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Health behaviours and their facilitation under depletion conditions: The case of snacking

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Abstract

Introduction: Previous research suggests that depletion (the state ensuing from self-control exertion) engenders lapses in health behaviours. The present study tested for that effect in relation to the health behaviour of limiting snacking, and investigated whether health goal-priming might facilitate such health behaviours even under depletion conditions.

Method: A laboratory study was conducted involving an analytic sample of 85 undergraduates (mean age = 20.08, *SD* = 3.96; female: *n* = 63). Depletion was manipulated by having participants watch a humorous video while suppressing their responses (depletion condition), or remaining natural (non-depletion condition). The activation of participants' health goals was then manipulated by subtly exposing (goal-priming condition) or not exposing (non-priming condition) participants to health-related words in a Scrambled Sentence Task. Finally, snacking was measured using a bogus taste-test.

Results and discussion: Controlling for initial hunger, snacking was higher among depleted compared to non-depleted participants. Snacking was lower among primed compared to non-primed participants. The interaction between depletion and goal-priming was not significant. These findings suggest that depletion should be recognised as a risk factor for lapses in health behaviours, and that health goal-priming may be a useful technique for facilitating such behaviours even when individuals are depleted.

Keywords: Self-control; Self-regulation; Depletion; Snacking; Eating; Goal priming

Introduction

The majority of deaths globally are due to non-communicable diseases such as diabetes and cardiovascular disease, which are largely attributable to behavioural risk factors (World Health Organisation, 2011). It is therefore important to identify factors associated with lapses in health behaviours and to develop techniques for addressing such lapses, where health behaviours include the performance of health-promoting behaviours (e.g., exercise) and the avoidance of health-compromising behaviours (e.g., smoking).

Health behaviours often involve self-control: the process of overriding competing internal reactions and behavioural tendencies in order to bring thoughts, feelings and behaviour in line with long-term goals and behavioural standards (Baumeister, Vohs, & Tice, 2007; de Ridder & de Wit, 2006; Muraven, 2012). This is especially true of healthy eating behaviours; in the current 'obesogenic' environment in which palatable but unhealthy foods are highly visible and readily available, it is often necessary to override temptation to overindulge in such foods in order to maintain a diet that is consistent with long-term health goals (Johnson, Pratt, & Wardle, 2012). Indeed, relatively high dispositional self-control has been associated with healthier eating patterns during a weight-loss program (Crescioni et al., 2011) and in general (Gerrits et al., 2010; Junger & van Kampen, 2010; Sproesser, Strohbach, Schupp, & Renner, 2011), as well as with concomitant health outcomes such as greater success in a weight-loss program (Crescioni et al., 2011) and lower body mass index (BMI) in general (Crescioni et al., 2011; Junger & van Kampen, 2010; Keller & Siegrist, 2014). When individuals have recently exerted self-control, they are said to be 'depleted' (Baumeister & Alquist, 2009). Due to the high frequency of everyday self-control demands (Hofmann, Baumeister, Förster, & Vohs, 2012), opportunities to perform health behaviours could often be expected to arise when individuals are already depleted. This raises questions about: (1) whether depletion impedes the exertion of further self-control in implementing

health behaviours, such as limiting snacking, and (2) how such health behaviours could be facilitated under depletion conditions.

Health behaviours under depletion conditions

The performance of self-control behaviours under depletion conditions has been widely investigated using Baumeister, Bratslavasky, Muraven, and Tice's (1998) sequential task paradigm. Here, experimental group participants are depleted by completing a task requiring high self-control (e.g., controlling their thoughts), while control participants instead complete a task that requires minimal self-control (e.g., free thought). Subsequently, all participants undertake a second, ostensibly unrelated task designed to measure performance of self-control behaviours. Typically, a 'depletion effect' is observed such that performance on the dependent self-control task is poorer among depleted compared to non-depleted participants. In a meta-analysis of 83 sequential task studies, Hagger, Wood, Stiff, and Chatzisarantis (2010) found a significant medium-to-large depletion effect across a wide range of self-control outcomes. Regarding health behaviours, depletion has been associated with fewer repetitions on exercise tasks (Dorris, Power, & Kenefick, 2012), increased likelihood of smoking (Shmueli & Prochaska, 2009), increased ad-lib alcohol consumption (Christiansen, Cole, & Field, 2012; Muraven, Collins, & Neinhaus, 2002), and increased snacking among restrained eaters (Kahan, Polivy, & Herman, 2003; Vohs & Heatherton, 2000; studies 1 and 3) and individuals with high BMI (Hagger et al., 2013), where 'snacking' refers to consumption of energy-dense foods of low nutritional value between meals.

Based on current evidence however, it remains unclear whether the depletion effect on snacking holds among broader samples (i.e., without subdividing based on dietary restraint or BMI). In one study it was found that depleted participants from a broader sample ate more than non-depleted participants when offered snack foods (Zyphur, Warren, Landis, & Thoresen, 2007; study 1), whereas other studies reported only a marginally significant effect (Friese, Hofmann, & Wänke, 2008; study 2), or no significant depletion effect on

snacking (Stillman, Tice, Fincham, & Lambert, 2009; study 3). These divergent findings may be accounted for by the lack of consideration given in these studies to the extent to which participants held long-term health goals and were tempted by the proffered snacks. These are important considerations since only if limiting snacking was consistent with participants' goals, but also required overriding temptation to indulge, would that behaviour involve self-control and hence be susceptible to a depletion effect on self-control behaviour.

Consequently, the first aim of the present study was to extend existing evidence concerning the effects of depletion on health behaviours, by investigating whether limiting snacking is compromised under depletion conditions among members of broader samples when that behaviour more clearly involves self-control.

Facilitating health behaviours under depletion conditions

If depletion impedes the enactment of health behaviours such as limiting snacking, this creates a need to develop effective techniques for facilitating health behaviours under depletion conditions. Many well-established interventions for health behaviours target explicit cognitions (e.g., health beliefs; Jones, Smith, & Llewellyn, 2014). The suitability of these techniques in the context of depletion is challenged however, by evidence that the influence of such explicit cognitions over self-control behaviour is attenuated under depletion conditions (Friese et al., 2008; studies 2 and 3; Hofmann, Rauch, & Gawronski, 2007). Accordingly, implicit techniques may be more useful in this context.

One implicit technique that is receiving increasing attention as a means of promoting healthy eating behaviours is goal-priming (Papies, 2012). This involves subtly exposing individuals to environmental cues (such as words or images) that are semantically related to a particular goal. This exposure is expected to implicitly activate ('prime') the cognitive representation of that goal, such that it proceeds to guide subsequent responses just as if it had been consciously activated (Custers & Aarts, 2010). Goal-priming has been successfully applied in relation to a range of eating behaviours. When health goals were primed through

subtle exposure to goal-related rather than goal-neutral cues, female restrained eaters snacked less while watching a movie (Anschutz, Van Strien, & Engels, 2011), overweight individuals purchased fewer snacks from a grocery store (Papies, Potjes, Keesman, Schwinghammer, & Van Koningsbruggen, 2013), restrained eaters and current dieters made healthier meal choices in a restaurant (Papies & Veling, 2012), and restrained eaters ate fewer product samples in a butcher's shop (Papies & Hamstra, 2010).

Researchers have also begun to test the efficacy of goal-priming in bolstering self-control performance under depletion conditions. Alberts, Martijn, Greb, Merckelbach, and de Vries (2007) reported that participants primed with perseverance cues performed better than non-primed participants on a subsequent physical endurance task, and that the extent of this priming effect either did not differ depending on depletion (study 1), or was even stronger among depleted compared to non-depleted participants (study 2). The authors suggested that their priming technique affected behaviour through activating the behavioural construct of perseverance. In their first study however, Alberts et al. utilised an adapted Scrambled Sentence Task as their priming manipulation, and this paradigm has frequently been interpreted as priming goals (e.g., Bargh, Lee-Chai, Barndollar, Gollwitzer, & Trötschel, 2001; experiment 2; Crone & Beike, 2012; Sheeran et al., 2005; experiment 2). An alternative interpretation of these results might therefore contend that Alberts et al.'s Scrambled Sentence Task affected behaviour through priming perseverance goals. On that interpretation, this study provides preliminary evidence that priming a goal promotes responses consistent with that goal, even under depletion conditions.

In the eating domain, two recent studies have examined the impact of health goal-priming on snacking under depletion conditions. Boland, Connell, and Vallen (2013) found that in the afternoon (but not in the morning), participants exposed to health cues consumed less during an opportunity for snacking than those exposed to indulgence or neutral cues. Boland et al. argued that since self-control demands accrue as the day progresses, individuals

are typically depleted by afternoon. Accordingly, they interpreted their findings as demonstrating that health goal-priming affects snacking when individuals are depleted. Yet while this proposed temporal pattern of depletion seems plausible, the time of day variable may have been confounded with several uncontrolled variables (e.g., wakefulness, cognitive load). Using more standard experimental manipulations, Walsh (2014) manipulated depletion and health goal-priming, before having participants choose between a healthy and unhealthy snack option in an imaginary shopping task. While goal-priming led to a higher proportion of participants choosing the healthy option overall, it seemed to have no effect on snack choices in the depletion condition.

Thus, results concerning the efficacy of goal-priming under depletion conditions have been mixed. Since the dependent variable in Walsh's (2014) study was a hypothetical choice, it remains to be seen whether health goal-priming can lead to reduction in actual snack consumption under experimentally induced depletion conditions just as well as under non-depletion conditions. The second aim of the present study was to conduct the first test of that possibility.

The Present Study

A sequential task design comprising of: (1) a depletion manipulation, (2) a goal-priming manipulation, and (3) a measure of snacking as a prototypical self-control behaviour, was adopted here. Consistent with earlier evidence linking depletion with compromised self-control performance (Hagger et al., 2010), and in view of the current study's measurement of snack consumption as a manifestation of poor self-control performance, it was hypothesised that consumption during the taste-test would be higher among depleted compared to non-depleted participants. Following evidence that subtly priming goals that are inconsistent with unhealthy eating promotes healthier eating behaviour (Papies, 2012), consumption was expected to be lower among participants whose health goals were primed than among non-primed participants. In view of previously mixed indications as to whether health goal-

priming is differentially effective under depletion and non-depletion conditions, no firm prediction was made as to whether depletion and goal-priming would interact in their effects on consumption.

Method

Participants and design

Ninety-one undergraduates from an Australian university volunteered in exchange for course credit. The recruitment advertisement specifically targeted individuals holding long-term health goals by only inviting participants who "value your health but don't always lead a healthy lifestyle". Participants were randomly allocated to a 2 (depletion vs. non-depletion) x 2 (goal-priming vs. non-priming) between-subjects full factorial design. The study was approved by the university's human research ethics committee.

Procedure

Participants were tested individually in a laboratory. They were informed that the session, which lasted approximately 45 minutes, would consist of three unrelated experiments followed by questionnaires. Informed consent was obtained from all participants prior to commencing the first experiment.

Experimental materials

Depletion manipulation: The 'first experiment' was introduced as an emotional processing task, and consisted of a widely-used depletion task (e.g., Balliet & Joireman, 2010; Vohs, Glass, Maddox, & Markman, 2011). The stimulus consisted of a video (9 minutes duration) comprising three consecutive humorous clips, which have been shown to elicit considerable self-reported amusement and facial expressivity (Simons, Pasqualini, Reddy, & Wood, 2004). Participants viewed the video while seated in front of a computer equipped with a webcam and headphones. They were informed that they were to focus on the video, as well as receiving the following specific instructions: *Depletion condition*: "It is important that you remain completely neutral. That is, please suppress internal emotional

reactions as well as any vocal or physical emotional expressions;" *Non-depletion condition*: "It is important that you remain completely natural. That is, please watch just as you would in the privacy of your own home." To improve compliance with the instructions, participants were told that their responses would be video-recorded.

Goal-priming manipulation: The 'second experiment' was introduced as a word relationship task, and consisted of a computerised Scrambled Sentence Task. Scrambled Sentence Tasks are designed to subtly expose participants in one condition to words that share a common theme in order to activate, or 'prime', cognitions related to that theme (Srull & Wyer, 1979). In the present Scrambled Sentence Task, 15 strings of five words each were presented individually. The words in each string were presented in a scrambled order, and participants were required to select and rearrange four of the five words to form a grammatically correct sentence or phrase. Twelve of the 15 word-strings differed between the two conditions on a critical word (Levesque & Pelletier, 2003), which in each case was health-related in the goal-priming condition, and thus expected to prime health goals, but was unrelated to health in the non-priming condition. The health theme was selected since it was thought to represent a relatively abstract desirable state, and was therefore considered especially likely to activate higher-order goals rather than lower-order behavioural constructs. Critical words were matched between conditions on number of letters and lexical category. For example, the word-string 'to flowerpot be aiming healthy' ('aiming to be healthy') appeared in the health goal-priming condition, whereas 'to flowerpot be aiming logical' ('aiming to be logical') appeared instead as the corresponding word-string in the non-priming condition. Two practice trials were included, and the order of the remaining word-strings was randomised. Participants completed the task at their own pace.

Bogus taste-test (dependent variable): The 'third experiment' was introduced as a product perception task. Participants were presented with three snack food samples: 125g of candied chocolates, 80g of savoury biscuits, and 60g of potato chips. This diverse array of

snacks was selected to increase the likelihood of participants with disparate tastes being tempted by the snacks. The samples were presented unwrapped in opaque plastic bowls. The pre-consumption weights were specified such that the bowls were full upon presentation, and a substantial amount could be consumed without leaving the bowls empty. Participants were informed that they would have 7 minutes to taste the products and rate them using a computerised questionnaire. In addition participants were informed (as though as an afterthought): "By the way, feel free to help yourself to as much of the samples as you want; we have heaps in the storeroom," before the experimenter left the room. In keeping with the taste-test cover story, the questionnaire asked participants to rate the extent to which they found each product appealing in terms of appearance, taste, and texture, and liked the product overall. Responses were made on a 5-point Likert scale (*strongly disagree – strongly agree*).

Manipulation checks: To check the effects of the depletion manipulation, participants were asked to complete the Positive and Negative Affect Scales (PANAS; Watson, Clark, & Tellegen, 1988), as well as rating how funny they found the video, and the extent to which they experienced difficulty, fatigue, effort-exertion, and fighting of an urge during the video task (each on a 7-point scale). The latter four questions were repeated to check the effect of the goal-priming manipulation. In addition, participants rated how important they had considered it to eat healthy food at the time of the taste-test (0: *not important* to 7: *very important*). Participants also indicated how many hours it had been since they last ate, and how hungry they had been on a unipolar scale from 0 (*not at all*) to 4 (*very much*), when they first arrived at the laboratory. These latter two items were drawn from Grand's (1968) widely used Hunger Scale. Finally, participants reported their demographic characteristics (age, sex, height, weight), and answered a free-response question to check for suspicion of the research questions. They were then thanked and fully debriefed.

Data preparation and analysis

The weight of snack food remaining in each bowl was measured to the nearest gram, and then subtracted from the pre-consumption weight. Those figures were summed to yield a composite measure of total snack consumption (Ward & Mann, 2000). The liking ratings for each of the three snack foods were summed to provide an index of overall liking (0 to 15; higher scores indicate greater liking). Total positive affect and negative affect scores were computed from the PANAS (higher scores indicate stronger affect; Watson et al., 1988). Hunger scores were standardised and summed to provide an overall measure of initial hunger (higher scores indicate greater hunger; Tapper & Pothos, 2010). Finally, body mass index (BMI) was calculated.

Initially, chi-square tests of independence were performed to check for coincidental between-group differences in sex and ethnicity; one-way analyses of variance (ANOVAs) were conducted to test for differences in age, BMI, initial hunger, and overall liking of the snack foods. Independent samples *t*-Tests were used to compare the experimental and control groups on the manipulation check variables. Furthermore, Pearson product moment correlation coefficients were calculated to investigate the relationships between participants' self-reported snack-related attitudes (overall liking of the snack foods), motivations (perceived importance of eating healthy food at the time of the taste-test), and initial hunger; with total snack consumption.

The primary research questions were addressed by testing the main effects and interaction between the depletion and goal-priming manipulations on total snack consumption using an analysis of covariance (ANCOVA). Based on evidence for the detrimental effect of hunger on limiting food intake (Tomiyama, Mann, & Comer, 2009), and on self-control more generally (Gailliot, 2013), initial hunger was included as a covariate. In the main analysis, partial eta squared effect sizes were calculated for significant effects, while non-significant effects were investigated using a sensitivity power analysis to reveal the minimum Cohen's *f* effect size to which the test was adequately sensitive.

Results

Sample characteristics and randomisation checks

After exclusions (suspicion of research question: n = 4; failure to comply with instructions during the taste-test: n = 2), 85 participants (mean age = 20.08, SD = 3.96; female: n = 63) remained in the final sample. The majority of the sample were in the normal weight range (n = 69, overweight: n = 7, underweight: n = 8, obese: n = 1; mean BMI = 21.37, SD = 2.65), and most identified as either Caucasian (n = 38) or Asian (n = 37).

Participants were randomly allocated to the non-depletion/non-priming, depletion/non-priming, depletion/goal-priming (n = 21 in each), or non-depletion/goal-priming (n = 22) condition. There were no significant between-group differences on the demographic, initial hunger, or overall liking of the snack foods variables (all $p > .05$).

Manipulation checks

Overall, participants appeared to like the snack foods (mean liking = 11.84, SD = 1.79; range = 0 - 15) and to consider it moderately important to eat healthy foods during the taste-test (mean liking = 3.71, SD = 1.84; range = 0 - 7). The manipulation checks revealed that depleted participants reported experiencing greater difficulty, effort-exertion, and fighting of an urge than non-depleted participants during the depletion manipulation (all $p <$ .01). No other significant differences emerged between the experimental and control groups on the variables in the manipulation checks (all $p > .05$). Total snack consumption was positively correlated with overall liking of the snack foods (r = .28, N = 85, p = .01), and negatively correlated with perceived importance of eating healthy foods during the taste-test (r = .40, N = 83, p = < .01).

Main analysis

Initial hunger was significantly positively correlated with total snack consumption (r = .22, p = .047). As a covariate, initial hunger was also significantly related to total snack consumption in the ANCOVA, $F(1, 79) = 6.61$, p = .01, η_p= .08. The main effect of depletion

was significant, such that consumption was higher in the depletion condition than in the non-depletion condition, $F(1,79) = 4.36$, $p = .04$, $\eta_p = .05$ The main effect of goal-priming was also significant, such that consumption was lower in the goal-priming condition than in the non-priming condition, $F(1,79) = 4.57$, $p = .04$, $\eta_p = .06$. The interaction between the depletion and goal-priming conditions was not significant, $F(1,79) = 0.74$, $p = .39$ (see Figure 1).[1] A sensitivity power analysis revealed that given the included sample of $N = 85$, a significance level of $p = 0.05$, and minimum power of $1 - \beta = 0.8$, the test of the interaction effect was sufficiently sensitive to detect effects of size $f = 0.31$ or larger.

[1] When the main analysis was repeated without controlling for initial hunger, the pattern of the group means for total snack consumption replicated that of the estimated marginal means in the original analysis. The depletion main effect became marginally significant ($F(1,81) = 3.90$, $p = .05$, $\eta_p = .05$), as did the goal-priming main effect ($F(1,81) = 3.03$, $p = .09$, $\eta_p = .04$). The depletion by goal-priming interaction remained non-significant ($F(1,81) = 0.66$, $p = .42$).

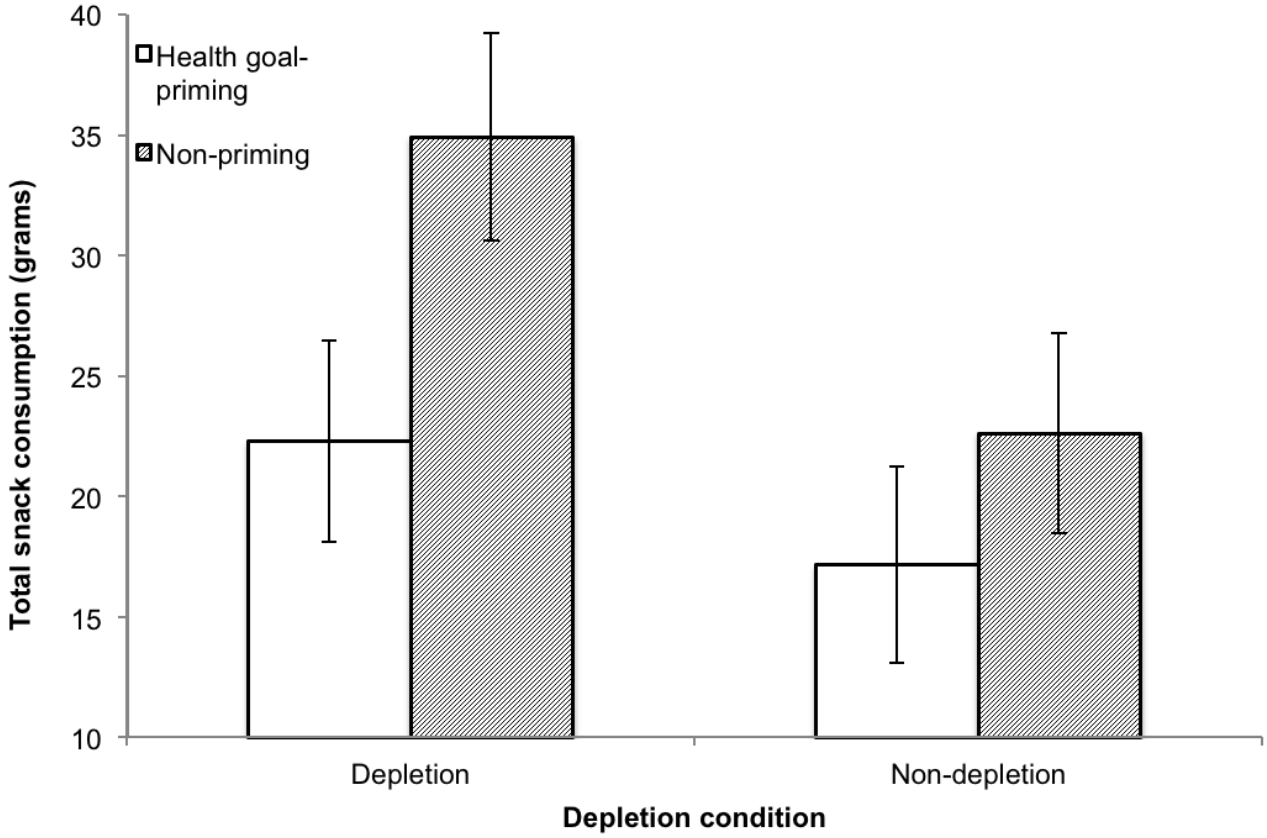

***Figure 1*. Mean total snack consumption during the bogus taste-test as a function of depletion and goal-priming condition, after statistically controlling for initial hunger (N = 84). Error bars show the standard error of the mean.**

Discussion

The present study was concerned with whether depletion undermines success in enacting health behaviours, and with how health behaviours could be facilitated under depletion conditions. Specifically, it investigated: (1) whether depletion results in decreased ability to limit snacking among members of broader samples (i.e., without subdividing based on dietary restraint or BMI), and (2) whether health goal-priming is an effective technique for reducing snacking regardless of depletion. In support of the hypotheses, snacking was higher among depleted than non-depleted participants, and lower among primed than non-primed participants. No evidence for the depletion by goal-priming interaction was found.

Health behaviours under depletion conditions

Depleted participants' ratings on the depletion manipulation check were broadly consistent with typical reports of the subjective experience of depletion (Hagger et al., 2010; Muraven, 2012), indicating that the manipulation was successful. The significant main effect of depletion is consistent with previous research showing the detrimental effect of depletion on self-control outcomes in general (Hagger et al., 2010), and on health behaviours in particular (Hagger, Wood, Stiff, & Chatzisarantis, 2009). Furthermore, the present findings help to clarify previously mixed reports as to whether the specific health behaviour of limiting snacking is compromised under depletion conditions, among members of broader samples (Friese et al., 2008; study 2; Stillman et al., 2009; study 3; Zyphur et al., 2007; study 1). To overcome the limitations of previous studies, the present research only recruited participants who held health goals, and included diverse foods in the taste-test in order to appeal to divergent tastes. Thus, it was ensured that the study's taste-test fulfilled common descriptions of self-control challenges (i.e., tasks requiring overriding competing internal reactions and response tendencies: temptation to consume unhealthy but appealing snacks; in order to direct behaviour towards long-term goals: health goals). The present findings therefore suggest that when the health behaviour of limiting snacking involves self-control, it is compromised under depletion conditions. Moreover, this effect appears to hold even in a more broadly inclusive sample than depletion effects on snacking have typically been observed in previously.

Practically, this implies that individuals may benefit from minimising exposure to other depleting situations at times when limiting snacking is especially valued. For example, it may be advisable to initiate the depleting lifestyle changes of improving one's diet and quitting smoking at separate times rather than simultaneously (Shmueli & Prochaska, 2009). Moreover, these findings highlight the need to develop interventions to facilitate health behaviours under depletion conditions, especially in relation to snacking.

Facilitating health behaviours under depletion conditions

Mixed evidence for the success of the goal-priming manipulation was found: there was no difference between the goal-priming and non-priming conditions on the manipulation check asking about perceived importance of eating healthy foods during the taste-test, yet in snacking less than non-primed participants the primed participants appeared to behave more consistently with their health goals. In view of previous evidence that such behavioural consequences of Scrambled Sentence Tasks are goal-driven (Chartrand & Bargh, 1996; Chartrand, Huber, Shiv, & Tanner, 2008), it seems likely that the goal-manipulation was successful though the manipulation check was insensitive to that effect. This insensitivity may have ensued because the measure of perceived importance of eating healthy foods consisted of a single item and would consequently have been disproportionately affected by any item-specific biases, though further research is needed to explore this possibility.

The significant main effect of goal-priming is consistent with previous evidence that priming health goals leads to healthier eating behaviours, including reduced snacking, among individuals aiming to maintain healthy diets (Papies, 2012). Importantly, the present study extended that evidence by providing one of the first tests of the efficacy of health goal-priming under depletion compared to non-depletion conditions. The lack of an interaction effect suggests that the beneficial effects of health goal-priming are not moderated by depletion. This non-significant result should, however, be approached with some caution. Although the post-hoc sensitivity analysis indicated that the sample was large enough to detect a significant medium-sized interaction effect, the validity of post-hoc power analyses has been debated (Hoenig & Heisey, 2001). A significant interaction may have emerged in a higher-powered study. Based on the pattern of group means for snack consumption however, such an interaction would have indicated that the goal-priming effect was stronger for depleted compared to non-depleted participants. In any case then, the present results imply

that health goal-priming is *at least* as effective when individuals are depleted as when they are not.

That conclusion mirrors Alberts et al.'s (2007) finding that the effects of priming perseverance were either not moderated by depletion (study 1), or were stronger among depleted participants (study 2). Whereas Alberts et al.'s outcome measure involved physical endurance, the present study found similar evidence with respect to performance in a different self-control domain: snacking. By contrast, Walsh (2014) recently found that the effect of health goal-priming on snack choices was eradicated when participants were depleted. These discrepant results may reflect the measurement of different outcomes: whereas Walsh assessed a hypothetical snack choice, the present study measured actual snack consumption. Depletion may diminish cognitive resources that are necessary to facilitate goal-priming effects on hypothetical thinking, but are not required for goal-priming to influence behaviour. Future research should clarify how specific cognitive and behavioural effects of goal-priming are affected by depletion.

Practically, these findings build on previous recommendations of goal-priming as a simple, low-cost, unobtrusive technique for facilitating health behaviours, and especially for reducing snacking (Papies, 2012). The present research strengthens that argument by demonstrating that goal-priming's beneficial effects may be harnessed even when individuals are depleted. This augments the importance of this technique since depleted individuals are at particular risk for lapses in health behaviours including snacking, and may be less able to benefit from health interventions that target more explicit cognitions (Friese et al., 2008; studies 2 and 3; Hofmann et al., 2007). In considering the applicability of this technique in real-world contexts however, it must be remembered that goal-priming is thought to affect individuals' behaviour without their conscious participation in, or even awareness of, this process (Custers & Aarts, 2010). Accordingly, issues of public acceptability and the ethics of consent should be explored with regard to such covert behaviour change techniques.

Limitations and conclusions

The present study had several potential limitations that should be considered when interpreting the results. Firstly, the sample was comprised solely of university undergraduates, and primarily of females in the normal weight range. The study needs replication with a more diverse sample in order to investigate the generalisability of the present conclusions to heterogeneous populations. Secondly, as with most experimental studies in this field, for ethical reasons depletion was induced by imposing only brief and relatively minor self-control demands. Consequently, the effects of depletion in this research may not represent the effects of more chronic and intense depletion episodes. Future research should investigate snacking and the effects of health goal-priming among individuals undergoing such significant depletion episodes in their everyday lives. Thirdly, snacking was also narrowly operationlised, as consumption of unhealthy foods presented to participants. Accordingly, the present results may not generalise to all instances of snacking. Future research should test the independent and multiplicative effects of depletion and health goal-priming on other snacking-related behaviours, such as seeking out snacks that are not readily available.

In view of high behavioural contributions to mortality worldwide, the present study extended research invoking self-control factors to improve understanding of lapses in, and facilitation of, health behaviours such as limiting snacking. The main novel conclusions are that: (1) when limiting snacking requires self-control, snacking appears to be elevated under depletion conditions. This effect seems to emerge in broader samples than has been previously shown (i.e., without subdividing based on dietary restraint or BMI), and (2) health goal-priming seems to facilitate reduced snacking, and this beneficial effect seems to be at least as strong when individuals are depleted as when they are not. These conclusions highlight the need to recognise and minimise the role of depletion as a risk factor for lapses in health behaviours. Furthermore, they point to the considerable promise of health goal-

priming as a simple but effective means of facilitating health behaviours even under depletion conditions, under which more explicit techniques may be expected to enjoy less success. It is now important to plan and encourage the translation of such understandings and techniques from the laboratory into everyday settings, such as homes and public spaces (e.g., through health-related posters) and the media (e.g., through health-related television broadcasts). Ultimately, these may constitute significant steps towards capitalising on self-control research in order to reduce behavioural contributions to non-communicable diseases.

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References

Alberts, H. J., Martijn, C., Greb, J., Merckelbach, H., & de Vries, N. K. (2007). Carrying on or giving in: The role of automatic processes in overcoming ego depletion. *British Journal of Social Psychology, 46*(2), 383-399.

Anschutz, D. J., Van Strien, T., & Engels, R. C. (2011). Exposure to slim images in mass media: Television commercials as reminders of restriction in restrained eaters. *Psychology of Popular Media Culture, 1(S)*, 48-59.

Balliet, D., & Joireman, J. (2010). Ego depletion reduces proselfs' concern with the well-being of others. *Group Processes & Intergroup Relations, 13*(2), 227-239.

Bargh, J. A., Lee-Chai, A., Barndollar, K., Gollwitzer, P. M., & Trötschel, R. (2001). The automated will: Nonconscious activation and pursuit of behavioral goals. *Journal of personality and social psychology, 81*(6), 1014-1027.

Baumeister, R. F., & Alquist, J. L. (2009). Self-regulation as a limited resource: Strength model of control and depletion. In J. P. Forgas, R. F. Baumeister, & D. M. Tice (Eds.), *Psychology of self-regulation: Cognitive, affective, and motivational processes* (pp. 53-71). New York: Psychology Press.

Baumeister, R. F., Bratslavsky, E., Muraven, M., & Tice, D. M. (1998). Ego depletion: Is the active self a limited resource? *Journal of personality and social psychology, 74*, 1252-1265.

Baumeister, R. F., Vohs, K. D., & Tice, D. M. (2007). The strength model of self-control. *Current directions in psychological science, 16*(6), 351-355.

Boland, W. A., Connell, P. M., & Vallen, B. (2013). Time of day effects on the regulation of food consumption after activation of health goals. *Appetite, 70*, 47-52.

Chartrand, T. L., & Bargh, J. A. (1996). Automatic activation of impression formation and memorization goals: Nonconscious goal priming reproduces effects of explicit task instructions. *Journal of personality and social psychology, 71*, 464-478.

437 Chartrand, T. L., Huber, J., Shiv, B., & Tanner, R. J. (2008). Nonconscious goals and
438 consumer choice. *Journal of Consumer Research, 35*(2), 189-201.
439 Christiansen, P., Cole, J. C., & Field, M. (2012). Ego depletion increases ad-lib alcohol
440 consumption: Investigating cognitive mediators and moderators. *Experimental and*
441 *clinical psychopharmacology, 20*(2), 118-128.
442 Crescioni, A. W., Ehrlinger, J., Alquist, J. L., Conlon, K. E., Baumeister, R. F.,
443 Schatschneider, C., & Dutton, G. R. (2011). High trait self-control predicts positive
444 health behaviors and success in weight loss. *Journal of health psychology, 16*(5), 750-
445 759.
446 Crone, T. S., & Beike, D. R. (2012). Priming the Nonconscious Goal to Self-Actualize: Can
447 Even the Highest Order Goals be Primed Nonconsciously? *The Humanistic*
448 *Psychologist, 40*(3), 274-282.
449 Custers, R., & Aarts, H. (2010). The unconscious will: How the pursuit of goals operates
450 outside of conscious awareness. *Science, 329*(5987), 47-50.
451 de Ridder, D. T. D., & de Wit, J. B. F. (2006). Self-regulation in health behaviour: Concepts,
452 theories, and central issues. In D. T. D. de Ridder & J. B. F. de Wit (Eds.), *Self-*
453 *regulation in health behavior* (pp. 1-23). Chichester, UK: John Wiley & Sons.
454 Dorris, D. C., Power, D. A., & Kenefick, E. (2012). Investigating the effects of ego depletion
455 on physical exercise routines of athletes. *Psychology of Sport and Exercise, 13*(2),
456 118-125.
457 Friese, M., Hofmann, W., & Wänke, M. (2008). When impulses take over: Moderated
458 predictive validity of explicit and implicit attitude measures in predicting food choice
459 and consumption behaviour. *British Journal of Social Psychology, 47*(3), 397-419.
460 Gailliot, M. T. (2013). Hunger and Reduced Self-Control in the Laboratory and across the
461 World: Reducing Hunger as a Self-Control Panacea. *Psychology, 4*(1), 59-66.

462 Gerrits, J. H., O'Hara, R. E., Piko, B. F., Gibbons, F. X., de Ridder, D. T., Keresztes, N., . . .
463 de Wit, J. B. (2010). Self-control, diet concerns and eater prototypes influence fatty
464 foods consumption of adolescents in three countries. *Health education research, 25*(6), 1031-1041.
465
466 Grand, S. (1968). Color-word interference II: An investigation of the role of vocal conflict
467 and hunger in associative priming. *Journal of Experimental Psychology, 77*(1), 31-40.
468 Hagger, M. S., Panetta, G., Leung, C.-M., Wong, G. G., Wang, J. C., Chan, D. K., . . .
469 Chatzisarantis, N. L. (2013). Chronic Inhibition, Self-Control and Eating Behavior:
470 Test of a 'Resource Depletion'Model. *PloS one, 8*(10). doi:
471 10.1371/journal.pone.0076888
472 Hagger, M. S., Wood, C., Stiff, C., & Chatzisarantis, N. L. (2009). The strength model of
473 self-regulation failure and health-related behaviour. *Health Psychology Review, 3*(2),
474 208-238.
475 Hagger, M. S., Wood, C., Stiff, C., & Chatzisarantis, N. L. (2010). Ego depletion and the
476 strength model of self-control: A meta-analysis. *Psychological bulletin, 136*(4), 495-
477 525.
478 Hoenig, J. M., & Heisey, D. M. (2001). The abuse of power. *The American Statistician,*
479 *55*(1), 19-24.
480 Hofmann, W., Baumeister, R. F., Förster, G., & Vohs, K. D. (2012). Everyday temptations:
481 An experience sampling study of desire, conflict, and self-control. *Journal of*
482 *personality and social psychology, 102*(6), 1318–1335.
483 Hofmann, W., Rauch, W., & Gawronski, B. (2007). And deplete us not into temptation:
484 Automatic attitudes, dietary restraint, and self-regulatory resources as determinants of
485 eating behavior. *Journal of Experimental Social Psychology, 43*(3), 497-504.
486 Johnson, F., Pratt, M., & Wardle, J. (2012). Dietary restraint and self-regulation in eating
487 behavior. *International Journal of Obesity, 36*(5), 665-674.

Jones, C. J., Smith, H., & Llewellyn, C. (2014). Evaluating the effectiveness of health belief model interventions in improving adherence: A systematic review. *Health Psychology Review, 8*(3), 253-269.

Junger, M., & van Kampen, M. (2010). Cognitive ability and self-control in relation to dietary habits, physical activity and bodyweight in adolescents. *International Journal of Behavioral Nutrition and Physical Activity, 7*(22), 7-22.

Kahan, D., Polivy, J., & Herman, C. P. (2003). Conformity and dietary disinhibition: A test of the ego- strength model of self- regulation. *International Journal of Eating Disorders, 33*(2), 165-171.

Keller, C., & Siegrist, M. (2014). Successful and unsuccessful restrained eating. Does dispositional self-control matter? *Appetite, 74*, 101-106.

Levesque, C., & Pelletier, L. G. (2003). On the investigation of primed and chronic autonomous and heteronomous motivational orientations. *Personality and Social Psychology Bulletin, 29*(12), 1570-1584.

Muraven, M. (2012). Ego depletion: Theory and evidence. In R. M. Ryan (Ed.), *The Oxford Handbook of Human Motivation* (pp. 111–126). New York: Oxford University Press.

Muraven, M., Collins, R. L., & Neinhaus, K. (2002). Self-control and alcohol restraint: An initial application of the Self-Control Strength Model. *Psychology of Addictive Behaviors, 16*(2), 113-120.

Papies, E. K. (2012). Goal priming in dieters: Recent insights and applications. *Current obesity reports, 1*(2), 99-105.

Papies, E. K., & Hamstra, P. (2010). Goal priming and eating behavior: Enhancing self-regulation by environmental cues. *Health Psychology, 29*(4), 384-388.

Papies, E. K., Potjes, I., Keesman, M., Schwinghammer, S., & Van Koningsbruggen, G. (2013). Using health primes to reduce unhealthy snack purchases among overweight consumers in a grocery store. *International Journal of Obesity*, 1-6.

514 Papies, E. K., & Veling, H. (2012). Healthy dining: Subtle diet reminders at the point of
515 purchase increase low-calorie food choices among both chronic and current dieters.
516 *Appetite*, 1-7.
517 Sheeran, P., Aarts, H., Custers, R., Rivis, A., Webb, T. L., & Cooke, R. (2005). The
518 goal- dependent automaticity of drinking habits. *British Journal of Social*
519 *Psychology, 44*(1), 47-63.
520 Shmueli, D., & Prochaska, J. J. (2009). Resisting tempting foods and smoking behavior:
521 Implications from a self-control theory perspective. *Health Psychology, 28*(3), 300-
522 306.
523 Simons, G., Pasqualini, M. C. S., Reddy, V., & Wood, J. (2004). Emotional and
524 nonemotional facial expressions in people with Parkinson's disease. *Journal of the*
525 *International Neuropsychological Society, 10*(4), 521-535.
526 Sproesser, G., Strohbach, S., Schupp, H., & Renner, B. (2011). Candy or apple? How self-
527 control resources and motives impact dietary healthiness in women. *Appetite, 56*(3),
528 784-787.
529 Srull, T. K., & Wyer, R. S. (1979). The role of category accessibility in the interpretation of
530 information about persons: Some determinants and implications. *Journal of*
531 *personality and social psychology, 37*(10), 1660-1672.
532 Stillman, T. F., Tice, D. M., Fincham, F. D., & Lambert, N. M. (2009). The psychological
533 presence of family improves self-control. *Journal of Social and Clinical Psychology,*
534 *28*(4), 498-529.
535 Tapper, K., & Pothos, E. M. (2010). Development and validation of a Food Preoccupation
536 Questionnaire. *Eating behaviors, 11*(1), 45-53.
537 Tomiyama, A. J., Mann, T., & Comer, L. (2009). Triggers of eating in everyday life.
538 *Appetite, 52*(1), 72-82.

Vohs, K. D., Glass, B. D., Maddox, W. T., & Markman, A. B. (2011). Ego Depletion Is Not Just Fatigue Evidence From a Total Sleep Deprivation Experiment. *Social Psychological and Personality Science, 2*(2), 166-173.

Vohs, K. D., & Heatherton, T. F. (2000). Self-regulatory failure: A resource-depletion approach. *Psychological Science, 11*(3), 249-254.

Walsh, D. (2014). Can priming a healthy eating goal cause depleted consumers to prefer healthier snacks? *Journal of Consumer Marketing, 31*(2), 126-132.

Ward, A., & Mann, T. (2000). Don't mind if I do: Disinhibited eating under cognitive load. *Journal of personality and social psychology*, *78*(4), 753-763.

Watson, D., Clark, L., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of personality and social psychology*, *54*(6), 1063-1070.

World Health Organisation. (2011). Global Status Report on Noncommunicable Diseases 2010. Geneva: World Health Organisation.

Zyphur, M. J., Warren, C. R., Landis, R. S., & Thoresen, C. J. (2007). Self-regulation and performance in high-fidelity simulations: An extension of ego-depletion research. *Human performance, 20*(2), 103-118.