-analysis of 83 studies concluding that ego  
79 depletion had a detrimental effect on the performance of subsequent self-control tasks,  
80 particularly during stressful conditions (Hagger, Wood, Stiff, & Chatzisarantis, 2010). This  
81 finding was robust for both perceptual motor (e.g., Englert & Bertrams, 2012; McEwan, Ginis,  
82 & Bray, 2013), and physical endurance (e.g., Bray, Martin Ginis, & Woodgate, 2011), tasks.

83 More recently, the ego depletion literature has come under intense scrutiny (e.g., Carter,  
84 Kofler, Forster, & McCullough, 2015), as studies have failed to replicate the ego depletion  
85 effect (e.g., Osgood, 2017; Xiao, Dang, Mao, & Liljedahl, 2014). Furthermore, Carter and  
86 McCullough's (2015) meta-analysis brought to light potential publication bias in the ego

87 depletion literature, hinting at a possible body of unpublished non-significant findings. In a  
88 separate study, Carter and colleagues (2015) argued that the initial support for ego depletion  
89 was likely driven by small sample sizes and publication bias. The inconsistent findings  
90 surrounding ego depletion initiated a registered replication report, but this also failed to find a  
91 significant ego depletion effect (Hagger et al., 2016). However, Hagger et al. (2016) did not  
92 conclude that the ego depletion effect does not exist, but rather encouraged future research to  
93 investigate the causes of the null finding. In line with the aforementioned research, a recent  
94 survey surrounding research practices and replication rates within ego depletion research,  
95 supports the assumption that a large body of grey literature on ego depletion exists, leaving the  
96 authors to call for additional exploration of the ego depletion effect (Wolf, Baumann, &  
97 Englert, 2018).

98         Adding to the controversy surrounding the resource model, is the inconclusive research  
99 surrounding the duration of primary and secondary self-control tasks. The impaired  
100 performance in secondary self-control tasks are said to be due to self-control replenishing  
101 slowly (Muraven, Collins, Shiffman, & Paty, 2005). Furthermore, it is expected that a linear  
102 association exists between primary self-control task duration and the size of the ego depletion  
103 effect on the secondary task (Hagger et al., 2010). Therefore, the ego depletion effect should  
104 scale with time. The average primary self-control task lasts five to six minutes, however, no  
105 lower limit for the duration of exertion has been specified (Hagger et al., 2010). Recent research  
106 suggests that the duration of the primary self-control task does not predict the magnitude of  
107 impairment in the secondary task (e.g., Giboin & Wolff, 2019). This is further supported by a  
108 high-powered study that varied the duration of the primary self-control task, finding no  
109 relationship between task duration and subsequent performance during a secondary self-control  
110 task (Wolff, Sieber, Bieleke, & Englert, 2019).

111 As the strength model of self-control has remained in doubt, alternative explanations  
112 and measures have emerged to challenge the resource model. For example, Tangney,  
113 Baumeister, and Boone (2004) explored trait self-control and performance, with research  
114 suggesting that an individual's ability to control behaviour predicts a wide range of positive  
115 outcomes (e.g., higher achievement, greater impulse control, and more optimal emotions;  
116 Tangney et al., 2004; De Ridder, van der Weiden, Gillebaart, Benjamins, & Ybema, 2019).  
117 However, findings are varied regarding trait self-control and propensity to be ego depleted.  
118 Indeed, while some research suggests that individuals higher in trait self-control are less  
119 vulnerable to ego depletion (e.g., Dvorak & Simons, 2009), more recent studies suggest that  
120 those higher in trait self-control are more vulnerable due to less frequent impulse inhibition in  
121 everyday life (e.g., Imhoff, Schmidt & Gerstenberg, 2014). Salmon and colleagues (2014) also  
122 explored a similar trait-like concept, termed 'depletion sensitivity' (Salmon, Adriaanse, De  
123 Vet, Fennis, & De Ridder, 2014), which referred to the different rates of ego depletion  
124 individuals experience when exerting self-control. Research has found that individuals higher  
125 in depletion sensitivity tend to perform worse on secondary self-control tasks, demonstrating a  
126 greater ego depletion effect (e.g., Salmon et al., 2014).

127 Other theoretical explanations related to the ego depletion effect have centred around  
128 individual perceptions of, and mindsets towards, self-control. For example, Clarkson and  
129 colleagues (2010) found that perceptions of resource depletion predicted performance patterns  
130 in the dual self-control task paradigm better than actual depletion (i.e. actual exertion of self-  
131 control; Clarkson, Hirt, Jia, & Alexander, 2010). Therefore, implying that depletion of self-  
132 control resources might be consciously perceptible. Moreover, Job, Dweck, and Walton (2010)  
133 propose that self-control is affected by individuals' implicit beliefs about willpower, and  
134 whether willpower is a finite resource or not. Interestingly, research has shown that individuals  
135 who do not believe that willpower is limited, are less susceptible to ego depletion after

136 completing a primary self-control task (e.g., Job et al., 2010). It remains both theoretically and  
137 empirically unclear how dispositional traits and beliefs of self-control interact. Due to various  
138 concerns and inconclusive evidence, researchers have called for improved empiricism and  
139 theory to find more conclusive answers to ‘if and why’ the ego depletion effect exists (Frieze,  
140 Loschelder, Gieseler, Frankenbach, & Inzlicht, 2018).

### 141 *Challenge and threat appraisals*

142 It has been suggested that research exploring the potential moderators and mediators,  
143 as well as testing the specific conditions under which ego depletion may or may not occur, will  
144 help to answer questions surrounding this phenomenon (Hagger et al., 2016). One possible  
145 theoretical framework that could help explore these issues is the biopsychosocial model  
146 (BPSM) of challenge and threat (Blascovich, 2008). According to the BPSM, when entering a  
147 potentially stressful situation (e.g., sporting competition, speech), an individual evaluates how  
148 demanding the situation is, and whether they have the necessary resources to cope effectively  
149 with those demands (Seery, 2011). If an individual evaluates that they have sufficient coping  
150 resources to meet the demands, they evaluate the stressful situation as more of a challenge. In  
151 contrast, if an individual evaluates that the situational demands exceed their coping resources,  
152 they evaluate the stressful situation as more of a threat (Seery, 2011). It is important to note  
153 that challenge and threat are not considered dichotomous states, but are instead conceptualised  
154 as anchors of a single bipolar continuum, meaning that relative rather than absolute differences  
155 in challenge and threat are typically examined (e.g., stressful situation is evaluated as more or  
156 less of a challenge or threat; Blascovich, 2008).

157 Challenge and threat are traditionally explored during motivated performance situations  
158 (e.g., sporting competitions, exams, public speaking), defined as potentially stressful situations  
159 in which an individual must actively perform cognitively or behaviourally in order to attain an  
160 important outcome (Blascovich, 2008). Crucially, challenge and threat evaluations have been



161 shown to have different effects on cardiovascular responses and task performance, with a threat  
162 evaluation (i.e., situational demands exceed coping resources) associated with a less efficient  
163 cardiovascular response (i.e., lower cardiac output and higher total peripheral resistance), and  
164 poorer task performance (see Hase, O'Brien, Moore, & Freeman, 2018 for a review). Despite  
165 these robust findings, to date, relatively little research has explored the factors that influence  
166 challenge and threat evaluations (Moore, Vine, Wilson, & Freeman, 2014). This is surprising  
167 given that such research will aid the development of interventions aimed at promoting  
168 challenge evaluations, or more positive responses to stress. One factor that could influence  
169 challenge and threat evaluations is ego depletion. Indeed, given that ego-depleted individuals  
170 have limited resources to use in subsequent self-control tasks, it is possible that ego depletion  
171 could lead individuals to evaluate tasks as more of a threat (i.e., insufficient resources to cope  
172 with task demands; Seery, 2011; Seery, 2009). Thus, this study aimed to shed light on this issue  
173 using a potentially stressful public speaking task.

174         One common method to evoke stress is to use a social evaluative task such as public  
175 speaking. Indeed, the Tier Social Stress Test (TSST) has been commonly used as such a task  
176 for many decades (Kudielka, Hellhammer, & Kirschbaum, Harmon-Jones, Winkielman, 2007),  
177 and has been consistently shown to provoke a profound stress response (Kirschbaum, Pirke, &  
178 Hellhammer, 1993). Although the TSST has been modified over the years (e.g., for groups;  
179 Vons-Dawans, Kirschbaum & Heinrichs, 2011), it typically requires participants to prepare  
180 and deliver a speech, and to verbally respond to a challenging mental arithmetic problem in the  
181 presence of a socially evaluative audience. Researchers using the TSST have found elevations  
182 in heart rate, blood pressure, and several endocrine stress markers (e.g., cortisol), highlighting  
183 its reliability in inducing a stress response (Birkett, 2011).

184 ***The present study***



## EGO DEPLETION AND CHALLENGE/THREAT

210 *very much* (5). The scores from all 13 items were summed, with a higher score indicating  
211 greater trait self-control. This scale has been used previously in the ego depletion literature  
212 (e.g., McEwan et al., 2013), and has been shown to be valid and reliable in assessing  
213 dispositional self-control (Tangey et al., 2004;  $\alpha = 0.92$ ).

214 ***Depletion sensitivity scale.*** Individual differences in depletion sensitivity were  
215 measured using the 11-item depletion sensitivity scale (Salmon et al., 2014). Participants rated  
216 the degree to which they agreed with each item on a 7-point Likert scale anchored between  
217 *totally disagree* (1) and *totally agree* (7). The scores from all 11 items were summed, with a  
218 higher score indicating greater depletion sensitivity. This scale has been used previously in the  
219 ego depletion literature (e.g., Englert, Persaud, Oudejans, & Bertrams, 2015), and has been  
220 shown to be valid and reliable in assessing depletion sensitivity (Salmon et al., 2014;  $\alpha = 0.92$ ).

221 ***Implicit theories of willpower.*** Individual differences in the beliefs regarding the nature  
222 of willpower, were assessed using the 6-item strenuous mental activity subscale of implicit  
223 beliefs about willpower scale (Job et al., 2010). Participants indicated the degree to which they  
224 agreed with each item on a 6-point Likert scale anchored between *strongly agree* (1) and  
225 *strongly disagree* (6). The scores from all 6 items were summed, with a higher score reflecting  
226 a greater belief that self-control is a limited resource. This measure has been used previously  
227 in the ego depletion literature and has been shown to be valid and reliable (Job, Walton, Dweck,  
228 & Bernecker, 2015;  $\alpha = 0.82$ ).

### 229 ***Self-control (ego depletion) manipulation checks***

230 Self-control was experimentally manipulated using a written transcription task. This  
231 task required participants to transcribe a text for six minutes (the most common length of time  
232 for ego depletion tasks; Giboin & Wolff, 2019). While the control group transcribed the text  
233 conventionally in full, requiring little self-control, the ego depletion group were asked to omit  
234 the letters “e” and “n”, an act that required suppression of their typical writing habits and thus

235 self-control. Importantly, this task, and time on the task, has been repeatedly shown to deplete  
 236 self-control resources in previous research (e.g., Bertrams, Englert, & Dickhauser, 2010;  
 237 Englert, Zwemmer, Bertrams, & Oudejans, 2015; Giboin & Wolff, 2019).

238 Performance on the transcription task was measured using the number of words  
 239 transcribed and errors (Bertrams et al., 2010). Transcription errors constituted grammatical  
 240 mistakes (e.g., spelling, lack of capital letters), missing words or sentences, and failing to miss  
 241 out the letters “e” and “n” (for the ego depletion group only). In addition, as a manipulation  
 242 check following the task, participants were asked “How strongly did you have to regulate your  
 243 writing habits?”, and “How effortful did you find the writing task?” (Englert & Bertrams, 2014;  
 244 Furley, Bertrams, Englert, & Delphia, 2013). The participants responded to both items on a 4-  
 245 point Likert scale anchored between *not at all* (1) and *very much* (4).

246 ***Challenge and threat evaluations***

247 To assess evaluations of task demands and personal coping resources, and thus  
 248 challenge and threat evaluations, two items from the cognitive appraisal ratio were used  
 249 (Tomaka, Blascovich, Kelsey, & Leitten, 1993). Evaluations of task demands were assessed  
 250 by asking “How demanding do you expect the upcoming speech task to be?”, while evaluations  
 251 of coping resources were measured by asking “How able are you to cope with the demands of  
 252 the upcoming speech task?”. Both items were rated on a 6-point Likert scale anchored between  
 253 *not at all* (1) and *extremely* (6). A demand resource evaluation score (DRES) was then  
 254 calculated by subtracting evaluated demands from resources (range -5 to +5), with a positive  
 255 score reflecting an evaluation more reflective of a challenge state (i.e., resources exceed  
 256 demands), and a negative score reflecting an evaluation more akin to a threat state (i.e.,  
 257 demands exceed resources). This measure has been used commonly in the challenge and threat  
 258 literature (e.g., Hase et al., 2018; Moore, Wilson, Vine, Coussens, & Freeman, 2013).

259 ***Subjective speech performance***

## EGO DEPLETION AND CHALLENGE/THREAT

260 In keeping with previous research (e.g., Nicholls, Polman, & Levy, 2010), participants  
261 were asked to rate how well they expected to perform in the upcoming speech task using a 7-  
262 point Likert scale anchored between *not at all well* (1) and *extremely well* (7).

### 263 ***Procedure***

264 Participants were randomly assigned to either an ego depletion or control group.  
265 Randomization was conducted using <https://www.randomizer.org/>. First, participants  
266 completed the trait self-control measures. Second, participants were required to perform the  
267 written transcription task for six minutes. Time was monitored by the researcher, and  
268 participants were informed when they had one-minute remaining. Next, after completing self-  
269 report items relating to the regulation of writing habits and effort during the transcription task,  
270 participants read a set of instructions that described a potentially stressful speech task.  
271 Specifically, participants were informed that they would give a five-minute speech about their  
272 dream job in front of their peers (all data was collected in taught sessions). To add an element  
273 of self-control, participants were asked to avoid standing still, closed body posture, negative  
274 facial expressions, unconfident body language, pausing for longer than five seconds, and using  
275 a monotonous voice. Participants were made aware that these criteria would be used to rate  
276 their performance, and their speech was going to be recorded via a digital video camera.  
277 Participants were then asked to report their challenge and threat evaluations and subjective  
278 ratings of performance. Finally, participants were debriefed, informed that they did not need to  
279 complete the potentially stressful speech task, and thanked for their participation.

### 280 ***Statistical analyses***

281 Missing data analysis revealed that 0.14% of the data from 262 participants was  
282 missing, however, Little's missing at random (MCAR) test was significant at the .05 level ( $\chi^2$   
283 = 1172.19,  $df = 1072$ ,  $p = .017$ ), therefore, we replaced missing data using the expectation  
284 maximization method. To ensure data was normally distributed, outlier analyses were

285 performed before the main statistical analysis. A total of eight outliers were identified.  
286 Specifically, for ‘number of words’, one outlier was identified for the control group and two  
287 for the ego depletion group. Moreover, for ‘number of errors’, four outliers were identified for  
288 the control group and one for the ego depletion group. The windsorization method was used to  
289 treat the outliers, with raw data being changed to 1% larger or smaller than the next most  
290 extreme score. Following outlier analyses, all data was normally distributed as skewness and  
291 kurtosis z-scores did not exceed 1.96.

292 A series of independent *t*-tests were performed on the trait self-control (i.e., trait self-  
293 control, depletion sensitivity, implicit theories of willpower), self-control (ego depletion)  
294 manipulation check (i.e., number of transcribed words and errors, ratings of writing habit  
295 regulation and effort), challenge and threat evaluation (i.e., DRES), and subjective speech  
296 performance data. For all *t*-tests, the degrees of freedom, *t* statistic, and probability values were  
297 corrected for homogeneity of variance assumption violations using the Levene’s test for  
298 equality of variances. Effect sizes were calculated using Cohen’s *d* (small = 0.20, medium =  
299 0.50, and large = 0.80; Cohen, 1992), and significance was set at 0.05. Furthermore, Pearson’s  
300 correlations were conducted to determine the relationships between the trait self-control  
301 measures, DRES, and subjective performance. In accordance with Cohen (1992), the strength  
302 of a relationship was considered small, moderate, and large, if a coefficient was reported as  
303 being above 0.2, 0.3 and 0.5 respectively. All analyses were performed on IBM SPSS statistics  
304 software (version 25).

## 305 **Results**

### 306 ***Trait self-control measures***

307 The results revealed no significant differences between the groups in terms of trait self-  
308 control ( $t_{(260)} = 0.58, p = .562, md = 0.53, 95\% \text{ CI } [-1.28, 2.36], d = 0.07$ ), depletion sensitivity  
309 ( $t_{(260)} = 0.15, p = .884, md = 0.21, 95\% \text{ CI } [-2.56, 2.97], d = 0.01$ ), or strenuous mental activity

## EGO DEPLETION AND CHALLENGE/THREAT

310 beliefs about willpower ( $t_{(261)} = -1.33, p = .148, md = -0.76, 95\% \text{ CI } [-1.89, 0.36], d = 0.16$ ).

311 This data is presented in Table 1 and supports the effectiveness of the randomisation procedure

312 used to allocate participants to the experimental groups.

313

314 INSERT TABLE 1 HERE

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### 316 *Self-control (ego depletion) manipulation checks*

317 The results revealed that the written transcription task required significantly more self-

318 control for the ego depletion group than the control group, with the ego depletion group

319 transcribing fewer words ( $t_{(192.2)} = 8.64, p < .001, md = 25.92, 95\% \text{ CI } [20.01, 31.83], d = 1.10$ ),

320 and making more errors ( $t_{(241.3)} = -13.11, p < .001, md = -6.76, 95\% \text{ CI } [-7.77, -5.74], d = 1.57$ ),

321 than the control group. Furthermore, the ego depletion group reported having to regulate their

322 writing habits more ( $t_{(260)} = -8.55, p < .001, md = -0.91, 95\% \text{ CI } [-1.12, -0.7], d = 1.06$ ), and

323 that the transcription task required more effort ( $t_{(219.9)} = -7.23, p < .001, md = -0.79, 95\% \text{ CI } [-$

324  $1.01, -0.57], d = 0.91$ ), than the control group. This data is presented in Table 2 and supports

325 the effectiveness of the self-control (ego depletion) manipulation.

326

327 INSERT TABLE 2 HERE

328

### 329 *Challenge and threat evaluations*

330 The results revealed no significant difference between the groups for DRES ( $t_{(260)} =$

331  $0.53, p = .828, md = 0.15, 95\% \text{ CI } [-0.41, 0.71], d = -0.06$ ). This data is presented in Table 3,

332 and suggests that the ego depletion and control groups did not differ in terms of how they

333 evaluated the potentially stressful speech task, with the descriptive data indicating that both

334 groups evaluated the task as more of a threat (i.e., task demands exceed coping resources).

335 ***Subjective speech performance***

336 The results revealed no significant difference between the groups in terms of subjective  
337 ratings of speech performance ( $t_{(255.2)} = 0.10, p = .915, md = 0.02, 95\% \text{ CI } [-0.35, 0.39], d =$   
338  $0.01$ ). This data is presented in Table 3, and implies that the initial self-control task (i.e., written  
339 transcription) had little effect on participants' perceptions of their performance prior to a  
340 subsequent self-control task (i.e., public speaking), with the descriptive data suggesting that  
341 both groups doubted that they could perform the potentially stressful speech task successfully.

342

343 INSERT TABLE 3 HERE

344 ***Exploratory analyses***

345 Pearson's correlations were used to assess the relationships between trait self-control  
346 measures, self-control manipulation checks, DRES, and subjective performance for each group  
347 separately (Table 4). For the control group, there was a significant negative correlation between  
348 trait self-control and effort ( $r = -.19, p = .034$ ). In addition, depletion sensitivity showed a  
349 significant positive correlation with effort ( $r = .29, p = .002$ ) and regulation of writing habits  
350 ( $r = .25, p = .006$ ). Regulation of writing habits also showed a significant negative correlation  
351 with DRES ( $r = -.18, p = .050$ ). However, these correlations were not significant for the ego  
352 depletion group.

353 Depletion sensitivity showed a significant negative correlation with DRES for both the  
354 control ( $r = -.33, p < .001$ ) and ego depletion ( $r = -.31, p < .001$ ) group. Depletion sensitivity  
355 also showed a significant negative correlation with subjective ratings of performance for both  
356 the control ( $r = -.31, p < .001$ ) and ego depletion ( $r = -.21, p = .008$ ) group. Furthermore,  
357 strenuous mental activity beliefs about willpower showed a significant negative correlation  
358 with DRES for both the control ( $r = -.21, p = .022$ ) and ego depletion ( $r = -.18, p = .025$ ) group.  
359 Strenuous mental activity beliefs about willpower also showed a significant negative



360 correlation with subjective ratings of performance, but only for the ego depletion group ( $r = -$   
361  $.17, p = .038$ ). Finally, DRES showed a significant positive correlation with subjective ratings  
362 of performance for both the control ( $r = .70, p < .001$ ) and ego depletion ( $r = .73, p < .001$ )  
363 group.

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INSERT TABLE 4 HERE

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### Discussion

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To date, relatively little research has explored the factors that influence challenge and threat evaluations despite their fairly robust effects on cardiovascular responses to, and performance during, potentially stressful tasks (Hase et al, 2018). Indeed, this is the first study to examine the effect of ego depletion on challenge and threat evaluations, and subjective ratings of performance, before a potentially stressful speech task. Contrary to our hypotheses, the results revealed no significant differences between the ego depletion and control groups in terms of challenge and threat evaluations or subjective ratings of performance.

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Consistent with previous research (e.g., Englert & Bertrams, 2012; Bertrams et., 2010), and supporting the effectiveness of the written transcription task, the ego depletion group transcribed fewer words and made more errors than the control group. In addition, the ego depletion group indicated that the written transcription task they completed required more effort, and greater regulation of writing habits, than the transcription task completed by the control group. Previous research would suggest that this result implicates a reduction in self-control resources or a successful ego depletion effect (e.g., Arber et al., 2017). Therefore, after being satisfied that the written transcription task caused ego depletion, the effect of this depletion on challenge and threat evaluations of a potentially stressful public speaking task was examined.

## EGO DEPLETION AND CHALLENGE/THREAT

385           Contrary to our hypothesis, the results revealed no significant difference between the  
386 ego depletion and control groups in terms of challenge and threat evaluations (i.e., evaluations  
387 of task demands and personal coping resources). The reduction in self-control resources  
388 experienced by the ego depletion group did not result in this group evaluating the potentially  
389 stressful speech as more of a threat (i.e., insufficient resources to cope with task demands). In  
390 addition to challenge and threat evaluations, we also examined whether ego depletion  
391 influenced how participants expected to perform in the potentially stressful public speaking  
392 task, which would have also required an element of self-control (e.g., avoid using a  
393 monotonous voice and standing still). Contrary to our hypotheses, the results revealed no  
394 significant differences between the ego depletion and control groups in terms of subjective  
395 ratings of performance. Despite experiencing a reduction in self-control resources as a result  
396 of the written transcription task, the ego depletion group did not report expecting to perform  
397 worse than the control group.

398           Secondary exploratory analyses revealed significant relationships and differences  
399 between trait measures of self-control, DRES, and subjective ratings of performance.  
400 Specifically, for both groups, participants more sensitive to depletion were more likely to  
401 evaluate the potentially stressful speech task as more of a threat. Similarly, participants who  
402 reported being more sensitive to depletion were also more likely to rate that they were going  
403 to perform poorly in the potentially stressful speech task. These findings extend previous  
404 research that has shown that depletion sensitivity can impact actual task performance following  
405 ego depletion (e.g., Salmon et al, 2014). Therefore, with previous and present findings, it is  
406 suggested that the ability and time taken to deplete an individual may vary due to depletion  
407 sensitivity, this further supports the conflict regarding time to depletion and task order.  
408 Importantly, the results also suggest a possible conscious level of depletion sensitivity and the  
409 impact of this on upcoming tasks. Further exploration of depletion sensitivity may provide

410 more insight into the contradictory null findings surrounding the resource model of ego  
411 depletion.

412         Secondly, for the control and ego depletion groups, participants whose beliefs were  
413 more aligned with the limited theory of willpower were more likely to evaluate the potentially  
414 stressful speech task as more of a threat. However, only those in the ego depletion group whose  
415 beliefs aligned with the limited theory of willpower were more likely to rate that they were  
416 going to perform poorly in the potentially stressful speech task. These findings extend previous  
417 research which has found that willpower beliefs may affect actual task performance following  
418 ego depletion (e.g., Job et al, 2010; Job et al., 2015). The current study suggests that depletion  
419 sensitivity and beliefs surrounding willpower may explain the variance in differing challenge  
420 and threat states and subjective performance.

### 421 *Strengths and Limitations*

422         In order to better contextualise the findings, several strengths and limitations should be  
423 considered. Firstly, whilst this was the first study to assess the effects of ego depletion on  
424 challenge and threat evaluations during a potentially stressful task, it should be noted that only  
425 subjective markers were used to measure challenge and threat evaluations and performance.  
426 However, previously subjective markers have been shown to be both valid and reliable when  
427 compared with an objective marker in other domains requiring measures of stress and  
428 performance (Arora et al, 2010). Evidence also suggests there is a valid need to assess  
429 subjective measures, as perceptions of depletion have been shown to be better predictors of  
430 performance, then actual depletion (Clarkson et al, 2010). Objective markers were not used in  
431 the current study due to the exploratory nature of the study design and large sample size (i.e.,  
432 a large volume of data was collected from multiple participants at one time point). Second,  
433 only single-item measures were used to assess challenge and threat evaluations. Research has  
434 shown that one item and multi-item measures perform equally as well (Bergkvist & Rossiter,

435 2007), future research is encouraged to replicate the findings of this study using multi-item  
436 measures (e.g. stress appraisal scale; Schneider, 2008). Despite the benefits of being an  
437 experimental study, the research was conducted in the ‘field’ (i.e., real teaching sessions),  
438 which limited control over potential confounding variables (e.g., class size, interaction between  
439 participants, etc.).

### 440 *Future research*

441 This is the first known study to assess the effect of ego depletion on challenge and threat  
442 evaluations and subjectively rated performance under potentially stressful conditions. Future  
443 studies are encouraged to further the current study findings by using both subjective and  
444 objective measures of challenge and threat, and pressurized speech performance. The  
445 introduction of cardiovascular reactivity measures would allow for additional exploration of  
446 subconscious and objective measures of challenge and threat and ego depletion, equally  
447 reducing possible subjectivity and bias (e.g., social desirability; Blascovich, 2008). It is also  
448 suggested that future research examine the relationship between ego depletion and challenge  
449 and threat in a controlled laboratory environment, enabling a more causal understanding of the  
450 relationship. Furthermore, as moderation analyses were not performed, future research is  
451 encouraged to explore if the effects of ego depletion on performance is moderated by challenge  
452 and threat appraisals. It is also important to explore other proposed mechanisms of ego  
453 depletion (rather than the consequence of a limited self-control resource) on challenge and  
454 threat evaluations, such as motivation or attention (e.g., Inzlicht and Schmeichel, 2012,  
455 Kurzban, Duckworth, Kable & Myers, 2013). Equally, further examination of the effect of ego  
456 depletion on other types of stress appraisals is warranted (e.g., Lazarus, 1984).

### 457 **Conclusion**

458 In summary, this study offered an initial test of the effect of ego depletion on challenge  
459 and threat evaluations and subjective ratings of performance during a potentially stressful

460 public speaking task. Although the results supported the effectiveness of the self-control (ego  
 461 depletion) manipulation (i.e., written transcription task), there were no significant differences  
 462 between the ego depletion and control groups in terms of challenge and threat evaluations or  
 463 subjective ratings of performance. Thus, the findings suggest that ego depletion might not  
 464 affect the appraisals of potentially stressful tasks. However, additional exploratory analyses  
 465 suggested that individuals who were more sensitive to depletion, and who believed that  
 466 willpower was more limited, were more likely to evaluate the potentially stressful task as a  
 467 threat and doubt in their ability to perform the task successfully. Thus, this study contributes to  
 468 the growing body of evidence questioning and examining the ego depletion phenomenon.

469 **References**

- 470 Arber, M. M., Ireland, M. J., Feger, R., Marrington, J., Tehan, J., & Tehan, G. (2017). Ego  
 471 depletion in real-time: An examination of the sequential-task paradigm. *Frontiers in*  
 472 *Psychology*, 8: 1672. doi:10.3389/fpsyg.2017.01672.
- 473 Arora, S., Aggarwal, R., Moran, A., Sirimanna, P., Crochet, P., Darzi, A., ... & Sevdalis, N.  
 474 (2011). Mental practice: effective stress management training for novice  
 475 surgeons. *Journal of the American College of Surgeons*, 212, 225-233.  
 476 doi:10.1016/j.jamcollsurg.2010.09.025.
- 477 Avital-Cohen, R., & Tsal, Y. (2016). Top-down processes override bottom-up interference in  
 478 the flanker task. *Psychological Science*, 27, 651-658.  
 479 doi:10.1177/0956797616631737.
- 480 Bandura, A. (1989). Human agency in social cognitive theory. *American Psychologist*, 44(9),  
 481 1175. doi:10.1037/0003-066X.44.9.1175.
- 482 Baumeister, R. F., & Heatherton, T. F. (1996). Self-regulation failure: An  
 483 overview. *Psychological Inquiry*, 7, 1-15. doi:10.1207/s15327965pli0701\_1.

## EGO DEPLETION AND CHALLENGE/THREAT

- 484 Bergkvist, L., & Rossiter, J. R. (2007). The predictive validity of multiple-item versus single-  
485 item measures of the same constructs. *Journal of Marketing Research*, *44*(2), 175-184.  
486 doi:10.1509/jmkr.44.2.175.
- 487 Bertrams, A., Englert, C., & Dickhäuser, O. (2010). Self-control strength in the relation  
488 between trait test anxiety and state anxiety. *Journal of Research in Personality*, *44*,  
489 738-741. doi:10.1016/j.jrp.2010.09.005.
- 490 Birkett, M. A. (2011). The Trier Social Stress Test protocol for inducing psychological stress.  
491 *Journal of Visualized Experiments*, e3238, doi:10.3791/3238.
- 492 Blascovich, J. (2008). Challenge and threat. In A. J. Elliot (Ed.), *Handbook of Approach and*  
493 *Avoidance Motivation* (pp. 431-445). New York; Psychology Press.
- 494 Bray, S. R., Ginis, K. A. M., & Woodgate, J. (2011). Self-regulatory strength depletion and  
495 muscle-endurance performance: A test of the limited-strength model in older  
496 adults. *Journal of Aging and Physical Activity*, *19*, 177-188. doi:10.1123/japa.19.3.177.
- 497 Calkins, S. D., & Fox, N. A. (2002). Self-regulatory processes in early personality  
498 development: A multilevel approach to the study of childhood social withdrawal and  
499 aggression. *Development and Psychopathology*, *14*, 477-498.  
500 doi:10.1017.S095457940200305X.
- 501 Carter, E. C., & McCullough, M. E. (2014). Publication bias and the limited strength model of  
502 self-control: has the evidence for ego depletion been overestimated?. *Frontiers in*  
503 *Psychology*, *5*: 823. doi:10.3389/fpsyg.2014.00823.
- 504 Carter, E. C., Kofler, L. M., Forster, D. E., & McCullough, M. E. (2015). A series of meta-  
505 analytic tests of the depletion effect: Self-control does not seem to rely on a limited  
506 resource. *Journal of Experimental Psychology: General*, *144*, 796-815.  
507 doi:10.1037/xge0000083.

## EGO DEPLETION AND CHALLENGE/THREAT

- 508 Clarkson, J. J., Hirt, E. R., Jia, L., & Alexander, M. B. (2010). When perception is more than  
509 reality: the effects of perceived versus actual resource depletion on self-regulatory  
510 behaviour. *Journal of Personality and Social Psychology*, *98*, 29-46.  
511 doi:10.1037/a0017539.
- 512 Cohen, J. (1992). Statistical power analysis. *Current Directions in Psychological Science*, *1*(3),  
513 98-101. doi:10.1111/1467-8721.ep10768783.
- 514 de Ridder, D., van der Weiden, A., Gillebaart, M., Benjamins, J., & Ybema, J. F. (2019). Just  
515 do it: Engaging in self-control on a daily basis improves the capacity for self-control.  
516 *Motivation Science*. doi:10.1037/mot0000158.
- 517 Duckworth, A. L., & Kern, M. L. (2011). A meta-analysis of the convergent validity of self-  
518 control measures. *Journal of Research in Personality*, *45*, 259-268.  
519 doi: 10.1016/j.jrp.2011.02.004.
- 520 Dvorak, R. D., & Simons, J. S. (2009). Moderation of resource depletion in the self-control  
521 strength model: Differing effects of two modes of self-control. *Personality and Social*  
522 *Psychology Bulletin*, *35*, 572-583. doi:10.1177/0146167208330855.
- 523 Englert, C., & Bertrams, A. (2012). Anxiety, ego depletion, and sports performance. *Journal*  
524 *of Sport and Exercise Psychology*, *34*, 580-599. doi:10.1123/jsep.34.5.580.
- 525 Englert, C., & Bertrams, A. (2012). Anxiety, ego depletion, and sports performance. *Journal*  
526 *of Sport and Exercise Psychology*, *34*, 580-599. doi:10.1123/jsep.34.5.580.
- 527 Englert, C., & Bertrams, A. (2014). The effect of ego depletion on sprint start reaction  
528 time. *Journal of Sport and Exercise Psychology*, *36*, 506-515. doi:10.1123/jsep.2014-  
529 0029.
- 530 Englert, C., Persaud, B., Oudejans, R., & Bertrams, A. (2015). The influence of ego depletion  
531 on sprint start performance in athletes without track and field experience. *Frontiers in*  
532 *Psychology*, *6*: 1207. doi:10.3389/fpsyg.2015.01207.

## EGO DEPLETION AND CHALLENGE/THREAT

- 533 Englert, C., Zwemmer, K., Bertrams, A., & Oudejans, R. R. (2015). Ego depletion and attention  
534 regulation under pressure: Is a temporary loss of self-control strength indeed related to  
535 impaired attention regulation? *Journal of Sport and Exercise Psychology, 37*, 127-137.  
536 doi:10.1123/jsep.2014-0219.
- 537 Ferguson, M. J., & Bargh, J. A. (2004). How social perception can automatically influence  
538 behavior. *Trends in Cognitive Sciences, 8*, 33-39. doi:10.1016/j.tics.2003.11.004.
- 539 Friese, M., Loschelder, D. D., Gieseler, K., Frankenbach, J., & Inzlicht, M. (2018). Is ego  
540 depletion real? An analysis of arguments. *Personality and Social Psychology Review,*  
541 *23*, 107-131. doi:10.1177/1088868318762183.
- 542 Fujita, K. (2011). On conceptualizing self-control as more than the effortful inhibition of  
543 impulses. *Personality and Social Psychology Review, 15*, 352-366.  
544 doi:10.1177/1088868311411165.
- 545 Furley, P., Bertrams, A., Englert, C., & Delphia, A. (2013). Ego depletion, attentional  
546 control, and decision making in sport. *Psychology of Sport and Exercise, 14*, 900-904.  
547 doi:10.1016/j.psychsport.2013.08.006.
- 548 Giboin, L. S., & Wolff, W. (2019). The effect of ego depletion or mental fatigue on subsequent  
549 physical endurance performance: A meta-analysis. *Performance Enhancement and*  
550 *Health, 100150*. doi:10.3390/brainsci9110317.
- 551 Hagger, M. S., Chatzisarantis, N. L., Alberts, H., Anggono, C.O., Batailler, C., Birt, A. R., &  
552 Calvillo, D. P. (2016). A multilab preregistered replication of the ego-depletion  
553 effect. *Perspectives on Psychological Science, 11*, 546-573.  
554 doi:10.1177/1745691616652873.
- 555 Hagger, M. S., Wood, C., Stiff, C., & Chatzisarantis, N. L. (2010). Ego depletion and the  
556 strength model of self-control: A meta-analysis. *Psychological Bulletin, 136*, 495-525.  
557 doi:10.1037/a0019486.



## EGO DEPLETION AND CHALLENGE/THREAT

- 558 Hase, A., O'Brien, J., Moore, L. J., & Freeman, P. (2019). The relationship between challenge  
559 and threat states and performance: A systematic review. *Sport, Exercise, and*  
560 *Performance Psychology*, 8, 123-144. doi:10.1037/spy0000132.
- 561 Heatherton, T. F., & Wagner, D. D. (2011). Cognitive neuroscience of self-regulation  
562 failure. *Trends in Cognitive Sciences*, 15, 132-139. doi:10.1016/j.tics.2010.12.005.
- 563 Imhoff, R., Schmidt, A. F., & Gerstenberg, F. (2014). Exploring the interplay of trait self-  
564 control and ego depletion: Empirical evidence for ironic effects. *European Journal of*  
565 *Personality*, 28, 413-424. doi:10.1002/per.1899.
- 566 Inzlicht, M., & Schmeichel, B. J. (2012). What is ego depletion? Toward a mechanistic revision  
567 of the resource model of self-control. *Perspectives on Psychological Science*, 7, 450-  
568 463. doi:10.1177/1745691612454134.
- 569 Job, V., Dweck, C. S., & Walton, G. M. (2010). Ego depletion - Is it all in your head? Implicit  
570 theories about willpower affect self-regulation. *Psychological Science*, 21, 1686-1693.  
571 doi:10.1177/0956797610384745.
- 572 Job, V., Walton, G. M., Bernecker, K., & Dweck, C.S. (2015). Implicit theories about  
573 willpower predict self-regulation and grades in everyday life. *Journal of Personality*  
574 *and Social Psychology*, 108, 637-647. doi:10.1037/pspp0000014.
- 575 Kirschbaum, C., Pirke, K. M., & Hellhammer, D. H. (1993). The 'Trier Social Stress Test' -  
576 A tool for investigating psychobiological stress responses in a laboratory  
577 setting. *Neuropsychobiology*, 28, 76-81. doi:10.1159/000119004.
- 578 Kudielka, B. M., Hellhammer, D. H., Kirschbaum, C., Harmon-Jones, E., & Winkielman, P.  
579 (2007). Ten years of research with the Trier Social Stress Test - revisited. *Social*  
580 *Neuroscience: Integrating Biological and Psychological Explanations of Social*  
581 *Behaviour*. New York, Guilford Press. New York.

## EGO DEPLETION AND CHALLENGE/THREAT

- 582 Kurzban, R., Duckworth, A., Kable, J. W., & Myers, J. (2013). An opportunity cost model of  
583 subjective effort and task performance. *Behavioral and Brain Sciences*, *36*, 661-679.  
584 doi:10.1017/S0140525X12003196.
- 585 Lazarus, R. S., & Folkman, S. (1984). *Stress, Appraisal, and Coping*. Springer publishing  
586 company.
- 587 Lurquin, J. H., & Miyake, A. (2017). Challenges to ego-depletion research go beyond the  
588 replication crisis: A need for tackling the conceptual crisis. *Frontiers in Psychology*, *8*:  
589 568. doi:10.3389/fpsyg.2017.00568.
- 590 McAuley, T., Chen, S., Goos, L., Schachar, R., & Crosbie, J. (2010). Is the behaviour rating  
591 inventory of executive function more strongly associated with measures of impairment  
592 or executive function? *Journal of the International Neuropsychological Society*, *16*,  
593 495-505. doi:10.1017/S1355617710000093.
- 594 McEwan, D., Ginis, K. A. M., & Bray, S. R. (2013). The effects of depleted self-control  
595 strength on skill-based task performance. *Journal of Sport and Exercise*  
596 *Psychology*, *35*, 239-249. doi:10.1123/jsep.35.3.239.
- 597 Metcalfe, J., & Mischel, W. (1999). A hot/cool-system analysis of delay of gratification:  
598 Dynamics of willpower. *Psychological Review*, *106*(1), 3-19.
- 599 Moore, L.J., Vine, S.J., Wilson, M.R., & Freeman, P. (2014). Examining the antecedents of  
600 challenge and threat states: The influence of perceived required effort and support  
601 availability. *International Journal of Psychophysiology*, *93*, 267-273.  
602 doi:10.1016/j.ijpsycho.2014.05.009.
- 603 Moore, L.J., Wilson, M.R., Vine, S.J., Coussens, A.H., & Freeman, P. (2013). Champ or  
604 chump? Challenge and threat states during pressurized competition. *Journal of Sport*  
605 *and Exercise Psychology*, *35*, 551-562. doi:10.1123/jsep.35.6.551.

## EGO DEPLETION AND CHALLENGE/THREAT

- 606 Muraven, M., Collins, R. L., & Neinhans, K. (2002). Self-control and alcohol restraint: An  
607 initial application of the self-control strength model. *Psychology of Addictive*  
608 *Behaviors, 16*(2), 113. doi:10.1037/0893-164X.16.2.113.
- 609 Muraven, M., Collins, R. L., Shiffman, S., & Paty, J. A. (2005). Daily fluctuations in self-  
610 control demands and alcohol intake. *Psychology of Addictive Behaviors, 19*, 140 -147.  
611 doi:10.1037/0893-164X.19.2.140.
- 612 Nicholls, A. R., Polman, R. C., & Levy, A. R. (2012). A path analysis of stress appraisals,  
613 emotions, coping, and performance satisfaction among athletes. *Psychology of Sport*  
614 *and Exercise, 13*, 263-270. doi:10.1016/j.psychsport.2011.12.003.
- 615 Nigg, J. T. (2017). Annual Research Review: On the relations among self-regulation, self-  
616 control, executive functioning, effortful control, cognitive control, impulsivity, risk-  
617 taking, and inhibition for developmental psychopathology. *Journal of Child*  
618 *Psychology and Psychiatry, 58*, 361-383. doi:10.1111/jcpp.12675.
- 619 Osgood, J. M. (2017). Effect of ego-depletion typing task on stroop does not extend to diverse  
620 online sample. *Journal of Articles in Support of the Null Hypothesis, 13*, (2), 84-90.
- 621 Quinn, P. D., & Fromme, K. (2010). Self-regulation as a protective factor against risky  
622 drinking and sexual behavior. *Psychology of Addictive Behaviors, 24*, 376-385.  
623 doi:10.1037/a0018547.
- 624 Richeson, J. A., & Shelton, J. N. (2003). When prejudice does not pay: Effects of interracial  
625 contact on executive function. *Psychological Science, 14*(3), 287-290.  
626 doi:10.1111/1467-9280.03437.
- 627 Salmon, S. J., Adriaanse, M. A., De Vet, E., Fennis, B. M., & De Ridder, D.T. (2014). “When  
628 the going gets tough, who keeps going?” Depletion sensitivity moderates the ego-  
629 depletion effect. *Frontiers in Psychology, 5*: 647. doi:10.3389/fpsyg.2014.00647.

## EGO DEPLETION AND CHALLENGE/THREAT

- 630 Schneider, T. R. (2008). Evaluations of stressful transactions: What's in an appraisal? *Stress*  
631 *and Health: Journal of the International Society for the Investigation of Stress*, *24*, 151-  
632 158. doi:10.1002/smi.1176.
- 633 Seery, M. D. (2011). Challenge or threat? Cardiovascular indexes of resilience and  
634 vulnerability to potential stress in humans. *Neuroscience & Biobehavioral Reviews*, *35*,  
635 1603-1610. doi:10.1016/j.neubiorev.2011.03.003.
- 636 Seery, M. D., Weisbuch, M., & Blascovich, J. (2009). Something to gain, something to lose:  
637 The cardiovascular consequences of outcome framing. *International Journal of*  
638 *Psychophysiology*, *73*, 308-312. doi:10.1016/j.ijpsycho.2009.05.006.
- 639 Tangney, J. P., Baumeister, R. F., & Boone, A. L. (2004). High self-control predicts good  
640 adjustment, less pathology, better grades, and interpersonal success. *Journal of*  
641 *Personality*, *72*, 271-324. doi:10.1111/j.0022-3506.2004.00263.x.
- 642 Tomaka, J., Blascovich, J., Kelsey, R. M., & Leitten, C. L. (1993). Subjective, physiological,  
643 and behavioural effects of threat and challenge appraisal. *Journal of Personality and*  
644 *Social Psychology*, *65*, 248-260. doi:10.1037/0022-3514.65.2.248.
- 645 Vohs, K. D., & Baumeister, R. F. (2004). Understanding self-regulation. *Handbook of Self-*  
646 *Regulation*, *19*.
- 647 Vohs, K. D., & Heatherton, T. F. (2000). Self-regulatory failure: A resource-depletion  
648 approach. *Psychological Science*, *11*(3), 249-254. doi:10.1111/1467-9280.00250.
- 649 Von Dawans, B., Kirschbaum, C., & Heinrichs, M. (2011). The Trier Social Stress Test for  
650 Groups (TSST-G): A new research tool for controlled simultaneous social stress  
651 exposure in a group format. *Psychoneuroendocrinology*, *36*, 514-522.  
652 doi:10.1016/j.psyneuen.2010.08.004.

## EGO DEPLETION AND CHALLENGE/THREAT

653 Wolff, W., Baumann, L., & Englert, C. (2018). Self-reports from behind the scenes:  
654 Questionable research practices and rates of replication in ego depletion research. *PloS*  
655 *One*, 13, e0199554. doi:10.1371/journal.pone.0199554.

656 Wolff, W., Sieber, V., Bieleke, M., & Englert, C. (2019). Task duration and task order do not  
657 matter: no effect on self-control performance. *Psychological Research*, 1-11.  
658 doi:10.1007/s00426-019-01230-1.

659 Xiao, S., Dang, J., Mao, L., & Liljedahl, S. (2014). When more depletion offsets the ego  
660 depletion effect. *Social Psychology*, 45, 421-425. doi:10.1027/1864-9335/a000197.

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664

665

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