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Self-control exertion and glucose supplementation prior to endurance performance

Ruth Boat*, Ian M. Taylor, Carl J. Hulston

Department of Sport, Exercise, and Health Sciences, Loughborough University, Loughborough, Leicestershire, LE11 3TU, United Kingdom

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ABSTRACT

Objectives: Completion of a task requiring self-control may negatively impact on subsequent self-regulatory efforts. This study explored a) whether this effect occurs during a well-practiced endurance task, b) the potential for glucose supplementation to moderate this effect, and c) whether this effect differed over time.

Method: Fourteen trained cyclists completed four simulated 16 km time trials on an electromagnetically braked cycle ergometer. Prior to each time trial, participants completed a congruent Stroop task or an incongruent Stroop task that required self-control. They also received either a glucose-based drink or placebo. Participants' performance time and heart rate were recorded throughout the time trials.

Results: Multilevel growth curve analysis revealed a significant three-way interaction between self-control, glucose, and time ($b = -0.91$; $p = 0.02$). When participants did not exert self-control (congruent Stroop) or consume glucose (placebo drink) they were slowest during the early stages of the time trial but quickest over the full distance. No differences were found in heart rate across the four conditions.

Conclusions: Findings suggest that pacing may explain why self-control exertion interferes with endurance performance. Moreover, the debate revolving around depletion of self-control must consider that any observed effects may be dependent on the timing of performance inspection.

Self-control alludes to any effort to amend one's own inner states or responses, including actions, feelings, thoughts, and task performances (Baumeister, Vohs, & Tice, 2007). This process facilitates desirable behavior by helping to resist inappropriate impulses and continuing with appropriate behavior. Self-control is important for sport performance because athletes are required to control their cognitive, emotional, and motor processes for superior athletic performance (Englert & Bertrams, 2012; Wagstaff, 2014). For example, athletes are required to resist discomfort and the urge to slow during sustained aerobic performance with the goal of producing the fastest time possible. Self-control ability can vary between individuals meaning that some individuals are generally better at self-control than others (i.e., trait self-control), as well as within individuals between situations (i.e., state self-control; Tangney, Baumeister, & Boone, 2004). For instance, some researchers suggest that the capacity to exert self-control is limited and becomes diminished when an individual regulates his or her behaviors, a state known as ego depletion (Baumeister et al., 2007). Consequently, the individual will have a reduced capacity to perform any subsequent behavior that requires self-regulation. This ‘limited resource’ perspective has received both meta-analytic support (Hagger, Wood, Stiff, & Chatzisarantis, 2010) and fervent challenge (e.g., Carter, Kofler, Forster, & McCullough, 2015; Hagger et al., 2016; Kurzban, 2016). Other researchers propose that self-control exertion is accompanied by shifts in motivation, emotion, and attention, and discount the limited resource explanation (Inzlicht & Schmeichel, 2012). When participants are confronted with a second self-control task, participants may be less motivated to comply with task-relevant goals (unless they receive incentives to do so).

Irrespective of the different explanations, considerable evidence exists that performance on subsequent physical tasks is reduced following an initial task requiring self-control. For example, individuals who were asked to regulate their emotions while watching an upsetting movie were unable to sustain an isometric handgrip squeeze for as long as individuals who watched the movie but engaged in no emotion regulation (Muraven, Tice, &

* Corresponding author.
E-mail address: r.boat@lboro.ac.uk (R. Boat).

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Baumeister, 1998). Although squeezing a handgrip primarily requires muscular strength, overcoming fatigue and overriding the urge to quit are acts of self-regulation. The ability for cognitive or emotion regulation to impair subsequent handgrip performance has been corroborated (e.g., Bray, Graham, Martin Ginis, & Hicks, 2011). Building on this work, researchers have attempted to enhance the ecological validity of the evidence so that conclusions regarding more complex human performance can be drawn. A variety of tasks requiring self-control (e.g., counting backwards from 1000 in multiples of seven while holding a spirit level, transcribing a neutral text whilst omitting the letters 'e' and 'n', completing an incongruent Stroop task, supressing emotions during an upsetting movie) have been associated with reduced performance in press-up tasks, basketball free-throw tasks, and cycling performance (Dorris, Power, & Kenefick, 2012; Englert & Bertrams, 2012; Englert & Wolff, 2015; Wagstaff, 2014).

Collectively, the studies above provide valuable insight into self-regulatory processes and athletic performance. However, it is currently unknown whether previous exertion of self-control impairs subsequent endurance performance when self-regulation is potentially automatic. In expert populations, the persistent pursuit of the same cognitive goal results in the automatization of cognitive processes (Williams, Huang, & Bargh, 2009), therefore, self-regulatory resources may not be required to the same extent as conscious self-regulation (Schmeichel & Baumeister, 2004). However, successful endurance performance involves considerable levels of discomfort and overcoming these demands may exacerbate the need for conscious self-regulation. As a result, even in an expert population, engaging in an initial task requiring self-control is likely to impair subsequent endurance performance because the self-regulation required to maintain effort and resist discomfort is salient.

As well as exploring the salience of self-control during well-practiced human performance, the present study aims to examine whether glucose can attenuate any decrements in performance due to prior self-control exertion. Tasks requiring controlled, effortful self-control demand increased cerebral functioning, possibly causing a concomitant rise in the requirement for blood glucose in the brain (Gailliot et al., 2007). Glucose in the blood is often measured under the assumption that equilibrium exists between glucose in the blood and the brain (Lund-Anderson, 1979). Glucose ingested immediately before and/or during exercise is rapidly digested, absorbed, and available for oxidation (Jeukendrup et al., 1999). Hence, glucose drinks may be a viable means of increasing the amount of glucose available for self-regulatory tasks, providing that one allows time for the glucose to reach the blood stream. Indeed, replenishing glucose with a drink containing sugar has been shown to restore performance during cognitive tasks that require self-control (DeWall, Baumeister, Gailliot, & Maner, 2008; Gailliot et al., 2007; Wang & Dvorak, 2010). In a meta-analysis, the effect of experimental glucose supplementation on the depletion effect was deemed to be large and homogeneous ($d = 0.75$; Hagger et al., 2010).

Although the evidence seems compelling, the role of glucose in counteracting self-control depletion has come under robust criticism. In a recent study that employed a selective attention task (delay discounting) as the self-control manipulation and dependent measure, glucose administration did not moderate the depleting effect (Lange & Eggert, 2014). Similar results were also observed following an emotionally upsetting video (versus an emotionally neutral video; Dvorak & Simons, 2009), as well as a go/no-go paradigm (versus an infrequent no-go paradigm; Lange, Seer, Rapior, Rose, & Eggert, 2014). It is possible that the exhaustion of self-control resources is moderated by glucose consumption only when dissimilar tasks are utilized as experimental manipulation and dependent variable measure (Dewitte, Bruyneel, & Geyskens, 2009). Engaging in two similar acts, like the design of Lange and Eggert's (2014) experiment, has been argued to allow cognitions or affective experiences concerning the primary self-control task to influence effort on the second self-control task and mask potential effects of glucose consumption (Chatzisarantis & Hagger, 2015a, 2015b; Wallace & Baumeister, 2002). Athletic endurance performance represents an interesting context to pursue this research agenda given the critical role played by glucose drinks in optimizing athletic performance (e.g., Jeukendrup, 2010). Sports drinks are so popular that their value is estimated to reach $2billion by 2016 in the United States alone (International Markets Bureau, 2010). It is significant, therefore, to investigate the moderating role of glucose supplementation on self-control exertion and subsequent athletic endurance performance. Understanding potential psychological effects of glucose supplementation on endurance performance (as opposed to well-researched physiological processes) would advance our understanding of human behavior during conditions of fatigue (e.g., Hagger & Chatzisarantis, 2012; Molden et al., 2012).

Extending the literature described above, the aims of the current research were to determine a) whether exerting self-control reduces endurance performance in well-trained individuals, b) the potential for glucose administration to attenuate any decrements in performance due to prior self-control exertion, and c) whether any observed effects are variable over different stages of endurance performance. We also examined heart rate because equivocal findings have been seen previously (Englert & Wolff, 2015; Marcora, Staiano, & Manning, 2009; Wagstaff, 2014). The latter aim of the study is particularly important as the various theoretical debates in the self-control literature have not appropriately considered the timing of performance inspection. As an initial insight to this point, Englert and Wolff (2015) reported that the deleterious effect of self-control exertion on cycling performance became more pronounced over time. Building on this work, the present study aimed to explore whether any effects of self-control exertion and/or glucose administration persist or change over the course of a subsequent endurance task.

In the present experiment, our initial task to manipulate self-control requirements was a congruent versus incongruent Stroop task carried out for four minutes. This task has been shown to require self-control (McEwan, Martin Ginis, & Bray, 2013) and has been successfully employed for the same length of time in previous research (i.e., four minutes; Hagger et al., 2010). To measure athletic performance we used a 16 km laboratory-based cycling time trial. This endurance task requires numerous self-regulation behaviors, including the inhibition of aversive feelings, such as physical pain and thermal discomfort, the urge to quit, as well as the regulation of attention and emotion throughout periods of physical stress (Marcora et al., 2009; Martin et al., 2016). Further, a time trial protocol may have greater ecological validity than time to exhaustion protocols often used in previous research (e.g., Carter, Jeukendrup, & Jones, 2005), because performance and physiological responses are similar compared to outdoor time trials (Currell & Jeukendrup, 2008). Finally, a 16 km distance is familiar and well-practiced by cyclists; therefore, it may reduce the need for conscious self-regulation (Schmeichel & Baumeister, 2004).

Based on the broad self-control literature (e.g., Bray, Graham, Ginis, & Hicks, 2011; Englert & Wolff, 2015; Wagstaff, 2014) it was hypothesized that engaging in a cognitively demanding task previously shown to require self-control (i.e., an incongruent Stroop task) would result in poorer performance on a 16 km cycling time trial, compared to a cognitively simple task (i.e., a congruent Stroop task). No significant difference in heart rate during the cycling task following the exertion of self-control was expected.