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

Word count: 3745

Abstract

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

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

Abstract word count: 203

Introduction

Self-regulation and control

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

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

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

Self-control theory and research

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

More recently, the ego depletion literature has come under intense scrutiny (e.g., Carter, Kofler, Forster, & McCullough, 2015), as studies have failed to replicate the ego depletion

effect (e.g., Osgood, 2017; Xiao, Dang, Mao, & Liljedahl, 2014). Furthermore, Carter and McCullough's (2015) meta-analysis brought to light potential publication bias in the ego depletion literature, hinting at a possible body of unpublished non-significant findings. In a separate study, Carter and colleagues (2015) argued that the initial support for ego depletion was likely driven by small sample sizes and publication bias. The inconsistent findings surrounding ego depletion initiated a registered replication report, but this also failed to find a significant ego depletion effect (Hagger et al., 2016). However, Hagger et al. (2016) did not conclude that the ego depletion effect does not exist, but rather encouraged future research to investigate the causes of the null finding. In line with the aforementioned research, a recent survey surrounding research practices and replication rates within ego depletion research, supports the assumption that a large body of grey literature on ego depletion exists, leaving the authors to call for additional exploration of the ego depletion effect (Wolf, Baumann, & Englert, 2018).

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

relationship between task duration and subsequent performance during a secondary self-control task (Wolff, Sieber, Bieleke, & Englert, 2019).

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

Other theoretical explanations related to the ego depletion effect have centred around individual perceptions of, and mindsets towards, self-control. For example, Clarkson and colleagues (2010) found that perceptions of resource depletion predicted performance patterns in the dual self-control task paradigm better than actual depletion (i.e. actual exertion of self-control; Clarkson, Hirt, Jia, & Alexander, 2010). Therefore, implying that depletion of self-control resources might be consciously perceptible. Moreover, Job, Dweck, and Walton (2010) propose that self-control is affected by individuals' implicit beliefs about willpower, and

whether willpower is a finite resource or not. Interestingly, research has shown that individuals who do not believe that willpower is limited, are less susceptible to ego depletion after completing a primary self-control task (e.g., Job et al., 2010). It remains both theoretically and empirically unclear how dispositional traits and beliefs of self-control interact. Due to various concerns and inconclusive evidence, researchers have called for improved empiricism and theory to find more conclusive answers to 'if and why' the ego depletion effect exists (Friese, Loschelder, Gieseler, Frankenbach, & Inzlicht, 2018).

Challenge and threat appraisals

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

Challenge and threat are traditionally explored during motivated performance situations (e.g., sporting competitions, exams, public speaking), defined as potentially stressful situations

in which an individual must actively perform cognitively or behaviourally in order to attain an important outcome (Blascovich, 2008). Crucially, challenge and threat evaluations have been shown to have different effects on cardiovascular responses and task performance, with a threat evaluation (i.e., situational demands exceed coping resources) associated with a less efficient cardiovascular response (i.e., lower cardiac output and higher total peripheral resistance), and poorer task performance (see Hase, O'Brien, Moore, & Freeman, 2018 for a review). Despite these robust findings, to date, relatively little research has explored the factors that influence challenge and threat evaluations (Moore, Vine, Wilson, & Freeman, 2014). This is surprising given that such research will aid the development of interventions aimed at promoting challenge evaluations, or more positive responses to stress. One factor that could influence challenge and threat evaluations is ego depletion. Indeed, given that ego-depleted individuals have limited resources to use in subsequent self-control tasks, it is possible that ego depletion could lead individuals to evaluate tasks as more of a threat (i.e., insufficient resources to cope with task demands; Seery, 2011; Seery, 2009). Thus, this study aimed to shed light on this issue using a potentially stressful public speaking task.

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

The present study

In order to offer an initial exploration into the effect of ego depletion on challenge and threat evaluations and subjective ratings of performance, this study used a social-evaluative speech task comparable to the one used as part of the Trier Social Stress Test (Kudielka, et al., 2007). It was hypothesised that participants randomly assigned to an ego depletion group would evaluate the potentially stressful speech task as a more of a threat (i.e., coping resources insufficient to meet task demands), and rate their expected speech performance as lower, compared to participants assigned to a control group. A secondary aim of this study was to explore relationships between trait measures of self-control, challenge and threat evaluations and subjective ratings of performance.

Method

Participants

Based on a power analysis using G*Power software with alpha set at 0.05 and beta set at 0.95, we determined that a sample size of 262 participants was required to detect a small effect size. Thus, following institutional ethical approval, 304 undergraduate university students were recruited. All data was screened prior to statistical analysis. Forty-six participants were excluded from all analyses as they failed to complete the most important parts of the study protocol, including the written transcription task and reporting challenge and threat evaluations. As such, the final sample consisted of 262 participants (150 males, 112 females; M_{age} = 20.5, *SD* = 4.3). All participants read an information sheet and provided written informed consent prior to taking part.

Measures

Trait self-control measures

Brief self-control scale. Individual differences in trait self-control were assessed using the 13-item brief self-control scale (Tangney et al., 2004). Participants indicated the degree to

which they agreed with each item on a 5-point Likert scale anchored between *not at all* (1) and *very much* (5). The scores from all 13 items were summed, with a higher score indicating greater trait self-control. This scale has been used previously in the ego depletion literature (e.g., McEwan et al., 2013), and has been shown to be valid and reliable in assessing dispositional self-control (Tangey et al., 2004; $\alpha = 0.92$).

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

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

Self-control (ego depletion) manipulation checks

Self-control was experimentally manipulated using a written transcription task. This task required participants to transcribe a text for six minutes (the most common length of time for ego depletion tasks; Giboin & Wolff, 2019). While the control group transcribed the text conventionally in full, requiring little self-control, the ego depletion group were asked to omit

the letters "e" and "n", an act that required suppression of their typical writing habits and thus self-control. Importantly, this task, and time on the task, has been repeatedly shown to deplete self-control resources in previous research (e.g., Bertrams, Englert, & Dickhauser, 2010; Englert, Zwemmer, Bertrams, & Oudejans, 2015; Giboin & Wolff, 2019).

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

Challenge and threat evaluations

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

Subjective speech performance

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

Procedure

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

Statistical analyses

Missing data analysis revealed that 0.14% of the data from 262 participants was missing, however, Little's missing at random (MCAR) test was significant at the .05 level (χ^2 = 1172.19, df = 1072, p = .017), therefore, we replaced missing data using the expectation

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

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

Results

Trait self-control measures

The results revealed no significant differences between the groups in terms of trait self-control ($t_{(260)} = 0.58$, $p = .562$, $md = 0.53$, 95% CI [-1.28, 2.36], $d = 0.07$), depletion sensitivity

($t_{(260)}$ = 0.15, p = .884, md = 0.21, 95% CI [-2.56, 2.97], d = 0.01), or strenuous mental activity beliefs about willpower ($t_{(261)}$ = -1.33, p = .148, md = -0.76, 95% CI [-1.89, 0.36], d = 0.16). This data is presented in Table 1 and supports the effectiveness of the randomisation procedure used to allocate participants to the experimental groups.

INSERT TABLE 1 HERE

Self-control (ego depletion) manipulation checks

The results revealed that the written transcription task required significantly more self-control for the ego depletion group than the control group, with the ego depletion group transcribing fewer words ($t_{(192.2)}$ = 8.64 p < .001, md = 25.92, 95% CI [20.01, 31.83], d = 1.10), and making more errors ($t_{(241.3)}$ = -13.11 p < .001, md = -6.76, 95% CI [-7.77, -5.74], d = 1.57), than the control group. Furthermore, the ego depletion group reported having to regulate their writing habits more ($t_{(260)}$ = -8.55, p < .001, md = -0.91, 95% CI [-1.12, -0.7], d = 1.06), and that the transcription task required more effort ($t_{(219.9)}$ = -7.23, p < .001, md = -0.79 , 95% CI [-1.01, -0.57], d = 0.91), than the control group. This data is presented in Table 2 and supports the effectiveness of the self-control (ego depletion) manipulation.

INSERT TABLE 2 HERE

Challenge and threat evaluations

The results revealed no significant difference between the groups for DRES ($t_{(260)}$ = 0.53, p = .828, md = 0.15, 95% CI [-0.41, 0.71], d = -0.06). This data is presented in Table 3, and suggests that the ego depletion and control groups did not differ in terms of how they

evaluated the potentially stressful speech task, with the descriptive data indicating that both groups evaluated the task as more of a threat (i.e., task demands exceed coping resources).

Subjective speech performance

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

INSERT TABLE 3 HERE

Exploratory analyses

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

Depletion sensitivity showed a significant negative correlation with DRES for both the control (r = -.33, p < .001) and ego depletion (r = -.31, p < .001) group. Depletion sensitivity also showed a significant negative correlation with subjective ratings of performance for both the control (r = -.31, p < .001) and ego depletion (r = -.21, p = .008) group. Furthermore,

strenuous mental activity beliefs about willpower showed a significant negative correlation with DRES for both the control (r = -.21, p = .022) and ego depletion (r = -.18, p = .025) group. Strenuous mental activity beliefs about willpower also showed a significant negative correlation with subjective ratings of performance, but only for the ego depletion group (r = -.17, p = .038). Finally, DRES showed a significant positive correlation with subjective ratings of performance for both the control (r = .70, p < .001) and ego depletion (r = .73, p < .001) group.

INSERT TABLE 4 HERE

Discussion

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.

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.

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

Secondary exploratory analyses revealed significant relationships and differences between trait measures of self-control, DRES, and subjective ratings of performance. Specifically, for both groups, participants more sensitive to depletion were more likely to evaluate the potentially stressful speech task as more of a threat. Similarly, participants who reported being more sensitive to depletion were also more likely to rate that they were going to perform poorly in the potentially stressful speech task. These findings extend previous research that has shown that depletion sensitivity can impact actual task performance following ego depletion (e.g., Salmon et al, 2014). Therefore, with previous and present findings, it is suggested that the ability and time taken to deplete an individual may vary due to depletion

sensitivity, this further supports the conflict regarding time to depletion and task order. Importantly, the results also suggest a possible conscious level of depletion sensitivity and the impact of this on upcoming tasks. Further exploration of depletion sensitivity may provide more insight into the contradictory null findings surrounding the resource model of ego depletion.

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

Strengths and Limitations

In order to better contextualise the findings, several strengths and limitations should be considered. Firstly, whilst this was the first study to assess the effects of ego depletion on challenge and threat evaluations during a potentially stressful task, it should be noted that only subjective markers were used to measure challenge and threat evaluations and performance. However, previously subjective markers have been shown to be both valid and reliable when compared with an objective marker in other domains requiring measures of stress and performance (Arora et al, 2010). Evidence also suggests there is a valid need to assess subjective measures, as perceptions of depletion have been shown to be better predictors of performance, then actual depletion (Clarkson et al, 2010). Objective markers were not used in the current study due to the exploratory nature of the study design and large sample size (i.e.,

a large volume of data was collected from multiple participants at one time point). Second, only single-item measures were used to assess challenge and threat evaluations. Research has shown that one item and multi-item measures perform equally as well (Bergkvist & Rossiter, 2007), future research is encouraged to replicate the findings of this study using multi-item measures (e.g. stress appraisal scale; Schneider, 2008). Despite the benefits of being an experimental study, the research was conducted in the 'field' (i.e., real teaching sessions), which limited control over potential confounding variables (e.g., class size, interaction between participants, etc.).

Future research

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

Conclusion

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

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Table 1. Means and SDs for all trait self-control data.

	Ego Depletion		Control	
	Mean	**SD**	**Mean**	**SD**
Trait self-control	41.08	7.49	41.61	7.38
Depletion sensitivity	44.83	11.30	45.04	11.26
Implicit beliefs about willpower	25.38	4.77	24.61	4.34

Table 2. Means and SDs for all self-control (ego depletion) manipulation check data.

	Ego Depletion		Control	
	Mean	**SD**	**Mean**	**SD**
Number of words	60.28	19.20	86.21	27.12***
Number of Errors	9.58	5.29	2.82	2.96***
Regulation of writing habits	2.94	0.83	2.03	0.87***
Required effort	2.94	0.80	2.15	0.93***

Note: significantly different from the ego depletion group, $^{***}p < .001$

719 **Table 3**. Means and SDs for challenge and threat evaluation (DRES) and subjective speech
720 performance data.
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	Ego Depletion		Control	
	Mean	**SD**	**Mean**	**SD**
DRES	-1.73	2.30	-1.58	2.29
Subjective speech performance	2.78	1.62	2.80	1.40

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738 **Table 4.** Correlations for trait self-control, self-control manipulation checks, DRES and subjective performance

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Variables	Trait self-control	Depletion Sensitivity	Willpower (Strenuous mental activity)	Regulation (of writing habits)	Effort (required in transcription)	DRES	Subjective performance
Trait self-control	1	-.522**	-.228**	-.081	-.012	.109	.075
Depletion Sensitivity	-.511**	1	.505**	.028	.033	-.311**	-.218**
Willpower (Strenuous mental activity)	-.249**	.596**	1	.086	.067	-.184*	-.170*
Regulation (of writing habits)	-.177	.259**	.137	1	.418**	.004	.006
Effort (required in transcription)	-.199*	.294**	.115	.559**	1	-.040	-.035
DRES	.032	-.339**	-.216*	-.185*	-.125	1	.734**
Subjective performance	.034	-.310**	-.100	-.089	-.140	.700**	1

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751 *N.B* Correlation for the control group is below the diagonal, the ego depletion group is above.

752 **. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

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