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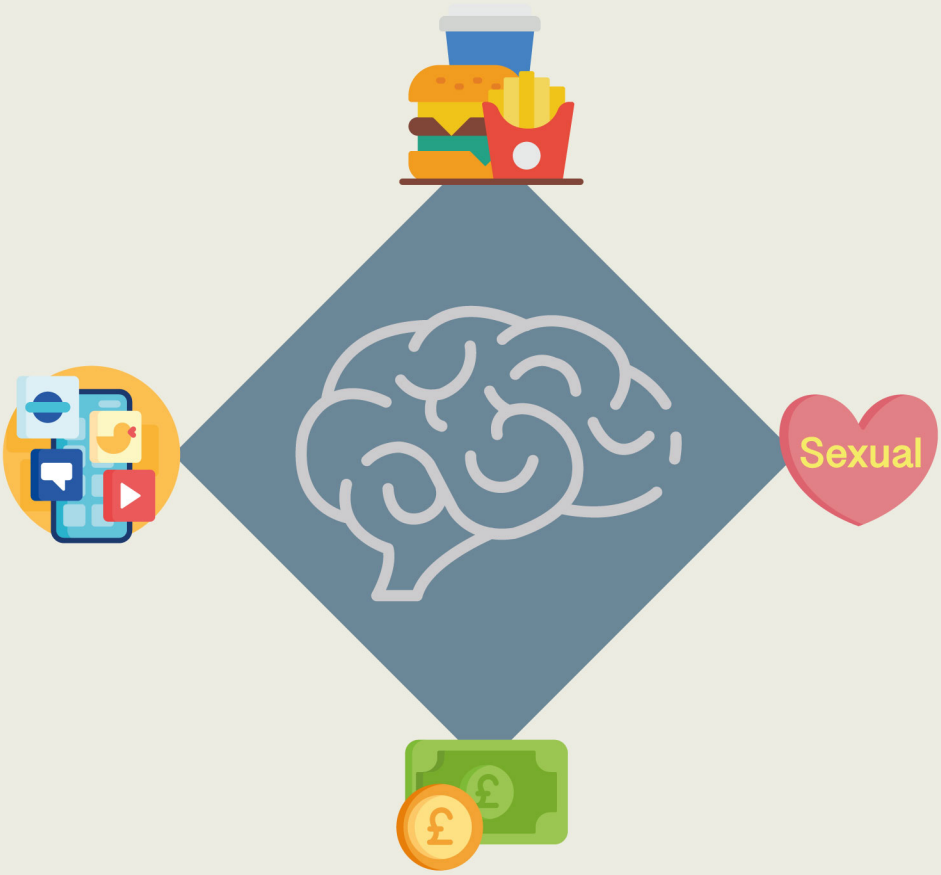
Ego Depletion and Multiple Rewards:

Implicit and explicit measures of the impact of self-control of one reward in other rewards



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Abstract

Ego depletion, referring to the phenomenon that exertion of self-control in one domain leads to depleted self-control in another domain, is a controversial concept regarding its interpretations and replicability. The current study explores ego depletion from a reward perspective. In Study 1, which used a lab-based experimental paradigm, all the participants were exposed to monetary and sexual rewards, while being asked to regulate snacking behaviour/food reward responses (experimental group) or not (control group). Participants' responses to the rewards were implicitly measured using measures of cheating behaviours (monetary reward) and picture viewing times (sexual reward). Participants were not asked to exert their self-control in the first phase of both tasks but subsequently asked to regulate their responses to the rewards in the second phase. In the monetary reward task, participants in the experimental group displayed stronger reward responses (more cheating behaviours) than those in the control group in the first phase, while this pattern disappeared in the second phase. The findings supported the process model (Inzlicht & Schmeichel, 2012) which explains ego depletion as a result of a motivational shift from 'have-to' to 'want-to' by displaying the shift in the first phase. Considering the participants in the experimental group were able to regulate their reward responses in the second phase, the findings disputed the interpretation of self-control as a limited resource. This evidence for a motivational shift was confined to the monetary reward. Hence, as a follow-up study, Study 2 used a vignette-based online experiment aimed to disentangle potential reasons of the different impacts of food rewards in sexual and monetary rewards, in which rewards can be categorised as materialistic or non-materialistic, and that such a shift can occur only within the same category. However, the findings showed that such a categorisation did not seem to explain the different impacts. Rather, Study 2 showed a different pattern from Study 1, showing that behaviours do not always correspond to attitudes and beliefs in self-control.

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Introduction

Self-control is defined as the ability to restrain one's thoughts, behaviours and emotions to strive for and achieve long-term and overarching goals (Baumeister, Vohs, & Tice, 2007). Self-control is a concept that is essential in our lives; hence, understanding the mechanisms underlying self-control is paramount. Many researchers have made efforts to uncover the mechanisms, but no agreement has been reached among them. This thesis aims to expand our knowledge pertaining to self-control in the context of ego depletion models. Specifically, this thesis's primary interest lies in providing further evidence for or against the existing self-control-based theories of ego depletion.

It is not uncommon that after you finish an exam that is draining, you break from your diet plans and eat unhealthy, high-calorie yet tasty food. Some researchers argue that this is because we have a limited capacity for self-control, so we are unable to resist eating appealing food after our control resources are used up (Baumeister, Bratslavsky, Muraven, & Tice, 1998). Some explain this as a result of the increased responses towards something you want, such as eating snacks, after the first self-control event, without the assumption of limited self-control resources (Inzlicht, Schmeichel, & Macrae, 2014). These explanations have been given much attention and have been substantially studied. Nevertheless, there is a lack of consensus on this topic. Thus, this thesis attempted to disentangle which explanation represents the phenomenon better (Study 1).

Another feature of the present studies is a focus on a reward perspective, as rewards are highly related to self-control and ego depletion can often be conceptualised as situations involving multiple rewards (Ciarocco, Echevarria, & Lewandowski Jr, 2012; Shmueli & Prochaska, 2009). Imagine that you refrain from eating your favourite snacks because you are

on a diet; would you then be inclined to be more sensitive to other rewards, for instance, keep money from a wallet that you spot under the bench? If you suppress urges to smoke when you attempt to quit smoking, would you be more likely to eat unhealthy snacks? In addition to examining which model can best explain the consequences after exertion of self-control as mentioned above, the present studies aimed to demonstrate such "reward compensations" effects. This effect can be defined as a situation in which one reward cannot be satisfied, such that responses to a different reward are increased to compensate for the unfilled reward. The present studies attempted to test how people would act in these situations, both implicitly and explicitly. In Study 1, a laboratory experiment was used to measure participants' implicit responses to a reward that had not been satisfied. Meanwhile, in Study 2, participants gave explicit (questionnaire) responses to a reward using online vignette-based scenarios.

1.1. The importance of self-control

Self-control has practical implications for many life areas. For instance, successful self-control has been linked to higher levels of academic achievement (Ayduk et al., 2000; Tangney, Baumeister, & Boone, 2004), well-developed interpersonal and social skills (Pronk & Righetti, 2015; Righetti & Finkenauer, 2011; Tangney et al., 2004) and overall better health (Moffitt et al., 2011; Tangney et al., 2004). These associations between self-control and positive life outcomes are also mirrored in findings showing that happiness, life satisfaction and well-being are associated with high levels of self-control (Cheung, Gillebaart, Kroese, & De Ridder, 2014a; Cheung, Gillebaart, Kroese, & De Ridder, 2014b; Hofmann, Luhmann, Fisher, Vohs, & Baumeister, 2014; Wiese et al., 2018).

On the other hand, self-control is closely linked to the concept of reward. Excessive indulgence in reward leads to negative consequences, and self-control plays a key role in

regulating the excessive pursuit of reward. For instance, implementation of self-control is essential for resisting attractive, high-calorie food and thus for weight management (Crescioni et al., 2011; Kitsantas, 2000). In addition, unsuccessful self-control has been linked to other reward behaviours, such as problematic gambling behaviour, indicating a failure to self-regulate (monetary) reward responses (Bergen, Newby-Clark, & Brown, 2012). There are also a number of studies indicating a relationship between self-control and problems related to sexual reward, including engaging in unprotected sex or committing sexual assault (Franklin, Bouffard, & Pratt, 2012; Hernandez & DiClemente, 1992).

1.2. Ego depletion and the 'strength model' of self-control

With regard to the mechanism underlying failures of self-control, Baumeister and colleagues (Baumeister et al., 1998; Baumeister & Heatherton, 1996; Baumeister et al., 2007) proposed a theoretical model, termed the 'strength model of self-control'. This theory views self-control as a limited commodity. Hence, once resources of self-control are depleted, one's capacity to exert self-control is diminished, which is referred to as 'ego depletion' (Baumeister et al., 1998). In other words, ego depletion describes the phenomenon that an initial exertion of self-control in one domain leads to a subsequent display of poor self-control in other domains. In order to provide empirical evidence of the existence of ego depletion, researchers have presented two tasks in close succession, i.e., used a 'dual-task paradigm' with two separate tasks (Baumeister et al., 1998; Muraven, Tice, & Baumeister, 1998). An experimental group is asked to exert self-control in both tasks, which are sequentially presented. For the control group, participants also engage in the two tasks, but it is only the second task which requires self-control, while the first task does not require self-control. This paradigm provides evidence in support of the strength model by showing diminished performance or failures of self-control in the second task only among

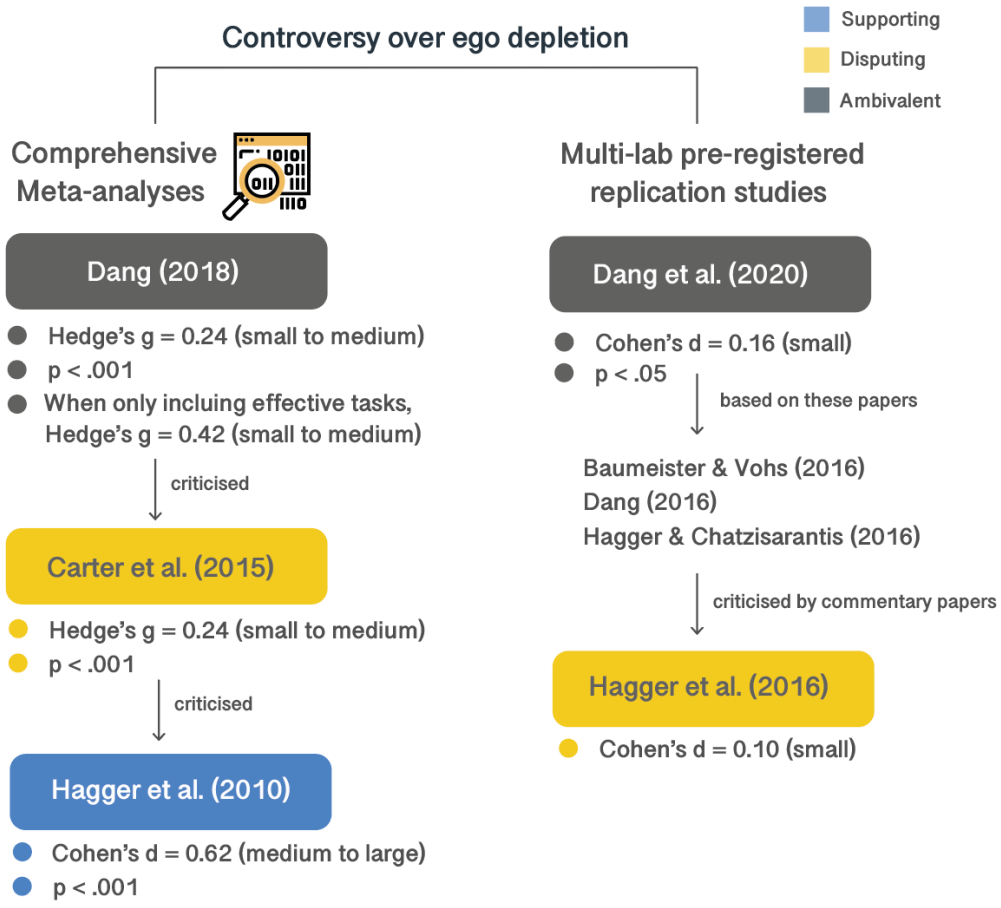
experimental participants who exerted self-control in the first task. For example, after being asked to suppress their emotions while watching a sad movie, participants tend to eat more ice-cream than those who did not have to exert self-control in the first task (Vohs & Heatherton, 2000). This paradigm also reveals domain generality of ego depletion by including two unrelated tasks, which do not have the same domain that requires self-control (i.e., attention, thoughts, emotions and reward responses) (Hagger et al., 2016).

1.3. Studies of ego depletion and its controversy

Although ego depletion has been supported by more than hundreds of studies over decades, controversy still remains with respect to the concept itself and how to interpret it. This can be specifically seen in a variety of different interpretations and results obtained in comprehensive meta analyses (Carter, Kofler, Forster, & McCullough, 2015; Dang, 2018; Hagger, Wood, Stiff, & Chatzisarantis, 2010) and multi-lab pre-registered replication studies (Dang et al., 2020; Hagger et al., 2016). See Figure 1. for a summary of the studies that will be discussed in the following sections.

Figure 1

Summary of the meta-analyses and multi-lab pre-registered replication studies



1.3.1. Meta-analyses

The first meta-analysis of ego-depletion studies was conducted by Hagger et al. (2010) who found a medium-to-large effect size of the reduction in self-control in a second task after a preceding self-control task. However, this meta-analysis has been criticised on a couple of grounds. First, their inclusion criteria of studies have been criticised as inappropriate and too loose by Carter et al. (2015), in that some tasks in the meta-analysis are not related to self-control and are not well-established. For instance, they included the study by Englert and Bertrams (2012) which used one's performance in throwing darts to measure one's degree of depletion. The association between throwing darts and self-control and thus the validity of

the task has not been demonstrated. Second, Hagger et al. (2010)'s meta-analysis has also been criticised for the presence of a publication bias, as they did not include unpublished papers in their analysis.

Tackling these criticisms, Carter et al. (2015) conducted a meta-analysis and applied tighter inclusion criteria (i.e., only including papers that used self-control related and validated tasks) and also unpublished papers. After controlling for publication bias and small-study effects (i.e., the phenomenon that studies with smaller sample size often obtain larger effect sizes than the ones with larger sample size), Carter et al. (2015) found the ego depletion effect to be indistinguishable from zero in their study. However, their study could not escape criticisms as well. Dang (2018) criticised Carter et al. (2015)'s meta-analysis as underestimating ego-depletion because of the methods they used and conclusions they drew. One of the criticisms stated that the effectiveness of individual tasks in inducing self-control has not been taken into account, so that ineffective tasks significantly lowered the effect size. Another criticism by Dang (2018) pertained to the criteria of self-control tasks in their meta-analysis. As mentioned above, Carter et al. (2015) criticised Hagger et al. (2010)'s criteria as being too loose and introduced tighter ones. However, according to Dang et al. (2018), the criteria used by Carter et al. (2015) were not appropriate. One example, according to Dang et al. (2018) was the inappropriate inclusion of studies using social exclusion manipulations. Social exclusion itself does not require self-control, so using social exclusion as a manipulation task was not appropriate.

When excluding these inappropriate studies and including newer studies in their meta-analysis, Dang (2018) found a significant small-to-medium effect size. However, Dang (2018) carefully categorised the types of tasks and found discrepancies between tasks in

terms of their effectiveness to induce self-control. They concluded that the 'attention video task' (i.e., ignoring distractors while maintaining focus on a video clip), which is the second most frequently used depleting tasks, was ineffective. Food temptation as a manipulation had the highest effect size but showed a high statistical heterogeneity between studies included in the meta-analysis. This means that even though overall the ego depletion effect in food temptation studies was high, their effect size varied between studies. Considering the variance of effectiveness between tasks, their conclusion was to pay attention to the effectiveness of depleting tasks, in order to draw a clear conclusion about ego depletion.

1.3.2. Multi-lab pre-registered replication studies

Apart from meta-analyses, another approach to evaluate the existence and strength of the ego depletion effect are multi-lab pre-registered replication studies. One such study is the study by Hagger et al. (2016), that was done in 23 laboratories with a total sample size of 2,143. In their study, participants took part in two sequential computer-administered tasks which were adopted from Sripada, Kessler, and Jonides (2014). The ego depletion task was a modified version of the 'letter e task' (Baumeister et al., 1998). In the depletion condition, participants were asked to press a button when a displayed word contained the letter "e", while holding back from pressing the button when there was a vowel next to or one letter away from the letter "e". In the control condition, participants were asked to press the button whenever the letter "e" appeared. As dependent variable task, a multi-source interference task (MSIT) was used (Bush, Shin, Holmes, Rosen, & Vogt, 2003). In this task, three digits (i.e., 323) were presented each trial on the computer screen, and participants were asked to respond to the one digit, which was different from the other two (i.e., 2 for 323), by pressing the corresponding key (i.e., 2) on the sequential digit panel on a keyboard. There are congruent (i.e., 2 for 323) and incongruent conditions (i.e., 2 for 233), depending on whether the order of numbers

presented on the screen matched the sequential order on the keyboard. The results in the MIST showed a small ego depletion effect which was almost indistinguishable from zero (d=.04).

The use of the multi-lab pre-registered replication was controversially discussed in several commentary papers (Baumeister & Vohs, 2016; Dang, 2016; Drummond & Philipp, 2017; Hagger & Chatzisarantis, 2016). The authors pointed out that the letter "e" task that was used in the replication study by Hagger et al. (2016) was different from the task in the preceding ego depletion studies. Participants in Hagger's study did not have a habituation period which only presented the congruent trials. Including the habituation period has been argued to be very essential (Baumeister & Vohs, 2016; Dang, 2016; Drummond & Philipp, 2017). Addressing these criticisms, Dang et al. (2020) conducted another multi-lab pre-registered replication study with a standard Stroop task (font colour naming) as depleting task and an antisaccade task as a dependent variable task. They chose to use a Stroop task as they had previously validated its effectiveness in their study results (Dang, 2018; Dang, Liu, Liu, & Mao, 2017). In the antisaccade task (Dang, Xiao, Liu, Jiang, & Mao, 2016), participants were asked to pay attention (and eye-movements) to the opposite side of the screen, while being asked to press a key in correspondence with three target letters on the screen (e.g., B, P, R for pressing keys 1, 2, 3 respectively). Their button press accuracy was measured. They found a significant and larger ego depletion effect (= poorer performance among depleted participants compared to control groups in the second task, i.e., antisaccade task), than Hagger et al. (2016) but the effect size remained small (d=.16).

Although both multi-lab pre-registered replication studies reported fairly small effect sizes (Dang et al., 2020; Hagger et al., 2016), the possibility of strong ego depletion effects should

not be ruled out for the following reasons: One reason is that conclusions should not be drawn from studies using relatively weak manipulations. In the multi-lab pre-registered replication studies and most other ego deletion studies, the tasks assumed to deplete self-control only lasted for a period of no more than 10 minutes, which may not be long enough for some individuals to reach depletion (Dang et al., 2020). Having a different degree of depletion among individuals, it is not surprising that there would be small effect sizes and inconsistent ego depletion results. In recent studies which made use of depletion tasks lasting for 1 hour or more, increased effect sizes from medium to large were found (Radel, Gruet, & Barzykowski, 2019; Sjåstad & Baumeister, 2018).

In addition, Baumeister and Vohs (2016) pointed out that pure cognitive tasks are not effective in leading to a depleted state, and focusing on other tasks related to impulsivity or emotion would lead to a stronger depletion state. These assumptions are supported by a theoretical perspective on the ego depletion effect which will be more thoroughly explained in the next section. To briefly explain, in contrast to the 'strength model' which focuses on the limited capacity of self-control, the 'process model' (Inzlicht & Schmeichel, 2012; Inzlicht et al., 2014) asserts that ego depletion is as a result of the shift in one's motivation. However, a cognitive lab task itself can be seen as insufficient to elicit strong intrinsic motivation (to do well) for these shifts to occur especially when incentives only involve small payments or course credits. In contrast, presenting tangible rewards, such as appetitive food, can be assumed to elicit stronger motivational responses and thus potentially allow for motivational shifts to happen.

Another reason for being cautious with completely disputing the ego depletion effect based on the multi-lab pre-registered replication studies is that the studies used only a single

paradigm, namely lab-based sequential tasks in a between-subject design (Lin, Saunders, Friese, Evans, & Inzlicht, 2020). Lin et al. (2020) pointed out that other approaches such as archival data sets, field data or experience sampling have in fact demonstrated the effect reliably in daily live (Dai, Milkman, Hofmann, & Staats, 2015; Hirshleifer, Levi, Lourie, & Teoh, 2019). It can be the case that using a different approach in a multi-lab pre-registered study might lead to a clearer demonstration of ego depletion. More recently, alternative approaches to study ego depletion were proposed, and interestingly, such approaches provided evidence against the classic theoretical model of self-control (i.e., strength model). For example, Lin et al. (2020) conducted within-subject studies wherein participants took part in both high-demand (a symbol counting task) and low-demand (watching a 5-minute wildlife video) tasks. In the symbol counting task, participants were asked to count the number of small black squares presented. After completing the tasks, participants took part in a Stroop task and their performances were fitted to a drift-diffusion model. Drift-diffusion modelling allows to estimate latent variables (e.g., fatigue effect, response caution, impulsivity) which are more fundamental to the ego depletion effect than observed performance, such as reaction time and accuracy. It was found that participants' performance (RTs and accuracy) was not heavily influenced by the degree of demands (high vs. low), but their task engagement (which was measured by response caution and impulsivity) was reduced as a result of taking part in high-demand tasks. The approach by Lin et al. (2020) demonstrates that the high-demand task produced an effect on engagement in another task, indicating the impact of self-control in one domain upon motivation in another domain. However, the results cannot be easily explained by the strength model of self-control and its assumption of finite control resources. According to the strength model, participants' performance in the task should have also been diminished as a result of a depletion state.

1.4. The 'process model' of ego depletion and its supporting evidence

However, the findings by Lin et al. (2020) are consistent with another theoretical explanation of reduced self-control following ego depletion situations, which is the 'process model' of ego depletion proposed by Inzlicht and Schmeichel (2012) and Inzlicht et al. (2014). In this model, tasks are distinguished based on whether they contain 'want-to' or 'have-to' components. A 'have-to' component usually involves the control of urges for a long-term goal, while a 'want-to' component involves a reward which brings about prompt indulgence. In the model, exerting self-control leads to a motivational, attentional, and emotional shift from 'have-to' to 'want-to' components, rather than a depletion of self-control resources. This model can explain the results of diminished engagement and unchanged performance from Lin et al. (2020). This is because the model argues for ego depletion not being about reduced performance due to limited capacity of self-control but being about a motivational shift from 'have-to' to 'want-to'.

As well as receiving support from the newer methodological approach used by Lin et al. (2020), the process model is compatible with another theoretical perspective on ego depletion effects which has been formulated based on neuroscientific evidence: The balance model proposed by Heatherton and Wagner (2011) argues that successful self-control requires a balance between the level of impulse control exerted and the strength of urges and desires elicited by rewards (Hofmann et al., 2014). Impulse control has been associated with the prefrontal cortex (PFC) (Hedy et al., 2010), and reward responses associated with urges and desires have been linked to the orbitofrontal cortex (OFC) (Morten, 2005; Rolls, 2000). Accordingly, the balance model points out the importance of a balance between OFC and PFC activation levels (Heatherton & Wagner, 2011). In a functional magnetic resonance imaging (fMRI) study by Wagner, Altman, Boswell, Kelley, and Heatherton (2013) using

participants who were currently dieting, an ego depletion group was asked to avoid reading distractor words (one or two syllabus words) while maintaining their focus on a 7-min video, while a control group did not have to avoid reading the words. Participants were then presented with food cues (pictures) probing the strength of their neural reward system response. Dieters in the depletion group exhibited greater activation of the OFC towards the food cues compared to dieters in the control group. Moreover, depleted participants displayed weakened neural connectivity between the OFC and the inferior frontal gyrus (IFG) of the PFC, which is linked to self-control, demonstrating the interrelationship between reward responses in the OFC and control mechanisms in the IFG. These findings support the notion that 'ego depletion' manipulations increase the strength of desires for reward instead of reducing control resources. In other words, in both the process and balance model, the key mechanism, underlying 'ego depletion' effects is the intensified reward response in the secondary task, resulting from a motivational shift from 'have-to' (control in the primary task) to 'want-to' in the secondary (reward) task, rather than a diminished ability to exert self-control.

1.5. "Reward compensation" effects

In ego depletion tasks that involve rewards in both the primary and secondary task, it could be argued that, at a psychological level, the mechanisms described in the process model (pointing to a motivational shift from 'have-to' to 'want-to', see above) can also be seen as a compensatory process, such that controlling or abstaining from one reward results in increased desires to engage with a different reward. Thus, having two rewards available allows participants to compensate and change their motivation and attention from inhibiting desires towards one reward to gratifying desires using the other reward. The presence of the effect can be predicted based on a general and domain-unspecific reward system (Kirsch et

al., 2003) and ego depletion studies that showed increased reward desirability in one reward domain after exerting self-control in unrelated domains (Ciarocco et al., 2012; Shmueli & Prochaska, 2009; Vohs & Heatherton, 2000). Regarding the general reward system, it seems to be clear that the above psychological process is also reflected in neural responses, i.e., similar areas are activated by different rewards. Different rewards commonly lead to the activation of the OFC, ventral striatum, and ventromedial PFC (Montague, King-Casas, & Cohen, 2006).

In line with the above idea of reward compensation, in studies where both manipulation (ego depletion) task and outcome (secondary) task encompassed reward, an increase of reward responses (= increased consumption of or engagement with the reward) has been consistently observed in the outcome task (Ciarocco et al., 2012; Shmueli & Prochaska, 2009; Vohs & Heatherton, 2000). In the study by Ciarocco et al. (2012), participants who were asked to refrain from eating cookies (and eat radishes instead) showed a higher likelihood of infidelity behaviour by giving their phone numbers to strangers and accepting coffee dates by them in an online format, compared to those who were allowed to eat the cookies. This can be seen as an increased sexual reward response as a result of the control of food rewards. Shmueli and Prochaska (2009) demonstrated that participants who were asked to resist vegetables (= suppression of non-reward, control group) were less likely to smoke during a break than those who refrained from eating sweets (= suppression of reward, experimental group). In Vohs and Heatherton (2000)'s study, participants were placed either in a high-temptation condition (an array of snacks including Doritos, Skittles, M&Ms, and salted peanuts was placed right next to them) or a low-temptation condition (snacks were distributed across the room), before taking part in a bogus taste-test of ice cream. Participants in the high temptation condition consumed more ice cream than those in the low temptation group. On

the other hand, results that are inconsistent with the idea of reward compensation come from a study by Dewitte, Bruyneel, and Geyskens (2009) which presented chocolate as reward in both tasks. After participants were asked to exert self-control in order to not eat from a bowl of chocolates while being asked to do a knowledge task (associating flavours with wrap colours and shape), they ate less chocolates in a subsequent bogus taste-test than those who were not exposed to chocolates in the first task (Dewitte et al., 2009). However, it is possible that increased consumption and desirability of the second reward was not observed in this study as the reward was exactly the same in the outcome task. Instead, the effect seems to be found in studies where qualitatively different rewards were presented in the self-control and outcome task.

The phenomenon of increased reward desirability after exerting self-control can be explained by the process model, assuming a motivational shift from 'have-to' to 'want-to'. For instance, Shmueli and Prochaska (2009) showed that the control of tempting food led to increased desires to smoke. After participants 'had to' control their urges to have tempting food, they smoked as they 'wanted to' smoke. Notably, such reward compensation effects can be predicted to also occur with simultaneously presented rewards, whereas depletion effects would depend on time or sequential task presentation. The longer participants exert self-control, the more depletion effect should occur, if depletion is the underlying mechanisms, while reward compensation effects would occur from the beginning.

Another thing to be pointed out is that these above studies measured the reward consumption but did not measure the ability for self-control in the second study. Reward consumption and self-control are considered to be the same processes, in that self-control is usually required for reward responses due to the common reasons of health or morality. However, it is

paramount to differentiate the ability to exercise self-control from the expression of self-control in this stance. Participants might still be able to exert control in the 2nd task (=ability), but it is them choosing not to (=expression of self-control), due to the motivational shift from 'have-to' to 'want-to'.

1.6. Reward in ego depletion studies

Previous ego depletion studies employed a variety of self-control tasks (control of attention, thoughts, emotions, and reward responses) to induce ego depletion and also different tasks to measure the effects of exerting self-control. Self-control of reward responses (e.g., abstinence/restraint) is one of the most widely used tasks, and there are many studies that used reward responses (e.g., consumption) as dependent variables, as illustrated in some of the examples presented above. However, only a few studies used a reward task as both manipulation and dependent variable (dual reward studies). Considering the association between self-control and reward, it is quite surprising that the debate over the ego depletion effect does not take reward into account much. The ego depletion studies pertaining to the control of reward responses are summarised in Table 1. In studies using rewards as dependent variable, a range of different rewards were used, including food, alcohol, tobacco, sexual and monetary reward responses. In studies using rewards as manipulation, only self-control related to food temptation has been used. Dang (2018) found in his meta-analysis that using food temptation as a manipulation has the highest effect size among other tasks used in ego depletion studies, although it has relatively high heterogeneity with regard to the type and number of stimuli presented. For instance, for the studies which used food temptation as a manipulation, the experimental group was asked to eat radish instead of chocolates in Baumeister et al. (1998), participants in study conducted Vohs and Heatherton (2000) were asked to just refrain from eating chocolates without eating something not tempting. In dual

reward studies, the manipulation variable typically consisted of the presence of food, while the dependent variables involved sexual, tobacco or food rewards.

To briefly summarise the ego depletion studies in Table 1. involving rewards, most studies showed increased reward consumption or diminished self-control in the secondary task. The most controversial results found were among the studies that measured risk-taking behaviour as an indication of monetary reward responses (e.g., Brevers et al., 2018; Freeman & Muraven, 2010; Unger and Stahlberg, 2011; see Table 1 for more studies). These studies typically found decreased risk-taking behaviour (which can be seen as decreased reward responses), but the interpretation of this effect was controversial (e.g., Langhe, Sweldens, van Osselaer, & Tuk, 2008). The interpretation of risk-taking behaviour will be discussed in the overview of Study 1. Other than this, only a few studies showed a null effect or decreased reward responses in the second task (e.g., Schmidt et al., 2017).

Table 1

Summary of ego depletion studies using rewards

Reward as dependent variable					
Types of reward	Author(s) (Year)	Manipulation	Dependent variable - Reward	Findings*	Effect size
Food	Bruyneel, Dewitte, Vohs, and Warlop (2006), Study 2, 3	Choice task – asking to choose candies from each of six different flavours of candy (highly appealing but overpriced vs less appealing but cheaper type) by using certain amount of money	The amount of overpriced but attractive candies purchased	+	Unreported
	Cheung, Gillebaart, Kroese, and De Ridder (2016)	Crossing out letters task - asking participants to cross out a certain letter with a complex rule (e.g., when it is two spaces away from a consonant)	Computer-based size perception task for healthy vs. unhealthy food objects	+	$\eta^2 = .05$ (small-to-medium)
	Friese, Engeler, and Florack (2015)	Crossing out letters task - asking participants to cross out a certain letter with a complex rule (e.g., when it is two spaces away from a consonant)	Bogus taste-test – Consumption of freshly baked cookies	+	Unreported
	Friese, Hofmann, and Wänke (2008), Study 2	Emotion video task - suppression of emotions while watching a video	Bogus taste-test – Consumption of potato crisps	+	Unreported
	Geisler, Kleinfeldt, and Kubiak (2016)	Emotion video task - suppression of emotions while watching a video	Heart rate variability (HRV) while being exposed to jellybeans	+	Unreported

Haynes, Kemps, and Moffitt (2016)	Crossing out letters task - asking participants to cross out a certain letter with a complex rule (e.g., when it is two spaces away from a consonant)	Bogus taste-test – Consumption of chocolate candies, savoury biscuits, potato crisps, and cookies	+	Unreported
Hofmann, Rauch, and Gawronski (2007)	Emotion video task - suppression of emotions while watching a video	Bogus taste-test – Consumption of chocolate candies	+	Unreported
Imhoff, Schmidt, and Gerstenberg (2014), Study 1	Modified Stroop task	Bogus taste-test – Consumption of chocolate candies	+	d =.72 (medium-to-large)
Kahan, Polivy, and Herman (2003)	Visual perception task which is a variation of Asch-type conformity task – asking participants to compare the proportion of blue and red shapes and presenting others' responses to cause pressure to conform	Bogus taste-test – Consumption of cookies	+	Unreported
Krpan and Schnall (2017), Study 2	Crossing out letters task - asking participants to cross out a certain letter with a complex rule (e.g., when it is two spaces away from a consonant)	Bogus taste-test – Consumption of chocolate candies	+	Unreported
Lattimore and Maxwell (2004)	Modified Stroop task	Bogus taste-test – Consumption of crisps, chocolates, and dried fruits	+	Unreported
Obara-Gołębiowska and Brycz (2017)	Cold-pressor task – asking participants to put their hands in cold water for a certain amount of time	Food choice (healthy vs. unhealthy options)	+	η_p^2 = .02 (small)

	Pollert and Veilleux (2018)	Crossing out letters task - asking participants to cross out a certain letter with a complex rule (e.g., when it is two spaces away from a consonant)	Attentional bias (measured by dot-probe task) & Bogus taste test – Consumption of chocolate candies	+	Unreported
	Sellahewa and Mullan (2015)	Emotion video task - suppression of emotions while watching a video	Bogus taste-test – Consumption of chocolate candies, savoury biscuits, potato chips	+	Unreported
	Stein, Greathouse, and Otto (2016)	The white bear task – asking participants to tell their thought without mentioning a white bear	Bogus taste-test – Consumption of chocolates	0	n/a
	Stillman, Tice, Fincham, and Lambert (2009), Study 3	Video attention control task – asking participants to ignore words appearing on the screen	Bogus taste-test – Consumption of cookies	0	n/a
	Vohs and Heatherton (2000), Study 3	Emotion video task - suppression of emotions while watching a video	Bogus taste-test – Consumption of ice-cream	+	Unreported
	Wang et al. (2015)	Crossing out letters task - asking participants to cross out a certain letter with a complex rule (e.g., when it is two spaces away from a consonant)	Bogus taste-test – Consumption of chocolates	0	n/a
Drug (Alcohol)	Friese et al. (2008), Study 3	Emotion video task - suppression of emotions while watching a video	Bogus taste-test – Alcohol consumption	+	Unreported
	Christiansen, Cole, and Field (2012)	Emotion video task - suppression of emotions while watching a video	Bogus taste-test – Alcohol consumption	+	Unreported

	Lindgren et al. (2019)	Crossing out letters task – asking participants to cross out a certain letter with a complex rule (e.g., when it is two spaces away from a consonant)	The relationship between implicit measures of alcohol-related associations and alcohol consumption (Control involved)	0	n/a
	Muraven et al. (1998)	Suppression of thoughts	Bogus taste-test – Alcohol consumption (Control involved)	+	Unreported
	Otten et al. (2014)	Crossing out letters task –asking participants to cross out a certain letter with a complex rule (e.g., when it is two spaces away from a consonant)	Alcohol intake during the break	+	Unreported
Drug (Tobacco)	Heckman, Ditre, and Brandon (2012)	Emotion video task - suppression of emotions while watching a video	Motivation to smoke	+ (Only for nicotine deprived smokers)	Unreported
Sexual	Gailliot and Baumeister (2007), Study 1	Modified Stroop task	Anagram tasks that could be solved with both sexual and non-sexual words	+	Unreported
	Gailliot and Baumeister (2007), Study 2	Crossing out letters task which asks participants to cross out a certain letter with a complex rule (e.g., when it is two spaces away from a consonant)	Scenario-based sexual infidelity assessment	+	Unreported
	Gailliot and Baumeister (2007), Study 4	Video attention control task – asking participants to ignore words appearing on the screen	Physical intimacy (sexual behaviours) with current dating partners	+	Unreported

	Ritter, Karremans, and van Schie (2010), Study 1	Emotion video task - suppression of emotions while watching a video	The percentage of selecting opposite-sex others as potential partners	+	$\eta^2 = .46$ (large)
	McIntyre, Barlow, and Hayward (2015)	Crossing out letters task which asks participants to cross out a certain letter with a complex rule (e.g., when it is two spaces away from a consonant)	Scenario-based sexual infidelity assessment	+ (Only when interacting with sexual desires)	Unreported
	Nolet, Rouleau, Benbouriche, Carrier Emond, and Renaud (2016)	Modified Stroop task	Inhibition of sexual responses that were measured with penile plethysmography	+	$\eta^2 = .22$ (large)
Monetary – Dishonesty	Wu, Peng, Mei, and Shang (2019), Study 1	Crossing out letters task which asks participants to cross out a certain letter with a complex rule (e.g., when it is two spaces away from a consonant)	Calculation task in which participants could easily be dishonest or cheat to earn monetary/material rewards	+	$\eta^2 = .23$ (large)
	Wu et al. (2019), Study 2	Crossing out letters task which asks participants to cross out a certain letter with a complex rule (e.g., when it is two spaces away from a consonant)	Choice task in which participants could easily be dishonest or cheat to earn monetary/material rewards	+	Unreported
	Gino, Schweitzer, Mead, and Ariely (2011), Study 1	Video attention control task – asking participants to ignore words appearing on the screen	Cheating task (Performance was tracked but told that they will be paid based on self-reported performance)	+	Unreported
	Mead, Baumeister, Gino, Schweitzer, and Ariely (2009), Study 1	Writing a short essay without using words that contain commonly used letters	Task performance that was compensated with monetary rewards for correct solutions (self-	+	$\eta^2 = .13$ (medium-to-large)

			scored vs. experimenter-scored conditions)		
	Mead et al. (2009)	Modified Stroop task	The type of bubble sheet chosen during quiz (pre-marked vs. unmarked) & The number of correct answers claimed; task performance was compensated with monetary rewards	+	$\eta^2 = .56$ (large)
Monetary – Risk-taking	Achtziger, Alós-Ferrer, and Wagner (2015)	Crossing out letters task - asking participants to cross out a certain letter with a complex rule (e.g., when it is two spaces away from a consonant)	Dictator game	+	$d = .18$ (small)
	Achtziger, Alós-Ferrer, and Wagner (2016)	Crossing out letters task - asking participants to cross out a certain letter with a complex rule (e.g., when it is two spaces away from a consonant)	Ultimatum game	+	Unreported
	Banker, Ainsworth, Baumeister, Ariely, and Vohs (2017), Study 1 & 3	Writing without specific letters	Reverse dictator game	- (Passive acceptance)	n/a
	Banker et al. (2017), Study 2	Vicarious depletion manipulation – asking participants to take another person's perspective who is exerting self-control	Reverse dictator game	- (Passive acceptance)	n/a
	Blain et al. (2019)	Physical training overload – overtraining athletes	Impulsivity in economic choice	+	Unreported

Brevers et al. (2018)	Mental-visualisation of effortful self-control events ('have-to')	Coin-flipping task (Gambling task) (Carr & Steele, 2010)	+	Unreported
Brevers et al. (2018)	Reading self-control sentences	Coin-flipping task (Gambling task) (Carr & Steele, 2010)	+	Unreported
Bruyneel et al. (2006)	Modified Stroop task	Opportunity to buy lottery tickets	+	Unreported
Langhe, Sweldens, van Osselaer, and Tuk (2008), Study 1	Modified Stroop task	Investment game	- (Avoid risk-taking)	n/a
Langhe et al. (2008), Study 2	Modified Stroop task	Iowa gambling task	- (Avoid risk-taking)	n/a
Freeman and Muraven (2010), Study 2	Video attention control task – asking participants to ignore words appearing on the screen	Balloon Analogue Risk Task	+	$d = .60$ (medium-to-large)
Halali, Bereby-Meyer, and Ockenfels (2013), Study 1	Modified Stroop task	Ultimatum game	+	Unreported
Halali et al. (2013), Study 2	Writing without specific letters	Dictator game	+	$\eta^2 = .12$ (medium-to-large)
Imhoff et al. (2014), Study 2	Working memory capacity task	Game of dice task	+	$d = .52$ (medium-to-large)
Li et al. (2019), Study 2	Modified Stroop task	Anonymous economic dictator game	+	$\eta^2 = .59$ (large)

	Osgood (2019), Study 1	Typing task – retyping paragraph without letter e or space bar	Economic social dilemma game (fishing game)	+	*d* = .23 (small-to-medium)
	Schmeichel, Harmon-Jones, and Harmon-Jones (2010), Study 3	Writing without specific letters	Detecting dollar signs (reward symbol) vs. percent sign (non-reward symbol) in pictures	+	Unreported
	Schmeichel et al. (2010), Study 2b	Writing without specific letters	Gambling task	+	Unreported
	Schmidt et al. (2017)	Modified Stroop task	Risk game/FRN	- [Behavioural results] + [Neuroimaging results]	n/a [Behavioural results] *d* = .4 (small-to-medium) [Neuroimaging results]
	Unger and Stahlberg (2011), Study 1	Vocabulary-learning task	Investment game (Riskiness of investment decision)	- (Avoid risk-taking)	*r* = -.69
	Unger and Stahlberg (2011), Study 2	Vocabulary-learning task	Investment game (Riskiness of investment detection), the amount of additional information used	- (Avoid risk-taking)	n/a
	Unger and Stahlberg (2011), Study 3	Emotion video task - suppression of emotions while watching a video	Investment game (Riskiness of investment decision)	- (Avoid risk-taking)	n/a
Reward as manipulation					
Types of reward	Author(s) (Year)	Manipulation - Reward	Dependent variable	Findings*	Effect size

Food	Baumeister et al. (1998)	Eating radish instead of chocolates	Time spent on unsolvable puzzles	+	Unreported
	Dewitte et al. (2009), Study 2	Tempted with attractive chocolates but refraining from eating	Time spent on possible anagram tasks	+	Unreported
	Segerstrom and Nes (2007)	Resist chocolates or cookies while eating carrots	Time spent on impossible anagram tasks	+	d = .41 (small-to-medium)
	Vohs and Heatherton (2000), Study 2	Different proximities of candied chocolates	Time spent on unsolvable puzzles	+	Unreported

Rewards in both tasks

Types of reward	Author(s) (Year)	Manipulation - Reward	Dependent variable - Reward	Finding*	Effect size
Food & Sexual	Ciarocco et al. (2012)	Eating radish while being exposed to cookies	Disclosure of a telephone number and acceptance of a coffee date	+	Φ = .43 (medium-to-large)
Food & Drug (Tobacco)	Shmueli and Prochaska (2009)	Resist to eat from either sweets or vegetables	Smoking during a break	+	Unreported
Food	Dewitte et al. (2009), Study 2	Tempted with attractive chocolates but refrained from eating	Bogus taste-test – Consumption of chocolates	-	n/a
	Vohs and Heatherton (2000), Study 1	Perceived availability and proximity of chocolates	Bogus taste-test – Consumption of ice cream consumed	+	Unreported

*In the findings section, +, 0, - symbols indicate whether responses (e.g., consumption) increased, did not change or decreased respectively

Study 1

2.1. Overview

2.1.1. Study rationale and aims

Despite the strong association between self-control and reward, there are only few studies in the ego depletion literature that involved rewards both at the level of manipulation and outcome measure as illustrated in the table. Most manipulations that were used in ego depletion studies were related to control of attention, thoughts, and emotions (Krpan & Schnall, 2017; Lattimore & Maxwell, 2004; Obara-Gołębiowska & Brycz, 2017). The present studies therefore sought to more systematically examine the effects of controlling reward response in one task on responses to (different) rewards in another task, using the motivational framework proposed by the process model (Inzlicht & Schmeichel, 2012). It can be assumed, particularly in the laboratory, that presenting tangible rewards, such as food, will elicit 'want-to' motivation to a greater degree than cognitive tasks used in many other ego depletion studies, which usually only involve small payments or course credits as incentives (which are given regardless of performance). Another important feature of the present paradigm was to present the tasks of interest simultaneously rather than sequentially. Ego depletion has mostly been studied in a sequential setting, meaning that one task is presented prior to the other task. There have only been a few ego depletion studies, in which ego depletion and outcome task occurred simultaneously (see Tuk, Zhang, and Sweldens, 2015). Tuk et al. (2015) conducted a meta-analysis based on their 18 studies using well-established tasks for exerting and measuring self-control of attention, food consumption, emotion, and thoughts. They investigated both tasks which were presented sequentially and tasks that were presented simultaneously. As one of their main findings, in contrast to the effects observed in sequential tasks, the studies using simultaneous tasks exhibited an improvement in self-control throughout the second task, which the authors explained by an 'inhibitory spillover' mechanism (Berkman, Burklund, & Lieberman, 2009). This refers to the

idea that self-control of a focal impulse implicitly facilitates the inhibition of impulses in other domains. Tuk et al. (2015) argued that the inhibitory spillover is not predicted by the process model but it is still compatible with the theory. It is important to note that Tuk and colleagues' study did not give direct support to the process model, as the motivational shifts from 'have-to' to 'want-to' were not demonstrated directly. With cognitive tasks - as used in their study- it is hard to demonstrate the motivational shifts in a simultaneous paradigm, as participants would not have enough time to get directed to 'want-to' motivation. The present study used a different approach to Tuk et al. (2015)'s by including rewards in both tasks. In the study by Tuk et al. (2015), the motivational shift was not directly demonstrated as they did not compare a condition in which participants were asked to exert control in the second task (=no motivational shift) with a condition in which they were not instructed to do so (=motivational shift occurs). This study used the idea of manipulating self-control requirements in task B, which shows that participants can regulate, i.e., resources are not depleted, but do not apply regulation if not asked to do so. In summary, the main goal of Study 1 was to test the idea of motivational shifts from 'have-to' to 'want-to' more directly in order to support the process model.

2.1.2. Study overview and theoretical predictions

To test the predictions of the process model more directly, two tasks were presented simultaneously that both involved a reward (task A and B) and varied the self-control requirements in task B (no regulation and regulation phases). One group of the participants was required to control their responses to the reward A, which consisted of appetitive food (popcorn and crisps). Another group was free to consume the food. No snack was presented to a third group. In addition and for all participants, we varied the self-control requirements in task B using different written instructions in two successive phases (no regulation required and self-control/regulation required). The strength model would predict an increased reward consumption in task B regardless of the regulation

requirement. This is because the strength model argues that the capacity of self-control is limited, meaning that once resources are used up, self-control cannot be further exerted, even if one is explicitly instructed to do so (Baumeister et al., 1998; Baumeister & Heatherton, 1996; Baumeister et al., 2007). On the other hand, the process model would predict that participants' reward responses in task B would be heightened (consumption would be increased) when no regulation is required (Inzlicht & Schmeichel, 2012; Inzlicht et al., 2014), reflecting a reward compensation effect. Crucially, the increase in reward responses will disappear when task B requires self-control regulation. As the process model assumes no depletion of self-control resources, self-control will still be possible. The above predictions are also consistent with the findings by Tuk et al. (2015), which were explained in the previous section. For the present study the idea of inhibitory spillover would predict that in the regulation phase, those being engaged in self-control in the primary task (task A) would regulate themselves better in task B and thus show reduced reward responses compared to the control group.

2.2. Methods

2.2.1. General methods and specific predictions

Our study involved manipulation of self-control during exposure to appetitive snacks (food reward; task A). A concurrent second task (task B) assessed responses to attractiveness/sexual reward (using an ostensible "picture perception task") and monetary reward (using an ostensible 'maths intuition task').

Participants were randomly assigned to one of three groups in which they were: (i) instructed to exert control and refrain from snacking during the sexual and monetary reward task (experimental group); (ii) asked to snack ad libitum (control group 1); or (iii) not exposed to the snacks before or during the sexual and monetary reward task (control group 2). In the sexual reward task, participants were

asked to freely view pictures of models in underwear and control pictures (models in workwear) and allowed to change picture size using a joystick, before rating them afterwards. Longer viewing times (and larger picture increases) were assumed to reflect stronger appetitive/consummatory responses to sexual reward (Imhoff et al., 2010; Krieglmeyer & Deutsch, 2010). In the monetary reward task, participants were asked to guess the answers to arithmetic problems based on their intuition (Wu et al., 2019), after which they gained or lost money, depending on whether their answers were correct or wrong. We deliberately made the arithmetic problems easier than the ones in Wu et al. (2019). This was done by putting the multiplication problems before the addition and subtraction ones, which made the problems easier that participants did not need to remember that they should do multiplication problems first and could just start to solve problems from the beginning. Longer response times (and higher accuracy) were assumed to reflect more 'cheating' (i.e., calculating and working out the solutions to the math problems rather than guessing), therefore indicating stronger responses to the monetary incentive of gaining money. Both tasks included two phases (within-subject conditions): The first phase involved no specific instruction to self-regulate responses (restrict viewing or problem-solving times), whereas in the second phase participants were explicitly instructed to self-regulate their picture viewing and problem-solving responses (limit the time spend on underwear pictures and not to calculate solution to the maths problems in their head).

In the sexual reward task, we assumed that longer viewing times reflected stronger appetitive/consummatory responses to sexual reward (Imhoff et al., 2010; Krieglmeyer & Deutsch, 2010). A recent meta-analysis showed that sexual pictures indeed activate the brain's reward system. (Mitricheva, Kimura, Logothetis, & Noori, 2019). Hence, a longer viewing time in response to sexual pictures can be interpreted as a stronger reward response. With respect to the monetary reward task, although tasks examining risk-taking behaviour are more widely used to measure the effect of ego depletion (see Table 1), we employed a dishonesty/cheating task which measures

cheating or dishonest behaviours in order to earn money. One reason is that a dishonesty/cheating task measure is indicative of a state rather than a trait, just as how ego depletion is more related to a state (Baumeister, 2014). Traits can be considered to be permanent, whereas states are more temporary and can be changed by the manipulation of situation (Chaplin, John, & Goldberg, 1988). Accordingly, the cheating paradigm in the context of ego depletion studies is not a measure of one's general cheating behaviour but rather a temporary state of the desire to obtain money (by cheating). It cannot be predicted that participants who cheated on this task will be more likely to cheat in ecological situations. Cheating itself is also found to be hugely influenced by situational factors (Day, Hudson, Dobies, & Waris, 2011; Murdock, Miller, & Kohlhardt, 2004) On the other hand, risk-taking is generally associated with traits such as personality (Mishra, Lalumière, & Williams, 2010; Zuckerman & Kuhlman, 2000) or genes (Kuhnen & Chiao, 2009; Mata, Hau, Papassotiropoulos, & Hertwig, 2012). Another reason for using a monetary reward task related to dishonesty/cheating was that it matched the nature of the other reward task in our study. The sexual reward task presents a conflict between 'have-to' and 'want-to' components: Participants 'had to' rate the attractiveness of the attractive pictures, but they 'wanted to' look at them longer. However, for tasks examining risk-taking behaviour, there is no clear cut between 'have-to' and 'want-to' components, since risk-taking behaviour can be interpreted both positively and negatively (Leigh, 1999). By contrast, for dishonesty/cheating, there is a clear distinction between 'have-to' (not cheating) and 'want-to' (receiving more money). For these reasons, using a monetary reward task associated with dishonesty/cheating seemed more appropriate in our study.

We predicted that the participants who were asked to resist food would display stronger responses to money and underwear pictures when self-control was not explicitly required. At the same time, they would be superior at regulating themselves when such regulation was explicitly required based on the 'inhibitory spillover' mechanism (Tuk et al., 2015).

2.2.2. Pre-registration

Our study was pre-registered on the Open Science Framework before conducting the study (https://osf.io/tz7yw/).

2.2.3. Design

A mixed design with one between- and two within-subject factors was used. The between-group factor was '*self-regulation of snacking'*, with three levels (1: instructed not to snack [experimental group], 2: free snacking [control group 1], 3: no snacks presented [control group 2]). One within-subject factor was '*reward domain*' with two levels (1: sexual reward, 2: monetary reward) and the other within-subject factor was '*self-regulation of second reward*' with two levels (1: first phase [not instructed to self-regulate], 2: second phase [instructed to self-regulate]).

To allocate participants to group (*self-regulation of snacking*), stratified randomisation was used to ensure that groups were balanced with regard to gender and order of reward tasks (monetary or sexual reward task first). The counterbalanced order was determined before conducting the research by using a randomly generated number sequence.

2.2.4. Participants

The originally targeted sample size was 150, and it was determined by an *a priori* sample-size calculation using G*Power (Faul et al., 2007). Our sample size calculations were based on an effect size of d=.22 reported in a recent study with a similar design and primary outcome to ours (see Tuk et al., 2015) and assuming a statistical power of 80% and α=.05. However, due to the COVID-19 outbreak and restrictions on face-to-face testing, the targeted sample was not able to be achieved. Eventually, 121 participants (46 males and 75 females) were recruited using standard internal channels of advertising research studies at Durham University (e.g., the participant credit system for

Psychology students, University newsletter). Additionally, advertisements were posted on the researchers' social media sites (see appendices for the advertising material).

Participants with a current or past eating disorder, diabetes or food allergy were excluded. In addition, participants who were uncomfortable with viewing images of people only wearing underwear or swimwear were asked not to take part in the study. Those who disliked the snacks that might be presented (or, would have had health concerns eating them) were also asked not to take part in the study.

The mean age was 20.5 (*SD* = 3.1), with an age range of 18-38. Groups were comparable in demographic and eating-related characteristics (i.e., age, weight, height, BMI, current attempts of dieting, and history of dieting; see Table 2). A one-way ANOVA showed that there was no significant difference between the groups in age (F(2,116)=.813, *p*=.446), weight (F(2,102)=.296, *p*=.745), height (F(2,115)=.035, *p*=.996) and BMI (F(2,102)=.316, *p*=.730). Chi-square tests of independence showed that there were no significant associations of groups with current attempts of dieting (X^2 (2, N = 119) = 1.498, p = .473) and history of dieting (X^2 (2, N = 119) = .196, p = .907). Randomisation to groups was therefore successful.

Individuals taking part in the study were compensated with participant credits for their time or £5. All participants gave informed consent in accordance with the guidelines set by the Ethics Sub-committee in the Department of Psychology at Durham University, which approved the study.

Table 2

Demographic and eating-related characteristics of participants in the experimental and control groups

	Experimental group (*n*=40)	Control group 1 (*n*=39)	Control group 2 (*n*=42)
Age	20.7 (4.3)	20.8 (2.4)	20 (2.0)
Weight (kg)	65.2 (11)	65.4 (14.2)	63.4 (10.2)

Height (m)	1.7 (0.1)	1.7 (0.1)	1.7 (0.1)
BMI	22 (2.7)	22 (4)	22 (2.4)
Dieting	9	12	9
History of dieting	24	24	26

Note. Mean age, weight, height, BMI (standard deviation (SD)), and number of participants who were on diets or had dieting attempts in the past

2.2.5. Materials

Pictorial stimuli

Pictures for the sexual reward task consisted of 128 images of clothing models in total. These pictures were retrieved from underwear brand websites and other clothing websites. Only pictures were used on which the brand names were not visible, so as not to influence participants with branding information. Pictures were presented in pairs of one female and one male model of the same category (underwear or workwear). 32 pairs were models in underwear and 32 sets were models in workwear. 16 pairs of each category were presented in the first and second phase of the task, respectively, with the order of pictures presented in a fully randomised order. For 32 pairs the left image showed a male model, and for the other 32 sets the right image showed a male model. During the viewing phase of the task, participants were able to change picture size by pulling a joystick, with the degree of pulling being proportionate to the size of the image (10% to 100% in increments of 10%, with 10% reflecting a minimum picture size of 140 x 105 pixels and 100% reflecting a maximum picture size of 1400 x 1050 pixels). The smallest picture had a visual angle of 3.5 x 2.6 degree, and the largest picture had a visual angle of 32.1 x 24.8 degree.

Multiple-choice arithmetic problems

In each phase of the task (first and second), there were 16 multiple-choice arithmetic problems consisting of four integers (e.g., 8*3+14-5= A.32 B.33 C.34 D.35) and thus 32 problems in total.

There were four choice options in each problem-solving trial, with only one option displaying the correct answer. The font was Tahoma, with font size 22 pt., and the colour in RGB was 255, 255, 255.

Questionnaires (see appendices)

(1) A paper-and-pencil question with a scale from 1-7 (anchors, 1 = not at all, 7 = very much) asked participants to rate their current hunger.

(2) A general information questionnaire included basic demographic information, such as age, sex, height, and weight. In addition, information related to general eating behaviour, including current diet and history of dieting, was included. When and what they ate before the study was also assessed.

(3) A questionnaire assessed participants' general sensitivity towards different rewards. Their reward sensitivity towards food, money and sex was measured on a scale of 1-7 (anchors) (e.g., "Do you find food rewarding?"). The meaning of "rewarding" was defined to the participants as how much they enjoy, care about, desire and seek something.

(4) A debriefing questionnaire was used to assess different factors that may be related to participants' responses in the computer-based tasks. For all groups, the degree of cheating in the monetary reward task was assessed. This was done by asking the participants how many maths problems they calculated in their head to earn the 10p. For the experimental group only, perceived self-regulation effort was measured (e.g., "How hard was it for you to not snack after having one bite?"), using a scale of 1-7 (1 = not at all, 7 = very hard).

(5) An information sheet and consent form were given prior to the study. A debriefing sheet was also provided to all participants at the end of the study.

2.2.6. Procedure

Participants were asked to abstain from eating for at least 3 hours before participating in the study. Data was collected in a small behavioural laboratory using a PC, a TFT screen and a joystick on a table. The size of the TFT screen was 19 x 12 inches, and the distance between average head position and the screen was 66.04 cm. The joystick was placed in front of participants and on the right side of the plate with the snacks (for the experimental group and control group 1). Contextual cues were added to the setting to increase subjects' readiness to engage in reward behaviour, including dimmed lighting (Biswas, Szocs, Chacko & Wansink, 2017) and a "star lamp", as well as decorative accessories on the table (see Figure 2). Participants were asked upon arrival to complete a consent form and a questionnaire to assess their level of hunger. The experiment was then split into three blocks:

Figure 2

Images of study set-up

Figure 2.1. The details of the contextual cues

Figure 2.2. The actual study set-up (with dimmed lighting)

First Block – Snacking manipulations

Only the experimental group and control group 1 were subjected to this phase, not control group 2. Participants were presented with unopened and similarly sized packets of four different types of snacks: Ready Salted Walkers Crisps (25g), Butterkist Sweet & Salted Popcorn (12g), Butterkist Sweet Popcorn (12g) and Butterkist Toffee Popcorn (20g). Participants were asked to choose which they wanted, and three bags of the chosen snack were opened in front of participants. Participants were allowed to sample one piece of their chosen snack before starting the computer-based tasks. Food was placed on a paper plate in front of the computer keyboard and to the left of the joystick. Both sexual and monetary reward tasks (i.e., second phase) were preceded by different instructions regarding the snacks presented, i.e., either to refrain from eating (experimental group), consume ad libitum during "snack breaks" (control group 1) or no instruction (control group 2). In both computer tasks we interspersed "break" screens after six consecutive trials, in which participants were reminded of these instructions (for the experimental group: "Break - Please remember NOT to eat the snacks!", for control group 1: "Break – Please help yourself to the snacks!"). Before the computer tasks, participants were also instructed not to move the plate, keyboard, or joystick while performing the tasks. To minimise the effects of social norms on eating, participants were left by themselves in the room while performing the tasks.

Second Block – Sexual and monetary reward tasks

All groups performed two computer-based tasks assumed to measure sexual and monetary reward processes, in randomised order. Each task consisted of two phases, with the first phase measuring reward responses without any self-regulation instruction given to the participants and the second phase measuring reward responses after explicitly instructing participants to control their behavioural responses:

(2a) Sexual reward task: In the first phase (32 trials), participants were instructed to freely view images of models in underwear and models in workwear and allowed to change the image sizes with the joystick, before rating them on a visual analogue scale afterwards. Participants were free to decide to end the picture viewing period at any time by pressing a button on the joystick, which then triggered the presentation of a visual analogue scale. The visual analogue scale was presented with the question "How attractive is the person you have selected?", with font size 24 pt. The size of the scale was 800 x 50 pixels, and the colour in RGB was 150, 150, 150. The right edge of the scale had the words "Very attractive", and the left edge said "Not at all", with 20 pt. font. The cursor had a size of 8 x 8 pixels and the colour in RGB was 0, 0, 0. Before the second block (containing 32 trials), a screen was presented which explicitly instructed participants to control themselves and to not spend more time looking at the underwear images than the workwear images. The regulation message was "Try to spend the same amount of time on each picture category (underwear and workwear pictures)! It is IMPORTANT that you control yourself and do NOT spend more time looking at the underwear pictures than the workwear pictures!". This message was repeated after 16 trials had elapsed in the second phase/block.

(2b) Monetary reward task: In the first phase (16 trials), participants were simply instructed to guess the answers to arithmetic problems based on their intuition (Wu et al., 2019), after which they gained 10p or lost 5p, depending on whether their answers were correct or incorrect. The instruction shown on the screen was "You will be presented with a set of different maths problems. Your task in this part of the study is to rely on your intuition and guess the correct answer. FOR EVERY CORRECT ANSWER YOU WILL EARN REAL MONEY (10p), and for every wrong response you will lose 5p". Each arithmetic problem was presented on the screen until a response occurred (see Figure 3). Participants were also asked to keep track of their earnings on the feedback screen so that they could be paid accordingly. The feedback screen was presented for 3 seconds. For the positive feedback, the

"smile" Unicode character (font = "J" in Wingdings; font size = 150; font colour in RGB = 0, 255, 0) and the words "Correct – Well done!" (font = Tahoma; font size = 40; font colour in RGB = 0, 255, 0) appeared. The negative feedback screen included the "frown" Unicode character (font = "L" in Wingdings; font size, 150; font colour in RGB = 140, 0, 0) and the word "Incorrect!" (font = Tahoma; font size = 40; font colour in RGB = 140, 0, 0). On both the positive and the negative feedback screens, the total earnings were displayed in pounds (£) with a font size of 45 pt. Before the second phase (16 trials), they were explicitly instructed to not spend time calculating and trying to work out the solution to the maths problems in order to earn 10p. Similar to the sexual reward task, this message was repeated after 16 trials after the start of the second block. Peripheral response keys on the keyboard (1, 2, 9, 0) were used to choose an answer among the four presented solutions. These response keys could be easily reached with both hands without touching the plate of the food in the middle.

Third Block – Questionnaires/debriefing

A compliance check to confirm that participants in the experimental group had successfully refrained from eating during the tasks. This was done by asking the participants if they had eaten any snacks, and also checking whether food had been taken from the plate visibly. Subsequently, participants in the experimental group were allowed to consume snacks while filling in questionnaires. Participants in the other two groups were also allowed to snack during the third phase. Participants were then asked to complete all questionnaires detailed above. After completing the questionnaires, participants were paid their earnings from the monetary reward task, and they were given a debriefing sheet. The total amount of snacks that each participant had eaten was measured in grams with a Salter kitchen scale after the participant left the room.

2.3. Results

2.3.1. Confirmatory analyses

The first confirmatory analysis consisted of a 3 (group) x 2 (reward domain) x 2 (self-regulation of second reward) mixed ANOVA on the primary outcome measure with one between-subject factor and two within-subject factors, testing for main effects and two- and three-way interactions. All outcome measures were z-standardised (based on the averages across all participants within a given task) to yield a "reward response index" affording comparability between the two tasks. For the picture perception task, the z-transformed differences between response times to underwear and workwear models were used.

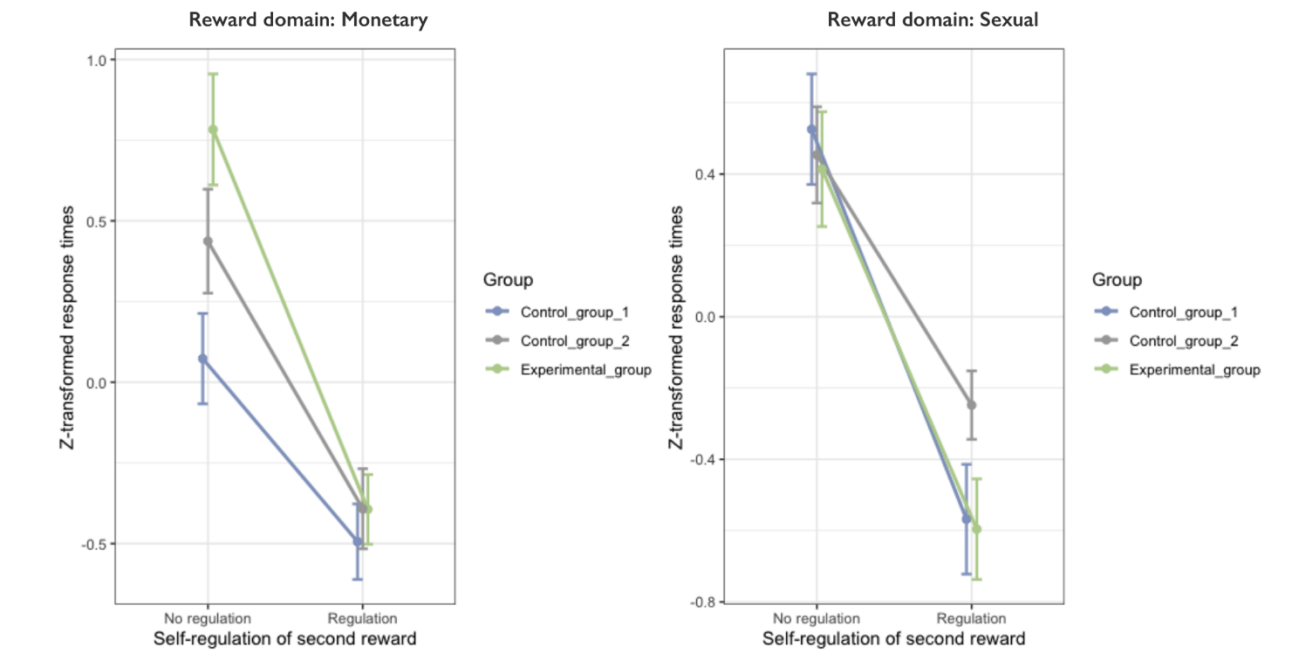
There was no main effect of reward domain, $F(1,116) = .003$, $p = .960$, $\eta_p^2 = .000$, and no two-way interaction between reward domain and group, $F(2,116) = 2.101$, $p = .127$, $\eta_p^2 = .035$.

We found a significant main effect of self-regulation of second reward, $F(1,116) = 197.485$, $p < .01$, $\eta_p^2 = .63$, showing a large effect size. As indicated in Figure 3, in both tasks the regulation instruction in the second half of the task led to a strong reduction in response times (i.e., in the times participants used to solve the Maths problem or the time participants spent viewing underwear models). No interaction effect between self-regulation of second reward and group was found, $F(2,116) = 2.479$, $p = .088$, $\eta_p^2 = .041$.

There was no interaction effect of reward domain and self-regulation of second reward, $F(1,116) = .349$, $p = .556$, $\eta_p^2 = .003$. We found a statistical trend towards a three-way interaction between reward domain, self-regulation of second reward and group, $F(2,116) = 2.896$, $p = .059$, $\eta_p^2 = .048$, showing a small-to-medium effect size. We did not find a significant between-subjects effect of group, $F(2,116) = 1.560$, $p = .208$, $\eta_p^2 = .027$.

Figure 3

The mean of z-transformed values in no regulation and regulation phases according to groups



Note. Error bars represent the standard errors.

The statistical trend for a significant three-way interaction between the reward domain, the self-regulation of second reward and the group warranted further analysis.

As a follow-up, mixed ANOVAs within each reward domain (self-regulation of second reward x group) were conducted on the z-transformed response times to compare response/viewing times in the no regulation and regulation phases between the experimental, the first control and the second control groups.

1) Reward domain: Monetary

Table 3

Mean (z-values) and SD for RT

Regulation of 2nd reward	No-regulation			Regulation		
Group	Experimental	Control 1	Control 2	Experimental	Control 1	Control 2
Mean	0.813	0.041	0.437	-0.386	-0.526	-0.392
(SD)	(1.076)	(0.876)	(1.044)	(0.666)	(0.736)	(0.802)

A follow-up 3 (group) x 2 (self-regulation of second reward) mixed ANOVA in the monetary task revealed a significant main effect of self-regulation of second (monetary) reward, $F(1,118) = 178.144$, $p < .01$, $\eta_p^2 = .602$, showing a large effect size and substantially increased response times in the no regulation condition. We also found a significant two-way interaction between self-regulation of monetary reward and group, $F(2,118) = 7.870$, $p < .01$, $\eta_p^2 = .118$, showing a medium to large effect size. Significant between-subject effects of group were found, $F(2,118) = 3.181$, $p = .045$, $\eta_p^2 = .051$, showing a small to medium effect size. Bonferroni post-hoc tests revealed that, when self-regulation of second reward was not required, there was a significant difference between the experimental and the first control groups, $p = .002$, $d = .354$, with a small-to-medium effect size and increased response times in the experimental group. No significant differences between the experimental and the second control group were found, nor between the two control groups when self-regulation of second reward was not required. We did not find any differences between all three groups when self-regulation of second reward was required. When comparing no-regulation and regulation phases for the three groups separately, significant differences were found with all the possible comparisons at $p < .01$. Effect size of the difference between no-regulation and regulation phases in the experimental group was large, $d = .8$, while other effect sizes were small to medium.

2) Reward domain: Sexual

Table 4

Mean (z-values) and SD for RT

Regulation of 2nd reward	No-regulation			Regulation		
Group	Experimental	Control 1	Control 2	Experimental	Control 1	Control 2
Mean	0.414	0.526	0.454	-0.596	-0.568	-0.248
(SD)	(1.008)	(0.957)	(0.875)	(0.878)	(0.950)	(0.622)

Another follow-up mixed ANOVA for the sexual reward task also showed a significant main effect of self-regulation of second (sexual) reward, F(1,116) = 70.695, $p < .01$, $\eta_p^2 = .379$, showing a large effect and increased viewing times in the no-regulation condition. However, there was no two-way interaction between self-regulation of sexual reward and group, F(2,116) = 1.171, $p = .314$, $\eta_p^2 = .020$. No between-subject effects of group was found, F(2,116) = .936, $p = .395$, $\eta_p^2 = .016$.

2.3.1. Secondary analyses

1) Accuracy in the monetary reward task

A 3 (group) x 2 (self-regulation of second reward) mixed ANOVA was carried out to analyse accuracy in the monetary reward task.

Table 5

Mean (%) and SD for accuracy

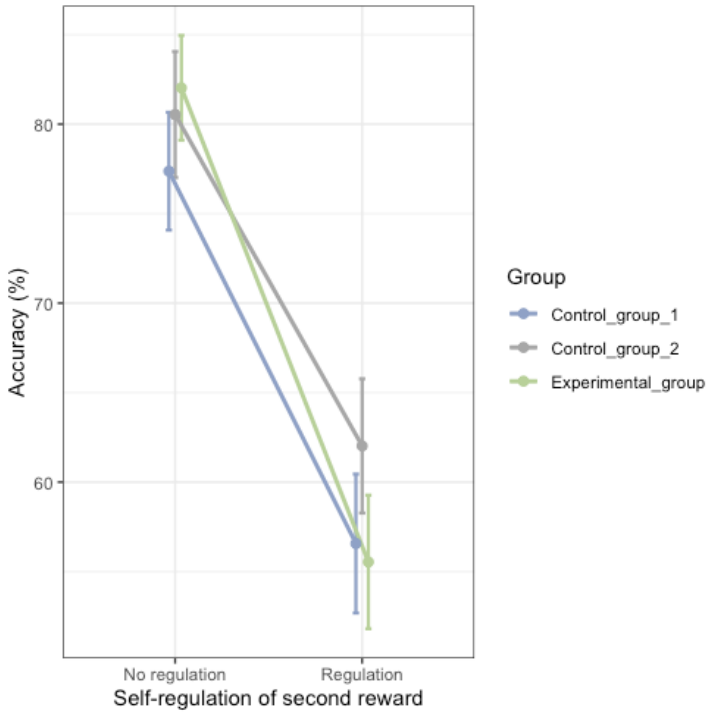
Regulation of 2nd reward	No-regulation			Regulation		
Group	Experimental	Control 1	Control 2	Experimental	Control 1	Control 2
Mean	82.031	77.372	80.536	55.542	56.571	62.024
(SD)	(18.518)	(20.555)	(22.793)	(23.616)	(24.204)	(24.273)

There was a significant main effect of self-regulation of monetary reward, F(1,118) = 127.541, $p < .01$, $\eta_p^2 = .519$, showing a large effect. Accuracy of the maths problems was significantly reduced with the regulation instruction in the second half of the task as indicated in Figure 4. However, we did not find an interaction between self-regulation of monetary reward and group, F(2,118) = 1.504,

p = .226, η_p^2 = .025. There was no between subject effect of group, F(2,118) = .488, p = .615, η_p^2 = .008.

Figure 4

The mean of accuracy (%) in no regulation and regulation phases according to groups



Note. Error bars represent the standard errors.

2) Largest picture size in the sexual reward task

Another secondary analysis of sexual reward task consisting of a 3 (group) x 2 (self-regulation of second reward) x 2 (category) mixed ANOVA was carried out to analyse how much participants had increased pictures in the sexual reward task during the viewing epoch. ANOVA using maximum picture sizes showed no main effect of self-regulation of second reward, F(1,116) = 1.698, p = .195, η_p^2 = .014, and no two-way interaction between self-regulation of second reward and group, F(2,116) = 1.147, p = .321, η_p^2 = .019. No main effect of category was found, F(1,116) = 1.669, p = .199, η_p^2

= .014, and we did not find any interaction between category and group, F(2,116) = 1.423, p = .245, η_p^2 = .024.

There was a significant two-way interaction between the self-regulation of second reward and category, F(1,116) = 8.738, p = .004, η_p^2 = .070, showing a small-to-medium effect size. Bonferroni post-hoc tests revealed that, there was only a significant difference between no regulation and regulation phases in the control picture category (p = .038). No three-way interaction between self-regulation of second reward, category and group was found, F(2,116) = 1.171, p = .314, η_p^2 = .020.

2.3.2. Complementary analyses

Two-factor ANOVAs within each group (reward domain x self-regulation of second reward) for the primary outcome measure were run as complementary analyses.

There was no main effect of reward domain in the experimental group, F(1,38) = 2.407, p = .129, η_p^2 = .06. We found a significant main effect of self-regulation of second reward, F(1,38) = 79.999, p < .01, η_p^2 = .678, with a large effect size. There was no two-way interaction between reward domain and self-regulation of second task, F(1,38) = .357, p = .553, η_p^2 = .009.

We also tested two-factor ANOVA for the first control group, and found no main effect of reward domain, F(1,38) = .707, p = .406, η_p^2 = .018. There was a significant effect of self-regulation of second reward, F(1,38) = 64.365, p < .01, η_p^2 = .629, showing a large effect size. We did not find a two-way interaction between reward domain and self-regulation of second task, F(1,38) = 6.570, p = .014, η_p^2 = .147.

No main effect of reward domain was found within the second control group, F(1,41) = .315, p = .578, η_p^2 = .008. There was a significant main effect of self-regulation of second reward, F(1,41) =

52.691, $p < .01$, $\eta_p^2 = .562$, showing a large effect size. There was no two-way interaction between reward domain and self-regulation of second reward, $F(1,41) = .394$, $p = .534$, $\eta_p^2 = .01$.

2.4. Discussion

The findings showed that in the monetary reward task, participants who were asked to refrain from eating (i.e., the experimental group) showed significantly increased monetary reward responses (longer response times to select the correct answer, i.e., more "cheating") in the non-regulation phase in comparison to the control group which was allowed to eat as many snacks as they wanted. This increased response to the monetary reward among the experimental group was not evident in the second phase, when self-control was required. Participants in all three groups displayed shorter response times (less "cheating") in the second regulation phase in comparison to the first phase where no regulation was required.

Therefore, our study appears to support the process model (Inzlicht & Schmeichel, 2012) and not the strength model (Baumeister et al., 1998). The strength model (Baumeister et al., 1998), which assumes limited resource of self-control cannot explain the results. In order to be compatible with the model, participants in the experimental group should have shown greater reward responses than those in the control group, regardless of whether or not regulation was required. In addition, according to the strength model, the degree of depletion should have also been influenced by how long participants were exposed to the situation in which self-control was needed. Hence, participants in the experimental group should have shown even higher reward responses (more cheating) in the second phase, even with the regulation required.

On the other hand, the process model of self-control highlights a motivational shift from 'have-to' to 'want-to' (Inzlicht & Schmeichel, 2012). This shift can be seen in the first phase of the experiment

which contained no regulation instruction: Participants in the experimental group showed prolonged response times in the monetary task, which can be interpreted to reflect an increased propensity to earn the monetary reward by calculating the answer rather than being 'honest' and merely guessing it. The fact that this effect occurred simultaneously (i.e., early on in the task and not only after prolonged 'depletion') could be explained by "reward compensation", in which missing out on one reward leads to the desire to have another reward for compensation. Participants in the experimental group spent significantly more time carefully calculating the answers than those in the control group. However, when regulation was required in the second phase of the task, participants in all groups showed faster and comparable response times (i.e., less 'cheating' to earn the monetary reward). This can be interpreted as a shift back to 'have-to' motivation in all groups. This study showed that participants' self-control ability was still intact, as when participants were instructed to use control, they could do so. This study successfully disentangled the ability to exert self-control in the second phase from the consumption measure. Reduced self-control in the first phase was just an expression rather than the ability to exercise self-control.

This pattern of two phases being significantly different for the experimental group was not found in the analysis of accuracy data (number of correct responses). We assume that this is because we had deliberately made the arithmetic problems much easier than the ones in the original study by Wu et al. (2019). Nevertheless, the fact that the experimental group spent longer on each item in the no-regulation phase still strongly indicates an increased desire to get the answer right and obtain a monetary reward.

The present results in the monetary reward task do not demonstrate an 'inhibitory spillover' effect in which an improvement of self-control in a second task is exhibited when participants are asked to engage in two self-control tasks simultaneously (Tuk et al., 2015). The difference between the

present study and that by Tuk et al. (2015) is that the present study used rewards in both tasks and that there had been two phases, one which required regulation and one which did not. These differences could have led to the absence of an 'inhibitory spillover' effect.

Results in the sexual reward task were not as clear as in the monetary task. The first (non-regulation) phase of the sexual reward task did not lead participants in the experimental group to show increased reward responses (prolonged viewing times) compared to the control group. This can be interpreted in different ways. One possible explanation is the different nature/type of the rewards used in this task. Rewards are often classified into primary and secondary rewards. Primary rewards include food, sex, and shelter, which can all be described as necessities for homeostasis and reproduction, while secondary rewards, such as money and power, are only indirectly related to one's survival (Sescousse, Caldú, Segura, & Dreher, 2013). It could be that primary rewards are not subject to the same motivational mechanisms as secondary rewards.

Alternatively, we considered the possibility that the diverging effects of food-related self-regulation on monetary versus sexual reward responses found in our study can be explained by conceptual distinctions between "materialistic" (e.g., money, luxury products) and "non-materialistic" (e.g., viewing sexually attractive models, entertainment, aesthetically appealing content) rewards. In other words, it might have been the case that there is an impact of food reward manipulation only on "materialistic" rewards but not on "non-materialistic" rewards. We examined this possibility in the second study.

Another potential way of explaining the different pattern of results for food-erotic rewards found in the current study is that the images used in our study might not have been enough to elicit sexual reward responses (in the sense of enjoyment when viewing erotic stimuli). We used images of underwear and swimwear models retrieved from commercial websites. Most studies studying

responses to erotic stimuli have used images of nude models (Lee, Jeong, Choi, & Kim, 2015; Moulier et al., 2006; Sabatinelli, Bradley, Lang, Costa, & Versace, 2007; Sescousse, Redouté, & Dreher, 2010). One such study divided stimuli into high- and low-intensity images, and underwear model images such as those we used were classified as low-intensity images (Sescousse et al., 2010). The use of low-intensity erotic images may thus explain the lack of effects in the present study.

Strengths and limitations

When the criticism is heavily placed on the dominant use of a single paradigm (i.e., lab-based sequential tasks in a between-subject design) in ego depletion studies (Lin et al., 2020), the use of concomitant tasks and differentiation of phases (non-regulation phase and regulation phase) is one of the very prominent strengths of this study, which also enabled us to provide direct supporting evidence to the process model and ego depletion. In addition, we included rewards in both tasks, which also distinguished it from most ego depletion studies and Tuk et al. (2015), as rewards play a pivotal role in the self-control process (Bergen et al., 2012; Crescioni et al., 2011; Hernandez & DiClemente, 1992). These components allowed us to demonstrate the direct motivational shift by comparing the regulation (=no motivational shift) and non-regulation (=motivational shift) conditions. Adapting a different method also allowed us to obtain a larger effect size than obtained in Tuk et al. (2015).

However, this study demonstrated ego depletion effect and motivational shift in the impact of self-control of food reward in monetary reward responses, but not in the impact of self-control of food reward in sexual reward. We were able to conjecture the underlying reasons for the different results found, but these were not demonstrated in the current study. Further study to disentangle the problem is needed.

Implications and future direction

By developing a new paradigm of ego depletion study, this study provides evidence which supports the process model (Inzlicht & Schmeichel, 2012) and disputes the strength model (Baumeister et al., 1998), rather than indirectly supporting the process model by disputing the strength model.

Taking the criticisms about ego depletion having a very small effect size into account, reaching a medium effect size shows that the ego depletion effect is not something that can be completely denied. Beyond supporting the process model (Inzlicht & Schmeichel, 2012) and the diminished expression of self-control, this study also points out the importance of adopting a new paradigm to surmount the controversy over ego depletion and the mechanism underlying self-control failures.

These implications will be further strengthened by carefully and systematically examining the relationship between the different rewards and validating tasks which examine the reward domains that should be sensitively dealt with, such as sexual reward, particularly in lab conditions.

2.5. Conclusions

Regardless of the limitations identified, our study contributes to an emerging perspective - rather than completely denying the phenomenon - which describes ego depletion differently (Kelley, Finley, & Schmeichel, 2019). Our study demonstrates the importance of reward in the ego depletion paradigm. As pointed out in the introduction, the use of reward-related tasks as both first (manipulation) and second (outcome) task has not been common. We used food temptation as a manipulation task and tasks related to monetary and sexual reward tasks as outcome tasks. This allowed us to demonstrate that self-control in one task can increase reward responses in another task without a depletion of control resources (as evident from reinstated self-control when participants

were instructed to do so). This can instead be explained by a compensatory shift in motivation from 'have-to' to 'want-to'.

Similarly to the present study, Tuk et al. (2015) studied ego depletion in a simultaneous setting and found that resources of self-control were not limited. Tuk and colleagues showed that participants who were depleted did not show diminished self-control capacity in the other simultaneously presented tasks (i.e., thereby disputing the strength model proposed by Baumeister et al., 2007). However, their study was unable to directly show a motivational shift from 'have-to' to 'want-to'. In contrast, our study showed that participants in the experimental group (i.e., 'depleted' group) were unimpaired in their self-control capacity when being asked to refrain from snacking but showed a shift in motivation (to the other available reward) when no such self-control requirement was imposed.

Study 2

3.1. Overview

3.1.1. Study rationale and aims

The study examined whether self-regulating responses to an available reward in one domain (1st reward) alters responses to an available reward in another domain (2nd reward), using imagined vignette-based reward scenarios in an experimental online study. This research was built on Study 1 which was a laboratory-based experimental study. The key research findings in Study 1 which informed the current study were as follows: (1) Self-regulation of food intake increased responses to simultaneously available monetary rewards. (2) Similar effects were not found for responses to pictures of sexually attractive models (sexual reward).

Regarding the findings stated above, this study tried to disentangle the diverging effects of exerting self-control to regulate food reward responses on monetary and sexual rewards by distinguishing such rewards in "materialistic" (e.g., money, luxury products) and "non-materialistic" (e.g., looking at sexually attractive models, entertainment, aesthetic reward) rewards. Hence, the aims were to: (a) replicate the finding that controlling one's responses to food increases responses to available money; (b) see whether there was the reverse effect (of controlling one's responses to money that increases responses to food reward); and (c) examine the interactions between food reward and non-materialistic rewards other than sexual reward. For the non-materialistic rewards, we included entertainment material such as books, movies, and social media based on a pre-study (in which we asked a group of participants how appealing the items were, see below for details) and also based on recent studies showing that such stimuli were associated with the reward system (e.g., Social media - Sherman, Lauren, Hernandez, & Dapretto, 2018; Video clips from YouTube - Tong, Acikalin, Genevsky, Shiv, & Knutson, 2020).

To meet these aims, a vignette-based experimental online paradigm was developed. A vignette is a concise, but carefully constructed and systematically combined description pertaining to a person, object, or situation (Atzmüller & Steiner, 2010). In a vignette-based study, participants' beliefs, attitudes, or judgments about scenarios are naturally elicited rather than explicitly asked. By systematically combining or varying the descriptions, such a study allows for an experimental design. The combining of the methodology of a traditional survey and an experiment enables researchers to address each method's problems. Survey methodology has a high external validity with its representativeness, while its internal validity is considered to be low due to the measured variables' multicollinearity (Atzmüller & Steiner, 2010). On the other hand, the classical experiments have low external validity with oversimplified methods and lack of representativeness, yet high internal validity from the orthogonal design plans (Atzmüller & Steiner, 2010). Both high internal and external validities can thus be achieved by using a vignette-based experimental study (Sniderman & Grob, 1996).

The vignette method was also useful as it could be implemented as an online study and thus overcome the limitations of human participating testing resulting from the COVID pandemic. Using such an approach was also novel in the field of ego depletion research. No other ego depletion studies have adopted vignette or online formats so far, with most studies relying on lab-based sequential tasks (Lin et al., 2020). Another advantage of the chosen study design was that it allowed comparing reward-related behaviours (as measures in study 1) with beliefs or attitudes about such behaviours (as measured in study 2). The attitude-behaviour relationship has long been of interest in psychology because of the often observed gap or discrepancy between the two (Eagly & Chaiken, 1993; Kraus, 1995).

3.1.2. Study overview and theoretical predictions

This study features a pre-study and the main study. The pre-study aims were the selection of vignette items (based on whether the items we would use were comparable in terms of the temptation elicited by different rewards) and the selection of non-materialistic reward domain we would focus on. Participants were presented with a number of vignette items which were split into full items. The full items included two components (statements of rewards A and B), and they could be categorised into different 'reward type pairs'. 'Reward type pairs' included the impact of the self-regulation of: (1) food reward on monetary reward responses (Food-Money), (2) monetary reward on food responses (Money-Food), (3) food reward on non-materialistic reward responses (Food-N.M), and (4) non-materialistic reward on food reward responses (N.M-Food). In the pre- and main study, the vignette items asked as to how participants would act in hypothetical situations. The hypothetical situations were presented alongside images which enabled participants to vividly imagine the situations. In these hypothetical situations, the first-person narrative was employed, as the third-person perspective may only gauge presented characters' stereotypes of how they would expect a stereotyped person to respond. Within the main study only, there were two groups. One group of participants was asked to imagine refraining from indulging rewards in reward A, and the other group was asked to imagine being able to freely consume reward A. Following that, their reward responses to reward B were measured by asking how they would react when presented with reward B.

We predicted that if categorising rewards into "materialistic" and "non-materialistic" rewards could explain the difference between monetary and sexual reward in study 1, there would be increased reward responses to reward B for Food-Money and Money-Food pairs, but not in the Food-N.M and N.M-Food pairs.

3.2. Pre-study

3.2.1. Methods

Design

A within-subject design was used. The within-subject manipulation included different '*Rewards*': 1) food, 2) money, and 3) non-materialistic rewards. Food comprised 12 items, money, and non-materialistic reward 6 items each. Hence, the total number of items was 24.

Participants

21 participants were recruited for the pre-study in total, but participants who answered an attention check question incorrectly were excluded. The attention check asked participants to choose 100 from the scale of 0-100 regardless of how they feel towards the scenario, but the attention check questions had the same structure with the other questions at a glance. 14 data were analysed at the end. Recruitment used standard university/departmental channels of advertising research studies (e.g., the "SONA" participant recruitment system). Participants with a current or past eating disorder were excluded, due to the potential adverse consequences of being exposed to food images.
Individuals taking part in the study were compensated with participants' credits. All participants gave informed consent in accordance with the guidelines set by the Ethics Sub-committee in the Department of Psychology at Durham University, which approved the study.

Materials/Procedures

For each item, participants were asked how tempting the scenario was. The plausibility of the described situation and comprehensibility of the items were also assessed. All participants were presented with 24 vignette items (which were bisected from the 12 full vignette items) that can be answered using a visual analogue scale (anchored from 0-100; 0 = not tempting/plausible/comprehensible, 100 = very tempting/plausible/comprehensible). For a summary of the items used, see the below table. The full questionnaire is included in the appendices.

Table 6

Summary of each vignette item used

Reward type pairs	Item no.	Location	First reward statement (a)	Second reward statement (b)
Food-Money			Food	Money
	1.1	Home	Cakes/crisps vs cucumber slices for snacks	Taking wrong amount of money sent by a friend or not
	1.2	Airplane	Business class meal vs water when being on a diet	Donation or not
	1.3	Friend's house	Having dessert or not after big starter and main	Buying stocks impulsively or not
Money-Food			Money	Food
	2.1	Shopping centre	Taking £100 found under a bench or not	Having snacks or not
	2.2	Café	Not telling about a wrong price tag when buying a tumbler	Taking free and unhealthy desserts or not
	2.3	Home	Taking online survey again to get more money or not	Cake/crisps vs cucumber slides for snacks
Food-N.M			Food	Non-materialistic
	3.1	University	Having unhealthy snacks from a vending machine or not	Watching a movie spontaneously or not
	3.2	Home	Having scrumptious snacks vs drinking only water	Spending much time to find out a good movie
	3.3	Home	Having a large and unhealthy brunch or not	Interesting novel vs boring book
N.M-Food			Non-materialistic	Food
	4.1	Home	Watching an entertaining series vs a documentary which is helpful for your assignment	Having a second serving
	4.2	Art gallery	Forcing yourself to go to Roman sculptures exhibition due to the assignment vs going to an interesting exhibition	Ordering only coffee or with cakes/biscuits in the gallery café
	4.3	Home	Forcing yourself not to check social media or checking when you want during the exam season	Having unhealthy but tempting drinks (e.g., milkshake) instead of water

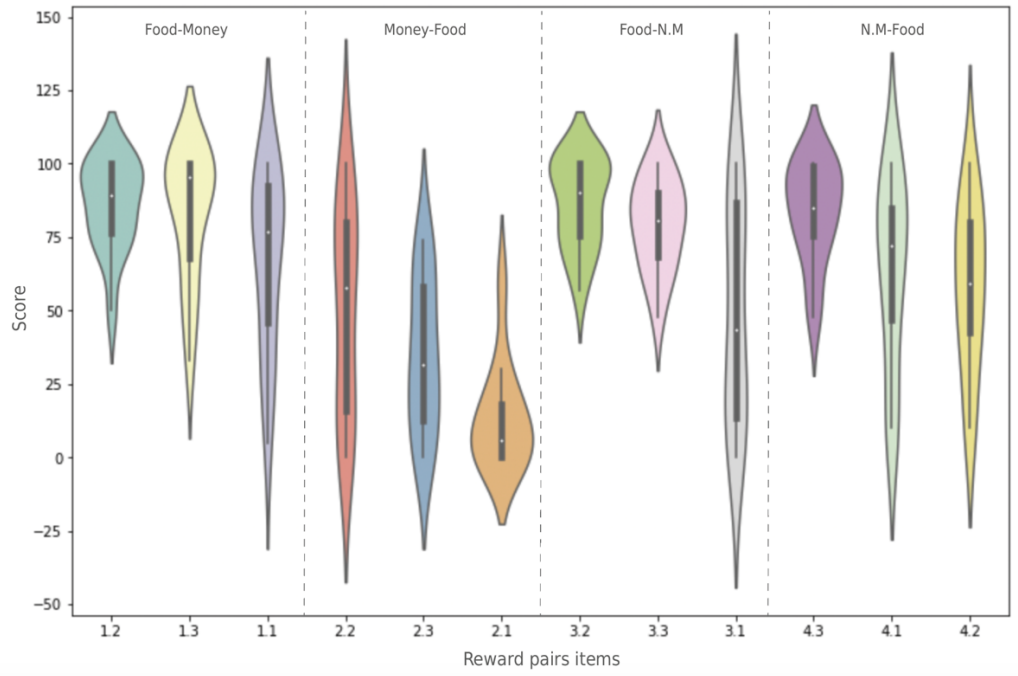
3.2.2. Results and changes made in the main study

Python 3.7.0 was used to generate violin plots showing the order/rank of each item's perceived temptation (see Figure 5 and 6), plausibility (see Figure 7), and comprehensibility (see Figure 8) in reward pair items. Violin plots have features of two methods, which are boxplot and Kernel Density Estimation (KDE). The dots in the plot refer to the mean, and the lines to the mean interquartile range. KDE allows the plots to show the probability density. There can be negative values or values higher than 100 although the scale ranges from 0-100, which are the artefacts of KDE. These do not mean that there were negative or above 100 data, but it means that the data contain values that are very close to negative (i.e., 0) or 100.

The items for the main study were selected mainly based on temptation scores. Regarding the first reward statement, the highest score and the second-highest score in each reward type pair were used.

Figure 5

The order/rank of first reward items' perceived temptation level sorted by rewards pairs



For the second reward statement, the first highest item was always selected. However, sometimes the third-ranked item was chosen instead of the second-ranked item due to the context or potential to become more tempting with some changes. With regard to the food-money pair (1), items 1.3 and 1.1 for the second reward statement (i.e., money) were found to be both not tempting compared to item 1.2 and even compared to the other items in different pairs. We chose to use 1.1 instead, as the item had the potential to become more tempting with a minor change. The subject who "sent a wrong amount of money" was changed from "friend" to "acquaintance", since it would be easier to deceive an acquaintance and take money from them than from a friend. In the money-food pair (2), all items illustrating the food reward were found to be tempting enough. Hence, item 2.3 was kept and 2.2 was chosen instead of 2.1, even though 2.1 was found to be slightly more tempting. This was because 2.2 was more appropriate and natural when this was combined with the first statement (money statement) chosen. Regarding the N.M-food pair (4), 4.3 was chosen to be used, as the item was more appropriate for the context in the first statement, and 4.2 and 4.3 showed not much of a difference.

Figure 6

The order/rank of second reward items' perceived temptation level sorted by rewards pairs

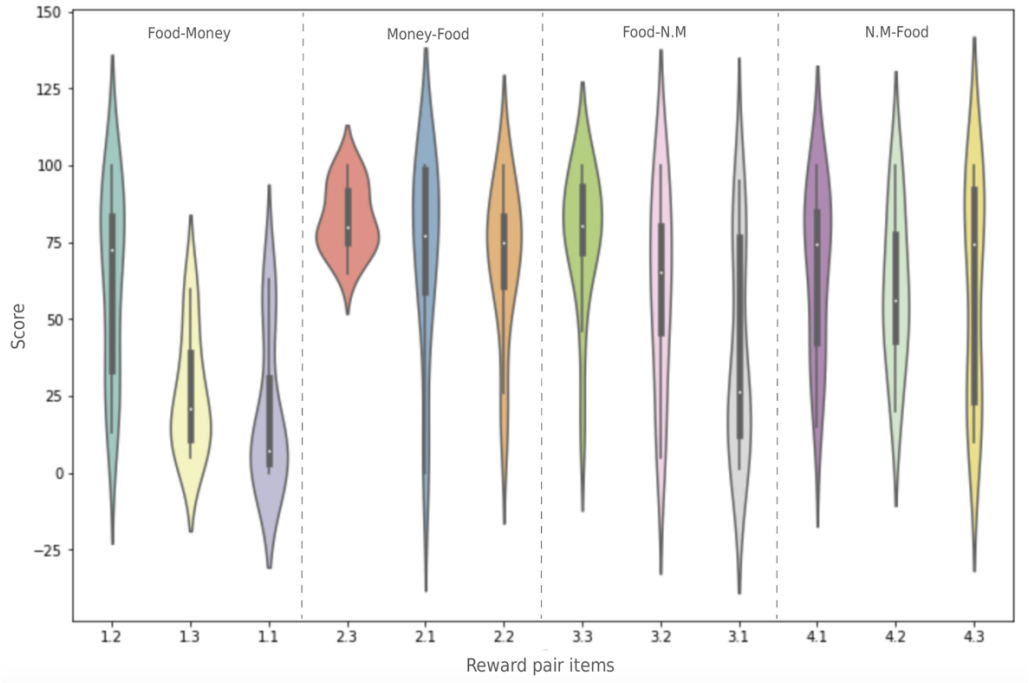
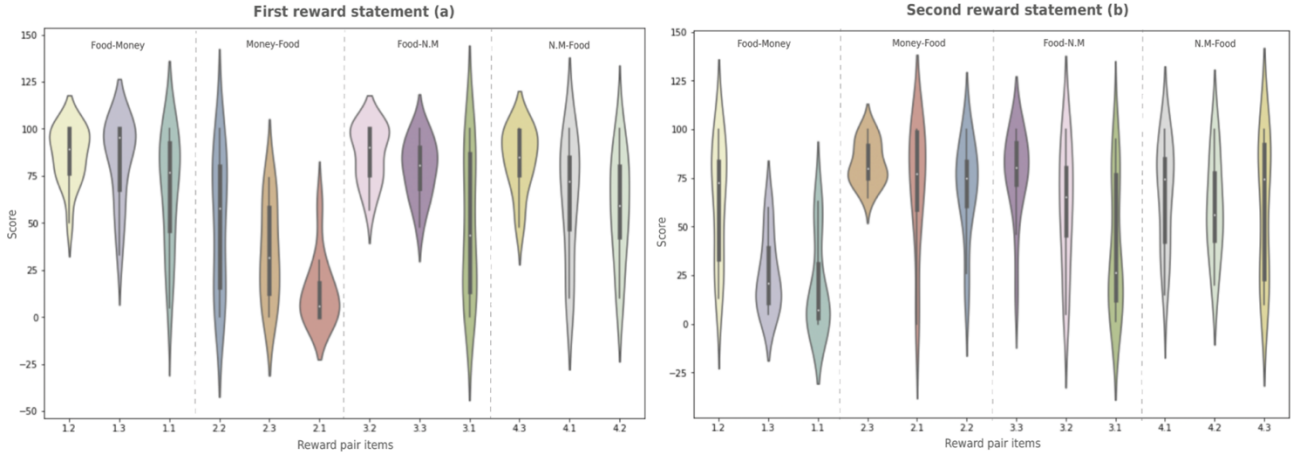


Figure 7

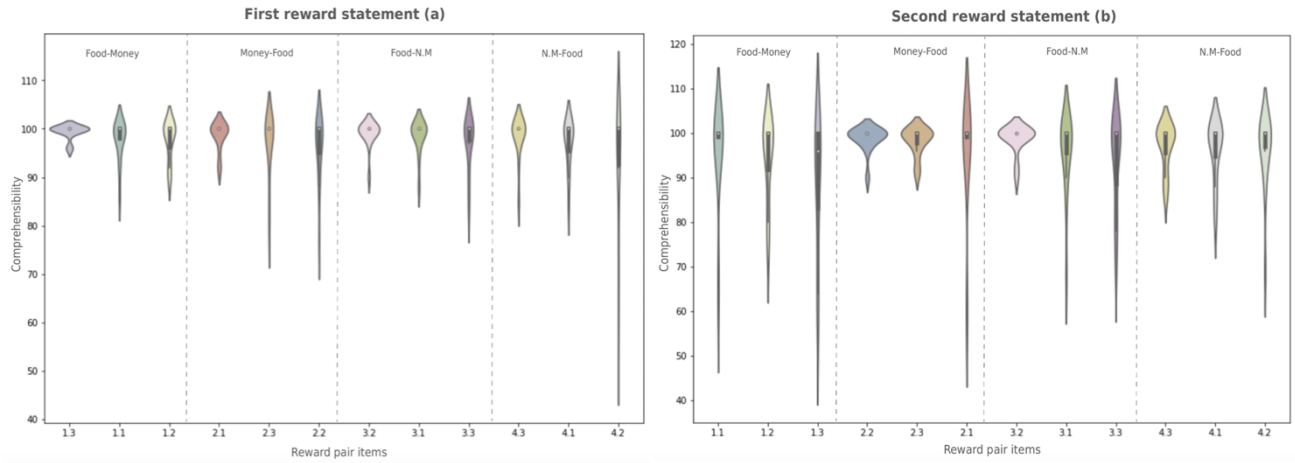
The order/rank of second reward items' perceived plausibility level sorted by rewards pairs



As indicated in Figure 8, participants did not have problems understanding most of the statements.

Figure 8

The order/rank of second reward items' perceived comprehensibility level sorted by rewards pairs



3.3.3. Selected items

Based on the order/rank of items in terms of temptation, the items were selected as shown in Table 7.

A change made is shown in italics.

Table 7

Summary of each vignette item used

Reward type pairs	Item no.	Location	First reward statement (a)	Second reward statement (b)
Food-Money			Food	Money
	1.1	Airplane	Business class meal vs water when being on a diet	Donation or not
	1.2	Friend's house	Having dessert or not after big starter and main	Taking wrong amount of money sent by an *acquaintance* or not
Money-Food			Money	Food
	2.1	Café	Not telling about a wrong price tag when buying a tumbler	Taking free and unhealthy desserts or not
	2.2	Home	Taking online survey again to get more money or not	Cake/crisps vs cucumber slides for snacks
Food-N.M			Food	Non-materialistic

	3.1	Home	Having scrumptious snacks vs drinking only water	Spending much time to find out a good movie
	3.2	Home	Having a large and unhealthy brunch or not	Interesting novel vs boring book
N.M-Food			Non-materialistic	Food
	4.1	Home	Watching an entertaining series vs a documentary which is helpful for your assignment	Having a second serving
	4.2	Home	Forcing yourself not to check social media or checking when you want during the exam season	Having unhealthy but tempting drinks (e.g., milkshake) instead of water

3.3. Main-study Methods

3.3.1. Pre-registration

The second study was preregistered before conducting the study using the AsPredicted platform (https://aspredicted.org/index.php).

3.3.2. Design

A mixed design with one between- and one within-subject factor was used. The between-group factor was (imagined) '*self-regulation of the first reward*', with two levels (1: regulation of first reward [experimental group]; 2: no-regulation of first reward [control group]). The within-subject manipulation included different '*reward type pairs*' with four levels ('*Reward type pairs*' included the impact of the self-regulation of 1: food reward on monetary reward responses; 2: monetary reward on food reward responses; 3: food reward on non-materialistic reward responses, and 4: non-materialistic reward on food reward response).

By using a 'Randomiser' function in Qualtrics, participants were randomly and equally allocated to a group (*self-regulation of the first reward*).

3.3.3. Participants

This study was powered with 99% to be able to detect a medium-size effect (d = .5) at p < .05, and 296 participants were tested. The sample size was determined by a *priori* sample size calculation using G*Power (Faul, Erdfelder, Lang, & Buchner, 2007).

Recruitment used standard university/departmental channels of advertising research studies (e.g., the "SONA" system). Additionally, the researchers' social media accounts were used. Participants with a current or past eating disorder were excluded, due to the potential adverse effect of being exposed to food images.

The mean age was 19 (SD=1.8), with an age range of 17-33. Differences between the experimental and control groups in demographic and other relevant variables will be detailed at the beginning of the Results section (i.e., control analyses).

3.3.4. Materials

Vignette-based items (see appendices)

The study contained 8 vignette items (for the sample see Figure 9) for each group with images that could be answered using a visual analogue scale (anchored from 0-100) pertaining to their temptations and could be divided into four 'reward type pairs' (2 vignette items per pair). The between-subject manipulation was implemented by using two versions of each vignette item, each of which was 100 words long on average. The items in the experimental versus control group differed only in one statement embedded in the vignette. In the experimental group, participants were asked not to consume rewards (e.g., "force yourself to not order anything, and only have a glass of water because you are on a diet"). In contrast, such restraint was not presented to the control group (e.g., "you choose to have a meal").

Figure 9

Sample of a vignette item

Other questionnaires (see appendices)

(1) A general information questionnaire included basic demographic information, such as age, sex, height, and weight. In addition, information related to general eating behaviour, including current diet and history of dieting, was included.

(2) The Brief Self Control (BSC) measure (Tangney et al., 2004) was used to measure participants' ability of self-control. This measure contains 13 items. Each item contains a sentence that illustrates one's tendency or trait in relation to self-control (e.g., "I have a hard time breaking bad habits."), and a 5-point scale ranging from 1 (*Not at all like me*) to 5 (*Very much like me*) was used.

(3) The Food Cravings Questionnaire (FCQ) Trait – reduced (FCQ-T-r) is a part of the most frequently used instruments for measuring one's food cravings, the Food Craving Questionnaire FCQ), which consists of a trait (FCQ-T; 39 items) and state (FCQ-S; 15 items) version. Each FCQ-

T-r questionnaire item has a 6-point scale ranging from *never* to *always*, and an example of the items is “I have no willpower to resist my food crave”.

(4) The Sensitivity to Reward (SR) questionnaire was used in order to assess one’s Behavioural Approach System (BAS; Gray, 1981). BAS refers to a system that is in charge of approach behavior towards rewards and incentives. The short-form by Cooper and Gomez (2008) was used in the study. This contains 24 items and each item asked participants *yes* or *no* questions (e.g., “Do you often do things to be praised?”).

3.3.5. Procedures

Participants could access the vignette-based experimental online study via a web link. The study was set up with “Qualtrics”.

Participants were provided with an information sheet and consent form at the beginning of the study and were required to read through them and indicate that they read and understood the information sheet and consent to participating in the research through selecting checkboxes. Then, they completed the general information questionnaire including basic demographic information. This was followed by the main part of the study which asked participants how likely they are to indulge in a specific reward after imaginarily exerting self-control in response to another reward (experimental group) or not imaginarily exerting self-control (control group). A participant’s answer on a visual analogue scale was recorded as a value between 1 (not at all likely) and 100 (extremely likely). The ‘Randomiser’ function in Qualtrics allowed participants to be exposed to the items in a random order.

After this, participants were asked to complete the BSC, FCQ-T-r, SR questionnaires, as detailed in the former section. These questionnaires were used to rule out any confounding differences in self-control, food craving, and sensitivity towards reward contributing to any possible group effects, also to run exploratory analyses examining the relationships with the results from the main variables.

3.4. Results

3.4.1. Exclusions

From the original sample, all participants who answered both attention check questions incorrectly were excluded. In the end, 170 participants who passed at least one attention check question were analysed.

3.4.2. Control analyses

Groups were comparable in demographic and eating-related characteristics (i.e., age, sex, ethnicity, weight, current attempts of dieting, and history of dieting; Table 8). An one-way ANOVA showed that there was no significant difference between the groups in age ($F(1,168)=.029$, $p=.865$), weight ($F(1,164)=.186$, $p=.666$), and height ($F(1,168)=.000$, $p=.988$). In addition, there were additional questionnaires that were used as control variables, including the BSC (Tangney et al., 2004), the FCQ-T-r (Meule, Hermann, & Kübler, 2014), and the SR (Cooper & Gomez, 2008).

An one-way ANOVA showed that there was no significant difference between the groups in BSC ($F(1,168)=.036$, $p=.851$), FCQ ($F(1,168)=.189$, $p=.664$), SR ($F(1,168)=.282$, $p=.569$). Chi-square tests of independence showed that there were no significant associations of groups with current attempts of dieting (X^2 (1, N = 170) = .607, p = .436) and history of dieting (X^2 (1, N = 170) = .336, p = .563).

Individuals taking part in the study were compensated with participants' credits. All participants gave informed consent in accordance with the guidelines set by the Ethics Sub-committee in the Department of Psychology at Durham University, which approved the study.

Table 8

Demographic and eating-related characteristics of participants in the experimental and control groups

	Experimental group (*n*=88)	Control group 1 (*n*=82)
Age	19 (1.9)	19 (1.7)
Weight (kg)	64 (10.5)	63.2 (11.1)
Height (cm)	158.8 (8.4)	158.7 (7.2)
BMI	25.4 (4.1)	25 (4.1)
BSC	39.8 (5)	39.9 (4.9)
FCQ-T-r	41.7 (11.8)	42.5 (11.7)
SR	5.3 (1.9)	5.1 (2.3)
Dieting	25	19
History of dieting	52	52

Note. Mean age, weight, height, BMI, scores of BSC, FCQ-T-r, SR (standard deviation (SD)), and number of participants who were on diets or had dieting attempts in the past

3.4.3. Confirmatory analyses

To reiterate, 'reward type pairs' included the impact of the self-regulation of: (1) food reward on monetary reward responses (food-money pair), (2) monetary reward on food reward responses (money-food pair), (3) food reward on non-materialistic reward responses (food-N.M pair), and (4) non-materialistic reward on food reward responses (N.M-food pair).

We ran two separate 2-way ANOVAs as stated in the preregistration. One was for reward type pairs 1 and 3 in a 2 (group) x 2 (type of the second reward) ANOVA. The type of first reward for these pairs, which required regulation in the experimental group but not in the control group, was food. We found a significant main effect of type of second reward, $F(1,338) = 414.599$, $p < .01$, $\eta_p^2 = .551$, showing a large effect size. Non-materialistic reward items were rated as having a higher likelihood

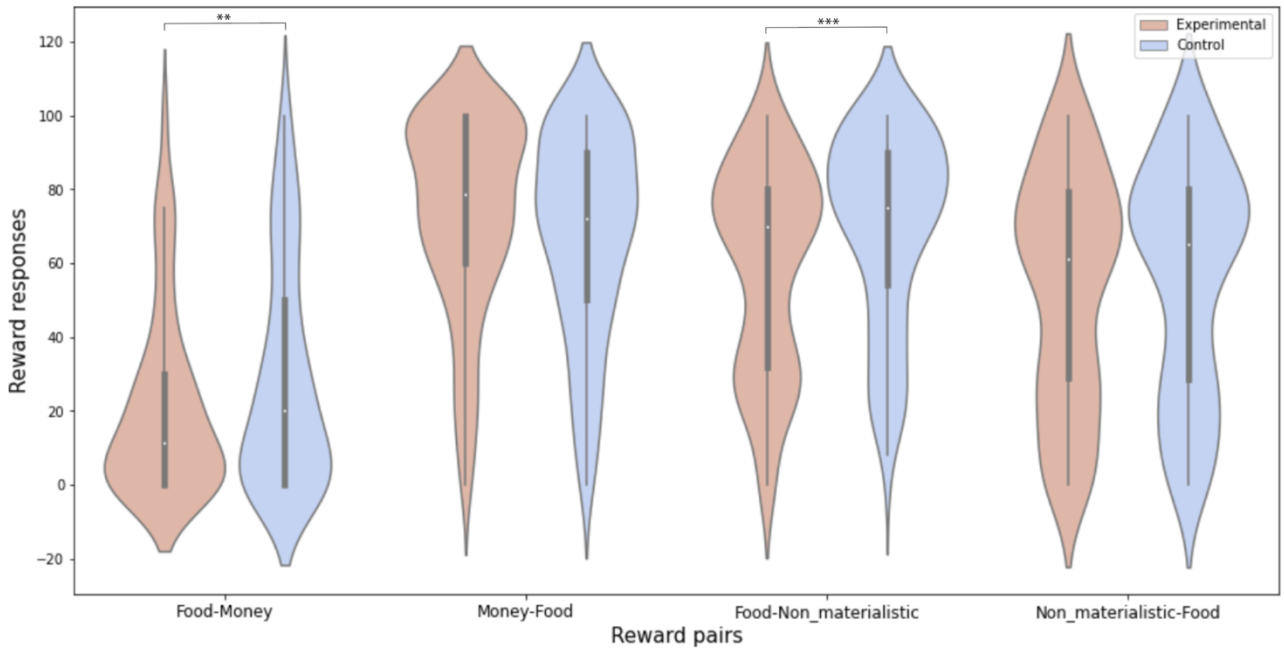
of reward consumption/indulgence than monetary reward items. No interaction effect between the type of second reward and group was found, $F(1,338) = .876$, $p = .35$, $\eta_p^2 = .003$. There was a significant between-subjects effect of group, $F(1,338) = 16.407$, $p < .01$, $\eta_p^2 = .046$, showing a small-to-medium effect size. The control group displayed higher likelihood of reward consumption that those in the experimental group.

The other 2-way ANOVA was for reward type pairs 2 and 4 in a 2 (group) x 2 (type of first reward) ANOVA. The type of the second reward for these pairs were food. There was a significant main effect of type of first reward, $F(1,338) = 54.17$, $p < .01$, $\eta_p^2 = .138$, showing a medium-to-large effect size. Monetary reward items were rated as having a higher likelihood of reward consumption than non-materialistic reward. We found a significant interaction effect between the type of first reward and group, $F(1,338) = 414.599$, $p < .01$, $\eta_p^2 = .551$, showing a medium-to-large effect. We did not find a significant between-subject effects of group, $F(1,338) = .32$, $p = .572$, $\eta_p^2 = .001$.

As post-hoc/follow-up analyses, a one-way ANOVAs were conducted for each reward type pair to test the impact of group on reward responses in each pair (see Figure 10. for the summary).

Figure 10

The means of likelihood to consume the 2nd reward in an imaginary situation (=reward responses) in each pair



Note. Statistical significance is indicated with asterisks (*: 0.01 to 0.05; **: 0.001 to 0.1, ***: 0.0001 to 0.001)

For the (1) food-money reward type pair, a significant main effect of group was found, $F(1,338)=5.889$, $p = .016$, $\eta_p^2 = .017$, showing a small effect size. Participants in the experimental group showed smaller reward responses towards monetary rewards after imagining the exertion of self-control of food rewards, compared to those in the control group.

There was no significant effect of imagined self-control of monetary reward on food reward responses (i.e., (2) money-food reward type pair), $F(1,338) = 3.810$, $p = .052$, $\eta_p^2 = .011$.

A significant main effect of group was found in the (3) food-N.M reward type pair, $F(1,338)=13.898$, $p < .001$, $\eta_p^2 = .039$, showing a small effect size. Similar to the (1) food-money pair, participants in

the experimental group showed smaller reward responses to the second reward, compared to those in the control group.

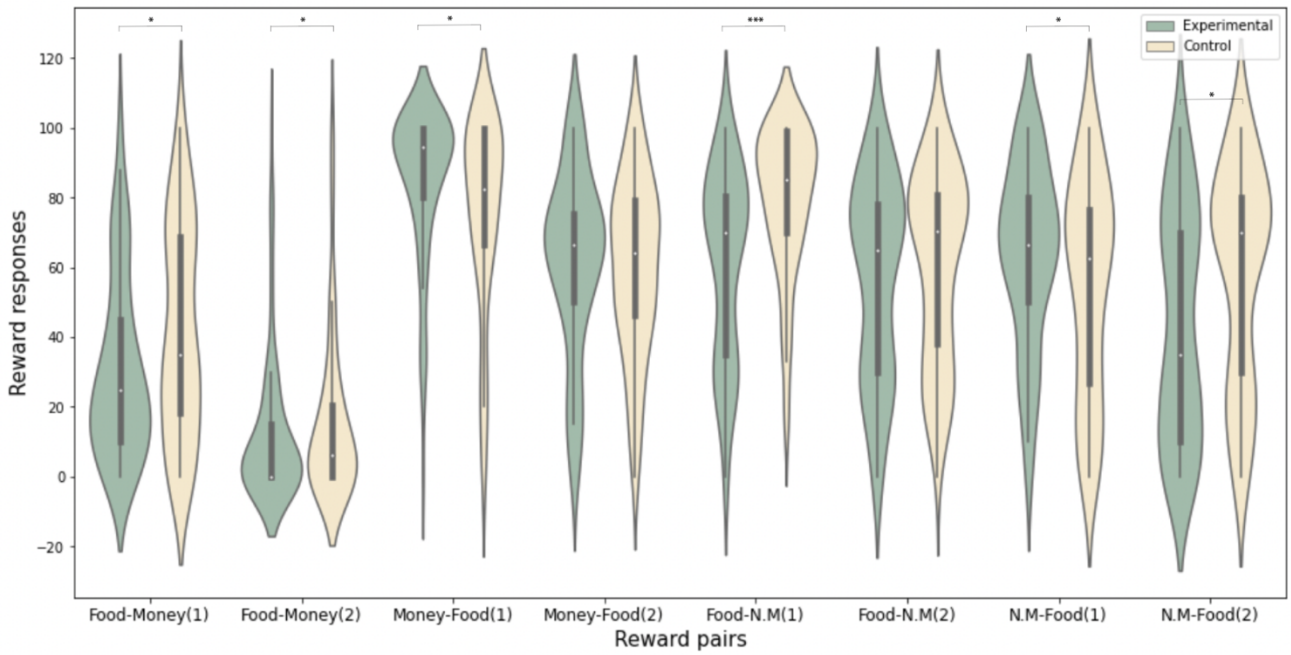
No significant effect was found in the (4) N.M-food reward type pair, F(1,338) = .820, p = .366, η_p^2 = .002.

3.4.4. Exploratory item-specific analyses

There were two items per each pair, and separate ANOVAs were conducted for each item to examine if there were any item-specific effects. For a summary, see Figure 11.

Figure 11

The means of likelihood to consume the 2nd reward in an imaginary situation (=reward responses) in each pair items



Note. Statistical significance is indicated with asterisks (*: 0.01 to 0.05; **: 0.001 to 0.1, ***: 0.0001 to 0.001).

Regarding the food-money reward type pair, responses related to the first item showed a significant difference between the experimental and control group, $F(1,168) = 6.384$, $p = .012$, $\eta_p^2 = .037$, with a small effect size. Stronger reward responses to monetary reward were found for the control group, compared to the experimental group. The same pattern of results was found for the second item, $F(1,168) = 1.141$, $p = .287$, $\eta_p^2 = .007$, showing a small effect size.

For the money-food reward type pair, there was a significant difference between the experimental and control group for the first item, $F(1,168) = 6.079$, $p = .015$, $\eta_p^2 = .035$, showing a small effect size. The experimental group showed stronger reward responses compared to the control group. No significant effect was found for the second item, $F(1,168) = .281$, $p = .597$, $\eta_p^2 = .002$.

Participants in the control group showed stronger reward responses towards non-materialistic rewards, compared to those in the experimental group, although the level of significance between the groups was different. The first item showed a significant result, $F(1,168) = 22.956$, $p < .001$, $\eta_p^2 = .120$, showing a medium to large effect. On the other hand, the second item's difference between groups was not found to be significant, $F(1,168) = .786$, $p = .376$, $\eta_p^2 = .005$.

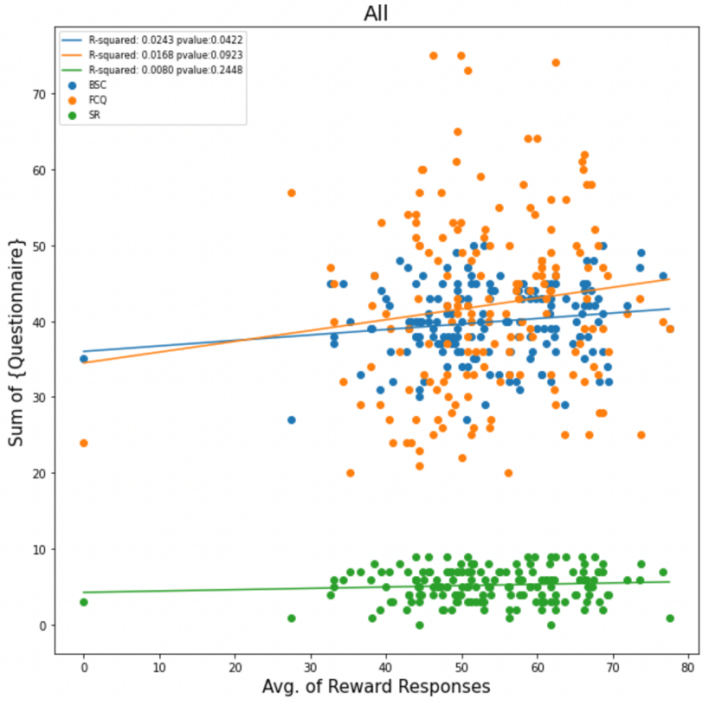
Regarding the N.M-food reward type pair, both items showed significant results in terms of differences between groups. However, the pattern of which group showed stronger reward responses to the second reward (i.e., non-materialistic) was different. For the first item, the control group showed a higher likelihood to consume the second reward than those in the experimental group, $F(1,168) = 4.391$, $p = .038$, $\eta_p^2 = .025$, showing a small effect size. For the second item, the pattern of the experimental group showed stronger reward responses, compared to the control group was found, $F(1,168) = 9.656$, $p = .002$, $\eta_p^2 = .054$, with a medium effect size.

3.4.5. Exploratory analyses – Relationship between reward responses and other constructs

Simple linear regressions were used to examine whether the food cravings, self-control ability, and reward sensitivity could predict reward responses in the vignette paradigm. BSC did not predict reward responses, $F(1,168) = 4.190$, $p < .5$, $R^2 = .024$, nor FCQ-T-r, $F(1,168) = 2.866$, $p = .092$, $R^2 = .017$. The regression coefficients ($B = .337$ and $B = .118$ for BSC and FCQ-T-r) indicated that higher scores in BSC and FCQ-T-r, on average, led to an increase in reward responses of 0.337 and 0.118 scores respectively. SR also did not explain a significant amount of the variance in reward responses, $F(1,168) = 1.362$, $p = .245$, $R^2 = .008$, and the regression coefficient was $B = .454$ (see Figure 12).

Figure 12

Scatterplot of the relationship between reward responses and each questionnaire's score

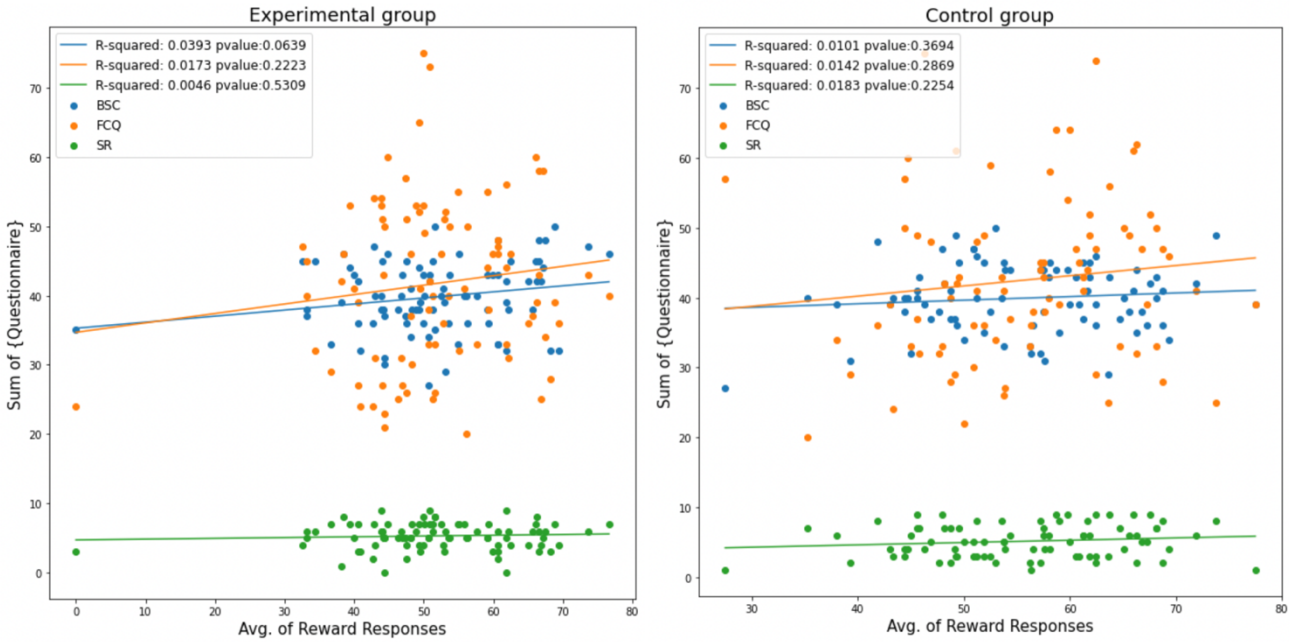


Simple linear regression analyses were carried out to investigate the relationships between reward responses and each questionnaire's score in the experimental and control groups (see Figure 13). In both groups, no questionnaire explained the variance in reward responses. In the experimental group,

reward responses were not predicted by any of the questionnaires used including BSC ($F(1,87) = 3.523$, $p = .064$, $R^2 = .039$, $B = .45$), FCQ-T-r ($F(1,87) = 1.511$, $p = .222$, $R^2 = .017$, $B = .127$), and SR ($F(1,87) = .396$, $p = .531$, $R^2 = .046$, $B = .408$). The control group showed a similar pattern: BSC ($F(1,81) = .815$, $p = .369$, $R^2 = .01$, $B = .196$), FCQ-T-r ($F(1,81) = 1.149$, $p = .287$, $R^2 = .014$, $B = .097$), and SR ($F(1,81) = 1.492$, $p = .225$, $R^2 = .018$, $B = .552$).

Figure 13

Scatterplot of the relationship between reward responses and each questionnaire's score according to groups



3.5. Discussion

We found that group effects were present for reward type pairs 1 (food-money) and 3 (food-N.M), but not for reward type pairs 2 (money-food) and 4 (N.M-food). Participants who were asked to imagine that they regulated food reward responses rated the likelihood to consume the second reward as lower (including money and non-materialistic rewards), compared to those who were not asked to imagine their exertion of self-control in relation to food rewards. However, this pattern was not

present for the reward type pairs 2 (money-food) and 4 (N.M-food). These findings disputed our categorisation of rewards, (as materialistic and non-materialistic rewards) in that the results varied, depending upon the type of first reward (i.e., food reward as a first reward domain produced a difference between the experimental and control groups) rather than depending on the combinations with materialistic rewards versus non-materialistic rewards.

The following discussion will focus on these three main findings: 1) Food as the first reward was overall the most effective reward domain to show a group difference; 2) There was a stronger likelihood to consume the second reward in the control group than in the experimental group; 3) There were domains which did not seem to relate to rewards in the initially categorised as non-materialistic rewards.

The first finding demonstrates that, in terms of the imagined exertion of self-control, food was more effective than the other reward. When the first reward was food, differences between the experimental and control groups were strongest. This pattern may be explained by the stimulus type of the current study. For all vignette stimuli of Study 2, we added images showing imaginary situations to increase reward responses. It seems that the images used formed an important part of the vignette stimuli that may have influenced the overall response pattern of results. Thus, one interpretation of our results is that food images elicited stronger reward responses than the other pictorial stimuli (e.g., images depicting monetary and social media reward). This is in line with brain imaging research that shows robust reward activation during exposure to food cues (Fearnbach et al., 2016; Wang et al., 2009), whereas less evidence exists for reward circuit activation in response to the other (pictorial) reward cues we used. In the current study, the elicitation of reward responses to the first reward was crucial in order to investigate the impact that self-control in relation to the first reward has on self-control related to the second reward.

Another key finding was that for the reward type pairs containing food as the first reward, increased reward responses in the control group were found. These results were inconsistent with the findings from Study 1, in which participants who exerted self-control during exposure to the first reward exhibited increased reward responses to the second reward. Indeed, the findings of the second study are compatible with the idea of an 'inhibitory spillover' effect (Berkman et al., 2009). This concept states that the stimulation of an inhibitory network, which is initiated by the intention to inhibit one response, is accompanied by the spread of the inhibition to other unrelated domains (Tuk et al., 2015). In the present study it is possible that since participants were asked to imagine successful self-control of the first reward, successful suppression was extended to the second reward.

However, it is important to note that these patterns were not demonstrated in Study 1. The key differences between the two studies were as follows: 1) Study 1 implicitly measured participants' responses to the second reward (level of cheating, viewing times in response to sexual images), while in the second study participants were explicitly asked how likely they would consume or engage with the second reward. 2) Study 1 presented real rewards (snacks) and measured actual self-control behaviour, while on the second study it was merely an imaginary situation in which participants exerted self-control in the current study. Since Study 2 examined a hypothetical situation, potential issues such as social desirability and cognitive biases could influence the results. Social desirability means trying to appear to be good in line with cultural norms (Krumpal, 2013). This could result in the display of the desired self rather than the display of reactions and feelings related to the hypothetical situations. In addition, it can be argued that the self-report responses towards the hypothetical situations used in Study 2 measured affective forecasting, which is susceptible to cognitive biases related to overestimating or underestimating the impact of affective responses (Wilson & Gilbert, 2005). Thus, it may have been the case that participants in the experimental group who imagined that they were successful in their self-control overestimated their ability of self-

control, while also underestimating the difficulty of suppressing reward responses. The measured responses thus reflected the participants' beliefs and attitudes rather than their actual behaviour in the given situations.

This phenomenon may be explained similarly by an 'hot-cold empathy' gap (Loewenstein, 2005). According to this idea, there are two affective states, a hot state (e.g., experiencing craving reward) and a cold state (e.g., not craving reward). When people are in a certain state, they tend to inaccurately judge how their preference and behaviour will differ in the other state. Being in a cold state causes people to underestimate the impact of the hot state (e.g., craving, desires, etc.), while those in a hot state would overestimate the degree of reward temptation. Similarly, in the current study, participants in the experimental group may have underestimated the impact of craving or desires in hypothetical situations, in that they imagined successful self-control, hence they were in a cold state.

In relation to this idea, further evidence for the assumption that participants relied on their attitudes or beliefs, rather than expressing their actual anticipated behaviour, was the lack of a relationship between responses to the vignette-based items and other trait-related self-control or reward measures, such as BSC, FCQ, and SR. This lack of a relationship indicates that participants' responses reflected momentary states rather than their stable traits.

The reason that these biases were only present for reward type pairs 1 and 3 (the pairs involving food as the first reward) may be that participants who were asked to control their reward responses to money and non-materialistic rewards did not really think about self-control, because the way in which these rewards were presented did not elicit sufficiently strong responses, as discussed above.

Finally, since movies (item 3.1), books (item 3.2), entertaining series (item 4.1), and social media (item 4.2) were arbitrarily categorised as non-materialistic rewards and such categorisation did not seem to exist, the individual 'non-materialistic reward' items were taken into account. For the first item from the Food-N.M category (i.e., movies; item 3.1), we found stronger reward responses among the control group compared to the experiment group, meaning that all the explanations including the 'hot-cold empathy' gap could be applied to the item. On the other hand, the second item from the Food-N.M category (i.e., books) did not show the significant result of increased reward responses among the experimental group. This could be interpreted as meaning that the second reward domain (i.e., books) being not rewarding at all.

In addition, item 4.1 showed significant results. Here, those in the experimental group were asked to imagine that they watched a documentary over an entertaining series, while the control group imagined that they watched the entertaining series. Item 4.1 showed that the experimental group displayed stronger reward responses compared to the control group after imagining that they exerted self-control while imagining being forced to watch a documentary. In contrast to item 3.2, this opposite result that does not align with the 'inhibitory spillover' effect could be interpreted as the first reward domain, which asked participants to imagine exerting self-control, not leading to imaginary self-control. Hence, participants did not enter the 'cold' state, as they thought that the first part of the item was not truly rewarding, or that it was something over which they had to exert self-control. On the other hand, item 4.2 resulted in the same pattern as other significant items, which the experimental group displaying the stronger food reward responses after forcing themselves not to check social media even when they wanted to. This can be interpreted as demonstrating that they were truly thinking about self-control and so were in the 'cold' state. To sum up, from the results of the study, movies and social media were found to be rewarding while watching a TV series over documentary and books were not rewarding.

Strength and limitations

This study attempted to develop a new online survey-based paradigm to examine self-control. By adapting a vignette-based experimental paradigm, a discrepancy between attitude and behaviour (Eagly & Chaiken, 1993; Kraus, 1995) could be demonstrated in the domain of self-control and reward. In addition, the second study identified not only the importance of using proper stimuli to stimulate one's reward responses, but also the effectiveness of palatable food images as stimuli, with the group difference present only when using food images as stimuli for the first reward. However, it appeared that the results were sometimes item dependent. Although a pre-test was conducted to eliminate any ineffective items, a more systematic approach is still required, as the vignette approach is new in the field of self-control and reward and all interpretations of the findings remain tentative.

Implications and future direction

To my knowledge, there has been no study so far examining self-control with such methods and, to this point, vignette-based studies have not yet tried to assess and/or predict one's behaviour in a self-control and reward context. This study showed the possibility of applying a vignette-based experimental paradigm to self-control studies. It also demonstrated that it might be hard to assess and predict one's behaviour utilising such a method due to the problems with social desirability and cognitive biases. Although the results cannot directly be linked to one's future behaviours, we can still explore how one's beliefs or attitudes shifts in reward-related situations.

More studies should be conducted not only to replicate the present but also to further develop the present methodological approach in order to uncover further mechanism behind self-control and ego depletion.

General discussion

Overview

The table below summarises the present two studies, which examined the impact that self-control with respect to one reward has on responses with respect to another reward. The table gives an overview of differences in the methods, measures, and findings of the two studies.

Table 9

Overviews of both studies

	Study 1	**Study 2**
Method	Lab-based experiment	Vignette-based experimental online survey
Measure	Implicit measure	Explicit measure
Reward domains examined	Food, Monetary, Sexual	Food, Monetary, Movie, Social media, Video content, Books
Relationship between two rewards	**Food and monetary rewards:** Stronger reward responses for the 2nd reward in the experimental group who exerted self-control with respect to the 1st reward than those who did not engage in self-control (the non-regulation phase)	**Food and monetary rewards; Food and movie rewards, and Social media and food rewards:** Weaker reward responses for the 2nd reward in the experimental group who imaginarily exerted self-control with respect to the 1st reward than those who did not engage in self-control
Conclusions	· Ego depletion can be best described by the process model	· Using images to elicit reward responses, particularly food is effective · Behaviours are not always aligned with attitudes/beliefs in the area of self-control (different results in Study 1 and 2) · Rewards cannot be categorised into materialistic and non-materialistic rewards

Theoretical contributions

Study 1 makes important contributions to the ego depletion literature by supporting the process model (Inzlicht & Schmeichel, 2012). As pointed out before, the area of ego depletion is highly controversial in terms of the existence of the phenomenon and its interpretations. By using

simultaneous tasks and implementing differentiation of phases (no regulation required phase and regulation required phase), the current study gave a direct support to the process model which argues that the exertion of self-control leads to increased motivation to do something which subjects 'want-to' (Inzlicht et al., 2014). It therefore also disputes the idea of the strength model that self-control is a limited resource (Baumeister et al., 1998).

Methodological implications

The current study applied novel methods to examine self-control and investigate ego depletion. In Study 1, instead of the sequential task typically used in the ego depletion literature two reward-related tasks were presented concurrently. In addition, we introduced a "no regulation" (without motivational shift) and "regulation" (with motivational shift) phases in the task. Introducing these conditions allowed the study to demonstrate a direct motivational shift from 'have-to' to 'want-to' as predicted by the process model (Inzlicht & Schmeichel, 2012).

Study 2 introduced a second new paradigm to study ego depletion, which was a vignette-based online experiment. It used an explicit measure of self-control and ego depletion, in which participants were asked to rate their likelihood to consume rewards (interpreted as equivalent to the expressions of self-control) after imagining that they had exerted self-control in another reward domain (in the experimental group) or not (in the control group). This allowed the study to find out participants' attitudes and beliefs on how they would behave in such situations (i.e., exerting self-control). The results obtained were different from those of Study 1 that after imaginarily exerting self-control in one domain, participants showed better self-control in another domain in a hypothetical situation. The different findings between Study 1 and Study 2 indicate that in the area of self-control, participants' attitudes and beliefs about their behaviours may differ from their actual behaviour.

Conclusions and future directions

To sum up, the current studies used tasks which introduced new components (e.g., concurrently presented biphasic tasks including non-regulation and regulation, and online vignette-based experimental study). These allowed the study to support the process model of ego depletion (Study 1), and find out that rewards cannot be categorised into materialistic and non-materialistic (Study 2) and that behaviours are not always aligned with attitudes/beliefs in the area of self-control (Study 2).

For Study 1, the supporting evidence for the process model was found in the food and monetary reward pair, not in the food and sexual reward pair. Based on the results, further investigations on the relationship between food and sexual rewards are needed to strength the support for the process model (Inzlicht & Schmeichel, 2012). In addition, results from Study 2 suggest that the application of vignette-based online experiments to study self-control should be further explored.

Appendices

Appendix 1. Study 1 – Advertising materials

OPEN The role of food availability in mathematical intuition and picture perception – 1 hour CREDIT

We invite you to take part in a study about the role of food availability in mathematical intuition and picture perception. You need to abstain from eating for at least 3 hours before taking part in the study. During the study, you will do two computer tasks and fill in some questionnaires. The computer tasks will involve a simple maths task, in which you can earn real money, and a picture perception task, where you rate different images. Please note that the pictures will show attractive models in underwear or swimwear. You shouldn't participate if you are uncomfortable with looking or evaluating such pictures.

For some participants, the study will also involve the presentation of freshly opened snacks, such as crisps or popcorn.
As food and eating is involved in this study, you cannot take part if you have a current or past eating disorder, diabetes or any food allergy. You also shouldn't take part if you dislike crisps and popcorn and/or would have concerns eating those snacks.

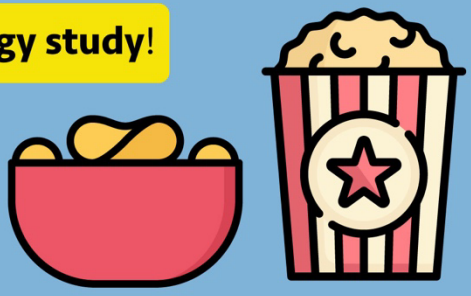
In total, the experiment will take approximately 40-50 minutes. You will be compensated for your time with participant pool credits.

The study will take place at the Durham Psychology department.

If you would like to take part in this study or have any questions, please contact:
Name: Ella Rho Email address: saeyeon.rho@durham.ac.uk

Take part in our interesting **psychology study**!

Please EMAIL me!



THE ROLE OF *food availability* IN MATHS INTUITION AND PICTURE PERCEPTION

01 Procedures?

- You will need to abstain from eating for at least 3 hours before taking part in the study.
- During the study, you will do two computer tasks and fill in some questionnaires.
- In total, it will take ca. 50 minutes.

02 Exclusion crieteria?

- There will be models in underwear shown in the study - if you are uncomfortable with such pictures, you shouldn't participate.
- The study will also involve crisps and popcorn - you can't take part if you have a current or past eating disorder, diabetes or any food allergy.

03 Compensations?

- If you are a psychology student, you will be compensated for your time with **1 hour credit**!

Please give a consent to be contacted by email
OR email to Ella (SAEYEON.RHO@DURHAM.AC.UK) to participate!

Appendix 2. Study 1 – Level of Hunger Questionnaire

Level of Hunger Questionnaire

This questionnaire is voluntary, and the data collected will be strictly confidential and unidentifiable. You can omit the question if you do not wish to answer.

On a scale of 1-7 (1 = not at all, 7 = very much), how hungry are you at the moment?

1	2	3	4	5	6	7

Appendix 3. Study 1 – General Information Questionnaire

General Information Questionnaire

The present questionnaire allows us to assess different factors that may be related to your responses in the previous tasks. This questionnaire is voluntary, and the data collected will be strictly confidential and unidentifiable. You can omit any questions that you do not wish to answer.

Age: _____

Sex: _____

Height: _____

Weight: _____

Are you currently on a diet or trying to lose weight? yes/no

Have you ever been on a diet or attempted to lose weight? yes/no

At what time did you last eat before the study? _____

What did you eat at that time? _____

Appendix 4. Study 1 – General Reward Questionnaire

General Reward Questionnaire

The present questionnaire allows us to assess your general sensitivity towards different rewards. This questionnaire is voluntary, and the data collected will be strictly confidential and unidentifiable. You can omit any questions that you do not wish to answer.

1. On a scale of 1-7 (1 = not at all, 7 = very much), do you find **food** rewarding*?

1	2	3	4	5	6	7

2. On a scale of 1-7 (1 = not at all, 7 = very much), do you find **money** rewarding*?

1	2	3	4	5	6	7

3. On a scale of 1-7 (1 = not at all, 7 = very much), do you find **sex** rewarding*?

1	2	3	4	5	6	7

**** Rewarding = How much you enjoy, how much you care about, how much you desire, how much you seek something.***

Appendix 5. Study 1 – Debriefing Questionnaire

Debriefing Questionnaire

The present questionnaire allows us to assess different factors that may be related to your responses in the previous tasks. This questionnaire is voluntary, and the data collected will be strictly confidential and unidentifiable. You can omit any questions that you do not wish to answer.

How much did you control yourself when asked not to eat from the provided snacks on a scale of 1-7 (1 = not at all, 7 = very much)? *(Experimental group only)*

1	2	3	4	5	6	7

How hard was it for you to not snack after having one bite on a scale of 1-7 (1 = not at all, 7 = very hard)? *(Experimental group only)*

1	2	3	4	5	6	7

When you did the mathematical intuition task, how many math problems did you calculate in your head to earn the 10p?

1	2	3	4	5
0 problem	1-10 problem(s)	10-20 problems	20-30 problems	30--40 problems

Appendix 6. Study 1 – Information Sheet

Information Sheet (Version 1: 7 November 2019)

Project title: The role of food availability in mathematical intuition and picture perception

Researcher(s): Ella Saeyeon Rho
Department: Psychology
Contact details: saeyeon.rho@durham.ac.uk

Supervisor name: Dr Niklas Ihssen
Supervisor contact details: niklas.ihssen@durham.ac.uk

You are invited to take part in a study that I am conducting as part of my Master's by Research project at the Psychology Department, Durham University. This study has received ethical approval from the Department of Psychology Ethics Sub-Committee of Durham University. Before you decide whether to agree to take part it is important for you to understand the purpose of the research and what is involved as a participant. Please read the following information carefully. Please get in contact if there is anything that is not clear or if you would like more information.

What is the purpose of the study?
The aim of this study is to better understand the role of food availability in mathematical intuition and picture perception.

Do I have to take part?
Your participation is voluntary and you do not have to agree to take part. If you do agree to take part, you can withdraw at any time, without giving a reason. You are also free to omit any items on questionnaires that you are not comfortable to answer.

What will happen to me if I take part?
If you agree to take part in the study, you will be asked to abstain from eating for at least 3 hours before taking part in the study.
[*Experimental group and control group 1*: At the beginning of the experiment, you will be asked to choose your favourite snack among various options (i.e., ready salted crisps and different flavours of popcorn) and have one "nibble" of the chosen snack. You will then take part in two computer tasks, a mathematical intuition task and a picture perception task.]
[*Control group 2*: During the study, you will be asked to complete two computer tasks, a mathematical intuition task and a picture perception task.]
In the intuition task, you will be asked to complete 40 multiple-choice mathematical questions consisting of four integers. The purpose of this task is to examine the role of intuition in the mathematical problems. Hence, you should guess your answers based on intuition. You will be rewarded 10p for each correct answer. For each wrong answer, 10p will be taken away. Note that if your balance is below £0, you do not need to pay money. In the picture perception task, you will be presented with images of two persons in underwear/swimwear. These pictures are taken from advertisements of famous swimwear/underwear brands, such as Victoria's Secret and Calvin Klein.

You will then be asked to rate the picture. Your responses in the tasks will be completely anonymised and the research data won't be attributable to you after you have completed the study. We will also ask you to complete several general questionnaires at the beginning and end of the study. You can omit any questions that you do not wish to answer. In total, the experiment will take ca. 40-50 minutes. You will be compensated for your time with participant pool credits.

Are there any potential risks involved?
[*Experimental and control group 1*: Due to the involvement of food, you cannot take part in the study if you have a current or past eating disorder, diabetes or food allergy.]
The present study involves the presentation of advertisement pictures showing attractive models wearing only swimwear or underwear. If you feel uncomfortable with being exposed to such images, you should not take part in the study. If you do experience any discomfort during the study, you are free to withdraw at any point.

Will my data be kept confidential?
The only personal information obtained during the study will be your signature on the consent from, which will be kept confidential. All research data that you provide will be entirely anonymous and will not be identifiable as yours. Full details are included in the accompanying Privacy Notice.

What will happen to the results of the project?
The results of this study will be used to write scientific publications and to present research findings at scientific conferences. Durham University is committed to sharing the results of its world-class research for public benefit. As part of this commitment the University has established an online repository for all Durham University Higher Degree theses which provides access to the full text of freely available theses. The study in which you are invited to participate will be written up as a thesis. On successful submission of the thesis, it will be deposited both in print and online in the University archives, to facilitate its use in future research. The thesis will be published open access.

Who do I contact if I have any questions or concerns about this study?
If you have any further questions or concerns about this study, please speak to the researcher or their supervisor. If you remain unhappy or wish to make a formal complaint, please submit a complaint via the University's Complaints Process.

Thank you for reading this information and considering taking part in this study.

Appendix 7. Study 1 – Consent Form

Consent Form

Project title: The role of food availability in mathematical intuition and picture perception

Researcher(s): Ella Saeyeon Rho
Department: Psychology
Contact details: saeyeon.rho@durham.ac.uk

Supervisor name: Dr Niklas Ihssen
Supervisor contact details: niklas.ihssen@durham.ac.uk

This form is to confirm that you understand what the purposes of the project, what is involved and that you are happy to take part. Please initial each box to indicate your agreement:

I confirm that I have read and understand the information sheet dated 7 November 2019 and the privacy notice for the above project.	
I have had sufficient time to consider the information and ask any questions I might have, and I am satisfied with the answers I have been given.	
I understand who will have access to personal data provided, how the data will be stored and what will happen to the data at the end of the project.	
I agree to take part in the above project.	
I understand that my participation is voluntary and that I am free to withdraw at any time without giving a reason.	

Participant's Signature_____ Date_____

(NAME IN BLOCK LETTERS)_____

Researcher's Signature_____ Date_____

(NAME IN BLOCK LETTERS)_____

Appendix 8. Study 1 – Debriefing Sheet

Debriefing Sheet

Project title: The role of food availability in mathematical intuition and picture perception

Thank you for taking part in this study. What I want to find out from this research is the how being exposed to one reward (e.g. snacks) affects our behaviour in relation to other rewards (e.g. the prospect of earning money or responses to attractive models). In particular, I am examining how exerting self-control in response to the first reward changes responses to the other reward. There are three groups of participants in my study: One group is presented with a snack and asked to NOT eat the food. The other two groups are control groups and are not asked to refrain from eating or not presented with food at all. According to a prominent model in psychology (the "strength model of self-control"), controlling your behaviour in response to rewards, such as snacks, can lead to so called "ego depletion". Researchers believe that in this state, which is transient, you are more likely to be tempted by other rewards, as you have spent all your self-regulation resources in the other (snack) task.

We use the mathematical intuition task that you did to measure responses to monetary reward: How long participants take and how accurate they are with each answer can be used as a measure of how often they calculate in their head to earn the money. The picture perception task is used to measure responses to physical/sexual attractiveness: How long participants look at the pictures and how much they enlarge the picture can be used as a measure of the strength of the visual reward. We do not tell our participants about this at the beginning in order to prevent them from deliberately controlling their responses in these tasks. Note that all your responses are completely anonymous and cannot be traced back to your identity. We kindly ask you to refrain from talking about the study while it is still taking place. This is because we want to ensure that potential prospective participants are not influenced after knowing the purpose of the study.

If taking part in this study has raised any specific concerns about your eating habits then I would suggest that you contact your GP who will be able to provide you with the right support and help.

If you would like further information about the study or would like to know about what my findings are when all the data has been collected and analysed then please contact me on saeyeon.rho@durham.ac.uk. Due to the anonymisation process, I cannot however provide you with your individual results. Due to the anonymisation process, you will also not be able to withdraw your data (except for the consent form with your signature) after today.

Appendix 9. Study 2 – Pre-study

Images were not included due to potential copyright issues.

Below survey was exported from Qualtrics.

Start of Block: Information sheet

Information Sheet

Project title: An Online Study of Responses to Reward

Researcher and contact details: Ella Rho (saeyeon.rho@durham.ac.uk)
Supervisors and contact details: Dr Niklas Ihssen (niklas.ihssen@durham.ac.uk), Dr Milica Vasiljevic (milica.vasiljevic@durham.ac.uk)

You are invited to take part in a study that I am conducting as part of my Master's by Research project at the Department of Psychology, Durham University. This study has been approved by the Department of Psychology Ethics Committee of Durham University. Before you decide to take part it is important for you to understand the purpose of the research and what is involved for you as a participant. Please read the following information carefully. Please get in touch if there is anything that is not clear or if you would like more information.

What is the purpose of the study?
The aim of this project is to examine how tempting different verbally described situations are and also how plausible and comprehensible the situation is. This is a pre-study for a larger later study (please note that you are not allowed to take part in the main study, if you participate in this study).

Do I have to take part?
Your participation is voluntary and you do not have to agree to take part. If you do agree to take part, you can withdraw at any time by closing the browser window, without giving a reason. If you do withdraw before finishing the study you will be ineligible for compensation.

Please note that data quality is very important for this survey. There is a simple test question in the study to check you are paying attention and taking care in answering all the questions. Please note that if you answer this simple question incorrectly, you will fail the quality control for the survey. Failing the quality control check does not count as withdrawal.

What will happen to me if I take part?
If you agree to take part you will be asked to complete an online study which would take ca. 15-30 mins. You will be compensated with your time with 0.5 participant pool credits (30 mins). You will first be asked some questions about your demographics. You will then be asked a series of questions

about how much you are tempted by imaginary situations described. Please complete this study on either a laptop, desktop computer, or tablet (preferably not with your mobile phone).

Are there any potential risks involved?
Due to food images being presented in some items, you cannot take part in the study if you have a current or past eating disorder or you have concerns with food images being presented (e.g. crisps, cakes, cookies, etc.). Please note that some questions in the questionnaires will relate to your weight. Note that you can omit any questions that you do not wish to answer without giving us specific reasons. If you do experience any discomfort during the study, you are free to withdraw at any point.

Will my data be kept confidential?
The data you provide will be stored in anonymised form and we will not collect any information that identifies you. All data will be stored in password-protected files. We have no way of linking responses back to an individual and it is not possible for us to connect data to the IP address from which the survey was completed.

What will happen to the results of the project?
Anonymised data may be used in publications, reports, presentations and other research outputs. At the end of the project, anonymised data may be archived and shared with others for legitimate research purposes. Results are normally presented in terms of groups of individuals, and as the data is totally anonymous there is no means of identifying the individuals who took part.

Who do I contact if I have any questions or concerns about the study?
If you have any further questions or concerns about this study, please get in touch with the researcher or their supervisor using the contact information. If you remain unhappy or wish to make a formal complaint, please submit a complaint via the University's Complaints Process.

Thank you for reading this information and considering participating in this study.

End of Block: Information sheet

Start of Block: Consent Form

Consent Form

Consent to participate in the study on responses to reward

Please tick each statement to indicate your agreement.
If you need any further information please e-mail Ella Rho at saeyeon.rho@durham.ac.uk.

- ☐ I consent to take part in this study (1)
- ☐ I confirm that I have read and understood the Participant Information Sheet (2)
- ☐ I understand that my participation is voluntary and that I am free to withdraw at any time without giving a reason (3)
- ☐ I understand that I should not be taking part if any of the exclusion criteria apply to me (4)
- ☐ I understand that I can ask any questions by emailing Ella Rho [saeyeon.rho@durham.ac.uk] (you will receive this address again at the end of the study) (5)
- ☐ I agree that data gathered in this study will be stored anonymously and securely, and may be used for future research (6)

End of Block: Consent Form

Start of Block: Demographic

D1 What is your age? (Please type your answer in numerical form e.g. 20)

_____

D2 What is your sex?

- Male (1)
- Female (2)
- Other (3)

D3 What is your ethnicity?

- White (6)
- Black or African American (7)
- American Indian or Alaska Native (8)
- Asian (9)
- Native Hawaiian or Pacific Islander (10)
- Other (11)

D4 What is your height? Please select from the dropdown menu:

▼ 1.22m = 4 ft 0 in (1) ... 2.13 m = 7 ft 0 in (73)

D5 What is your weight? Please select from the dropdown menu:

▼ 50 kg = 110 lbs = 7.9 stones = 7 stones & 12 lbs (1) ... 200 kg = 441 lbs = 31.5 stones = 31 stones & 7 lbs (151)

D5 Are you currently on a diet or trying to lose weight?

- ◯ Yes (1)
- ◯ No (2)

D6 Have you ever been on a diet or attempted to lose weight?

- ◯ Yes (1)
- ◯ No (2)

End of Block: Demographic

Start of Block: Instructions

Instruction

On the following pages, a number of situations are described. Please read carefully and imagine the situations vividly. You will then be asked to judge how you will most likely react in the described situation.There are questions related to plausibility and comprehensibility of each item as well.

Please note that data quality is very important for this survey. There are some simple test questions in the study to check you are paying attention and taking care in answering all the questions. Please note that if you answer these simple questions incorrectly, you will fail the quality control for the survey.

End of Block: Instructions

Start of Block: 1.1.a.

1.1.a. Imagine that you have just finished your dinner, but you still feel hungry.

There are hummous and cucumber slices in your fridge, crisps in the cupboard and freshly baked pastries in the oven, which your mum baked.

	Not at all likely — Extremely likely
How tempting is it to have crisps or freshly baked desserts instead of cucumbers although you are on a diet?	
How likely is the situation to happen in real life?	
How easy to understand is the situation described above?	

End of Block: 1.1.a.

Start of Block: 1.1.b.

1.1.b.
You find a message from your friend that he has paid back the money that he had borrowed.

However, your friend seems to have forgotten how much he had borrowed.

Your friend has sent £80 instead of £50 to your bank account.

	Not at all likely	Extremely likely
How tempting is it to reply to your friend with a thank you message WITHOUT mentioning the extra £30?		
How likely is the situation to happen in real life?		
How easy to understand is the situation described above?		

End of Block: 1.1.b.

Start of Block: 1.2.a.

1.2.a. Imagine that you are a PhD student. You are on a field trip for your PhD and you are on a flight. Since you are on a diet, you informed the airline that you do not want to be served a meal at all and would like to just have a glass of water. Luckily, your flight has been upgraded to business class.

Hence, you have been given a great selection of choices for your meal.

	Not at all likely	Extremely likely
How tempting is it to choose a business-class meal instead of just having water, although you are on your diet?		
How likely is the situation to happen in real life?		
How easy to understand is the situation described above?		

End of Block: 1.2.a.

Start of Block: 1.2.b.

1.2.b. Imagine that you are a PhD student. You are on a field trip for your PhD and you are on a flight. Before you land, you are asked by the flight attendant to put some money in the envelope if you want to make a donation to a charity. You only have £20 notes in your purse.

	Not at all likely — Extremely likely
How tempting is it to forgo the opportunity to donate instead of donating a £20 note?	
How likely is the situation to happen in real life?	
How easy to understand is the situation described above?	

End of Block: 1.2.b.

Start of Block: 1.3.a.

1.3.a. Imagine that you are invited for dinner by your family friend, and your host is a great cook. You were so amazed by the starter and main course.

	Not at all likely — Extremely likely
How tempting is it to have dessert although you are on a diet?	
How likely is the situation to happen in real life?	
How easy to understand is the situation described above?	

End of Block: 1.3.a.

Start of Block: 1.3.b.

1.3.b. Imagine that you are invitied for dinner by your family friend. During the dessert course, people at the dinner table start to talk about investments. Someone says that there is a stock that has a

high potential for earnings.

The other dinner guests buy the stocks on an App. You have some extra money to spend, but you do not really know much about stock markets.

	Not at all likely	Extremely likely
How tempting is it to buy the stocks to earn money?		
How likely is the situation to happen in real life?		
How easy to understand is the situation described above?		

End of Block: 1.3.b.

Start of Block: 2.1.a.

2.1.a. Imagine that you are at a big shopping mall with your best friend. It is 5pm and you have been there for two hours (but you haven't bought anything). You are about to leave but your friend needs to go to the bathroom.

While you wait for him, you spot a wallet under a bench that someone has lost. When you open it, you find £100 and a University library card in the wallet but nothing else.

	Not at all likely	Extremely likely
How tempting is it to keep the money when you are keen to buy a new phone but cannot afford it currently?		
How likely is the situation to happen in real life?		
How easy to understand is the situation described above?		

End of Block: 2.1.a.

Start of Block: 2.1.b.

2.1.b. Imagine that you are at a big shopping mall with your best friend. It is 5pm and you have been there for two hours (but you haven't bought anything).

You are about to leave but your friend needs to go to the bathroom. On the way out he offers you a chocolate bar, which happens to be your favourite.

	Not at all likely	Extremely likely
How tempting is it to accept the offer and eat the chocolate bar?		
How likely is the situation to happen in real life?		
How easy to understand is the situation described above?		

End of Block: 2.1.b.

Start of Block: 2.2.a.

2.2.a. Imagine that you are in a large coffee shop where you can also buy tumblers and mugs.

You like the design of one of the mugs on display very much.You realise that these types of mugs are more expensive but the mug that you took from the shelf has a wrong price tag.

You can save £15 by not telling the cashier about this.

	Not at all likely	Extremely likely

How tempting is it not to tell the cashier the truth and save £15?	
How likely is the situation to happen in real life?	
How easy to understand is the situation described above?	

End of Block: 2.2.a.

Start of Block: 2.2.b.

2.2.b.

Imagine that you are in a large coffee shop.

In the coffee shop, there is a new dessert on the menu and the cashier offers it to you for free for a try. It is one of your favourites.

	Not at all likely	Extremely likely
How tempting is it to take up the offer even when you are on a diet?		
How likely is the situation to happen in real life?		
How easy to understand is the situation described above?		

End of Block: 2.2.b.

Start of Block: 2.3.a.

2.3.a.
Imagine that you receive an email about taking part in a 10mins questionnaire study at the end of which you will receive £15 compensation. You want to take part in the study as it is good money and you do not have anything to do at the moment.

However, you find out that you took part in the study previously and they asked you not to take part

more than once. Due to the anonymised system, they would not know if you take part in the study twice when you use a different device.

	Not at all likely	Extremely likely
How tempting is it to take part in the study and earn £15 again?		
How likely is the situation to happen in real life?		
How easy to understand is the situation described above?		

End of Block: 2.3.a.

Start of Block: 2.3.b.

2.3.b.
Imagine that you go to your kitchen and find various options for snacks. There are some delicious but unhealthy snacks and some healthy options.

	Not at all likely	Extremely likely
How tempting is it to choose to eat the delicious snacks rather than the healthy options?		
How likely is the situation to happen in real life?		
How easy to understand is the situation described above?		

End of Block: 2.3.b.

Start of Block: 3.1.a.

3.1.a. Imagine that you have just sat through a long and boring lecture during which everyone almost fell asleep.

As you leave, you see a vending machine that has your favourite snack.

	Not at all likely	Extremely likely
How tempting is it to buy it?		
How likely is the situation to happen in real life?		
How easy to understand is the situation described above?		

End of Block: 3.1.a.

Start of Block: 3.1.b.

3.1.b.
Imagine that you has just sat through a long and boring lecture during which everyone almost fell asleep.

On the way home, you pass by the cinema and find out that one of the movies that you always wanted to watch is about to start in 10 minutes.

	Not at all likely	Extremely likely
How tempting is it to stop over there to watch the movie?		
How likely is the situation to happen in real life?		
How easy to understand is the situation described above?		

End of Block: 3.1.b.

Start of Block: 3.2.a.

3.2.a.
Imagine that you want to watch some movies while having scrumptious snacks and drinks.

	Not at all likely	Extremely likely
How tempting is it to have the snacks instead of sitting down in front of the TV with a glass of water?		
How likely is the situation to happen in real life?		
How easy to understand is the situation described above?		

End of Block: 3.2.a.

Start of Block: 3.2.b.

3.2.b.
Imagine that you want to watch some movies.

	Not at all likely	Extremely likely
How tempting is it to find a good movie on the video streaming service instead of going to bed?		
How likely is the situation to happen in real life?		
How easy to understand is the situation described above?		

End of Block: 3.2.b.

Start of Block: 3.3.a.

3.3.a. Imagine that your family members have a large and tasty Sunday brunch, which smells amazing.

	Not at all likely	Extremely likely

How tempting is it to have a large and tasty Sunday brunch even when you are on a diet?	
How likely is the situation to happen in real life?	
How easy to understand is the situation described above?	

End of Block: 3.3.a.

Start of Block: 3.3.b.

3.3.b. Imagine that you decide to read a book. In your reading list, you have a very interesting novel and an old and boring book that you have to read for your course.

Not at all likely Extremely likely

How tempting is it to choose to read the interesting novel instead of the boring book?	
How likely is the situation to happen in real life?	
How easy to understand is the situation described above?	

End of Block: 3.3.b.

Start of Block: 4.1.a.

4.1.a.
Imagine that you are a history student. It is Sunday afternoon, and you want to watch a movie on Netflix.

When you browse what to watch, you find a really great series that all your friends have recommended.

However, you are torn between the recommended TV series and a history documentary that might help you complete one of your assignments.

Not at all likely Extremely likely

How tempting is it to start watching the recommended TV series instead of the history document even though you know that it will make you less productive for the entire week?	
How likely is the situation to happen in real life?	
How easy to understand is the situation described above?	

End of Block: 4.1.a.

Start of Block: 4.1.b.

4.1.b.
Imagine that you have your dinner on Sunday.

You have had enough for your first serving, but the dinner menu is one of your favourites. When you are nearly finished, one of your flatmates next to you has a second serving and asks if anyone else wants more.

	Not at all likely	Extremely likely
How tempting is it to have the second portion?		
How likely is the situation to happen in real life?		
How easy to understand is the situation described above?		

End of Block: 4.1.b.

Start of Block: 4.2.a.

4.2.a. Imagine that you are doing an arts degree and go to an arts museum because you have to write a report for your assignment about Roman sculptures, which you find really boring.

You learn that the museum has also launched one of your favourite artist's collections, and it appears to be really popular. You want to go to this exhibition as well, but you need to force yourself to focus

only on your assignment due to lack of time before the museum closes.

	Not at all likely	Extremely likely
How tempting is it to go to your favourite artist's exhibition instead of visiting the Roman sculptures section, even though the museum closes soon?		
How likely is the situation to happen in real life?		
How easy to understand is the situation described above?		

End of Block: 4.2.a.

Start of Block: 4.2.b.

4.2.b.
Imagine you are going to a cafe for a coffee.

	Not at all likely	Extremely likely
How tempting is it to order a slice of cake (or another baked good) in addition to the coffee?		
How likely is the situation to happen in real life?		
How easy to understand is the situation described above?		

End of Block: 4.2.b.

Start of Block: 4.3.a.

4.3.a.
Imagine that you love using social media, but you try not to use social media as often as you used to, as you are now preparing for important exams. After dinner, you have some time to relax. You have an urge to check your social media accounts because it has been a while since you have checked them.

Not at all likely Extremely likely

How tempting is it to check your social media accounts?	
How likely is the situation to happen in real life?	
How easy to understand is the situation described above?	

End of Block: 4.3.a.

Start of Block: 4.3.b.

4.3.b.

You want to drink something, and you find various options in your kitchen.

	Not at all likely	Extremely likely
How tempting is it to drink something other than water (e.g. coke, coffee, milkshake)?		
How likely is the situation to happen in real life?		
How easy to understand is the situation described above?		

End of Block: 4.3.b.

Start of Block: Attention checker 1

AC 1
Imagine that you have your favourite food for dinner. Everyone finishes their portions and you also have had enough. You put the leftovers away. Please select extremely likely for all the questions below regardless of the scenario.

	Not at all likely	Extremely likely

How tempting is it to eat more?	
How likely is the situation to happen in real life?	
How easy to understand is the situation described above?	

End of Block: Attention checker 1

Start of Block: Attention checker 2

AC2
Imagine that you are cooking for dinner, and you have vegetables to cook.
You like to pan fry or cook them in the oven with butter, olive oil, goose fat, salt and/or herbs. Please select extremely likely for all the questions below regardless of the scenario.

	Not at all likely Extremely likely
How tempting is it to cook in that way rather than boiling the vegetables?	
How likely is the situation to happen in real life?	
How easy to understand is the situation described above?	

End of Block: Attention checker 2

Start of Block: Perspective

How likely is it that you made your decisions based on how you would react in the situation?

	Not at all likely Extremely likely
	

End of Block: Perspective

Start of Block: Debriefing

Debriefing Sheet

Project title: Self-regulation and Multiple Rewards

Thank you for taking part in this study.

This study was a pre-study for another larger study that we will conduct over the next few months. What we wanted to find out from this pre-study is whether the descriptions of the situations and the images that you saw are suitable for the main study.

In the main study we are going to examine what would happen if you are asked to NOT indulge in a specific reward (such as a cake). Does this influence your response to another reward? Are you more likely to indulge in that other reward? In one of our previous studies we found that people who control their urges to eat something are more likely to be tempted by a money reward than people who indulge in the food.

If taking part in this study has raised any specific concerns about your eating habits and/or your own body image, then I would suggest that you contact your GP who will be able to provide you with the right support and help.

You can also use the following website and telephone number to seek further advice if taking part in this study has raised any specific concerns about your eating behaviour and/or your body image: https://www.b-eat.co.uk; B-eat (Beat Eating Disorders) Helpline: 0808 801 0677

If you would like further information about the study or would like to know about what my findings are when all the data has been collected and analysed then please contact me on saeyeon.rho@durham.ac.uk. Due to the anonymisation process, I cannot however provide you with your individual results.

End of Block: Debriefing

Appendix 10. Study 2 – Main Study

Images were not included due to potential copyright issues.

Below survey was exported from Qualtrics.

Start of Block: Information sheet

Information Sheet

Project title: An Online Study of Responses to Reward

Researcher and contact details: Ella Rho (saeyeon.rho@durham.ac.uk)
Supervisors and contact details: Dr Niklas Ihssen (niklas.ihssen@durham.ac.uk), Dr Milica Vasiljevic (milica.vasiljevic@durham.ac.uk)

You are invited to take part in a study that I am conducting as part of my Master's by Research project at the Department of Psychology, Durham University. This study has been approved by the Department of Psychology Ethics Committee of Durham University.

Before you decide to take part it is important for you to understand the purpose of the research and what is involved for you as a participant. Please read the following information carefully. Please get in touch if there is anything that is not clear or if you would like more information.

What is the purpose of the study?
The aim of this project is to examine how different rewards influence each other and how different people respond to these rewards.

Do I have to take part?
Your participation is voluntary and you do not have to agree to take part. If you do agree to take part, you can withdraw at any time by closing the browser window, without giving a reason. If you do withdraw before finishing the study you will be ineligible for compensation.

Please note that data quality is very important for this survey. **There are simple test questions in the study to check you are paying attention and taking care in answering all the questions.**

Please note that if you answer this simple question incorrectly, you will fail the quality control for the survey. Failing the quality control check does not count as withdrawal. If you wish to withdraw from the study you can e-mail Ella Rho (saeyeon.rho@durham.ac.uk)

What will happen to me if I take part?
If you agree to take part you will be asked to complete an online study which would take ca. 30 - 45 mins. You will be compensated with your time with 0.75 participant pool credits (45 mins) or reimbursed for your time with money paid at rates determined by participant recruitment providers. You will first be asked some questions about your demographics. You will then be asked a series of questions about how you would act in imaginary situations. There will be also questions

related to your eating behaviour and other personality traits. Please complete this study on either a laptop, desktop computer, mobile phone or tablet.

Are there any potential risks involved?
Due to food images being presented in some items, you cannot take part in the study if you have a current or past eating disorder or you have concerns with food images being presented (e.g. crisps, cakes, cookies, etc.). You cannot take part in this study if you took part in the online pre-study of this project. The pre-study was also run by me and had the same study title. Please note that some questions in the questionnaires will relate to your weight. Note that you can omit any questions that you do not wish to answer. If you do experience any discomfort during the study, you are free to withdraw at any point.

Will my data be kept confidential?
The data you provide will be stored in anonymised form and we will not collect any information that identifies you. All data will be stored in password-protected files. We have no way of linking responses back to an individual and it is not possible for us to connect data to the IP address from which the survey was completed.

What will happen to the results of the project?
Anonymised data may be used in publications, reports, presentations and other research outputs. At the end of the project, anonymised data may be archived and shared with others for legitimate research purposes. Results are normally presented in terms of groups of individuals, and as the data is totally anonymous there is no means of identifying the individuals who took part.

Who do I contact if I have any questions or concerns about the study?
If you have any further questions or concerns about this study, please get in touch with the researcher or their supervisor using the contact information. If you remain unhappy or wish to make a formal complaint, please submit a complaint via the University's Complaints Process. Thank you for reading this information and considering participating in this study.

End of Block: Information sheet

Start of Block: Consent form

Consent Form

Consent to participate in the study on responses to reward

Please tick each statement to indicate your agreement. If you need any further information please e-mail Ella Rho at saeyeon.rho@durham.ac.uk.

- ☐ I confirm that I have read and understood the Participant Information Sheet (1)
- ☐ I have had the opportunity to ask questions and had them answered (2)
- ☐ I understand that information gathered in this study will be stored anonymously and securely and may be used for future research (3)
- ☐ I understand that my participation is voluntary and that I am free to withdraw at any time without giving a reason (4)
- ☐ I consent for my anonymous responses to be shared with other researchers (6)

End of Block: Consent form

Start of Block: General Information

Age What is your age? (Please type your answer in numerical form e.g. 20)

_____

Sex What is your sex?

- ○ Male (1)
- ○ Female (2)
- ○ Other (3)
- ○ Prefer not to answer (4)

Eth What is your ethnicity?

- ○ White (6)
- ○ Black or African American (7)
- ○ American Indian or Alaska Native (8)
- ○ Asian (9)
- ○ Native Hawaiian or Pacific Islander (10)
- ○ Other (11)

Hei What is your height? Please select from the dropdown menu:

▼ 1.22m = 4 ft 0 in (1) ... 2.13 m = 7 ft 0 in (73)

Wei What is your weight? Please select from the dropdown menu:

▼ 50 (1) ... 200	kg	=	110	lbs	=	7.9	stones	=	7	stones &	12	lbs		
	kg	=	441	lbs	=	31.5	stones	=	31	stones &	7	lbs (151)		

Diet Are you currently on a diet or trying to lose weight?

- ○ Yes (1)
- ○ No (2)

HDiet Have you ever been on a diet or attempted to lose weight?

- ○ Yes (1)
- ○ No (2)

End of Block: General Information

Start of Block: Experimental group - 1.1.

1.1.1. Imagine that you are a PhD student. You are on a field trip for your PhD and you are on a flight.

Luckily, your flight has been upgraded to business class. Hence, you have been given a great selection of choices for your meal.

However, you force yourself to not order anything and only have a glass of water because you are on a diet.

While drinking your water, you are asked by the flight attendant to put some money in an envelope if you want to make a donation to a charity. You only have £20 notes in your wallet.

In your opinion, what is the likelihood that you will donate one of your £20 notes?

	50%	
Not at all likely 0%		Extremely likely 100%

End of Block: Experimental group - 1.1.

Start of Block: Experimental group - 1.2.

1.2.1. Imagine that you had been invited for dinner by your family friend, and your host is a great cook. You were so amazed by the starter and main course.

You want to try the host's selection of homemade desserts, but you prevent yourself from eating anymore because you are on a diet.

While not having anything, you find a message from an acquaintance on your phone that he has paid back the money that he had borrowed.

However, he seems to have forgotten how much he had borrowed. Your acquaintance has sent £80 instead of £50 to your bank account.

In your opinion, what is the likelihood that you will reply to your acquaintance with a thank you message WITHOUT mentioning the extra £30?

	Not at all likely 0%	50%	Extremely Likely 100%
			

End of Block: Experimental group - 1.2.

Start of Block: Experimental group - 2.1.

2.1.1. Imagine that you are in a large coffee shop where you can also buy tumblers and mugs. You like the design of one of the mugs on display very much. You realise that these types of mugs are more expensive but that the mug that you took from the shelf has a wrong price tag. You can save £25 by not telling the cashier about this.

However, you force yourself to tell the cashier the truth and pay the actual price, which means that you have to pay £25 more.

In the coffee shop, there is also a new dessert on the menu and when you pay for your mug the cashier offers it to you for free for a try. It is one of your favourites.

In your opinion, what is the likelihood that you will take up the offer and try the new dessert?

	Not at all likely 0%	50%	Extremely Likely 100%
			

End of Block: Experimental group - 2.1.

Start of Block: Experimental group - 2.2.

2.2.1. Imagine that you receive an email about taking part in a 10 minutes online questionnaire study, at the end of which you will receive £30 compensation. You want to take part in the study as it is good money and you do not have anything to do at the moment.

However, you find out that you took part in the study previously and they asked you not to take part more than once. Due to the anonymised system, they would not know if you take part in the study twice when you use a different device. You force yourself to close the browser, although it is a great opportunity to earn extra money.

You then go to your kitchen and find various options for snacks.

In your opinion, what is the likelihood that you will choose to eat some delicious snacks rather than the healthy options?

	Not at all likely 0%	50%	Extremely Likely 100%
			

End of Block: Experimental group - 2.2.

Start of Block: Experimental group - 3.1.

3.1.1. Imagine that you want to watch some movies while having scrumptious snacks and drinks. However, you suppress the urge.

You then sit down in front of the TV with a glass of water.

In your opinion, what is the likelihood that you will put a lot of time and effort into finding a good movie on the video streaming service?

	Not at all likely 0%	50%	Extremely Likely 100%
			

End of Block: Experimental group - 3.1.

Start of Block: Experimental group - 3.2.

3.2.1. Imagine that your family members have a large and tasty Sunday brunch, which smells amazing.
Since you are on a diet, you have only boiled eggs without any salt.

After having them, you decide to read a book. In your reading list, you have a very interesting novel and an old and boring book that you have to read for your course.

In your opinion, what is the likelihood that you will choose to read the interesting novel instead of the book for your course?

	Not at all likely 0%	50%	Extremely Likely 100%
			

End of Block: Experimental group - 3.2.

Start of Block: Experimental group - 4.1.

4.1.1. Imagine that you are a history student. It is Sunday afternoon, and you want to watch a movie on Netflix. When you browse what to watch, you find a really great series that all your friends have recommended.

However, you force yourself not to watch it because you know that starting a new series will make you less productive for the entire week.

Instead, you choose to watch a history documentary that might help you to complete one of your assignments.
After watching half of the documentary, you have your dinner with your flatmates, before watching the second half of the documentary. You have had enough for your first serving, but the food is one of your favourites. When you are nearly finished, one of your flatmates next to you has a second serving and asks if anyone else wants more.

In your opinion, what is the likelihood that you will have a second portion?

	Not at all likely 0%	50%	Extremely Likely 100%
			

End of Block: Experimental group - 4.1.

Start of Block: Experimental group - 4.2.

4.2.1. Imagine that you love using social media, but you try not to use social media as often as you used to, as you are now preparing for important exams. After dinner, you have some time to relax. You have an urge to check your social media accounts because it has been a while since you have checked them.

However, you know that checking your apps will make it more difficult to go back to studying, so you decide not to check them.

You then want to drink something, and you find various options in your kitchen.

In your opinion, what is the likelihood that you will choose to drink something more than just water or tea?

	Not at all likely 0%	50%	Extremely Likely 100%
			

End of Block: Experimental group - 4.2.

Start of Block: Attention checker 1

AC1 Imagine that you have your favourite food for dinner. Everyone finishes their portions, and you find that your portion was enough to fill you.

When you put the leftovers away, you are tempted to eat more, but you control yourself not to eat anymore. Please select extremely likely regardless of the question below.

In your opinion, what is the likelihood that you would eat more of the leftover food?

	Not at all likely 0%	50%	Extremely Likely 100%
			

End of Block: Attention checker 1

Start of Block: Attention checker 2

AC2 Imagine that you are cooking for dinner, and you have vegetables to cook.

You like to pan fry or cook them in the oven with butter, olive oil, goose fat, salt and/or herbs. However, you force yourself to boil them without any salt. Please select not at all likely regardless of the question below.

In your opinion, what is the likelihood that you will boil them instead of frying or cooking with them with seasoning?

	Not at all likely 0%	50%	Extremely Likely 100%
			

End of Block: Attention checker 2

Start of Block: Control group - 1.1.

1.1.2. Imagine that you are a PhD student. You are on a field trip for your PhD and you are on a flight. Luckily, your flight has been upgraded to business class.

Hence, you have been given a great selection of choices for your meal.

You choose to have a business-class meal.

While enjoying your rich and scrumptious meal, you are asked by the flight attendant to put some money in an envelope if you want to make a donation to a charity. You only have £20 notes in your wallet.

In your opinion, what is the likelihood that you will donate one of your £20 notes?

Not at all likely 0%	50%	Extremely Likely 100%

End of Block: Control group - 1.1.

Start of Block: Control group - 1.2.

1.2.2. Imagine that you had been invited for dinner by your family friend, and your host is a great cook. You were so amazed by the starter and main course.

There is a great dessert selection and you enjoy them very much.

During the dessert course, you find a message from an acquaintance on your phone that he has paid back the money that he had borrowed. However, he seems to have forgotten how much he had borrowed. Your acquaintance has sent £80 instead of £50 to your bank account.

In your opinion, what is the likelihood that you will reply to your acquaintance with a thank you message WITHOUT mentioning the extra £30?

Not at all likely 0%	50%	Extremely Likely 100%

End of Block: Control group - 1.2.

Start of Block: Control group - 2.1.

2.1.2. Imagine that you are in a large coffee shop where you can also buy tumblers and mugs.

You like the design of one of the mugs on display very much. You realise that these types of mugs are more expensive but that the mug that you took from the shelf has a wrong price tag.

You don't tell the cashier about this so that you save £25.

In the coffee shop, there is also a new dessert on the menu and when you pay for your mug the cashier offers it to you for free for a try. It is one of your favourites.

In your opinion, what is the likelihood that you will take up the offer and try the new dessert?

	Not at all likely 0%	50%	Extremely Likely 100%
			

End of Block: Control group - 2.1.

Start of Block: Control group - 2.2.

2.2.2. Imagine that you receive an email about taking part in a 10 minutes online questionnaire study, at the end of which you will receive £30 compensation. You want to take part in the study as it is good money and you do not have anything to do at the moment.

However, you find out that you took part in the study previously and they asked you not to take part more than once. Due to the anonymised system, they would not know if you take part in the study twice when you use a different device. Hence, you take part in the study again and earn £60 from this study in total.

You then go to your kitchen and find various options for snacks.

In your opinion, what is the likelihood that you will choose to eat some delicious snacks rather than the healthy options?

	Not at all likely 0%	50%	Extremely Likely 100%
			

End of Block: Control group - 2.2.

Start of Block: Control group - 3.1.

3.1.2. Imagine that you want to watch some movies while having scrumptious snacks and drinks.

You sit down in front of the TV with your choice of snacks.

In your opinion, what is the likelihood that you will put a lot of time and effort into finding a good movie on the video streaming service?

	Not at all likely 0%	50%	Extremely Likely 100%
			

End of Block: Control group - 3.1.

Start of Block: Control group - 3.2.

3.2.2. Imagine that your family members have a large and tasty Sunday brunch, which smells amazing. You also enjoy the brunch so much and have all the brunch items you wanted to eat during

the week.

After having them, you decide to read a book. In your reading list, you have a very interesting novel and an old and boring book that you have to read for your course.

In your opinion, what is the likelihood that you will choose to read the interesting novel instead of the book for your course?

	Not at all likely 0%	50%	Extremely Likely 100%
			

End of Block: Control group - 3.2.

Start of Block: Control group - 4.1.

4.1.2. Imagine that you are a history student. It is Sunday afternoon, and you want to watch a movie on Netflix.

When you browse what to watch, you find a really great series that all your friends have recommended. Hence, you start the series and you really like it.

After watching a few episodes, you have your dinner with your flatmates, before watching a few more episodes. You have had enough for your first serving, but the food is one of your favourites. When you are nearly finished, one of your flatmates next to you has a second serving and asks if anyone else wants more.

In your opinion, what is the likelihood that you will have a second portion?

	Not at all likely 0%	50%	Extremely Likely 100%

End of Block: Control group - 4.1.

Start of Block: Control group - 4.2.

4.2.2. Imagine that you love using social media, but you try not to use social media as often as you used to, as you are now preparing for important exams. After dinner, you have some time to relax. You have an urge to check your social media accounts because it has been a while since you have checked them.

You open the apps and browse your social media accounts.

You then want to drink something, and you find various options in your kitchen.

In your opinion, what is the likelihood that you will choose to drink something more than just water?

Not at all likely 0%	50%	Extremely Likely 100%

End of Block: Control group - 4.2.

Start of Block: The Brief Self-control measure (Tangley et al., 2004)

BSC Using the scale provided, please indicate how much each of the following statements reflects how you typically are.

	1 (Not at all) (1)	2 (2)	3 (3)	4 (4)	5 (Very much) (5)
1. I am good at resisting temptation.	○	○	○	○	○
2. I have a hard time breaking bad habits.	○	○	○	○	○
3. I am lazy.	○	○	○	○	○
4. I say inappropriate things.	○	○	○	○	○
5. I do certain things that are bad for me, if they are fun.	○	○	○	○	○
6. I refuse things that are bad for me.	○	○	○	○	○
7. I wish I had more self-displine.	○	○	○	○	○
8. People would say that I have iron self-discipline.	○	○	○	○	○
9. Pleasure and fun sometimes keep me from getting work done.	○	○	○	○	○
10. I have trouble concentrating.	○	○	○	○	○
11. I am able to work effectively toward long-term goals.	○	○	○	○	○
12. Sometimes I can’t stop myself from doing something, even if I know it is wrong.	○	○	○	○	○

13. I often act without thinking through all the alternatives.	○	○	○	○	○

End of Block: The Brief Self-control measure (Tangley et al., 2004)

Start of Block: FCQ-T-r (Meule, 2014)

FCQ Indicate the degree to which you agree with each item.

	Never (1)	Rarely (2)	Sometimes (3)	Often (4)	Usually (5)	Always (6)
1. When I crave something, I know I won't be able to stop eating once I start.	○	○	○	○	○	○
2. If I eat what I am craving, I often lose control and eat too much.	○	○	○	○	○	○
3. Food cravings invariably make me think of ways to get what I want to eat.	○	○	○	○	○	○
4. I feel like I have food on my mind all the time.	○	○	○	○	○	○
5. I find myself preoccupied with food.	○	○	○	○	○	○
6. Whenever I have cravings, I find myself making plans to eat.	○	○	○	○	○	○
7. I crave foods when I feel bored, angry or sad.	○	○	○	○	○	○
8. I have no will power to resist my food crave.	○	○	○	○	○	○
9. Once I start eating, I	○	○	○	○	○	○

have trouble stopping.						
10. I can't stop thinking about eating no matter how hard I try.	○	○	○	○	○	○
11. If I give in to a food craving, all control is lost.	○	○	○	○	○	○
12. Whenever I have a food craving, I keep on thinking about eating until I actually eat the food.	○	○	○	○	○	○
13. If I am craving something, thoughts of eating it consume me.	○	○	○	○	○	○
14. My emotions often make me want to eat.	○	○	○	○	○	○
15. It is hard for me to resist the temptation to eat appetising foods that are in my reach.	○	○	○	○	○	○

End of Block: FCQ-T-r (Meule, 2014)

Start of Block: SR-S Cooper & Gomez, 2008)

SR Please answer the following questions by checking either yes or no.

	Yes (1)	No (0)
1. Does the good prospect of obtaining money motivate you strongly to do some things?	○	○
2. Do you often do things to be praised?	○	○
3. Do you like being the centre of attention at a party or a social meeting?	○	○
4. When you are in a group, do you try to make your opinions the most intelligent or the funniest?	○	○
5. Do you often take the oppotunitiy to pick up people you find attractive?	○	○
6. Do you generally give preference to those activities that imply an immediate gain?	○	○
7. Do you like to compete and do everything you can to win?	○	○
8. Do you sometimes do things for quick gains?	○	○
9. Would you like to be a socially powerful person?	○	○
10. Do you like displaying your physical abilities even though this may involve danger?	○	○

End of Block: SR-S Cooper & Gomez, 2008)

Start of Block: Debriefing sheet

Debriefing Sheet

Project title: Self-regulation and Multiple Rewards

Thank you for taking part in this study.

What we want to find out from this research is what happens if people are asked to NOT indulge in a specific reward (such as a cake). Does this influence your response to another reward? Are you more likely to indulge in that other reward? In one of our previous studies we found that people who control their urges to eat something are more likely to be tempted by a money reward than people who indulge in the food. In the present study we wanted to show this effect again and also look at rewards other than food and money. We tested two groups: If you were in the experimental group, you were asked to imagine what happens if you resist the temptation of the reward. If you were in the control group, we didn't ask you to control yourself. We also presented different questionnaires (to both groups) in order to examine whether responses to the different situations are influenced by certain personality traits, such as your general sensitivity to reward.

If taking part in this study has raised any specific concerns about your eating habits and/or your own body image, then I would suggest that you contact your GP who will be able to provide you with the right support and help.

You can also use the following website and telephone number to seek further advice if taking part in this study has raised any specific concerns about your eating behaviour and/or your body image: https://www.b-eat.co.uk; B-eat (Beat Eating Disorders) Helpline: 0808 801 0677

If you would like further information about the study or would like to know about what my findings are when all the data has been collected and analysed then please contact me on saeyeon.rho@durham.ac.uk. Due to the anonymisation process, I cannot however provide you with your individual results. By clicking on the next button your responses will be submitted and you will no longer be able to withdraw your data.

Please click the next button to receive the credits!

End of Block: Debriefing sheet

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