Effects of Gratitude and Cognitive Load on Delay Discounting: Replication Failures in Two Experiments

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Abstract

Delay discounting is the phenomenon whereby the value of future rewards is discounted as a function of time. Individual differences in discounting rate have been linked to a range of correlates and research has suggested a lower discounting rate to be more adaptive. One mechanism that may reduce discounting rate involves effortful self-regulation achieved through the engagement of executive function processes. This mechanism, however, is reliant on a limited-capacity cognitive system. Cognitively demanding contexts and low baseline capacity therefore create vulnerability to higher discounting rates and the associated negative sequelae. The affective state of gratitude has been proposed as an alternative mechanism to reduce discounting rate. It has been described as independent of effortful self-regulation with the implication that it is not demanding of limited cognitive resources. However, this had not been tested experimentally. The current research program comprised two experiments. The primary aims were as follows: (1) to replicate previous findings showing the effects of gratitude and cognitive load on discounting rate, and (2) to extend previous findings by investigating whether the effect of one of these predictors depends on the level of the other. Experiment 1 manipulated gratitude and cognitive load and subsequently measured discounting rate. No support was found for an effect of gratitude but, in line with previous findings, high cognitive load increased discounting rate. One reason identified as a possible explanation for the failed replication of gratitude was the time delay between the manipulation of gratitude and the measurement of discounting rate. The completion of the cognitive load manipulation task was the reason for the delay. Consequently, in Experiment 2, the procedure was replicated using a cognitive load manipulation task of shorter duration. Once again, no effect of gratitude emerged. Further, the effect of cognitive load on discounting was not replicated. Additional areas of investigation included heart rate variability and altruistic behaviour as correlates of discounting, neither of which were supported. The replication failures in the current research were examined through a systematic evaluation and comparison with relevant published research. Insights from this examination are outlined alongside a discussion of replication failures in the field of psychological science.

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List of Abbreviations

The following provides the meaning of abbreviations and acronyms used throughout the dissertation. The page on which each is defined or first used is also given.

Abbreviation	Meaning	Page
ADHD	Attention-deficit/hyperactivity disorder	39
BDEFS	Barkley's Deficits in Executive Functioning Scale	41
ECG	Electrocardiogram	17
DG	Dictator game	70
GQ-6	Gratitude Questionnaire-6	34
HRV	Heart rate variability	16
I7	Eysenck Impulsiveness Questionnaire	12
k	Discounting rate	32
MCQ	Monetary Choice Questionnaire	18
RMSSD	Root mean square of successive difference	18
SDNN	Standard deviation of normal beats	17
SDT	Social Discounting Task	70
TDM	Triple Dominance Measure	70

Effects of Gratitude and Cognitive Load on Delay Discounting: Replication Failures in Two Experiments

People differ in the extent to which they are willing to wait for delayed rewards. Despite these individual differences, when given the choice between a smaller immediate reward and delayed reward of greater value, there is a tendency to prefer the immediate option. This preference results from the phenomenon of delay discounting, whereby the value of a reward is discounted as a function of the duration of the delay (Ainslie, 1975). Patience for delayed rewards is adaptive. Beyond obtaining a reward of greater value, the ability to wait for delayed rewards is associated with positive correlates in a wide range of areas (Bickel et al., 2014; Bickel & Marsch, 2001; Gray & MacKillop, 2015; MacKillop, 2016).

Discounting the value of future rewards is a universal tendency observed in humans and other animals (Vanderveldt et al., 2016). However, the rate at which future rewards are discounted is variable and differs according to numerous individual and contextual factors. Given the adaptive nature of a lower discounting rate, understanding predictors of lower discounting rates is an important area of research with far reaching implications.

One mechanism thought to enable a lower discounting rate is self-regulation by way of cognitive control (Barkley, 2001; Berns et al., 2007; Endres et al., 2014; Finn, 2002; Finn et al., 2015; Mischel et al., 2011). This cognitive pathway to a lower discounting rate is demanding of limited cognitive resources (Bailey et al., 2018; Endres et al., 2014; Finn, 2002; Finn et al., 2015; Hinson et al., 2003) and depends on baseline cognitive ability (Aranovich et al., 2016; Bobova et al., 2009; Finn et al., 2015; Shamosh et al., 2008). As such, individuals are vulnerable to impulsive decision-making because of elevated discounting rates if cognitive capacity is low or when cognitive demands are high.

An alternative approach to increasing patience for delayed rewards has been proposed that relies on affective rather than cognitive processing. According to this model, the affective state of gratitude can reduce discounting rate (DeSteno, 2009). Experimentally manipulated gratitude, mean daily levels of gratitude, and self-reported state gratitude have been reported to predict discounting rate (DeSteno et al., 2014; Dickens & DeSteno, 2016).

This pathway has been described as effortless and resistant to depletion on the basis that it is distinct from the cognitive pathway that relies on self-regulation through effortful cognitive control (DeSteno et al., 2014). However, this has not yet been demonstrated experimentally. The current research sought to replicate the effect of gratitude on discounting rate using the delay discounting paradigm. A further aim was to experimentally test the hypothesis that this affective pathway is distinct from the cognitive pathway that relies on a limited-capacity cognitive system. Findings to this effect would support the idea that the gratitude pathway to a lower discounting rate is effortless and resistant to depletion. The current research program also investigated correlates of discounting rate, in a multimethod investigation including personality, behavioural, and electrophysiological variables.

Delay Discounting

Delay discounting is the tendency for rewards to be devalued as a function of time. People discount the value of rewards the further they lie in the future which leads to a preference for rewards of lesser absolute value if they are more immediately attainable (Ainslie, 1975; Berns et al., 2007; Herrnstein, 1961; Loewenstein & Prelec, 1992). Discounting rate varies as a function of a variety of contextual and individual factors, some of which are malleable and others which are relatively fixed. A greater discounting rate results in more impulsive decision-making and, therefore, a reduced ability to delay gratification (Bickel et al., 2014). A lower discounting rate has been associated with a myriad of positive correlates encompassing academic performance, health, substance abuse, smoking, and other areas involving self-regulation (Białaszek et al., 2017; Chabris et al., 2008; Kirby et al., 2005; Konecky & Lawyer, 2015; Mischel et al., 1988; 2011).

Intertemporal decision-making refers to choices with consequences that manifest over a variable period of time (Berns et al., 2007). Different models have been proposed to explain how this type of decision-making differs from decisions without variability in outcome timing. According to the discounted utility model, the relationship between the value of an outcome and its distance in time can be explained by an exponential discounting of the outcome's value as a function of its temporal distance from the present (Berns et al., 2007; Samuelson, 1937). This model assumes that intertemporal decision-making differs only from other types of decision-making in terms of temporal distance. The discounted utility model states that after mathematically accounting for the difference in time by reweighting the outcome's value, the decision-making process can be accurately modelled (Berns et al., 2007; Samuelson, 1937). Decades of behaviour economics research has shown that the constant discount factor proposed by the discounted utility model does not accurately explain behavioural observations of intertemporal decision-making (Ainslie, 1975; Kirby, 1997; Loewenstein & Prelec, 1992). The curve representing the rate at which the value of outcomes is discounted over time is better represented by a hyperbolic function (Ainslie, 1975; Berns et al., 2007; Kirby, 1997; Kirby et al., 2005; Myerson & Green, 1995). This means that the discount curve begins at an accelerated rate and attenuates over time (Loewenstein & Prelec, 1992). Intertemporal decision-making is better accounted for by the delay discounting model which describes the hyperbolic function of the discounting curve and variability depending on contextual and individual factors (Ainslie, 1975;

Berns et al., 2007; Bickel et al., 1999; Kirby, 1997; Myerson & Green, 1995). Both delay discounting and temporal discounting refer to the discounting of the value of a rewarding outcome as a function of time; these two terms are used interchangeably in the literature (Daugherty & Brase, 2010; Myerson & Green, 1995).

Delay discounting is studied by examining individual preferences when given the choice between a smaller immediate and a larger delayed reward (Bickel et al., 2014). Financial rewards are most often used because they are universally rewarding, easily quantifiable, and relatively stable in value (Bickel et al., 2014). Individuals indicate their preference between the receipt of a smaller immediate reward and a larger delayed reward; in most discounting protocols, the value of the reward and the length of the delay are varied in a series of forced-choice questions. On the basis of the responses to these questions, an indifference point is calculated which represents the value at which a future reward is perceived as equal in value to an immediate reward (Daugherty & Brase, 2010; MacKillop, 2016). The indifference point is used to calculate an estimate of the rate at which rewards are discounted as function of time (Daugherty & Brase, 2010).

Delay discounting and delay of gratification are related but distinct constructs. Delay discounting involves a single choice (i.e., the selection between the immediate or the delayed option) whereas delay of gratification requires ongoing abstinence from an immediate reward to obtain a larger reward after a period of delay (Bickel et al., 2014). Delay of gratification, defined as the ability to resist a small immediate reward in favor of a delayed reward of greater value, is inversely related to discounting rate (Göllner et al., 2018; Mischel et al., 2011). The more that a future reward is devalued as a function of time, the lower the likelihood that an individual will abstain from an immediate reward to obtain it.

The work of Walter Mischel and colleagues, beginning with the well-known delay-of-gratification paradigm colloquially referred to as ‘the marshmallow experiment’ measured the ability of young children to delay gratification to gain a deeper understanding of willpower and self-regulation with respect to intertemporal decision-making (Mischel et al., 2011). Delay discounting and the ability to delay gratification are both relevant to the study of intertemporal decision-making. The relationship between delay discounting and behaviours that rely on the ability to delay gratification is well-established; the tendency to steeply discount the value of future rewards is associated with a reduced ability to delay gratification and predicts less adaptive functioning (Bickel et al., 2014; Bickel & Marsch, 2001; Gray & MacKillop, 2015; MacKillop, 2016).

Correlates of Discounting Rate

Discounting rate is associated with a broad range of characteristics, abilities, and behaviours. A greater understanding of the factors that influence discounting rate can help inform interventions and strategies to increase patience for delayed rewards. This is particularly relevant for specific populations for which high rates of discounting are typical. Correlates of discounting are reviewed herein and areas requiring further study are highlighted.

Demographics. Demographic variables such as age, gender, and ethnicity have been examined in relation to delay discounting. A nonlinear relationship between age and discounting rate has been observed. In studies where the participant sample consisted of young to middle aged adults, no differences in discounting rates were seen (Kirby et al., 1999; Kirby & Petry, 2004). When a broader age range was utilized, however, a curvilinear pattern emerged. In a study where participants ranged from ages 9-101, a U-shaped relationship was observed such that discounting rate was highest in children and older adults, and lowest among adults aged 18-55 (Göllner et al., 2018). Studies that have used samples with a more limited age range have found results consistent with the curvilinear relationship between age and discounting. For example, a study with a sample age range of 18-86 found that discounting rates increased with age (Liu et al., 2016) whereas a study with a sample aged 9-23 found that discounting rate decreased with age (Olson et al., 2007). Further, a study with participants aged 10-30 revealed that adolescents under the age of 16 discounted future rewards at a greater rate than older participants (Steinberg et al., 2009). These results are consistent with the reported U-shaped relationship between age and delay discounting.

Most of the research evidence surrounding delay discounting and the ability to delay gratification suggests that rates do not differ according to gender. Mischel and Metzner (1962) did not find gender differences in delay of gratification among elementary school children and no gender differences were observed in discounting rate among undergraduate students (Daugherty & Brase, 2010; Dennhardt, & Murphy, 2011; Kirby & Marakovic, 1995; Koff & Lucas, 2011; Kollins, 2003), adolescents between the ages of 9 and 23 (Olson et al., 2007), nor adults with or without substance abuse problems (Finn et al., 2015; Jarmolowicz et al., 2014; Kirby & Petry, 2004). While some studies have found significantly higher discounting rates in men compared to women (Athamneh et al., 2017; Bobova et al., 2009), a meta-analysis of gender differences in impulsivity found no difference in delay discounting between male and females (Cross et al., 2011). It should be noted that gender effects have emerged as moderators of other factors in the prediction of discounting rate (see for example Koff & Lucas, 2011).

Few studies have assessed racial, ethnic, or cultural factors in the assessment of delay discounting. Some studies have found greater discounting rates among individuals of African descent compared to individuals of European descent (de Wit et al., 2007; Dennhardt, & Murphy, 2011). However, this result is most likely due to confounding variables. Currently, there is not enough evidence to suggest an association between ethnicity and delay discounting.

Contextual Factors. Patience for delayed rewards is affected by several contextual factors including the degree of certainty regarding the acquisition of the delayed reward (Mischel & Staub, 1965) and the length of the delay period (Mischel & Metzner, 1962). The sign effect, which states that rewards or gains are discounted at a greater rate than losses, has been demonstrated (Baker et al., 2003; Johnson et al., 2007) as has the magnitude effect which pertains to the value of the delayed reward. Specifically, outcomes of greater value are subjected to lower discount rates than outcomes of lesser value (Baker et al., 2003; Johnson et al., 2007; Kirby, 1997; Kirby et al., 1999; Kollins, 2003; Liu et al., 2016; Mischel et al., 1989). Delay discounting can also be affected by social influences such as peer modelling, which are thought to take effect through observational learning (Mischel et al., 1989; Stumphauzer, 1972).

Achievement. Delay discounting is related to achievement in academia. Students who exhibit higher discounting rates perform less well academically. This relationship has been shown in postsecondary school students (Acuff et al., 2017; Kirby et al., 2005), and high school students (Freeney & O'Connell, 2010; Wang et al., 2017). With respect to educational attainment, more education has been correlated with a lower discounting rate (de Wit et al., 2007; Jaroni et al., 2004; Reimers et al., 2009) while other studies have found no relationship (Kirby et al., 1999; Kirby & Petry, 2004). In adults, a lower discounting rate predicts higher income (de Wit et al., 2007; Hampton et al., 2018; Reimers et al., 2009). Delayed gratification has been associated with achievement. This ability, measured in children with the delay of gratification paradigm, predicts academic achievement in adolescence according to parental ratings and SAT scores (Mischel et al., 1988; 1989).

Health-Related Behaviours. Discounting rate predicts various health-related behaviours and factors including body mass index (Amlung et al., 2016; Barlow et al., 2016; Chabris et al., 2008; Jarmolowicz et al., 2014; Reimers et al., 2009; Wainwright et al., 2018; Weller et al., 2008), breakfast consumption (Daugherty & Brase, 2010), healthy eating (Appelhans et al., 2011; 2012; Barlow et al., 2016; Epstein et al., 2021; Rollins et al., 2010; Shuval et al., 2016), and frequency of physical exercise (Chabris et al., 2008; Epstein et al., 2021). Findings are somewhat inconsistent, however, with other studies having found no association between discounting and exercise (Daugherty & Brase, 2010), body mass index, nor body fat percentage (Daly et al., 2009). Significant relationships have been found between discounting rate and use of both seat belts and sunscreen (Daugherty & Brase, 2010). Delay discounting is also related to health-related behaviour in medical populations. Discounting rate is associated with medication adherence and glycemic control among prediabetics and type II diabetics (Epstein et al., 2021; Lebeau et al., 2016) in addition to medication adherence in individuals with breast cancer (Vaughn et al., 2021). In examining health-related behaviours, patience for delayed rewards is associated with more positive correlates.

Psychopathology. It has been argued that discounting rate functions as a transdiagnostic process underlying various types of psychopathology (Bickel et al., 2012; Bickel & Mueller, 2009). Specifically, a higher discounting rate is thought to predict mental illness. Many studies have compared discounting rates between specific clinical populations and healthy controls. For example, there is strong evidence supporting a relationship between elevated discounting rates and ADHD (Jackson & MacKillop, 2016). A meta-analysis by Amlung et al. (2019) demonstrated that greater discounting rates are observed among numerous clinical populations compared to nonclinical controls. These clinical groups include major depressive disorder, schizophrenia, borderline personality disorder, bipolar disorder, obsessive-compulsive disorder, bulimia nervosa, and binge eating disorder (Amlung et al., 2019). Small to medium effect sizes were observed for all disorders except bipolar and borderline personality disorders for which medium effect sizes emerged (Amlung et al., 2019). The opposite pattern of results was shown for anorexia nervosa; individuals belonging to this clinical group exhibited a significantly lower discounting rate relative to controls (Amlung et al., 2019). One area of psychopathology that has been extensively studied with respect to delay discounting is addiction.

Addiction. The relationship between addictive behaviours and delay discounting is well-established; there is a large body of evidence supporting the link between a higher rate of discounting and alcohol use, substance use, and behavioural addictions. In a meta-analytic study comparing clinical groups and controls, MacKillop et al. (2011) demonstrated a significant relationship between delay discounting and addiction with a medium effect size ($d = .58$). Significant group differences with medium effect sizes were shown for alcohol ($d = 0.50$), tobacco ($d = .57$), opiates ($d = .76$), and pathological gambling ($d = .79$). The same meta-analysis found a large effect size magnitude for stimulant use ($d = .87$) and no effect for cannabis (MacKillop et al., 2011). Only one study of cannabis use was included in this meta-analysis and, consequently, its relationship with delay discounting remains unclear. Higher discounting rates have been linked with earlier age at first use of marijuana (Kollins, 2003), greater frequency of use (Sofis et al., 2020), and problematic use (Finn et al., 2015). While there is some evidence to suggest a relationship between cannabis used and a higher discounting rate, the effect size of this relationship appears to be much smaller than other substances of abuse (Johnson et al. 2010).

In a separate meta-analysis of continuous associations between delay discounting and addictive behaviours, Amlung et al. (2017) demonstrated a significant relationship with an overall effect size of small magnitude ($r = .14$). This meta-analysis included addictive behaviours such as gambling and use of alcohol, tobacco, cannabis, stimulants, and opiates. No significant differences between the different forms of addictive behaviour were found. In line with previous research (e.g., MacKillop et al., 2010), both meta-analytic studies supported clinical severity of the addictive behaviour as a moderator of the observed relationship between delay discounting and addiction. MacKillop et al. (2011) found larger effect sizes for addictions that met clinical levels relative to subthreshold addictions. Similarly, Amlung et al. found a significant relationship between discounting rate and addiction severity.

A third meta-analysis examined the relationship between delay discounting and nonsubstance behavioural addictions (Weinsztok et al., 2021). Like Amlung et al. (2017) and MacKillop et al. (2011), Weinsztok et al. (2021) found a significant relationship between discounting rate and gambling. Effect size magnitudes ranged from small (r = .22) to large (d = .82), depending on whether studies employing categorical comparisons or continuous associations were considered (Weinsztok et al., 2021). A significant group difference with a large effect size was shown in a comparison of individuals with internet gaming disorder and controls (d = .89); when one influential study was excluded, the effect size was medium (d = .53; Weinsztok et al., 2021). Internet smartphone use was significant with a small effect size when continuous association studies were considered (r = .13) but did not reach significance with categorical comparisons (Weinsztok et al., 2021). Food addiction was significant with a small effect size (r = .12).

Personality. Individual differences in personality have been examined in relation to delay discounting with mixed results. Some studies have shown a higher discounting rate to correlate with greater extraversion and lower conscientiousness (Daly et al., 2009; Daugherty & Brase, 2010; Mahalingam et al., 2014); these findings were not replicated in a study by Yeh et al.

(2021). Discounting rate was significantly associated with agreeableness in one study (Yeh et al., 2021), but not in another (Daly et al., 2009). Mahalingam et al. (2014) showed a relationship between discounting rate and neuroticism that Yeh et al. could not replicate. Mahalingam et al. found greater discounting rate to correlate with lower openness whereas Daly et al. (2009) found no relationship. According to Mahalingam et al., these inconsistent results stem from a reliance on small, student samples of convenience. However, using a sample of over 5,000 international participants recruited using a popular social media website, Mahalingam et al.'s results were similar to many of the previously conducted studies. The relationship between personality and delay discounting is complex and likely warrants the consideration of moderating variables.

One personality construct that has been examined extensively in relation to delay discounting is impulsivity. Delay discounting is considered a behavioural index of trait impulsivity (MacKillop et al., 2016). Further, impulsivity is defined as the preference for an immediate reward of lesser value over a delayed reward of greater value (Ainslie, 1975). This would suggest a striking degree of overlap between impulsivity and delay discounting. The empirical evidence, however, is less straightforward. Numerous studies have demonstrated positive correlations between discounting rate and impulsivity according to self-report measures (Bobova et al., 2009; Coffey et al., 2003; de Wit et al., 2007; Hinson et al., 2003; Kirby et al., 1999; Kirby & Finch, 2010; Kirby & Petry, 2004; Koff & Lucas, 2011). It should be noted that the strength of evidence linking self-reported trait impulsivity and discounting differs depending on the specific impulsivity factor. For example, using a frequently used self-report measure of impulsivity, the Barratt Impulsiveness Scale (Patton et al., 1995), some studies have shown that discounting rate is related to nonplanning impulsivity but not attentional nor motor impulsivity (de Wit et al., 2007; Koff & Lucas, 2011). Further, others have failed to show a relationship between self-report measures of impulsivity and discounting. Crean et al. (2000) showed that discounting rate was significantly higher among psychiatric outpatients who were considered high risk for impulsive behaviours on the basis psychiatric diagnosis compared to outpatients considered low risk; however, no relationship was found between discounting rate and scores on a self-report measure of impulsivity, the Eysenck Impulsiveness Scale (I7; Eysenck et al., 1985). Reynolds et al. (2006) found no association between discounting rate and trait impulsivity measured using the Barratt Impulsiveness Scale nor the I7 and Patalano et al. (2018) found no relationship between discounting rate and the Barratt Impulsiveness Scale. Like other personality traits inconsistently found to correlate with discounting rate, the actual relationship between impulsive personality and discounting rate is likely contingent on moderating variables.

Cognition. In children, the ability to delay gratification has been linked with IQ (Mischel & Metzner, 1962). Numerous studies have demonstrated an association between discounting rate and general intelligence in adults; a higher rate of discounting correlates with lower cognitive ability (Bobova et al., 2009, de Wit et al., 2007; Dohmen et al., 2010; Dom et al., 2007; Kirby & Petry, 2004; Olson et al., 2007; Shamosh & Gray, 2008; but c.f. Kirby et al., 1999).

Dube et al. (2020) examined delay discounting in relation to the Behavioral Rating Inventory of Executive Function (Barkley, 2011), a self-report measure of executive function. Of the eight subscales, only emotional control was associated with discounting such that greater emotional control was related to less discounting (Dube et al., 2020). Using a different self-report measure of executive function, the Dysexecutive Questionnaire (Wilson et al., 1996), Hinson et al. (2003) found a relationship between executive function and discounting rate; individuals who scored higher on the Dysexecutive Questionnaire exhibited a greater rate of discounting. It should be noted that the original sample was reduced in this study to include only extreme scores (high and low) on the Dysexecutive Questionnaire.

Discounting rate has been found to correlate with lower verbal and abstract reasoning skills (Kirby & Petry, 2004). Impaired learning and memory scores have also been associated with greater discounting rates among methamphetamine users (Hoffman et al., 2006). However, this effect did not emerge among the nondrug using controls. Further, no associations in either group were found between discounting and visuospatial function, attention, or executive function (Hoffman et al., 2006).

Studies have shown that patience for delayed rewards is associated with greater working memory capacity (Aranovich et al., 2016; Bobova et al., 2009; Finn et al., 2015; Shamosh et al., 2008) and that taxing this information processing system with a working memory load increases discounting rate (Bailey et al., 2018; Finn et al., 2015; 2018; Hinson et al., 2003). Working memory has been suggested to be the limited-capacity cognitive system that facilitates a lower discounting rate by enabling self-regulation (Finn et al., 2015).

Individual differences in delay discounting have been linked to neurocognition. A neuroimaging study by Elton et al. (2017) used functional magnetic resonance imaging to reveal a differential pattern of brain activity among individuals who preferred larger delayed rewards over smaller immediate rewards. Specifically, greater discounting was associated with a pattern of neural activation in a temporal lobe network comprising the amygdala, hippocampus, parahippocampal gyrus, posterior insula, and superior temporal gyrus, while lower rates of discounting were associated with neural activity in the frontoparietal-striatal network (Elton et al., 2017).

Self-Regulation. Self-regulation is one mechanism thought to promote adaptive decision making in line with long term goals (Barkley, 2001). Self-regulation is effortful and overriding the preference for an immediate reward is demanding of limited cognitive resources (Muraven & Baumeister, 2000). Self-regulation refers to a collection of cognitive processes that allow an individual to inhibit goal-incongruent behaviour and suppress attention directed at goal-incongruent stimuli (Casey et al., 2002). It involves the implementation of behaviours necessary to achieve a long-term goal while in the presence of immediately gratifying alternatives (Berns et al., 2007). Attainment of a long-term goal requires not only an intertemporal decision that favours the long-term goal, but also sustained cognitive control to inhibit the temptation to pursue immediate gratification (Berns et al., 2007).

The work of Walter Mischel and colleagues provided evidence linking self-regulatory capacity with the ability to delay gratification using an experimental research paradigm commonly referred to as the Marshmallow Test (Mischel et al., 2011). Under this paradigm, children were given the option of acquiring a preferred snack food if they were able to wait for a period of time. Alternatively, they could signal at any point during the waiting period to terminate the waiting, forfeit the preferred snack food, and acquire a less preferred snack food. In other words, the child was made to choose between a less valued immediate reward and a delayed reward of greater value. The ability to delay gratification, using this paradigm, has been linked to future behaviours related to effective self-regulation (Mischel et al., 2011; 1988; 1989). According to Mischel et al. (2011), the relationship between the desirable psychological, behavioural, health-related, and economic outcomes predicted by a greater ability to delay gratification are mediated by willpower or self-control. By engaging inhibitory cognitive processes, individuals can exert the self-control needed to forgo immediate temptations in favour of larger delayed rewards (Eigsti et al., 2006). Like delay of gratification ability, delay discounting has also been linked to self-regulation. Studies have shown a connection between lower discounting rates and better cognitive control and self-regulation according to self-report measures (Daly et al., 2009; Dube et al., 2020).

The relationship between delay discounting and self-regulation is also supported by neurocognitive evidence demonstrating the shared brain areas involved in self-regulation and in patience for delayed rewards. The lateral prefrontal cortex is involved in self-regulatory processes like cognitive control related to response inhibition and cognitive control of emotions (Carter & van Veen, 2007; Hare et al., 2009; Ochsner & Gross, 2005). Greater lateral prefrontal cortex activity is associated with a lower discounting rate (Figner et al., 2010; Lebreton, 2013; McClure et al., 2004; Stranger et al., 2013).

Self-regulatory resources can be exhausted by engaging in demanding executive function tasks resulting in decreased activity in the lateral prefrontal cortex (Blain et al., 2016; Persson et al., 2013). Demanding executive function tasks that recruit the lateral prefrontal cortex, such as those involving working memory or task-switching, are often used experimentally in studies of ego-depletion to produce conditions of cognitive load (Koechlin et al., 2003; Owen et al., 2005; Wesley & Bickel, 2014). Ego-depletion is a term that is used to describe the indiscriminate nature of cognitive fatigue. In other words, the exhaustion of cognitive resources that is achieved through sustained performance on a task that requires executive control, should have carry-over effects which present as fatigue and impaired performance in other areas that depend upon the lateral prefrontal cortex (Baumeister et al., 1998; Persson et al., 2013).

Heart Rate Variability. Cardiac vagal tone is a marker of self-regulation and, thereby, a potential correlate of delay discounting. According to neurovisceral integration theory, cardiac vagal tone is involved in self-regulation, particularly with respect to the regulation of attention and emotions (Thayer et al., 2009; Thayer & Lane, 2000; 2009). Cardiac vagal tone refers to the activity of the vagus nerve on the heart and is hypothesized to serve as a marker of the efficiency of the autonomic nervous system in responding to changes in the internal and external environments of the individual (Thayer & Lane, 2000). Adaptive, goal-directed behaviour requires the precise organization of various processes in the service of a desired outcome. The successful orchestration of goal-directed behaviour is therefore reliant upon inhibitory processes which serve to interrupt and redirect affective or attentional processes that are incongruent with a desired goal (Thayer & Lane, 2000). The efficiency with which this overall process functions manifests in terms of affective and behavioural flexibility for which heart rate variability (HRV) is a marker (Thayer & Lane, 2000). The prefrontal cortex enables goal-directed behaviour through its inhibitory action on subcortical centers. The inhibitory control of the prefrontal cortex also extends to subcortical circuits involved in heart rate acceleration.

The central autonomic network, which comprises a collection of brain structures involved in the coordination of goal-directed behaviour that responds in an adaptive and flexible manner to environmental requirements, is connected to the sinoatrial node (i.e., the pacemaker) of the heart via the stellate ganglia (sympathetic) and vagus (parasympathetic) nerves which, together, influence the beat-to-beat variability of heart rate (Saul, 1990; Thayer & Lane, 2000). It is through these nervous connections that HRV is associated with the efficiency of the organism's self-regulatory capacity (Thayer & Lane, 2000). Greater input from the parasympathetic branch of the autonomic nervous system serves an inhibitory role which can contribute to the ability of an individual to self-regulate thoughts, feelings, and behaviours.

The neurovisceral integration model posits that the self-regulatory capabilities that serve to help the individual adapt to their environment are mirrored by changes in HRV with high variability serving as a marker of high adaptation capability (Thayer & Lane, 2000). Research has demonstrated the utility and validity of HRV as an index of self-regulatory strength and the exertion of self-regulatory effort (Segerstrom & Nes, 2007).

Cardiac vagal tone can be assessed at rest or during a task of interest and both indices, resting HRV and HRV reactivity, represent distinct constructs. Resting HRV, or tonic HRV, refers to the beat-to-beat variability of the heart at baseline (Laborde et al., 2017). The neurovisceral integration model posits that greater resting HRV is more adaptive (Thayer et al., 2012) and studies have shown greater resting HRV to predict better self-regulation (Forte et al., 2021; Reynard et al., 2011; Maier & Hare, 2017). Applied to the topic of delay discounting, greater resting HRV could thereby be expected to predict more adaptive functioning which would be represented by a lower discounting rate. This result was shown in a study by Daly et al. (2009). In this study, participants had their cardiac activity measured continuously from morning until night for 1 full day using a portable heart rate monitor. A metric called SDNN was derived from the electrocardiogram (ECG) recording to represent resting HRV. An ECG recording contains repeating patterns of QRS complexes that represent sinus node depolarization (Malik, 1996). The distinctive peak of each complex is referred to as an R spike. The distance between successive R spikes is known as the interbeat interval, or R-R interval, and represents the duration of a single heartbeat which is variable over time. It is the variability in successive R-R intervals that comprises HRV. There are three general methods for calculating HRV indices, namely the time domain, the frequency domain, and nonlinear methods (Laborde et al., 2017). Within each method, there are numerous HRV metrics, the utility of which depends on the specific research question and the methods of ECG data collection. The SDNN variable used by Daly et al. is calculated by obtaining the standard deviation of all R-R intervals in the ECG recording. The SDNN variable represents all the cyclic components that contribute to variability in the ECG recording (Malik, 1996). This variable is affected by recording length and 24-hour recordings are typically recommended (Malik, 1996). While shorter recordings can be used, recordings of different lengths should not be compared because of the strong influence that recording length has on the estimate of HRV; SDNN reflects greater HRV as recording length increases (Malik, 1996). It is unclear whether a constant recording length was used by Daly et al. The study reports only that cardiac activity was recorded from waking until bedtime. Daly et al. used the Monetary Choice Questionnaire (MCQ; Kirby et al., 1999) to measure discounting rate and found a significant relationship with HRV such that greater SDNN was associated with a lower rate of discounting. While this finding suggests a relationship between resting HRV and discounting rate, the result was not replicated in another study (Steenbergen et al., 2020).

Rather than using SDNN, Steenbergen et al. (2020) used the root mean square of successive difference (RMSSD) metric to represent resting HRV. RMSSD is the most used metric within the time-domain methods (Laborde et al., 2017; Malik, 1996). It reflects vagal tone (Laborde et al., 2017; Malik, 1996) and, unlike other metrics, it is relatively free of the influence of respiratory sinus arrhythmia (Hill & Siebenbrock, 2009). RMSSD can also be used for very short recordings (i.e., under 5 minutes in length; Malik, 1996). Further, because RMSSD is an index of vagal tone but not overall HRV, the requirement of equal recording length is less important than it is for overall HRV indices like SDNN (Laborde et al., 2017; Malik, 1996). Steenbergen et al. used a 5-minute baseline ECG recording to calculate an index of resting HRV using RMSSD. Instead of the MCQ, Steenbergen et al. used the Adjusting Immediate Amount task (Holt et al., 2012). This task comprises 12 questions with two delayed amounts, and six periods of delay. As such, there is less variability in immediate amount, delay amount, and delay period as compared to the MCQ. Steenbergen et al. did not find an association between resting

HRV and discounting rate. No published study to date has investigated the relationship between resting HRV and discounting rate using RMSSD and the MCQ.

In contrast to resting HRV, HRV reactivity refers to a change in HRV that occurs when cardiac activity is measured at two different timepoints (Laborde et al., 2017). Usually, HRV is measured at baseline and then measured a second time during a task of interest. The difference in HRV between the two measurements is referred to as HRV reactivity or phasic HRV. Vagal withdrawal, which is a reduction in HRV relative to baseline, is considered adaptive in response to both physical and mental stressors (Porges, 2007). However, in stress inducing situations that necessitate executive resources, increased HRV relative to baseline is thought to be the more adaptive response (Laborde et al., 2017). Given the putative role of executive working memory in reducing discounting rate (Finn et al., 2015), and the adaptiveness of lower discounting rate, greater HRV reactivity would be expected to predict a lower discounting rate, according to neurovisceral integration theory (Thayer et al., 2012).

A paucity of experimental studies has examined the relationship between HRV reactivity and delay discounting. Guan and He (2018) showed increased HRV reactivity during the completion of a Stroop task and a delay discounting task among those high in trait-self control relative to those low in trait self-control. However, the relationship between HRV reactivity and discounting rate was not directly examined.

Fung et al. (2017) directly compared HRV reactivity and discounting rate and did not find a significant relationship. In this study, discounting rate was measured using a discounting task that was not the MCQ. Limited details about the task were provided by the authors; it is, however, reported that there are six periods of delay and that the amount of money offered in the immediate option varied between \$20 and \$30 (Fung et al., 2017). The high frequency metric was used for HRV analysis. This is a frequency domain measure that reflects vagal tone and is highly correlated with RMSSD (Laborde et al., 2017). Unlike RMSSD, it is highly influenced by respiratory sinus arrhythmia (Hill & Siebenbrock, 2009). Respiratory sinus arrhythmia refers to the changes in HRV that are observed because of breathing. Heart rate acceleration is observed following inspiration and heart rate deceleration occurs following expiration (Segerstrom & Nes, 2007). This variability does not reflect the activity of the vagus nerve but is reflected in the high frequency variable. Further, Fung et al. did not obtain two measurements of cardiac activity at distinct timepoints. Rather, cardiac activity was continuously measured over the course of 1 hour lasting the entirety of the experimental procedure. Consequently, the resulting high frequency HRV metric does not reflect resting HRV, nor does it reflect HRV reactivity because there is no baseline point for comparison.

A recent meta-analysis showed that greater resting HRV was predictive of adaptive decision-making using a variety of decision-making tasks (Forte et al., 2022). Limited research to date, however, has examined the relationship between either resting HRV or HRV reactivity and performance on delay discounting tasks. Further study is required using best practices for HRV analysis and using the MCQ to measure discounting rate.

Experimental Manipulations and Discounting Rate

In addition to the numerous studies that have identified correlates of delay discounting, research has also focused on changes in discounting rate following the experimental manipulation of different factors. A meta-analytic study of experimentally manipulated decreases in discounting rate found significant effects of variety of different types of experimental manipulations (Rung & Madden, 2018). Significant reductions in discounting with varying effect sizes were shown for clinical manipulations, episodic future thinking manipulations, framing manipulations, priming manipulations, cueing manipulations, contextual manipulations, instruction-based manipulations, and learning-based manipulations (Rung & Madden, 2018). No significant effects of perspective manipulations were found. Others have shown that discounting rate can be increased following the experimental manipulation of cognitive load.

Cognitive Load. The ability to engage in effective self-regulation is a limited resource that can be temporarily exhausted by cognitively demanding tasks (Muraven, & Baumeister, 2000). Studies have shown that compromising cognitive resources leads to increased discounting rates (Blain et al., 2016; Guan & He, 2018). Haushofer et al. (2013) demonstrated the specificity of the cognitive component's influence on discounting rate. Haushofer et al. measured discounting rate in two groups with equivalent cognitive load. One of the groups had an additional social evaluation component intended to elicit psychosocial stress. The results showed that discounting rates did not differ between groups and provided support for the specific role of cognitive resource availability in delay discounting. One cognitive aspect that appears to be particularly relevant for the prediction of discounting rate is working memory.

Working Memory. Working memory is a cognitive system that allows for a limited quantity of information to be held in focus and attended to through the integration of attention and memory processes (Cowan, 1998; Cowan et al., 2005; Engle et al., 1999; Shipstead et al., 2012). According to Cowan's model of working memory, there are two separate but related components of working memory: the span and the scope (Shipstead et al., 2012). The scope refers to the amount of information that can be actively held in working memory (Cowan, 2001; Fukuda et al., 2010; Vogel & Machizawa, 2004). The span refers to the control of attention. Often referred to as the central executive component of working memory, this component ensures that attention remains focused on goal-congruent information and stimuli (Fukuda &

Vogel, 2009; Healey & Miyake, 2009; Kane et al., 2001; Kane & Engle, 2003). According to Baddeley's model of working memory, the scope can be further subdivided into two distinct systems: a phonological system for the brief storage of memory traces involving sound and language and a visuospatial system for visual information (Baddeley, 2003). The capacity of the scope of working memory can be assessed using working memory span tasks (see Conway et al., 2005). Phonological and visual working memory both have limited capacity (Baddeley, 2003) but their capacities are nonoverlapping (Waters et al., 2003). The working memory models of Baddeley and Cowan both acknowledge and emphasize the role of the central executive and are not incompatible with each other.

The central executive component of working memory is involved in attentional control and is responsible for coordinating goal-directed behaviour. According to one model of decision-making (Endres et al., 2014; Finn, 2002; Finn et al., 2015), the central executive component of working memory influences delay discounting through the control of attention during the deliberation phase of decision-making. It is argued that greater executive working memory capacity enables more adaptive decision-making because the cognitive processes required to facilitate optimal decision-making are demanding of a limited-capacity system (Finn et al., 2015). Neuroimaging results support this idea, having shown a relationship between discounting rate and engagement of an executive attention control network (Stranger et al., 2013).

Attentional capture is a phenomenon whereby attention is involuntarily redirected to salient stimuli even if they are distractors or are incongruent with goals. Fukuda and Vogel (2009) demonstrated that the ability to override attentional capture by salient stimuli is predicted by working memory capacity. With reference to the discounting paradigm, options that confer immediate rewards are more salient because they are more relevant to the present; they are therefore more likely to draw immediate attention. Finn and colleagues (2015) argue that greater executive working memory capacity allows the individual to direct their attention away from the more salient, immediately relevant option in order to consider the delayed choice, and to be able to shift attention between the two options during the process of deliberation, while engaging in other cognitive processes (e.g., memory retrieval, cost-benefit analysis).

The effortful process of redirecting attention away from the more salient immediate reward to consider to delayed reward of greater value is demanding of the limited cognitive resources available in the working memory systems. Further, this process may specifically draw upon the capacity of the central executive working memory system. Studies have shown that depletion of attentional control resources, specifically, increases the preference for smaller immediate rewards in certain populations (Finn et al., 2015). While this suggests advantages for individuals who have a greater working memory capacity, it also highlights a method of experimentally increasing discounting rate. Experimental studies have used this method and shown that the addition of a working memory load increases discounting of delayed rewards (Bailey et al., 2018; Finn et al., 2015; Hinson et al., 2003).

Hinson et al. (2003) conducted four experiments to assess the relationship between working memory load, delay discounting, impulsive personality, and executive functioning. Using a sample of psychology undergraduate students, the first study manipulated cognitive load and measured discounting rate. Participants completed a discounting task in which they indicated their preferences between the receipt of an immediate hypothetical sum of money or a delayed amount of larger value. Three blocks of the discounting task were completed, each involving a different cognitive condition. All participants completed three different cognitive conditions: (1) digit load, (2) random number generation, and (3) control. The three conditions were completed in random order. In the digit load condition, they were presented with a string of five digits and instructed to remember it until after indicating their preference between the immediate or delayed reward. Once they had made their choice, they were presented with one of the five digits and asked to recall the digit to the right of the presented number. In the random number generation condition, participants were asked to generate a number from between one and nine. In the control condition, a number between one and nine was presented and they had to press the corresponding number on the computer keyboard. A significantly higher discounting rate was observed for the digit load conditions, compared to both the random number generation and control conditions which did not differ from each other. The results show that the working memory load led to an increased preference for immediate rewards of smaller value.

Using a different sample of psychology undergraduate students, the second experiment conducted by Hinson et al. (2003) showed a dose-dependent effect of working memory load on discounting rate. The same procedure was used, except instead of the three cognitive conditions used previously, only the digit load procedure was used. Using a within-groups design, the level of cognitive load was varied across three conditions by manipulating the number of choices on the discounting task. Participants indicated their preference selecting between two, three, or four hypothetical sums of money, depending on the condition. Results showed that discounting rate increased along with the number of choices on the discounting tasks, suggesting that greater demands placed on working memory produce greater increases in discounting rate.

In the third experiment conducted by Hinson et al. (2003), a larger sample of psychology undergraduate students completed two self-report measures. The first was a measure of trait impulsivity (Barratt Impulsiveness Scale; Patton et al., 1995) and the second was a measure of executive function (Dysexecutive Questionnaire; Wilson et al., 1996). A small subset of respondents who were either very high or very low in trait impulsivity were invited to complete the same procedure described in the second experiment. The results of this experiment revealed a greater discounting rate in the high impulsivity group, and a correlation between trait impulsivity and executive dysfunction, as well as between executive dysfunction and discounting rate. In sum, impulsive participants with reduced executive control displayed higher discounting rates.

In the fourth and final experiment conducted by Hinson et al. (2003), a small sample of psychology undergraduate students completed the delay discounting task with three cognitive conditions. In the first, they made a choice between two reward options (control), in the second they made a choice between three reward options, and in the third they made a choice between two reward options but also completed the digit load recall task described in the first experiment. Whereas the first three experiments used hypothetical sums of money, in this fourth experiment, participants were told that one participant would be selected to win one of the money values described, at the time-delay described for one of their intertemporal decisions on the discounting task. Results showed that discounting rate was significantly lower in the control group than the digit load and three choice conditions, which did not differ from each other. Taken together, the results reported by Hinson et al. provide support for the use of a working memory load to experimentally increase discounting rate (cf. Franco-Watkins et al., 2006 who provides a different interpretation of the findings). Moreover, they show that trait impulsivity and executive dysfunction are related factors that warrant further examination.

A 2015 study by Finn et al. examined the influence of baseline executive working memory capacity and working memory load on delay discounting in a sample of young adults. All study participants had externalizing psychopathology including alcohol and substance use disorders, antisocial personality disorder, and conduct disorder. A variety of measures were administered to participants to estimate baseline executive working memory capacity. Participants were then randomized either to the no-load or to the working memory load condition. In the no-load condition, the participants responded to a series of intertemporal choice questions, indicating their preference between a given amount of money received immediately or the receipt of $50.00 after a delay. The value of the immediate reward ranged from $2.50 to $47.50 and the delay period varied between one of six different lengths of time. Participants indicated their choice for each question after a 10-second delay. Participants in the working memory load condition completed the same discounting task with the addition of a cognitive load. After each intertemporal question choice was presented, a three-dight number was displayed for the participant to remember. They were instructed to count backwards from the presented number by threes for 10 seconds, make their choice between the smaller immediate and larger delayed reward, and then recall the three-digit number. Finn et al. found a significantly higher rate of discounting in the working memory load condition. Further, lower baseline executive working memory capacity predicted greater discounting which remained significant after controlling for IQ (Finn et al., 2015). Because this study examined a clinical sample of individuals with externalizing psychopathology, the generalizability of these findings to nonclinical populations remains unknown.

Using a small sample of adults, Aranovich et al. (2016) examined the effect of cognitive load on delay discounting and assessed concurrent neurocognitive activity. Participants completed a delay discounting task and an *N*-back task, the latter of which was used to manipulate cognitive load. The *N*-back task involves the presentation of irregular shapes on a computer screen, one by one in sequence. Participants are instructed to indicate whenever a presented shape matches the shape that was presented *n* shapes previously. The variable *n* varies according to condition. In this study, participants completed blocks where *n* = 1 (low cognitive load), *n* = 4 (high cognitive load), or *n* = 0 (rest). In addition to using this load to challenge cognitive resources, the authors also sought to induce negative affect and stress in these high cognitive blocks. Blocks of the discounting task followed the completion of 4-back and 1-back blocks to provide an estimate of the influence of the challenging cognitive task on discounting compared to the low cognitive load block (1-back). Participants completed the entire task while undergoing fMRI scanning. The results obtained by Aranovich et al. (2016) showed that greater working memory capacity, operationally defined by 4-back performance accuracy, predicted a lower rate of discounting. Overall, the challenging cognitive task (4-back) did not produce a higher rate of discounting than the easier cognitive task (1-back). However, when performance on the 4-back was also considered, a significant effect emerged. The results showed a correlation between poorer 4-back performance and increased discount rate; those who performed well on the 4-back task were more to have a lower discount rate than those who performed poorly.

Bailey et al. (2018) studied delay discounting and working memory load in a sample of undergraduate students with alcohol use disorder, and healthy controls. A shortened version of the delay discounting task described in Finn et al. (2015) was used by Bailey et al.; the smaller immediate rewards were presented in increments of $5.00 instead of $2.50. This resulted in a smaller number of intertemporal choices between smaller immediate and larger delayed rewards. Further, the discounting procedure in Bailey et al. included an additional component to assess discounting rate of losses, following the previously described procedure used to estimate reward discounting. Finn et al.'s procedure for manipulating working memory load across two conditions was replicated in this study. However, whereas Finn et al. used a between-subjects design, Bailey et al. used a within-subjects design; all participants completed both the no-load and the working memory load condition procedures, in a counterbalanced order. Bailey et al. found that working memory load significantly increased discounting rate. Two important interaction effects were observed, involving clinical group and sex. First, the working memory load increased discounting among the healthy controls but had no effect on the alcohol use disorder group. This finding contradicts what was found by Finn et al. (2015). Second, the working memory load increased discounting in men, but not in women.

In a more recent study using a sample of college students, Gunn et al. (2018) demonstrated main and interaction effects of clinical group, working memory load, and of an intervening refocusing prompt on discounting rate. Participants were categorized into one of three clinical groups: alcohol use disorder and antisocial personality disorder, alcohol use disorder only, and healthy controls without externalizing psychopathology. Participants were randomized to one of three experimental conditions: working memory load, no-load, or refocusing. The first two conditions employed the same procedure described in Finn et al. (2015). In the working memory load condition, participants were presented with a three-dight number to remember, instructed to count backwards by threes for 10 seconds, made their choice between a smaller immediate reward and a larger delayed reward, and then recalled the presented three-digit number. This process was repeated for each intertemporal choice question. In the no-load condition, the participants answered the intertemporal choice questions, without a cognitive load, but with a 10-second delay before indicating their choice. The refocusing condition was identical to the working memory load condition, but participants were prompted to refocus on the choice before making their selection between the smaller immediate and larger delayed reward. Working memory load and no-load conditions used the same data reported in the study by Finn et al. (2015). Gunn et al. (2018) recruited a new sample for the refocusing group. Gunn et al. (2018) found a significantly higher discounting rate in the working memory load condition compared to both the no-load and refocusing conditions; discounting did not differ between the latter two. This suggests that prompting the participants to refocus their attention on the choice was able to offset the negative effect of the working memory load on discounting rate. However, this remediating effect of refocusing was only present among the clinical groups; refocusing attention did not offset the negative effect of working memory load among the healthy controls.

The reviewed studies demonstrate the ability of a working memory load to increase discounting rate. Taken together, these results support the idea of a working memory system as the limited-capacity cognitive system that facilitates a lower discounting rate (Finn et al., 2015). This cognitive pathway to lower discounting rate may have adaptive utility owing to the association between a lower discounting rate and a myriad of positive behaviours. However, this cognitive pathway is not without limitations. First, this method is reliant on a limited capacity system. The successful use of cognitive control to lower discounting rate depends upon resource availability which can be depleted by other tasks (Bailey et al., 2018; Finn et al., 2015; Hinson et al., 2003). Consequently, individuals are vulnerable to impulsive decision-making when cognitive resources are taxed by competing demands. Moreover, the successful use of cognitive control to lower discounting rate appears to depend on baseline working memory ability (Aranovich et al., 2016; Bobova et al., 2009; Finn et al., 2015; Shamosh et al., 2008). As such, the desirable aspects associated with a lower discounting rate may be less attainable for individuals with lower baseline working memory capacity.

Gratitude. One group of researchers has proposed an alternative pathway to lower discounting rate that is not subject to the limitations of a limited-capacity system. DeSteno (2009) suggests that social emotions, defined as mental states that arise in order to facilitate the successful navigation of interpersonal interactions, can also provide benefits beyond social interactions. He argues that waiting for delayed rewards is part of forming relationships with reciprocal benefits and, as such, the social emotions that give rise to human social behaviour can also lead to patience for delayed rewards (DeSteno, 2009). Specifically, gratitude, which is the positive affective state experienced after either receiving or being offered something of value from another person (McCullough et al., 2001; 2004) has been suggested as an alternative to the previously described cognitive pathway to lower discounting rate (DeSteno, 2009). Two empirical studies conducted by this research group have provided support for this hypothesis, demonstrating that trait gratitude, state gratitude, and experimentally manipulated gratitude are each associated with significantly lower discounting rates (DeSteno et al., 2014; Dickens & DeSteno, 2016).[1]

In the first of these studies, DeSteno et al. (2014) showed that the experimental induction of gratitude led to a lower discounting rate relative to two other affective conditions. In this study, university student participants were assigned to one of three experimental conditions that differed according to the emotion that was induced. Autobiographical recall was used to manipulate affect. Participants were instructed to think about an event that made them feel happy, grateful, or to think about the events of a typical day, depending on their condition assignment. Next, they were instructed to write about the event for a duration of 5 minutes which was followed by the completion of a brief questionnaire assessing affective state. This questionnaire was used to discern the intensity of self-reported state gratitude and to check

[1] In 2018, Patalano et al. published the results of a study replicating DeSteno et al.'s (2014) gratitude manipulation procedure and using an alternative to the MCQ to measure discounting rate. Patalano et al. did not find a significant relationship between gratitude and discounting rate. The study by Patalano et al. was not yet published when data collection for the current program of research was initiated.

whether the manipulation of affect across conditions was successful. The participants then completed the MCQ. Results revealed that those assigned to the gratitude condition displayed significantly lower discounting rates when compared to those assigned to the happiness or neutral conditions with a medium effect size ($d = 0.62$). Discounting did not differ between the happiness and neutral groups. Furthermore, the intensity of self-reported state gratitude also predicted discounting such that more gratitude was associated with a lower rate of discounting.

In a follow-up study, Dickens and DeSteno (2016) demonstrated the relationship between mean daily levels of gratitude and delay discounting. Using a university student sample, gratitude was experimentally induced in a laboratory setting using a contrived social situation involving a confederate (see Bartlett & DeSteno, 2006; DeSteno et al., 2010). Participants then completed a brief questionnaire to ensure the success of the affective manipulation and to measure intensity of state gratitude. Participants then completed a daily questionnaire for 3 weeks; the questionnaire assessed mean levels of gratitude and happiness. At the end of the 3-week period participants competed the MCQ. Mean daily levels of gratitude predicted discounting rate such that more gratitude was associated with less discounting. Results also revealed a correlation between the intensity of self-reported state gratitude following the initial gratitude induction and mean daily gratitude (Dickens & DeSteno, 2016).

DeSteno et al. (2014) argue that gratitude offers a way to reduce discounting rate in a manner that is not subject to limitations of relying on self-regulation because it does not depend on a limited-capacity cognitive system. DeSteno et al. describe the proposed gratitude pathway as effortless and intuitive. If this pathway is distinct from the cognitive pathway that relies on a limited capacity working memory system, then the reduction in discounting rate that is observed following a gratitude induction should not be attenuated by a working memory load. This has not yet been tested empirically. The effect of a gratitude induction on discounting rate under working memory load needs to be examined in order to strengthen the argument that the emotional experience of gratitude represents a distinct pathway to lower discounting rate.

Experiment 1

Discounting rate is influenced by several individual and contextual factors and has been linked to a wide range of positive characteristics, achievements, and behaviours. Discounting rate is typically represented by the variable *k*. Higher *k* represents greater impatience or a stronger preference for smaller immediate rewards. Identifying predictors of discounting rate, *k*, and understanding the mechanisms that underlie individual differences in *k* is of value because this information can inform interventions designed to reduce *k* in individuals for whom impulsive decision-making leads to impaired functioning. Further, this information can lead to the development of strategies that can protect against impulsive decision-making in contexts known to increase *k*.

One pathway to reduce *k* by overriding the preference for an immediate reward involves effortful self-regulation achieved by engaging executive function processes (Barkley, 2001; Berns et al., 2007; Endres et al., 2014; Finn, 2002; Finn et al., 2015). It has been suggested that this cognitive pathway to lower *k* relies on a limited-capacity cognitive system involving executive working memory (Endres et al., 2014; Finn, 2002; Finn et al., 2015). To this effect, individual differences in working memory ability predict *k* (Aranovich et al., 2016; Bobova et al., 2009; Finn et al., 2015; Shamosh et al., 2008) and the experimental manipulation of cognitive load that taxes working memory resources increases *k* (Bailey et al., 2018; Finn et al., 2015; Hinson et al., 2003). Individuals with a tendency toward higher *k* are more likely to have lower working memory capacity and there is some evidence that cognitive strategies such as attention refocusing can reduce *k* in these individuals (Gunn et al., 2018). However, because this cognitive pathway relies on a system of limited capacity, such cognitive strategies are unlikely to be effective in contexts where the limited-capacity system is taxed by heavy demands, regardless of working memory capacity.

An alternative to this cognitive pathway has been proposed by one research group. According to this group, gratitude can reduce *k* through an affective pathway that is different from the pathway involving executive function (DeSteno et al., 2014; Dickens & DeSteno, 2016). They argue that this affective pathway can reduce *k* without effortful self-regulation and describe this alternate pathway as effortless and intuitive (DeSteno et al., 2014). They have shown experimentally that manipulating gratitude reduces *k* and have posited that their results "strongly support a second route to combat excessive impatience" (DeSteno et al., 2014, p. 1265). Further, they argue that "this route can operate relatively intuitively and thus effortlessly from the bottom up" (DeSteno et al., 2014, p. 1265). As this group has highlighted, the value of a pathway to lower *k* that is effortless and that does not involve executive function lies in its resistance to depletion effects and self-regulatory failure resulting from contextual factors. Moreover, a gratitude pathway would present a promising avenue to reduce *k* in individuals with lower working memory capacity and to protect against increased *k* in contexts where cognitive demand is elevated. If the gratitude pathway is distinct from the cognitive pathway, then a cognitive load that taxes the limited-capacity working memory system thought to underlie the cognitive pathway should not influence the effect of gratitude on *k*.

The purpose of the current study was to replicate the effects of gratitude and cognitive load on *k*. Gratitude condition and cognitive load condition were experimentally manipulated in a 2 x 2 between-groups design to ascertain their predictive ability for the criterion variable *k*. In line with previous findings (e.g., Bailey et al., 2018; Finn et al., 2015; Hinson et al., 2003), a main effect of cognitive load condition was predicted. High cognitive load was expected to increase *k*. Further, a main effect of gratitude condition was expected, as was shown by DeSteno et al. (2014). Specifically, it was hypothesized that the experimental manipulation of gratitude would reduce *k* relative to the control group. Whether an interaction effect would emerge between cognitive load and gratitude conditions remained to be seen. An interaction would mean that the effect of gratitude condition on *k* depends on the level of cognitive load. Consequently, this would demonstrate that the gratitude pathway is not distinct from the cognitive pathway. An interaction would show that taxing cognitive resources interferes with the ability of gratitude condition to reduce *k* which would thereby mean that the gratitude pathway is not effortless, that it requires executive function, and that it is subject to depletion effects. In contrast, the absence of an interaction would support the idea that the gratitude pathway is different than the effortful cognitive pathway to lower *k.* DeSteno et al. (2014) and Dickens and DeSteno (2016) argue that gratitude-based interventions should be investigated as means of reducing *k.* It remains to be seen whether the proposed gratitude pathway to lower *k* is influenced by cognitive load. The results of the current program of research will shed light on whether cognitive- or gratitude-based interventions should be pursued for the reduction of *k* for populations and contexts where elevations in *k* are expected and reductions therein are deemed beneficial.

In addition to the experimental manipulation of gratitude, two other gratitude indices have been linked to *k*. State gratitude (DeSteno et al., 2014) and mean levels of gratitude in daily life (Dickens & DeSteno, 2016) have been shown to predict lower *k*. The current research sought to replicate these findings. Trait gratitude, operationally defined using the Gratitude Questionnaire-6 (GQ-6; McCullough et al., 2002), was measured as part of an online questionnaire battery. State gratitude was assessed with the same three self-report questions used by DeSteno et al. (2014) to measure this construct following their gratitude manipulation. For both trait and state variables, it was hypothesized that higher levels of gratitude would predict lower *k.*

According to the general view in the delay discounting literature, individuals can override a preference for immediate rewards in favour of delayed rewards of greater value by engaging in self-regulation. Further, executive functions are processes that enable self-regulation with the goal of altering an individual’s behaviour to influence more adaptive future outcomes for the individual (Barkley, 2001). The neurovisceral integration model proposes that higher HRV reflects better self-regulation and executive function, and that this relationship stems from the connection between the heart and prefrontal cortex through the vagus nerve and central autonomic network (Thayer et al., 2009). Under this model, higher resting HRV predicts more adaptive functioning (Thayer et al., 2012). Moreover, the association between higher resting HRV and adaptive decision-making has been shown experimentally using a range of decision-making tasks (Forte et al., 2022). Limited research to date, however, has examined the relationship between resting HRV and *k.* Daly et al. (2009) showed that greater resting HRV predicted lower *k.* In their study, resting HRV was defined as the SDNN, obtained from an ECG recording over 1 day and *k* was measured using the MCQ. Steenbergen et al. (2020) did not find a relationship between resting HRV and *k.* Resting HRV was defined in their study as the RMSSD obtained from a 5-minute baseline recording and *k* was measured using the adjusting immediate amount task which has fewer questions and less variability in delay amounts and delay periods than the MCQ. The current research program aimed to replicate Daly et al.’s findings using the MCQ to operationalize *k* but replacing SDNN with RMSSD obtained from a

5-minute baseline ECG recording. In line with the expected results under the neurovisceral integration model as well as Daly et al.'s experimental findings, it was hypothesized that greater resting RMSSD would predict lower *k.* A finding to this effect would support the idea that self-regulation involving executive function is a mechanism that underlies lower *k.*

The current experiment also investigated HRV reactivity during the completion of the MCQ as a predictor of *k.* Unlike resting HRV for which higher levels are most often considered adaptive, whether HRV reactivity is considered adaptive appears to depend on context (Laborde et al., 2017). Vagal withdrawal refers to a decrease in HRV. Greater vagal withdrawal during the task of interest is adaptive unless the task requires executive function (Porges, 2007; Thayer et al., 2012). When executive function is required, greater vagal withdrawal is considered maladaptive (Thayer et al., 2012). With respect to delay discounting, lower *k* is more advantageous than higher *k*. Thus, assuming that lower *k* is achieved by engaging is self-regulation through executive function, greater HRV during the completion of the MCQ would be expected to predict lower *k.* In a study by Fung et al. (2017), no relationship was found between HRV and *k*. However, this study did not use the MCQ to calculate *k.* Further, HRV was obtained from a 1-hour ECG recording that spanned the full experimental procedure. As such, no specific conclusions can be made about the relationship between *k* and HRV reactivity during the completion of the discounting task. The current research program investigates the relationship between *k* and HRV reactivity during the completion of a discounting task. Recall that under the neurovisceral integration model, greater vagal withdrawal is considered maladaptive when the task of interest requires executive function (Thayer et al., 2012) and that lower *k* is more adaptive. Assuming executive function contributes to adaptive performance on the discounting task, it was hypothesized that lower HRV during the MCQ would predict higher *k.*

The current study required the completion of an online questionnaire battery to measure personality traits and individual difference variables followed by a laboratory session. The laboratory session used an exact replication of DeSteno et al. (2014) in the experimental manipulation of gratitude condition and to measure *k*. To investigate whether DeSteno et al.'s proposed gratitude-based pathway to lower *k* is separate from the mechanism involving self-regulation and requiring executive function, cognitive load was experimentally manipulated following the gratitude induction. A demanding adaptive version and an easy version of the *N*-back task were used to manipulate high and low cognitive load, respectively (Jaeggi et al., 2010). This 20-minute cognitive task was completed after the gratitude manipulation and before the MCQ.

ECG was used to measure HRV. A 5-minute baseline recording was obtained at the outset of the experimental procedure. HRV reactivity was obtained from the recording taken during the completion of the MCQ. Both resting HRV (i.e., RMSSD at baseline) and HRV reactivity (i.e., RMSSD during the completion of the MCQ, controlling for RMSSD at baseline) were examined as predictors of *k*.

Elevated scores on the self-report measure of impulsivity I7 have been linked with higher *k* (Bobova et al., 2009; Coffey et al., 2003; Kirby et al., 1999; Kirby & Petry, 2004). However, *k* operationalizes the construct of impulsive choice which is distinct from the construct of impulsivity as a personality trait (MacKillop et al., 2016; Reynolds et al., 2006). Because *k* was the criterion variable in all analyses in the current study, the I7 was included as a covariate in all models.

Hypotheses

The specific hypotheses of the current experiment were as follows:

1. Gratitude induction would decrease *k* and high cognitive load condition would increase *k.* No prediction was offered for an interaction effect. The absence of an interaction, however, would provide support for a gratitude-based pathway to lower *k* that does not require effortful self-regulation or executive function.
2. Trait gratitude and state gratitude would predict lower *k.*
3. Higher resting RMSSD would predict lower *k* and lower RMSSD reactivity would predict higher *k.*

Method

Participants

A total of 142 participants were enrolled in Experiment 1. One participant did not adhere to procedural instructions during the laboratory session and another did not complete the online questionnaire battery. Three additional participants did not respond to all items on the MCQ resulting in an inability to calculate *k.* These five participants were excluded from all analyses, producing a total sample size of 137. Technical difficulties and ECG equipment failure led to other participants being excluded from the analyses that involved HRV variables. For the analysis that included resting HRV only, the sample size was 129. For the analysis that also included HRV reactivity, the sample size was 124.

Of the 137 participants, 136 reported their gender. The number of participants who described themselves as female was 95 (70%) and the number who described themselves as male was 41. Participants were also asked to indicate their ethnicity; 136 participants provided a response to this question. Ninety-six participants (70.1%) described themselves as Caucasian or White, 16 (11.7%) as South Asian, 8 (5.8%) as African, African Canadian, or Black, 5 (3.6%) as Aboriginal or First Nation, 4 (2.9%) as East Asian, 2 (1.5%) as Middle Eastern, and 5 (3.6%)

identified as multiracial. Age was reported by 129 participants and ranged from 18 to 60 (*M* = 23.66, *SD* = 8.33). A majority of the sample (76.7%) was aged 25 and under. Six participants (4.4%) reported a diagnosis of ADHD, 15 (10.9%) reported a diagnosis of depression, and five (3.6%) reported a traumatic brain injury.

Participants were recruited in Thunder Bay, Ontario from Lakehead University and Confederation College as well as nonstudent members of the public; 124 participants (90.5%) were university students, 7 (5.1%) were college students, and 6 (4.4%) were nonstudents. Among the university student respondents, 50 were 1st year students, 36 were 2nd year students, 19 were 3rd year students, 12 were 4th year students, and four were graduate students.

To be eligible to participate in the study, participants had to confirm they were fluent in English, nonsmokers, and not taking antidepressant, hypertensive, or cold medication at the time of participation. Further, participants were asked to abstain from alcohol for 12 hours prior to participation in the laboratory session and from exercise, food, caffeine, and nicotine for two hours prior. These variables are known to affect cardiac function (Laborde et al. 2017) and could therefore interfere with the integrity of the ECG recordings.

Participants who were registered in Lakehead University psychology courses eligible for bonus points were directed to the Sona Experiment Manager System where they could sign up to complete an online questionnaire battery via SurveyMonkey. All other participants could register for the study by contacting the researcher by email. A recruitment poster (Appendix A) approved by the Lakehead University Student Union was affixed throughout the university. The poster directed potential participants to search for the proposed study on the SONA experiment manager system or to contact the researcher via email. The same poster advertisement, approved by the Student Union of Confederation College, was affixed at the Confederation College campus. Whether registering for the study through SONA or by emailing the researcher, participants were provided with the SurveyMonkey weblink to access the online questionnaire battery. Upon visiting the SurveyMonkey website, the participant first viewed an information letter (Appendix B) which provided information about both components of the study (the online questionnaire battery and the laboratory component), time requirements, exclusionary criteria, and compensation for participation. Next, participants reviewed a participant consent form (Appendix C) where they were asked to indicate their consent before beginning the online questionnaire battery.

All participants were entered into a draw to win one of five prepaid gift cards, each valued at $100. A random number generator was used to select the winners after data collection for the first experiment had concluded. Lakehead student participants who were registered in a Psychology course eligible for bonus points at the time of participation received one bonus point for completing the online questionnaire battery and one and one-half bonus points for completing the laboratory visit. Bonus points were applied to participants' final grade in an undergraduate psychology course eligible for bonus points.

Statistical power analyses were performed using G-Power software (Version 3.1.9.7; Faul et al., 2009). Previous studies have reported medium effect sizes for gratitude condition, cognitive load, trait gratitude, and state gratitude in the prediction of k (DeSteno et al., 2014; Dickens & DeSteno, 2016; Finn et al., 2015). Using a significance level of $\alpha = .05$, and 80% power, the calculated sample size was 68 participants to detect statistically significant effects of gratitude and cognitive load conditions, and 55 participants to detect effects of trait and state gratitude. Given the sample size of 137, the study was sufficiently powered to detect statistical effects.

Measures

Demographic Questionnaire. A demographic questionnaire was used to identify variables such as age, gender, and ethnicity (see Appendix D). This questionnaire was completed as part of the online questionnaire battery prior to attending the laboratory session. The following questionnaires were also included in the online questionnaire battery.

Eysenck Impulsiveness Questionnaire. The Eysenck Impulsiveness Questionnaire (I7; Eysenck et al., 1985; Appendix E) is a self-report questionnaire measuring impulsivity. There are three subscales: impulsiveness, venturesomeness, and empathy. The impulsiveness subscale taps into impulsiveness that occurs because of the failure to consider consequences and the venturesomness subscale assesses thrill and adventure-seeking behaviour (Eysenck & Eysenck, 1978; Kirby et al., 1999). The empathy subscale was included in this measure to add variability in question content and is not an index of impulsivity (Eysenck & Eysenck, 1978). This questionnaire consists of 54 forced choice yes/no items. Subscales scores were calculated using the scoring algorithm provided by Eysenck et al. (1985).

The impulsiveness subscale of the I7 was included in this study as an index of trait impulsivity. This is a widely used measure of impulsivity and elevated scores have been associated with higher k (Bobova et al., 2009; Coffey et al., 2003; Kirby et al., 1999; Kirby & Petry, 2004). The impulsiveness subscale of the I7 has shown good internal consistency with Cronbach's α values ranging from .83 to .85 (Eysenck et al., 1985; Eysenck & Eysneck, 1978) which is inline with the internal consistency found in the current study (α = .83).

Barkley's Deficits in Executive Functioning Scale. Barkley's Deficits in Executive Functioning Scale (BDEFS; Barkley, 2011; Appendix F) is a self-report behavioural rating scale measuring processes related to executive functioning. It includes five subscales: selfmanagement to time, self-organization/problem-solving, self-restraint, self-motivation, and self-regulation of emotions. For each of the 89 items, the respondent is asked to indicate the frequency with which they have engaged in the described behaviour over the previous 6 months. There are four response options for each item (never or rarely, sometimes, often, very often). Scores for items on each subscale are summed to obtain subscale scores which can also be summed to produce a total score. The total executive function summary score was used in the current study. Higher scores indicate greater executive functioning deficits.

The internal consistency originally reported by the author is excellent (Cronbach's α = .91 – .96; Allee-Smith et al., 2013; Barkley, 2011). An independent study was also able to demonstrate good to excellent internal consistency ranging from Cronbach's α = .89 – .93 across the subscales (Brunelle & Flood, 2016). In the current study, the internal consistency of the total executive function summary score was excellent (Cronbach's α = .97). Previous research has demonstrated the influence of executive functioning deficits on *k* (Hinson et al., 2003). Consequently, the total executive function summary score of the BDEFS was included in the current study to ensure that the randomly assigned experimental groups did not inherently differ in executive functioning deficits which would affect the ability of the current study to draw internally valid conclusions about the influence of the manipulated variables on *k.*

Gratitude Questionnaire-6. The GQ-6 (McCullough et al., 2002; Appendix G) is a six-item self-report questionnaire that measures trait gratitude. Seven response options exist along a Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). Responses are summed to produce a total score where a higher number indicates a greater tendency toward a grateful disposition. Exploratory factor analysis was used to construct the scale from 39 items considered for inclusion; confirmatory factor analysis was subsequently used with an independent sample of participants. The authors have demonstrated the good internal consistency of the scale using a series of studies with independent samples (Cronbach's α = .82 – .87; McCullough et al., 2002). The current study found the internal consistency of this scale to be adequate (Cronbach's α = .78). This scale was included in the current study as a measure of trait gratitude.

Manipulation Check Questionnaire. Six questions assessing affective state were posed to the participant following the emotion manipulation. Three of the questions measured gratitude and the other three measured general positive affect. Participants were asked to rate the extent to which they felt each sentiment using a Likert-type scale with five response options. A higher score represented greater affect. Scores were summed and divided by the number of questions to produce an index of gratitude and an index of general positive feelings. In the current study, the internal consistency of the gratitude subscale was good (Cronbach's α = .82), and the internal consistency of the positive affect subscale was acceptable (Cronbach's α = .76).

This manipulation check questionnaire (see Appendix H) was used to ensure the internal validity of the gratitude manipulation. The success of this manipulation was determined by assessing whether the participants randomized to the gratitude condition felt more grateful than those randomized to the neutral condition. The gratitude questions were also used to operationally define self-reported state gratitude which was included as a predictor variable in Hypothesis 2. These questions were adapted from those used as a manipulation check in a similar study (DeSteno et al., 2010) and were also used by the only two known studies that have investigated gratitude and k (DeSteno et al., 2014; Patalano et al., 2018).

Monetary Choice Questionnaire. The MCQ (Kirby et al., 1999; Appendix I) is a 27-item questionnaire that assesses the rate at which monetary rewards are discounted as a function of time. Respondents indicate their preference between obtaining a small immediate or a larger delayed reward for each forced-choice questionnaire item. Responses are examined to calculate the present value of the delayed reward (V) using the following hyperbolic equation:

$$\boldsymbol{V = A/(1 + kD)}$$

In this function, D represents the period of delay, A is the amount of the delayed reward, and k is the discounting rate (Kirby & Marakovic, 1995). Whereas A represents the actual value of the delayed reward, V is the perceived value taking into consideration the period of delay and the rate at which the reward is discounted by an individual due the influence of various contextual and individual factors.

In the present study, the discounting rate parameter, *k*, was calculated using the 27-item Monetary Choice Questionnaire Automated Scorer (Kaplan et al., 2014; 2016) which is a Microsoft Excel spreadsheet tool with embedded formulas. The overall *k* variable, which is an index of discount rate that spans across reward magnitude, was used in all analyses. The MCQ is a frequently used task that serves as an index of delay discounting. The present study used hypothetical monetary rewards for this task. Previous research has failed to find differences in delay discounting according to whether hypothetical or actual rewards are employed (Chabris et al., 2008; Crean et al., 2000; Baker et al., 2003; Johnson & Bickel, 2002; Johnson et al., 2007; Lagorio & Madden, 2005; Madden et al., 2003; Reed & Martens, 2011). The test-retest reliability of delay discounting tasks has been demonstrated by Baker et al. (2003) who demonstrated a strong correlation between performance on two separate occasions, ranging from r = .71 - .90 for hypothetical monetary outcomes and from r = .76 – .82 for real monetary outcomes.

Apparatus

Recording of the Electrocardiogram. Electrocardiogram (ECG) recordings were obtained at baseline and during the completion of the MCQ. A 72-channel amplifier (Advanced Neuro Technology, Enschede, Netherlands) was used to record ECG activity at a sampling frequency of 1024 Hz. Three electrodes were used for the recording, placed in a lead-II configuration below the right clavicle and below the left rib, with a ground electrode placed below the left clavicle (Appendix J). The ECG recordings were inspected using ASA-LAB software (Version 16; Advanced Neuro Technology, Enschede, Netherlands) and analyzed using Kubios HRV specialized analysis software (Biosignal Analysis and Medical Imaging Group; http:// kubios.uef.fi/; version 3). HRV analysis can be conducted in time, frequency, or nonlinear domains. One commonly used index of HRV within the time domain is the root mean squares of successive differences (RMSSD). The RMSSD was derived from ECG recording using Kubios software. The RMSSD metric was extracted from the baseline ECG recording and from the MCQ ECG recording and included in subsequent analyses.

Procedure

Data collection for the first experiment involved two phases: an online questionnaire battery and a laboratory session. Informed consent was obtained at the outset of each phase. Participants could decline to answer any question and could terminate their participation in the study at any time. Participation in phase I was a prerequisite to participation in phase II; however, participation in the first phase did not obligate participation in the second phase. Only data from participants who completed both phases (the online questionnaire battery and laboratory session) were included in the analyses.

Phase I: Online Questionnaire Battery. The first phase of data collection occurred online. Participants provided information using personal electronic devices. Regardless of the method of recruitment, all participants were directed to a SurveyMonkey link where they reviewed information about the study and signified their consent to participate. Next, they completed a questionnaire battery including a demographic questionnaire, the I7, the BDEFS, and the GQ-6.

Phase II: Laboratory Session. After the completion of the online questionnaire battery, participants attended a laboratory session. Participants were advised not to exercise or consume food, caffeine, or nicotine in the 2 hours prior to their scheduled laboratory session and not to consume any alcohol in the 12-hour period before their session.

Upon arrival to the laboratory, the experimental procedure was explained to the participant. A timeline of this procedure is provided in Figure 1. The participant was asked to read the participant information letter and to read and sign the consent form, both of which had previously been read and/or signed prior to the online completion of the questionnaire battery. The participant was then instructed to clean their skin with an alcohol solution and to attach three electrodes in a lead-II ECG configuration, below the right clavicle (positive), below the left rib (negative), and below the left clavicle (ground). The electrode placement instructions that were presented to the participant are included in Appendix J. The placement of the electrodes was verified by the experimenter. The participant was then seated and instructed to remain as still as possible, apart from movements required to engage in tasks throughout the experiment.

First, a baseline ECG recording was obtained while the participant sat quietly for a period of 5 minutes, looking straight ahead as they fixed their gaze upon a fixation cross presented on a large computer screen. Two shapes were briefly presented during this baseline recording and the participant was later asked to identify the shapes. The purpose of this was to ensure that they remained attentive with eyes open during the baseline period. Next, the participant completed the emotion manipulation task, assigned either to the gratitude or neutral emotion condition, and completed the manipulation check questionnaire. Participants then completed the cognitive load task in either the high or low cognitive load condition. Finally, the participant completed the MCQ, during which a second ECG recording was obtained.

Gratitude Manipulation Task. Participants were randomly assigned to one of two emotion conditions, gratitude or neutral. Random assignment was facilitated by the SurveyMonkey website which randomly selects a condition for each participant at the time of participation. This resulted in 71 participants (52%) assigned to the gratitude condition and 66 participants assigned to the neutral condition.

The autobiographical recall procedure described by DeSteno et al. (2014) was used to manipulate gratitude. Participants assigned to the gratitude condition were asked to recall the events of an experience they had that made them feel grateful toward another person. Participants assigned to the neutral condition were asked to recall the events of a random, uneventful day in recent memory. Participants in both conditions were then asked to write, in detail, about their memory for a duration of 5 minutes. The manipulation check questionnaire was then completed.

Cognitive Load Manipulation Task. Participants were also randomly assigned to one of two cognitive load conditions (high or low). Cognitive load was manipulated using two variations of the *N*-back task (Jaeggi et al., 2010). The *N*-back task is a demanding visuospatial working memory task in which a series of stimuli are presented, and participants are asked to indicate when the currently presented stimulus was presented *N* stimuli previously. The variable *N* represents a number that varies depending on condition assignment, block, and performance. In a 1-back block of trials (i.e., when $N = 1$), participants must indicate if the currently presented stimulus was also presented in the immediately previous presentation. In a 2-back block of trials, participants must indicate if the currently presented stimulus was presented two presentations previously. In a 3-back block of trials, participants must indicate if the currently presented stimulus was presented three presentations previously. In a 4-back block of trials, participants must indicate if the currently presented stimulus was presented four presentations previously. There are adaptive and nonadaptive version of the *N*-back task. A nonadaptive *N*-back involves fixed blocks where the participant is instructed to complete a 1-, 2-, 3-, or 4-back according to a specified schedule that is not influenced by the participant's performance. In an adaptive version, the instructions in subsequent blocks (i.e., whether the participant is instructed to complete either a 1, 2, 3, or 4 back procedure) are dependent upon their success rate in the previous block. As performance improves, *N* of the subsequent block increases by 1 and as performance decreases, *N* of the subsequent block decreases by 1. For example, if a participant performs well on a block of trials in which they are instructed to "do a 2-back", the subsequent block of trials will instruct the participant to "do a 3-back." Participants start at $N = 1$ and can move up indefinitely. In the current study, participant performance on the *N*-back was maintained at a success rate of between 75 and 90%. If performance exceed 90%, *N* increased in the subsequent block and if performance fell below 75%, *N* decreased.

The *N*-back was used to manipulate cognitive load. Participants who were randomized to the high cognitive load condition completed an adaptive *N*-back task as described above. Participants who were randomized to the low cognitive load condition performed a 1-back for the entire duration of the task. As such, the same activity and time duration was involved for both conditions but the demand to working memory resources was substantially lower for those assigned to the low cognitive load condition. In the present study, an adaptive *N*-back task was used for the high cognitive load group so that cognitive load was high, relative to the capacity of each individual participant. The *N*-back task has been used in several studies as means of manipulating cognitive load (e.g., Koike et al., 2013; Loschky et al., 2014; Shucard et al., 2011). Typically, $N = 1$ is used for conditions of low cognitive load; the demand to cognitive resources increases along with the value of *N*.

In the current study, the *N*-back task was administered using Inquisit Software (version 4.0 (www.millisecond.com). The single *N*-back task adaptive (1 key version) script was used for the high cognitive load condition and the single *N*-back task non-adaptive (1 key version) script was used for the low cognitive load condition. The latter script was modified so that participants completed a 1-back for the duration of the task. Both scripts were contributed to the millisecond test library by K. Borchert (2011) and are based on the procedure described in Jaeggi et al. (2010). The presented stimuli were irregular yellow shapes, each presented for 3 seconds on a black background. The participant indicated the presence of a repeated stimuli by pressing the "A" key of a standard keyboard.

Delay Discounting Task. The MCQ was used to estimate the rate of delay discounting. All participants indicated their choices to the series of questions comprising this measure which was presented electronically on a large computer screen using SurveyMonkey. After the completion of this task, participants were instructed to remove the electrodes from their body, were thanked for their participation, and excused.

Data Analytic Approach

Preliminary Analyses

Prior to conducting the main analyses of the current experiment, preliminary analyses were performed to rule out three possibilities with the potential to produce biased results in the main analyses. The three tested possibilities were a gratitude manipulation failure, MCQ response inconsistency, and inherent group differences on pre-existing variables.

First, it was tested whether participants randomized to the gratitude condition reported a significantly greater level of state gratitude compared to those randomized to the neutral condition, following the experimental manipulation of gratitude. The absence of a significant difference in state gratitude between the two conditions would indicate a manipulation failure that would undermine the internal validity of the experiment. Simple moderation analyses involve testing for conditional effects of two antecedent variables, one predictor (X) and one moderator (W), as well as their interaction (XW) in the prediction of a criterion variable (Y). A conditional effect, like a simple effect, is the relationship between one antecedent and the criterion when the second antecedent is set to equal 0 (Hayes, 2018). The interaction refers to whether the effect of X on Y depends on the level of W. When the antecedent variables are dichotomous, main effects parameterization can be used to estimate the main effects of the antecedents without impacting the estimation of the interaction (Hayes, 2018). Main effects parameterization was used in this analysis by coding both gratitude condition and cognitive load condition variables with codes of -0.5 and 0.5 rather than conventional dummy codes of 0 and 1. Regressing state gratitude (Y) on gratitude condition (X) with cognitive condition serving as moderator (W) thereby allowed testing for main effects of both antecedents as well as their interaction. A significant main effect of gratitude condition would indicate a difference in state gratitude between the groups. If the manipulation worked as intended, there should be no main effect of cognitive load condition and no interaction. Findings to this effect would show the success of the gratitude manipulation and support the internal validity of this component of the study.

Second, MCQ response inconsistency was investigated. It has been suggested that increases in *k* observed in response to experimental cognitive loads represent an increase in random responding (Franco-Watkins et al., 2006; 2010; Olschewski et al., 2018). To rule out this possibility, an independent *t*-test was conducted to determine whether response consistency differed according to cognitive load condition. The independent *t*-test is an appropriate test to compare means between two experimental conditions with different participants in each (Field, 2013).

Third, inherent group differences on pre-existing variables between the gratitude conditions was investigated. Despite random assignment of participants to experimental conditions, inherent group differences on pre-existing variables can, nonetheless, influence criterion variables. To rule out this possibility, four independent *t*-tests were conducted to test for differences between gratitude conditions on measured variables with the potential to influence *k*. Independent *t*-tests were used to assess for significant difference between the gratitude conditions on the I7, the BDEFS, the GQ-6, and in resting RMSSD. These four *t*-test were then repeated using cognitive load condition rather than gratitude condition as the grouping variable to test for inherent difference between the cognitive load conditions.

Main Analyses

The main hypotheses of the current study were tested using a multiple linear regression-based approach facilitated by the SPSS *PROCESS* macro (Hayes, 2018). This is a tool that enables the estimation of a variety of moderation and moderated moderation models. The variable *k* was the criterion (*Y*) in all main analyses of Experiment 1.

The first hypothesis was tested using a simple linear moderation analysis. As described previously, simple linear moderation allows for the detection of conditional effects of two antecedents, *X* and *W*, on *Y* in addition to their interaction, *XW*. When dichotomous predictors are used, main effects parameterization enables testing of main effects of the antecedents as well (Hayes, 2018). To investigate the predicted main effects of gratitude condition and cognitive load condition, both dichotomous predictors were coded as -0.5 and 0.5. This approach is equivalent to that of a 2 x 2 factorial analysis of variance and produces identical results. The advantage of using multiple regression over analysis of variance is that the selected multiple regression approach allows for the exploration of conditional effects and interactions with variables that are both dichotomous and continuous (Hayes & Rockwood, 2017). Hypothesis 1 was analysed using *PROCESS* macro for model 1 (Hayes, 2018). A conceptual diagram of this model can be seen in Figure 2. In the current experiment, gratitude condition (*X*) was the predictor, cognitive load condition (*W*) was the moderator, and the I7 was a covariate.

Hypotheses 2 and 3 were analysed using a moderated moderation analysis. This approach differs from simple linear moderation in that it involves a third antecedent (*Z*). Conditional effects of all three antecedent variables were tested in addition to all 2-way and 3-way interactions.

Hypothesis 2 consisted of two separate models both analyzed using *PROCESS* macro for model 3 (Hayes, 2018). The conceptual model for model 3 can be seen in Figure 3. The first tested for a simple effect of GQ-6 (*X*), including gratitude condition (*W*), and cognitive load condition (*Z*) as antecedents, and I7 as a covariate; *XW*, *XZ, WZ,* and *XWZ* interaction terms were all included in the model. The analysis was then repeated substituting state gratitude for GQ-6.

PROCESS macro for model 3 (Hayes, 2018) was used to test Hypothesis 3. In the first of two models, resting RMSSD was the predictor (*X*), gratitude condition (*W*) and cognitive load condition (*Z)* served as moderators, and the I7 was a covariate. This model was than repeated substituting RMSSD reactivity as the predictor (*X*). In this second model, resting RMSSD was included as a covariate. In assessing the predictive ability of RMSSD reactivity for *k,* it is the change in RMSSD from baseline that is of interest. Difference scores, calculated by subtracting the baseline measure from the secondary measurement, are a commonly used method to investigate this type of variable. However, the use of difference scores can produce biased results because of regression to the mean, a phenomenon whereby difference scores tend to be negatively correlated with baseline measurements and positively correlated with later measurements (Hayes & Rockwood, 2017). Consequently, Hayes and Rockwood (2017) recommend covarying out the baseline measurement when a difference or reactivity score is included in a model.

The continuous predictors in all models were mean centered prior to analysis. This process is no longer considered necessary for the purpose of reducing multicollinearity (Hayes & Rockwood, 2017). Mean centering does not impact statistical hypothesis testing but it does influence the scale of the measurement tools such that a single unit becomes equal to one standard deviation (Hayes & Rockwood, 2017). While mean centering does not reduce testing bias or impact results, it was utilized in the current study because it facilitates the interpretability of results.

Parametric Assumptions. A multiple regression-based data analytic approach was used to test the main hypotheses. Ordinary least squares linear models, and their derivatives, operate on the basis of assumptions that dictate the conditions under which the results of the model can be assumed to be accurate and valid. A strength of regression-based statistical approaches is their robustness. Nonetheless, the predictive accuracy of regression-based models is maximized when statistical error meets three assumptions. Namely, these three assumptions are independence, homoscedasticity, and normality of statistical error. Given the unobservable nature of statistical error, these qualities were examined in the residuals. Residuals, or fitting error, provide an observable estimate of true statistical error, thus allowing inferences about the independence, homoscedasticity, and normality of the errors.

The assumption of independence assumes that the errors in estimation are statistically unrelated (Field, 2013). This means that the errors do not correlate with the predictors. This assumption was first examined by visually inspecting residual plots for each model, using the fitted values of Y and the residuals. None of the residual plots revealed a pattern in the data points, which would suggest a violation of this assumption. The independence of errors was further assessed by checking for serial correlations between errors using the Durbin-Watson test (Field, 2013). Durbin-Watson test statistics ranged from 2.21 to 2.32. There was no evidence of serial correlations between errors.

The assumption of homoscedasticity of variance assumes that the variance of the errors does not differ across levels of the predictor variable. Heteroscedasticity can produce bias in the estimate of standard error which has consequences for inferences based on this estimator including hypothesis testing and confidence intervals (Hayes & Cai, 2007). Residual scatterplots were visually examined to determine the presence of heteroscedasticity. One of the models concerning Hypothesis 2 testing the predictive ability of the GQ-6 for criterion variable k, showed potential heteroscedasticity. The assumption of homoscedasticity was further assessed by using an empirical test to look for a systematic relationship between the absolute values of the residuals and the fitted values of Y for each linear model (Hayes & Cai, 2007). None of these analyses produced significant results which suggests that the assumption of homoscedasticity was not violated for any of the models. Nonetheless, due to the possible heteroscedasticity indicated by the residual plot for the GQ-6 model, a heteroscedasticity-consistent standard error estimator was used to test this hypothesis.

A variety of heteroscedasticity-consistent standard error estimators are available for use depending on other characteristics of the data. When heteroscedasticity is suspected, the HC3 estimator is generally recommended unless cases with high leverage points are identified, in which the HC4 estimator is a better choice (Hayes & Cai, 2007). Leverage was assessed to determine whether the influence of individual cases on the overall model was within an appropriate range. The average leverage for each regression model was calculated as $(k+1)/n$ where k = the number of predictors and n = the sample size. The convention of leverage values greater than 3 times the average was used to identify cases of concern (Stevens, 2002). One case with high leverage was identified in the GQ-6 model. As such, the HC4 heteroscedasticity-consistent standard error estimator was used to test this model of Hypothesis 2.

The assumption of normality for regression-based statistical approaches refers to the shape of the distribution of errors. Normality of the errors was inferred through an examination of the residuals for each regression-based analysis. The z_{skewness} statistic was calculated for the residuals of each regression model. Absolute values ranged from 0.04 to 0.75, all of which are below the convention of 1.96 (Field, 2013) thus confirming the assumption of normality of errors was not violated.

Results

Data Preparation

Using ASA-LAB software (Version 16; Advanced Neuro Technology, Enschede, Netherlands) a band-pass filter was applied to the ECG recordings with a low cut-off frequency of 1 Hz and a high cut-off frequency of 100 Hz to smooth the signal and eliminate noise. The filtered signal was then visually inspected for artifacts and manually corrected using Kubios

HRV specialized analysis software (Biosignal Analysis and Medical Imaging Group; http:// kubios.uef.fi/; version 3). The two RMSSD variables, one obtained during from the baseline ECG recording and the other during the completion of the MCQ, were derived using Kubios software and entered into IBM SPSS Statistics v.28. Both variables were significantly skewed in the positive direction; the $z_{skewness}$ statistic for both variables exceeded the convention of 1.96 (Field, 2013). As is customary with HRV data, the variables were subjected to the natural logarithmic transformation which remedied the skew (Labonte et al., 2017). The transformed variables were retained for all relevant analyses. Descriptive statistics of the original and transformed HRV variables can be seen in Table 1.

Discounting rates were calculated using Kaplan et al.'s (2014) automated scoring algorithm. Overall *k* was the variable of interest for the current study. This variable is a hyperbolic estimate and tends to produce skewed data. In line with previous studies (e.g., MacKillop et al., 2006), *k* was normalized using the natural logarithmic transformation and the transformed variable was used in all analyses. Descriptive statistics for *k,* pre and post transformation, are presented in Table 1.

All psychometric data were entered in IBM SPSS Statistics v.28. Missing values were replaced using a prorating strategy and a 20% cutoff rule. The missing values for a given measure were imputed using the individual's average score based on the completed items on that measure. If more than 20% of a participant's responses were missing on one measure, the missing values were not imputed and their total score for the measure was not calculated. Such cases were therefore excluded from any relevant analyses. No missing values were imputed for MCQ data.

Outliers were defined as values that had absolute standardized scores of 3.29 or greater.

They were detected by calculating standardized scores and remedied using the winzorizing procedure described by Field (2013). The identified outliers were replaced with values equal to the mean plus or minus 3.29 times the standard deviation (Field, 2013).

Psychometric variables were assessed for normality by calculating $z_{skewness.}$ Skewed variables were transformed using the natural logarithmic transformation. However, this transformation did not remedy the observed skew for any of the psychometric variables and the transformed variables were, therefore, not retained. Regression-based approaches are robust to violations of normality in data distributions as long as the errors are independent, there is no evidence of heteroscedasticity, and the sample size is large enough with greater than 10 observations per variable (Schmidt & Finan, 2018). As such, the skewed psychometric variables were used, in their raw form, in relevant analyses.

Reliability and Descriptive Statistics

Means and standard deviations of the raw and transformed discounting rate variables, *k* and ln *k,* are presented separately by gratitude and cognitive load conditions in Table 2. Means and standard deviations of all remaining psychometric variables are presented in Table 3. In the current sample, all of the measure used were shown to have acceptable reliability. The internal consistency of the BDEFS was excellent. The manipulation check questionnaire measuring state gratitude and the GQ-6 had good internal consistency and the manipulation check questionnaire assessing positive affect had adequate internal consistency. Cronbach's alpha reliability coefficients are presented in Table 3. Also shown in Table 3 are the normality coefficients for each of the psychometric measures. All measures had skewed distributions, represented by an absolute $z_{skewness}$ value > 1.96.

Table 4 displays an intercorrelation matrix for all psychometric variables in addition to *k* and the HRV variables. Given the significant degree of skew in the psychometric variables, Spearman correlation coefficients are also reported (see Table 5). However, the results did not appreciably differ between the parametric and nonparametric correlations.

As expected, significant correlations were observed between the GQ-6 and state gratitude, between the I7 and the BDEFS, as well as between resting RMSSD and RMSSD reactivity. In line with previous findings (e.g., Bobova et al., 2009; Coffey et al., 2003; Kirby et al., 1999; Kirby & Petry, 2004), the I7 was correlated with k although no other variables showed a relationship with k. Examination of Table 4 also reveals a correlation of the BDEFS with the GQ-6, state gratitude, and positive affect. Greater trait gratitude, state gratitude, and positive affect are correlated with lower deficits in the executive function.

Preliminary Analyses

Manipulation Check. To ensure the internal validity of the gratitude manipulation, two separate moderation analyses were conducted using *PROCESS* macro (model 1; Hayes, 2018). First, with gratitude condition as the predictor, cognitive load condition as the moderator, and state gratitude as the criterion variable, the success of the gratitude manipulation was assessed. The overall model was significant, $F(3, 133) = 8.18$, $p < .001$, $R^2 = .16$. As intended, a significant main effect of gratitude condition emerged, $b = 0.53$, $p < .001$, 95% CI [0.31, 0.75]. As shown in Table 6, state gratitude did not differ according to cognitive load condition and no interaction emerged. The results support the internal validity of the study with respect to the success of the gratitude manipulation. Participants randomized to the gratitude condition felt significantly more grateful than those randomized to the neutral condition, and there was no difference in feelings of gratitude between participants randomized to high or low cognitive load conditions. The means and standard deviations for state gratitude and positive affect are reported separately by gratitude condition in Table 7.

When positive affect was substituted for state gratitude in the analysis described above, the overall model was not significant, $F(3, 133) = 1.59$, $p = .194$, $R^2 = .03$. Although a significant main effect of gratitude condition was observed, $b = 0.27$, $p = .033$, 95% CI [0.02, 0.52], the effect size was smaller than that of the previous model. The model accounted for 16% of the variance in state gratitude whereas it explained only 3% of the variance in positive affect. Table 8 shows the absence of other main or interaction effects in the second model. Whether or not a difference in positive affect between the gratitude and neutral conditions was found would not affect the internal validity of the study. However, the absence of a difference in positive affect would provide support for the specificity of the gratitude emotion over positive affect more generally in predicting *k,* were an effect of gratitude condition on *k* to emerge. In the current experiment, both state gratitude and positive affect significantly differed between the gratitude conditions. However, the difference in gratitude was larger than the difference in positive affect.

MCQ Response Consistency. In addition to calculating *k* from the MCQ, a response consistency variable was derived using Kaplan et al.'s (2014) automated scoring algorithm. The response consistency variable represents the percentage of responses that are endorsed consistently by a participant, meaning they align with their response pattern (Kaplan et al., 2016). Consistency scores < 75% are cause for concern as they could indicate random responding (Kaplan et al., 2016). In the current study, consistency scores ranged from 81 to 100% for the overall *k* variable used in all analyses, suggesting no participants where random responding was of concern. Further, an independent *t*-test revealed that response consistency did not differ between the high and low cognitive load conditions, $t(135) = 0.20$, $p = .842$, $d = 0.03$, 95% CI [-0.30, 0.37]. As such, any effects of cognitive load condition on *k* in the current experiment cannot be attributed to differences in random responding on the MCQ.

Group Differences. Participants in the gratitude and neutral conditions did not significantly differ on the I7, $t(135) = 0.83$, $p = .409$, $d = 0.14$, 95% CI [-0.19, 0.48], the BDEFS, $t(135) = 0.01$, $p = .996$, $d = 0.00$, [-0.33, 0.34], the GQ-6, $t(135) = 1.22$, $p = .224$, $d = 0.21$, [-0.13, 0.55], nor in baseline RMSSD, $t(127) = -1.38$, $p = .171$, $d = -0.24$, [-0.59, 0.11]. These results suggest no inherent differences in trait impulsivity, executive dysfunction, trait gratitude, or baseline HRV between the gratitude conditions. Any observed effects of gratitude condition on *k* in the current experiment thereby cannot be explained by group differences in these variables.

Next, the high and low cognitive conditions were compared on these same four variables. No differences were found between the groups on the I7, $t(135) = 0.71$, $p = .479$, $d = 0.12$, 95% CI [-0.21, 0.46], the BDEFS, $t(135) = 1.19$, $p = .237$, $d = 0.20$, [-0.13, 0.54], the GQ-6, $t(135) = -0.07$, $p = .947$, $d = -0.01$, [-0.35, 0.32], nor in baseline RMSSD, $t(127) = -1.55$, $p = .123$, $d = -$-0.27, [-0.62, 0.07]. Consequently, inherent differences in these measured variables between the cognitive load conditions cannot explain any of the observed finings in the current experiment.

Test of Hypotheses

Hypothesis 1. A moderation analysis conducted with *PROCESS* macro (model 1; Hayes, 2018) was used to test Hypothesis 1 which predicted main effects of gratitude and cognitive load conditions. The I7 was included in this analysis as a covariate. Gratitude was expected to reduce *k* whereas cognitive load was expected to increase *k*. The overall model was significant, $F(4, 132) = 2.71$, $p =.033$, $R^2 = .08$. Contrary to Hypothesis 1, there was no main effect of gratitude condition, $b = 0.09$, $p = .716$, 95% CI [-0.42, 0.61]. An effect of cognitive load condition was shown at a trend level, *b* = 0.49, *p* = .063, [-0.03, 1.00]. An interaction effect between gratitude condition and cognitive load condition did not emerge, *b* = 0.05, *p* = .931, [-0.98, 1.07]. However, a significant main effect of I7 was observed, *b* = 0.09, *p* = .006, [0.03, 1.15]. [2] Unstandardized beta coefficients and confidence intervals for all tested main and interaction effects are displayed in Table 9.

Hypothesis 2. Separate moderated moderation analyses were used to examine Hypothesis 2 which stated that state and trait gratitude would predict *k*. Regarding the latter, the main effect of GQ-6 was examined using *PROCESS* macro (model 3; Hayes, 2018) wherein gratitude and cognitive load conditions served as moderator variables and I7 as a covariate. Although the overall model was significant, *F*(8, 128) = 2.29, *p* = .022, R^2 = .10, the predicted main effect of GQ-6 was not, *b* = 0.02, *p* = .356, 95% CI [-0.02, 0.07].[3] A significant main effect of I7 was shown, *b* = 0.09, *p* = .003, [0.03, 1.15]. As can be seen in Table 10, no other significant main or interaction effects emerged.

Substituting state gratitude into the above analytic strategy failed to produce an overall significant model, *F*(8, 128) = 1.44, *p* = .188, R^2 = .08, or a main effect of state gratitude, *b* = -0.14, *p* = .606, 95% CI [-0.68, 0.40]. [4] A significant main effect of I7 emerged, *b* = 0.09, *p* = .007, [0.02, 0.15]. As shown in Table 11, no other main effects or interactions reached significance.

Hypothesis 3. Hypothesis 3 was examined using two separate moderated moderation

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[2] When this analysis was conducted without the I7 as a covariate, the overall model was not significant, *F*(3, 133) = 0.96, *p* =.416, R^2 = .02 and the *p* value of the main effect of cognitive load condition was larger, *b* = 0.44, *p* = .096, 95% CI [-0.08, 0.97].

[3] Without the I7 covariate, the overall model was not significant, *F*(7, 129) = 1.26, *p* =.274, R^2 = .04. The main effect of GQ-6 remained not significant, *b* = 0.02, *p* = .458, 95% CI [-0.04, 0.08]

[4] The results did not appreciably differ without the inclusion of the I7 covariate. The overall model remained not significant, *F*(7, 129) = 0.53, *p* = .807, R^2 = .03, and no main effect of state gratitude was observed, *b* = -0.23, *p* = .397, 95% CI [-0.78, 0.31].

analyses. Higher baseline RMSSD was expected to predict lower *k,* whereas lower MCQ RMSSD, controlling for baseline RMSSD, was expected to predict higher *k.* The first part of Hypothesis 3 was tested using *PROCESS* macro (model 3; Hayes, 2018) with baseline RMSSD as the predictor, gratitude condition and cognitive load condition as moderators, I7 as a covariate, and *k* as the criterion variable. The overall model was not significant, $F(8, 120) = 1.52$, $p = .156$, $R^2 = .09$ and the predicted main effect of baseline RMSSD did not emerge, $b = 0.14$, $p = .589$, 95% CI [-0.37, 0.65]. A significant main effect of I7, however, was observed, $b = 0.09$, $p = .013$, [0.02, 0.15], in addition to a main effect of cognitive load at a trend level, $b = 0.55$, $p = .054$, [-0.01, 1.10].[5] Table 12 displays the results of this analysis.

A significant overall model was not produced when this analysis was repeated with MCQ RMSSD as the predictor and baseline RMSSD as a second covariate, $F(9, 114) = 1.75$, $p = .085$, $R^2 = .12$. The predicted main effect of MCQ RMSSD did not emerge, $b = 0.45$, $p = .361$, 95% CI [-0.52, 1.41], but significant main effects of cognitive load condition, $b = 0.65$, $p = .020$, [0.10, 1.21], and I7, $b = 0.09$, $p = .005$, [0.03, 0.16], were observed.[6] The unstandardized coefficients and 95% confidence intervals can be seen in Table 13.

Discussion

The main purpose of Experiment 1 was to clarify the relationship between gratitude, cognitive load, and discounting rate, *k.* Participants were randomized to one of two affective manipulation conditions (gratitude or neutral) and one of two cognitive load conditions (high or

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[5] The results of this model did not appreciably differ when covariate I7 was excluded. The overall model remained not significant, $F(7, 122) = 0.80$, $p = .591$, $R^2 = .04$, no main effect of baseline RMSSD was shown, $b = 0.08$, $p = .764$, 95% CI [-0.43, 0.59], and a main effect of cognitive load condition was observed at a trend level, $b = 0.54$, $p = .062$, [-0.03, 1.10].

[6] The results did not appreciably differ when covariate I7 was excluded. The overall model was not significant, $F(8, 116) = 0.91$, $p = .515$, $R^2 = .06$, no main effect of MCQ RMSSD was shown, $b = 0.55$, $p = .270$, 95% CI [-0.43, 1.54], and a significant main effect of cognitive load emerged, $b = 0.62$, $p = .032$, [0.05, 1.18].

low), and *k* was subsequently measured. The predicted main effect of gratitude condition did not emerge, nor did an interaction between gratitude and cognitive load conditions. As predicted, cognitive load increased *k* but the effect was tenuous with trend level statistical significance. Regarding the secondary aim of exploring vagal tone as a predictor of *k*, none of the hypotheses involving HRV variables proved significant.

Cognitive Load and Discounting Rate

In line with existing theory (Endres et al., 2014; Finn, 2002; Finn et al., 2015) and experimental research (Bailey et al., 2018; Finn et al., 2015; Hinson et al., 2003), the predicted main effect of cognitive load was observed in Experiment 1. As expected, *k* was higher in the high cognitive load condition compared to the low cognitive load condition. However, this effect was tenuous and dependent on the inclusion of the I7 covariate in the model. As such, replication of this effect was warranted in a second experiment.

Gratitude and Discounting Rate

An effect of gratitude condition on *k* was shown in a previous investigation by DeSteno et al. (2014) and was expected to manifest in Experiment 1 of the current research. There are four explanations that could account for a failure to replicate the effect of gratitude condition on *k* in the context of the procedure used in Experiment 1. Namely, a failed replication could be explained by: (a) an unsuccessful gratitude manipulation, (c) insufficient statistical power, (b) inherent group differences on pre-existing variables, or (c) methodological differences between Experiment 1 and the study by DeSteno et al. First, as discussed previously, participants randomized to the gratitude condition in Experiment 1 felt significantly more grateful than those in the neutral condition. This demonstrates the success of the gratitude manipulation. The failure of Experiment 1 to replicate DeSteno et al.'s gratitude effect, therefore, cannot be attributed to an unsuccessful manipulation of gratitude.

Second, a statistical power analysis performed a priori determined the required sample size to detect a statistically significant effect of gratitude condition on *k* to be 68 participants. As the sample size of 137 exceeds the calculated requirement, inadequate statistical power cannot explain the replication failure in the current study.

Third, there were no significant differences between the gratitude and neutral conditions in impulsivity, baseline HRV, executive function deficits, or trait gratitude in Experiment 1. Consequently, pre-existing differences on these variables cannot explain the replication failure.

Fourth, replication failures can be attributed to methodological differences. For example, a study by Patalano et al. (2018)[7] also failed to replicate DeSteno et al.'s (2014) effect of gratitude condition on *k*. One explanation offered by Patalano et al. was a difference in methodology. Unlike DeSteno et al., Patalano et al. did not use the MCQ to measure *k.* Further, Patalano et al. provided the instructions for their discounting task prior to the gratitude manipulation whereas in DeSteno et al., the instructions were provided after the gratitude manipulation. These specific methodological differences can be ruled out as explanations for the replication failure in Experiment 1 of the current research which, like in DeSteno et al., used the MCQ to measure *k.* Further, the instructions for the completion of the MCQ were provided immediately prior to its completion in Experiment 1 which exactly replicates the procedure used by DeSteno et al.

Experiment 1 differed methodologically from DeSteno et al., however, by adding a second manipulation in the form of the cognitive load task. Although the low cognitive load

[7] The study by Patalano et al. (2018) had not yet been published when the current program of research was conceptualized, and data collection initiated.

condition was not meant to tax the working memory system or exhaust cognitive resources, the task was, as required of a control condition, comparable in duration to that of the high cognitive load condition. Consequently, regardless of the cognitive load condition assignment, all participants completed a task of approximately 20 minutes in length following the gratitude manipulation and prior to the completion of the MCQ. This differs from the procedure used by DeSteno et al. where the MCQ was completed immediately after the gratitude manipulation. Therefore, one possible explanation for the failure of Experiment 1 to replicate the effect of gratitude condition on *k* is that the duration of the cognitive load task used in the current study washed out any effect of gratitude on *k*. Thus, a second experiment was deemed necessary to test for a main effect of gratitude condition on *k,* as well as to investigate a possible interaction between gratitude condition and cognitive load, using a cognitive load manipulation of shorter duration.

Cognitive Load Manipulation Tasks

In Experiment 1, the *N*-back task (Jaeggi et al., 2010), was used to manipulate cognitive load across two experimental conditions. It has been used in previous work to experimentally manipulate cognitive load (e.g., Koike et al., 2013; Loschky et al., 2014; Shucard et al., 2011) and specifically to manipulate cognitive load with the aim of increasing *k* (Aranovich et al., 2016). Although a cognitive load effect was shown in Experiment 1, the length of the load task itself may have interfered with the ability to detect a main effect of gratitude condition. As such, the current research program aimed to replicate the procedure using a cognitive load manipulation that recruited the same cognitive processes but that was shorter in duration. The digit span task, which requires retaining a sequence of numbers in memory and later retrieving the sequence to produce the numbers in the correct order, is a suitable candidate for this purpose.

Previous research has shown that performance on the *N*-back task is associated with performance on the digit span task whereas the relationship between the *N*-back task and other working memory tasks is negligible (Jaeggi et al., 2010; Roberts & Gibson, 2002). Further, while working memory training interventions using the *N*-back task improve performance on the digit span task, they do not improve performance on more complex working memory tasks (Jaeggi et al., 2008). Despite its comparative simplicity, these findings suggest that the digit span task is more closely related to the *N*-back task than alternative experimental approaches used to manipulate working memory load. Digit span tasks are brief to administer and have been used in previous experimental research to manipulate cognitive load (Rao et al., 2020; van Dillen & van Steenbergen, 2018). These factors support the digit span task as a replacement for the *N*-back task to manipulate cognitive load in Experiment 2.

Executive working memory has been suggested to underlie the cognitive pathway to lower *k (*Endres et al., 2014; Finn, 2002; Finn et al., 2015) and, as such, the current research program sought to manipulate cognitive load using tasks that tax this limited-capacity system. Both forward and backward digit span tasks engage central executive resources (Grégoire & Van der Linden, 1997; Hester et al., 2004). However, the forward digit span task has a stronger association with performance on the *N*-back task than the backward digit span task (Jaeggi et al., 2010) and, thus, is the better option for the cognitive load manipulation in Experiment 2.

Experimental tasks that effectively manipulate cognitive load by taxing executive resources engage the lateral prefrontal cortex (Koechlin et al., 2003; Owen et al., 2005; Wesley & Bickel, 2014). Activation of this brain area has been linked with self-regulation through executive function (Carter & van Veen, 2007; Hare et al., 2009; Ochsner & Gross, 2005) and with lower *k* (Figner et al., 2010; Lebreton, 2013; McClure et al., 2004; Stranger et al., 2013).

The recall of a seven-digit number sequence leads to activation in the dorsolateral prefrontal cortex whereas the recall of a one-digit sequence does not (van Dillen & van Steenbergen, 2018). As such, Experiment 2 of the current research sought to manipulate cognitive load using a digit span task. A seven-digit sequence was used for the high cognitive load condition and a one-digit sequence was used for the low cognitive load condition. The aim of the methodological change, replacing the *N*-back task with this digit span task, was to tax the central executive working memory system without adding a lengthy delay between the manipulation of gratitude and the measurement of *k*.

Experiment 2

The second experiment re-examined the first and second hypotheses of Experiment 1 using an alternative methodology. As previously discussed, a reduction in *k* following the gratitude induction could have gone undetected due to the length of the task used to manipulate cognitive load. The 20-minute *N*-back task used in Experiment 1 was replaced with the digit span task in Experiment 2. The digit span task was chosen because of its demonstrated similarity to the *N*-back task. Specifically, individuals perform similarly on the two tasks, and both tasks engage executive working memory resources (Grégoire & Van der Linden, 1997; Hester et al., 2004; Jaeggi et al., 2010; Roberts & Gibson, 2002). The importance of substituting a similar task in place of the *N*-back task was to minimize procedural differences between Experiment 1 and 2 aside from the duration of the cognitive load task. The methodology used to manipulate gratitude and to measure *k* exactly replicated Experiment 1. The same hypotheses from Experiment 1 regarding gratitude, cognitive load, and *k* were offered in Experiment 2: namely, that gratitude would lead to lower *k* and that cognitive load condition would lead to higher *k.* Once again, no predictions were offered with respect to an interaction between gratitude and cognitive load conditions. However, the absence of an interaction effect would support the idea put forth by DeSteno et al. (2014) that the gratitude-based pathway to lower *k* is distinct from the cognitive pathway that requires self-regulation and executive function.

A further aim of Experiment 2 was to examine a potential correlate of *k*, altruism, which is defined as helping behaviour that benefits another at a cost to the individual (Kurzban et al., 2015; Trivers, 1971). The reciprocal altruism hypothesis (Trivers, 1971) explains the evolution of altruistic behaviour as stemming from the survival advantage that a reputation of being a helper would confer. The idea is that others would be more likely to aid someone who is known for having provided help in the past. Put differently, natural selection is thought to have favoured altruistic behaviour because delayed benefits could occur following an immediate sacrifice. Altruism has been theoretically (Trivers et al., 1971) and experimentally linked with gratitude (Bartlett & DeSteno, 2006; DeSteno et al., 2010). The affective state of gratitude has been suggested as the underlying mechanism that motivates altruistic behaviour (Trivers et al., 1971), and experimental research has shown that individuals behave more altruistically when they are made to feel grateful (Bartlett & DeSteno, 2006; DeSteno et al., 2010). Bartlett and DeSteno (2006) put forth the hypothesis that a mediational relationship whereby gratitude exerts its effect on altruism through its effect on a potential mediator. Specifically, they suggested that gratitude may influence adaptive social behaviour by “encouraging individuals to accept short-term losses in order to reap longer-term rewards” (Bartlett & DeSteno, 2006, p. 324). Taken together with subsequent findings by this research group linking gratitude with *k* (DeSteno et al., 2014; Dickens & DeSteno, 2016), it appears that *k* could be the suggested mediator representing the trade-off between short-term losses and delayed rewards. Such a model implies a direct relationship between *k* and altruism whereby higher *k* leads to less altruistic behaviour. Very few studies, however, have examined altruism and discounting. In two experiments, Jones and Rachlin (2009) did not find a relationship between *k* and altruism, the latter of which was operationalized by the value of a hypothetical donation. In Jones and Rachlin, *k* was measured using a series of questions with a fixed delay amount rather than the MCQ.

Jones and Rachlin (2009) also compared social discounting and delay discounting. Social discounting is a construct involving prosocial behaviour as a function of relationship closeness (Jones & Rachlin, 2006; 2009; Rachlin & Jones, 2008). Studies have shown that as relationship closeness increases, so does helping behaviour (Jones & Rachlin, 2006; Rachlin & Jones, 2008). Jones and Rachlin showed that social discounting is correlated with *k.* This result was replicated using the MCQ to measure *k* in study by Wainwright et al. (2018).

Although social discounting and altruism are similar constructs, in the former, helping behaviour is contingent upon relationship closeness whereas in the latter, it is not. Experimental research has shown that gratitude predicts altruistic behaviour, whether or not the person in need of help is known to the participant or has helped the participant previously (Bartlett & DeSteno, 2006; DeSteno et al., 2010). Despite the demonstrated relationship between social discounting and *k,* the relationship between altruism and *k,* as measured using the MCQ, has not yet been examined. The current study addressed this gap by examining whether *k* predicted altruistic behaviour toward an unfamiliar person. Further, altruism as a correlate of *k* has not been investigated using a real-world altruistic behaviour. In the current study, the relationship between *k* and the value of a real-world charitable donation was assessed.

Both trait and state gratitude have been established as predictors of altruistic behaviour (Dewani et al., 2016; Li & Chow, 2015; Ma et al., 2017; McCullough et al., 2002). State gratitude and the GQ-6 were therefore included as covariates in all analyses for which altruism served as the criterion variable. Given strong relationship between prosociality and social discounting (Böckler et al., 2016) the Triple Dominance Measure (TDM; van Lange et al., 1997) was used to index prosociality as a continuous variable and included in all analyses in which altruism was the criterion.

Experiment 2 replicated the design of the first experiment, using an online questionnaire battery to measure demographic and personality variables followed by a laboratory session. The exact gratitude induction procedure used in Experiment 1 and in the study DeSteno et al. (2014) was used, followed by a 1- or 7-digit span task to manipulate low versus high cognitive load, respectively. Subsequently, *k* was measured using the MCQ. Participants then completed a modified dictator game (DG) in which they chose to allocate some, none, or all of their payment for participation to a charitable organization. The donation amount, called DG amount donated*,* was used as one index of altruism. Finally, they completed the Social Discounting Task (SDT). Rather than calculating the rate of social discounting, the current study used the amount of money forgone by the participant in order to provide a hypothetical $75 to an unfamiliar person as a second altruism variable, called SDT amount forgone*.*

Hypotheses

In line with the overarching objectives of the current research program to identify predictors and correlates of *k,* the current study re-examined affective, cognitive, and personality variables in relation to *k*. Further, altruism was investigated as a criterion variable predicted by *k.* Specific hypotheses were as follows:

1. As in Experiment 1, gratitude condition was expected to decrease *k,* high cognitive load condition was expected to increase *k,* and no prediction was offered regarding an interaction. The failure to observe an interaction would support a gratitude-based

pathway to lower *k* that is distinct from the cognitive pathway involving self-regulation and executive function.

2. As in Experiment 1, both trait gratitude and state gratitude were expected to predict lower *k*.
3. Variable *k* was expected to predict greater altruism.

Method

Participants

The second experiment enrolled 93 participants. Three participants did not respond to all questions on the MCQ, and *k* was unable to be calculated. One additional participant did not adhere to procedural instructions during the laboratory session. These four participants were excluded from all analyses resulting in a sample size of 89. Four participants did not respond to all questions on the TDM which served as a covariate in both models predicting altruism. Consequently, the sample size for the model predicting DG amount donated was 85. Four additional participants displayed invalid response patterns on the SDT (i.e., multiple crossovers) and were thus excluded from the model predicting SDT amount forgone. This model had a final sample size of 81.

Of the 89 participants included in the primary analyses (67 female and 22 male), participants identified their ethnicity as Caucasian/White (n = 60, 67.4%), South Asian (n = 10, 11.2%), East Asian (n = 5, 5.6%), Aboriginal/First Nation (n = 2, 2.2%), African/African Canadian/Black (n = 3, 3.4%) and Middle Eastern (n = 3, 3.4%). Six participants (6.7%) described themselves as mixed-race or as an ethnicity not captured by the listed categories. Eighty-one participants reported their age, which ranged from 18 to 51. The mean age was 21.60 (SD = 5.94) and most of the participants were aged 25 or younger (86.3%). Two participants

(2.2%) reported a diagnosis of ADHD, 16 (18.0%) reported a diagnosis of depression, and three (3.4%) reported a traumatic brain injury.

Most participants were Lakehead University students (*n* = 87, 97.8%) and the remainder were students at Confederation College (*n* = 2, 2.2%). Of the Lakehead University students, 43 (49.4%) were 1st year students, 22 (25.3%) were 2nd year students, 12 (13.8%) were 3rd year students, six (6.9%) were 4th year students, and four (4.6%) were either graduate students or in another year.

Eligibility criteria included English fluency, nonsmoking, and not taking antidepressant, hypertensive, or cold medication at the time of participation in the laboratory session. Participants were asked to refrain from exercising or consuming food, caffeine, or nicotine in the 2 hours prior to the laboratory session and to avoid alcohol in the 12 hours prior.

Participants were recruited from the Lakehead University and Confederation College campuses using poster advertisements (see Appendix K). A virtual advertisement was also circulated to the Lakehead student community through a university-run mass email update service. Participants signed-up for the study by emailing the researcher or by registering through the Sona Experiment Manager System available to Lakehead University students enrolled in psychology courses eligible for bonus points. All participants were directed to a SurveyMonkey weblink to view a participant information letter (Appendix L) and provide consent (Appendix M) before proceeding to complete the online questionnaire battery. After completing the online questionnaire battery, participants were eligible to sign-up for the laboratory session which could be done through the SONA experiment manager system or by emailing the researcher. The completion of the online questionnaire battery was a prerequisite to participate in the laboratory session. However, participants who completed the questionnaire battery were not obligated to sign-up for the laboratory session. Only those participants who completed both components were included the current study.

All participants who completed the laboratory session were provided $10.00 CAD as compensation for their participation.[8] Lakehead students who were enrolled in a psychology course that was eligible for bonus points also received one bonus point for completing the online questionnaire battery and 1.5 bonus points for completing the laboratory session. The bonus points were subsequently applied to the final grade of the participants in an eligible psychology course.

The sample of 89 participants exceeded the required sample size to detect statistical effects of gratitude and cognitive load conditions (68 participants) and trait and state gratitude (55 participants) that was determined by the power analysis completed for Experiment 1. An additional power calculation was completed using G-Power software (Version 3.1.9.7; Faul et al., 2009) to determine the sample size required to detect a statistically significant effect of *k* on altruism. The paucity of empirical studies investigating a direct relationship between *k* and altruistic behaviour prevented the completion of a power calculation based on published effect sizes. However, medium effect sizes have been reported in two experiments for the relationship between *k* and social discounting (Jones & Rachlin, 2009) and one additional study reported a small-to-medium effect size (Wainwright et al., 2018). Furthermore, meta-analytic findings have demonstrated a large effect size for the relationship between gratitude and altruism (Ma et al., 2017). This is relevant because *k* has been suggested as a mediator of this relationship. Using a significance level of $\alpha = .05$, and 80% power, the calculated sample size was 55 participants with

[8] All participants were offered $10.00 as compensation for their participation. As part of the procedure, participants were given the option to donate their compensation (or a portion of it) to a charitable organization. As such, the actual monetary value of participant compensation varied from $0 to $10.00.

a medium estimated effect size and 81 participants with a small-to-medium estimated effect size. The samples used to test the two models predicting altruism consisted of 85 and 81 participants which exceeds the more conservative estimate of required sample size. Therefore, the current study was sufficiently powered to detect statistical effects.

Measures

The demographic questionnaire, I7, BDEFS, GQ-6, manipulation check questionnaire, and MCQ administered in Experiment 1 were also used in Experiment 2. Additional measures that were introduced in Experiment 2 include the TDM and the SDT.

Triple Dominance Measure. The TDM (van Lange et al., 1997; Appendix N) measures social value orientation. Social value orientation refers to a preference surrounding patterns of outcomes for the self and others (van Lange et al., 1997). Individuals might prefer to maximize their own benefit in absolute terms, to maximize their own benefit relative to others, or they may favor equality in outcomes between themselves and others (van Lange et al., 1997). The TDM was designed to categorize individuals according to these preferences, earning them the label of either an individualist who maximizes personal gain, a competitor who maximizes the difference in gains between the self and others, or a prosocial who maximizes the gains of others.

The TDM consists of nine questions, each presenting three possible distribution scenarios of hypothetical finances. In each scenario, a sum of money is allocated to the respondent and another sum of money is allocated to “other” which refers to a hypothetical random person. The respondent must choose the distribution scenario that they prefer for each of the nine questions. For each question, one distribution scenario corresponds to a category (individualist, competitor, or prosocial). If six out of the nine questions are answered in accordance with a particular category, the individual is classified under the corresponding category. The competitor and individualist categories can be collapsed to form a category termed “proself.” Alternatively, the total number of prosocial choices can be summed to produce a continuous index of prosociality as was done by Böckler et al. (2016). Exploratory and confirmatory factor analyses showed the loading of the summed total of prosocial choices onto a factor labelled altruistically motivated prosocial behaviour (Böckler et al., 2016). Böckler et al. also demonstrated the convergent validity of the TDM; the categorizations of the TDM correlate with social discounting measured by the SDT ($r = .91$).

Participants in the current study completed the TDM as part of the online questionnaire battery. The summed total of the prosocial choices was calculated to create a continuous variable representative of a stable disposition toward prosociality. This variable was included as a covariate in the models predicting altruistic behaviour.

Social Discounting Task. The SDT (Jones & Rachlin, 2006; Appendix O) requires the respondent to answer a series of questions to assess altruistic decision-making. The participant makes choices about distributing hypothetical sums of money as a function of social distance to another person (i.e., how close of a relationship they have to the person).

First, the respondent is instructed to imagine having made a list of the 100 closest people to them, with #1 being the closest and #100 being a distant acquaintance. The respondent does not actually make this list, the purpose of imagining is to provide anchors for the different points along the continuum of 1 to 100. Each question asks whether they would prefer to receive (a) X amount of dollars for them alone; or (b) $75 dollars for them and $75 dollars for person #___. There are nine versions of option A beginning with $145 and decreasing by increments of $10 down to $75. There are seven versions of option B: both monetary values are always $75 but person # varies between 1, 2, 5, 10, 20, 50, and 100. Each option A is paired with each option B such that there are 63 items in total. A crossover point is calculated for each social distance which represents the value of money at which the respondent switches from choosing option A to choosing option B. If a participant crosses over more than once (i.e., switches to the sharing option and then back again), their responses are not considered valid. The average amount of money forgone can also be calculated for each social distance as a function of the crossover points. For example, a participant who begins by choosing option A and then switches to option B when option A is valued at $105 is willing to forgo $30 ($105 - $75) in order to provide $75 to another person.

Exploratory and confirmatory factor analyses have demonstrated that altruistically motivated prosocial behaviour, defined as behaviour that is costly to the self and unconditionally provides a benefit to another, is a factor underlying the SDT (loading = -.602; Böckler et al., 2016). Experimental studies have used the SDT to study altruism (e.g., Locey & Rachlin, 2015; Yi et al., 2016). In these experiments, altruism is represented by a lower rate of social discounting which result in more generosity at further levels of social distance. Put differently, a greater willingness to help others, regardless of how close the relationship, is indicative of greater altruism.

In the current study, only the furthest social distance on the SDT (i.e., person # 100) was included in analyses. Participants completed the SDT during the laboratory session. A crossover point was established for each participant, defined as the monetary value at which they switched from choosing to keep all funds to choosing to keep $75 and provide $75 to person #100. The amount forgone was then calculated by subtracting 75 from the crossover point. The resulting variable, which was the amount of money that participants were willing to forgo in order to provide a hypothetical $75 to a person they have classified as a distant acquaintance, was used as one index of altruistic behaviour.

Procedure

Data collection for Experiment 2 was collected in two phases. In the first phase, participants completed an online questionnaire battery. After completing the first phase, participants were eligible to register for the second phase which comprised a laboratory session. Informed consent was obtained prior to participating in phase I and again before participating prior to phase II. Data collected from participants who completed both phases of the study were included in analyses.

Phase I: Online Questionnaire Battery. An online questionnaire battery was completed by participants using their personal electronic devices. Participants were directed to a SurveyMonkey weblink to access the participant information letter, consent form, and the questionnaires. The questionnaire battery included a demographic questionnaire, the I7, the BDEFS, the GQ6, and the TDM.

Phase II: Laboratory Session. Participants attended a laboratory session after completing phase I and were instructed to avoid exercise, food, caffeine, and nicotine for 2 hours prior to their scheduled lab session and to avoid alcohol for 12 hours prior. In the laboratory, the experimental procedure (see Figure 4) was explained to participants and informed consent was obtained. Participants were randomized to either the high or low cognitive load conditions and were presented with a string of digits and asked to recall the digit string for later. The length of the digit string depended on condition assignment.

Next, the participant completed the emotion manipulation task which was identical to the emotion manipulation task described for the first experiment. Participants were randomly assigned to either the gratitude or neutral condition, were asked to recall an autobiographical memory relevant to their assigned condition and were asked to write about the memory for 5 minutes. Participants then completed the manipulation check questionnaire and were asked to enter the previously presented digit string on the computer, followed by the completion of the MCQ.

Participants were asked to recall the digit string for a second time and then completed the two measures of altruism, namely, the DG and the SDT. Participants were then thanked for their participation, provided with their financial compensation, and excused.

Cognitive Load Manipulation Task. Cognitive load was manipulated using a digit span task. Participants were randomly assigned to one of two cognitive load conditions. Participants were shown a string of digits on a large computer screen, asked to remember the string, and informed that they would need to recall it later in the procedure. They were prompted to enter the digit string using a computer keypad once prior to completing the MCQ again prior to the first altruism task. Participants randomized to the low cognitive load condition were presented with a single digit to remember, whereas participants randomized to the high cognitive load condition were presented with seven digits to remember.

Altruism Tasks. After completing the MCQ, participants completed two tasks measuring altruism. The first task, the DG, was an experimental procedure designed to enable the participant to make a real-life decision about allocating resources for no personal benefit nor reputational incentive. The participant then completed the SDT.

The Dictator Game. The DG (Simpson & Willer, 2008) is an experimental procedure that provides an opportunity for participants to behave in a prosocial manner. The DG consists of two sequential conditions. In the private condition, the participant has the opportunity to behave prosocially without reputational incentives; in the public condition the participant has the opportunity to behave prosocially with reputational incentives (Simpson & Willer, 2008). These conditions assess different aspects of prosocial behaviour. Altruism, a variable of interest in the current study, is defined as unconditional helping behaviour which means that it is not dependent on building a reputation as a helper in order to obtain reciprocation in the future. As such, only the condition of the DG without reputational incentives was used in this study.

The standard DG procedure consists of two people, the dictator or decider and the receiver. The participant (the dictator/decider) is informed that they will be allotted funds for their participation and that they must decide how much of the monetary funds, if any, to pass on to a hypothetical individual (the receiver). Exploratory and confirmatory factor analyses have shown that the amount of money given to the receiver loads onto a factor labelled altruistically motivated prosocial behaviour (Böckler et al., 2016).

In the current study, a modification of the DG was used to enable a procedure without a confederate and without deception. Each participant was offered $10.00 as reimbursement for their participation in the laboratory session. Rather than allocating funds to another person, the participant was given the choice of how much money, if any, to provide to a local charity. The charity was not selected at the time of the study. However, once participants had completed all components of the study, they were asked to provide suggestions for a charity or type of charity to which the summed donations from all participants could be provided. Participants chose the value of their donation by selecting the amount on a computer screen. The options ranged from $0.00 to $10.00 in $0.50 increments. The amount donated was used as one index of altruism.

Data Analytic Approach

Preliminary Analyses

Preliminary analyses were undertaken to rule out three potential sources of bias in the same way as in Experiment 1. Specifically, inferential testing was used to determine the presence of a gratitude manipulation failure, MCQ response inconsistency, or inherent group differences on pre-existing variables. A simple linear moderation analysis using *PROCESS* macro (model 1; Hayes, 2018) with gratitude condition (X) and cognitive load condition (W) as the antecedents and state gratitude (Y) as the criterion was conducted to determine the success of the gratitude manipulation. Main effects parameterization was used to test for a main effect of gratitude condition on state gratitude. An independent t-test was completed to test for group differences in response consistency between the high and low cognitive load conditions. Four independent t-tests were conducted to test for group differences on the I7, the BDEFS, the GQ-6, and the TDM between the two gratitude conditions. These four independent t-tests were repeated substituting cognitive load condition as the grouping variable.

Main Analyses

All main analyses were conducted the multiple linear regression approach facilitated the SPSS *PROCESS* macro described previously. The first hypothesis exactly replicates Hypothesis 1 of the first experiment. *PROCESS* macro (model 1; Hayes, 2018) was used to test a simple moderation analysis with gratitude condition (X) as the predictor, cognitive load condition (W) as the moderator, and k (Y) as the criterion, covarying for I7. Main effect parameterization was used to test for main effects of gratitude and cognitive load conditions.

Hypothesis 2 in the current experiment was also a replication of the same analysis completed in Experiment 1. Two separate moderated moderation analyses were completed using *PROCESS* macro (model 3; Hayes, 2013). In the first model, GQ-6 served as the predictor (X), gratitude condition (W) and cognitive load condition (Z) served as moderators, and k (Y) served as the criterion, covarying for I7. In the second model of the Hypothesis 2, state gratitude replaced the GQ-6 as the predictor variable.

Two separate moderated moderation analyses were conducted using PROCESS macro (model 3; Hayes, 2018) to test Hypothesis 3. In the first model, *k* was the predictor (*X*), gratitude condition (W) and cognitive load condition (Z) served as moderators, and DG amount donated was the criterion variable (*Y*). The GQ-6, state gratitude, and the TDM were included as covariates. In the second model, SDT amount forgone was substituted as the criterion variable (*Y*).

Parametric Assumptions. All continuous predictors were mean centered prior to analysis. The assumptions of independence, homoscedasticity, and normality of the errors were assessed as described for the first Experiment. Residual plots revealed no evidence of serial correlation for any of the models. Further, Durbin-Watson test statistics ranged from 1.78 to 2.22. Taken together, these results show the assumption of independence was not violated.

Homoscedasticity was first examined by examining residual plots for each of the models, none of which suggested the presence of heteroscedasticity. This result was further supported by the absence of a statistically significant relationship between the absolute values of the residuals and the fitted values of Y for any of the models. In the second model of Hypothesis 2, however, a trend level relationship was observed, indicating possible heteroscedasticity. This model was examined with and without the use of a heteroscedasticity-consistent standard error estimator. It was concluded that the homoscedasticity assumption was not violated for the remaining models.

The z_{skewness} statistic was calculated for the residuals of each model. The absolute value of the z_{skewness} statistic for the model predicting SDT amount forgone was -2.05. This indicates a violation of the normality assumption because the absolute value exceeds 1.96. As previously discussed, regression-based models are robust to violations of normality in the absence of violations of independence and homoscedasticity assumptions as long as sample size exceeds 10 observations per variable (Schmidt & Finan, 2018). These criteria were met in this model predicting SDT amount forgone and so the normality violation was not considered to be cause for concern. The absolute value of the z_{skewness} statistic for the remaining models ranged from 0.21 to 1.53, indicating normal error distributions.

Results

Data Preparation

All data were entered into IBM SPSS Statistics v.28. Variable *k* was subjected to the natural logarithmic transformation which remedied the significant degree of skew observed in the original variable. Table 14 presents descriptive statistics for the original and transformed variables. No missing values were imputed for MCQ data. For the remainder of the psychometric data, the same prorating strategy and 20% missing cutoff rule described in the method section of Experiment 1 were used. No outliers were observed.

Normality of the distributions for the remaining variables was assessed by calculating z_{skewness}; absolute values greater than 1.96 were considered representative of a significant degree of skew (Field, 2013). As can be seen in Table 15, the GQ-6, state gratitude, the TDM, and the SDT amount forgone variables all exhibited a significant degree of skew. Transforming the variables using the natural logarithmic transformation did not remedy the skew of these variables. Given the robustness of regression-based analytic approach to nonnormality of data distributions (Schmidt & Finan, 2018), the original skewed variables were retainined and used in subsequent analyses.

Reliability and Descriptive Statistics

The means and standard deviations of *k* before and after transformation are displayed in

Table 16 by gratitude and cognitive load conditions. Descriptives for the psychometric and altruism variables can be seen in Table 15. The reliability was acceptable for all measures used in Experiment 2. The internal consistency of the BDEFS and the TDM were excellent. The internal consistency of the I7 was good. The GQ-6 as well as the manipulation check questionnaires for state gratitude and positive affect were acceptable. Reliability coefficients for these measures are shown in Table 15.

An intercorrelation matrix containing Pearson's correlation coefficients is presented in Table 17 for all psychometric variables, altruism variables, and *k.* Because of the skewed distributions of some of the psychometric variables, Spearman's correlation coefficients are also reported and can be seen in Table 18. However, the nonparametric correlations do not appreciably differ from the parametric correlations.

As expected, significant correlations were observed among the TDM, DG amount donated, and SDT amount forgone. As shown in Experiment 1, the I7 was correlated with the BDEFS. However, the significant correlation between the I7 and *k* that was found in Experiment 1 was no longer present in Experiment 2. Interestingly, the I7 was correlated with both the TDM and SDT amount forgone; greater trait impulsivity was associated with lower trait prosociality and less altruistic behaviour. The significant correlation between the GQ-6 and the BDEFS that was found in Experiment 1 was replicated in the current Experiment 2, as was the correlation between the BDEFS and positive affect. Unlike Experiment 1, in the current experiment, a significant relationship between the BDEFS and state gratitude did not emerge. As expected, the GQ-6 was correlated with state gratitude and positive affect. The GQ-6 also correlated significantly with DG amount donated; those higher in trait gratitude exhibited greater altruism by donated more to charity.

Preliminary Analyses

Manipulation Check. As in the first experiment, the internal validity of the gratitude manipulation was verified in Experiment 2 by conducting two moderation analyses using *PROCESS* macro (model 1; Hayes, 2018). In the first analysis, gratitude condition was the predictor, cognitive load condition was the moderator, and state gratitude was the criterion. The overall model was significant, $F(3, 85) = 3.32$, $p = .024$, $R^2 = .10$, and a main effect of gratitude condition was shown, $b = 0.37$, $p = .004$, 95% CI [0.12, 0.61]. Thus, the manipulation of gratitude condition was successful; those randomized to the gratitude condition felt significantly more grateful than those in the neutral condition. As can be seen in Table 19, state gratitude did not differ between cognitive load conditions and there was no interaction between gratitude and cognitive load conditions.

Substituting positive affect in place of state gratitude as the criterion variable in the second analysis produced an overall model that was not significant, $F(3, 85) = 1.78$, $p = .158$, $R^2 = .06$. There was a trending main effect of gratitude condition, $b = 0.29$, $p = .061$, 95% CI [-0.01, 0.59], although the effect size was smaller than of the previous analysis. This model predicted only 6% of the variance in positive affect whereas 10% of the variance was predicted for state gratitude. As shown in Table 20 no other main or interaction effects emerged. While not relevant to the success of the gratitude manipulation, this result increases confidence that any differences found between conditions could be more attributable to the emotional state of gratitude specifically and not to positive affect more generally. The means and standard deviations for state gratitude and positive affect are reported separately by gratitude condition in Table 21.

MCQ Response Consistency. Response consistency was calculated using Kaplan et al.'s (2014) automated scoring algorithm to determine whether random responding on the MCQ was an issue in the current study. Consistency scores for the overall *k* variable ranged from 85 – 100%, showing that no cases fell below the 75% cut-off recommended by Kaplan et al. (2016). Further, an independent *t*-test revealed that response consistency did not differ between the cognitive load conditions, $t(87) = 0.77$, $p = .439$, $d = 0.17$, 95% CI [-0.25, 0.58]. Consequently, differences in random responding cannot account for any observed effects of cognitive load condition on *k* in the current experiment.

Group Differences. Four independent *t*-tests were completed to test for inherent differences in trait impulsivity, executive dysfunction, trait gratitude, and prosociality between the gratitude conditions. No group differences were found for the I7, $t(87) = -0.30$, $p = .769$, $d = -0.06$, 95% CI [-0.48, 0.35], the BDEFS, $t(87) = 0.70$, $p = .488$, $d = 0.15$, [-0.27, 0.56], the GQ-6, $t(87) = 0.74$, $p = .460$, $d = 0.16$, [-0.26, 0.57], nor the TDM, $t(83) = -0.38$, $p = .706$, $d = -0.08$, [-0.51, 0.34].

The same four independent *t*-tests were conducted to test for pre-existing group differences between the high and low cognitive load conditions. The cognitive load conditions did not significantly differ on the I7, $t(87) = -0.03$, $p = .976$, $d = -0.01$, 95% CI [-0.42, 0.41], the BDEFS, $t(87) = -0.90$, $p = .370$, $d = -0.19$, [-0.61, 0.23], the GQ-6, $t(87) = -0.09$, $p = .927$, $d = -0.02$, [-0.44, 0.40], nor the TDM, $t(83) = -1.28$, $p = .204$, $d = -0.28$, [-0.71, 0.15]. Neither pre-existing differences between the gratitude conditions nor the cognitive load conditions on these measured variables can explain the findings of the current experiment.

Test of Hypotheses

Hypothesis 1. In a replication of Hypothesis 1 of Experiment 1, *PROCESS* macro (model 1; Hayes, 2018) was used in a moderation analysis predicting main effects of gratitude and cognitive load conditions. Gratitude condition was the predictor, cognitive load condition was the moderator, *k* was the criterion, and the I7 was included as a covariate. The overall model was not significant, $F(4, 84) = 0.10$, $p = .983$, $R^2 = .00$. There was no main effect of gratitude condition, $b = 0.19$, $p = .548$, 95% CI [-0.49, 0.87], cognitive load condition, $b = 0.08$, $p = .820$, [-0.60, 0.76], nor I7, $b = 0.00$, $p = .982$, [-0.08, 0.08]. An interaction between gratitude condition and cognitive load condition did not emerge, $b = 0.19$, $p = .781$, [-1.16, 1.56].[9] The results of this analysis are displayed in Table 22.

Hypothesis 2. Hypothesis 2 of the current study was a replication of the second hypothesis of Experiment 1 predicting main effects of trait and state gratitude on *k.* This hypothesis was tested using separate moderated moderation analyses with *PROCESS* macro (model 3; Hayes, 2018). For the examination of trait gratitude, GQ-6 was entered into the model as a predictor with gratitude and cognitive load conditions as moderators, the I7 as a covariate, and *k* as the criterion variable. The overall model was not significant, $F(8, 80) = 0.32$, $p = .957$, $R^2 = .03$, and the predicted main effect of GQ-6 did not emerge, $b = 0.00$, $p = .892$, 95% CI [-0.08, 0.07].[10] As shown in Table 23, no other significant main or interaction effects were found.

The second model of Hypothesis 2 in which state gratitude replaced the GQ-6 as the predictor variable was not significant, $F(8, 80) = 1.12$, $p = .359$, $R^2 = .10$, and no main effect of state gratitude was found, $b = -0.16$, $p = .617$, 95% CI [-0.80, 0.48]. [11] However, a significant

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[9] The results did not appreciable differ without including the I7 as covariate. The overall model remained not significant, $F(3, 85) = 0.13$, $p = .940$, $R^2 = .00$, and no significant effects emerged for gratitude condition, $b = 0.19$, $p = .582$, 95% CI [-0.49, 0.86], nor cognitive load condition, $b = 0.08$, $p = .818$, [-0.60, 0.75].

[10] The results of this analysis did not appreciably differ when the I7 covariate was omitted from the model. The overall model remained not significant, $F(7, 81) = 0.37$, $p =.919$, $R^2 = .03$, and no main effect of the GQ-6 emerged, $b = -0.01$, $p = .884$, 95% CI [-0.07, 0.06]

[11] When the I7 covariate was excluded from the model, the results did not appreciably differ. The overall model was not significant, $F(7, 81) = 1.28$, $p = .272$, $R^2 = .08$, and a no main effect of state gratitude was observed, $b = -0.15$, $p = .635$, 95% CI [-0.78, 0.48]. The significant state gratitude by gratitude condition interaction, $b = -1.49$, $p = .021$, [-2.75, -0.23], and the trend level state gratitude by cognitive load condition interaction, $b = -1.24$, $p = .053$, [-2.50, 0.02], remained.

interaction between state gratitude and gratitude condition was found, *b* = -1.51, *p* = .021, [-2.79, -0.24], in addition to a trending interaction between state gratitude and cognitive load condition, *b* = -1.27, *p* = .052, [-2.54, 0.01]. Table 24 shows the absence of any other significant main effects or interactions. As stated previously, the second model of Hypothesis 2 evidenced possible heteroscedasticity at a trend level. To increase confidence in the obtained results, the model was re-examined using a heteroscedasticity-consistent standard error estimator (HC3; Hayes & Cai, 2007). The results of this analysis are presented in Table 25 and demonstrate that the interactions found in the previous model were no longer significant. As such, the unexpected interactions that emerged in the original model were not explored further.

Hypothesis 3. The third hypothesis examined *k* in two separate models as the predictor variable rather than the criterion. This hypothesis predicted an inverse relationship between *k* and altruism. That is, lower *k* was expected to predict greater altruism. Hypothesis 3 was examined using two moderated moderation models with *PROCESS* macro (model 3; Hayes, 2018). In the first model, altruism was operationally defined as DG amount donated whereas in the second, it was defined as SDT amount forgone. In both models, *k* was the predictor, gratitude and cognitive load conditions served as moderating variables, the I7, the GQ6, and the TDM were included as covariates, and altruism (DG amount donated or SDT amount forgone) was the criterion variable.

Regarding the former, the overall model was not significant, $F(10, 74) = 1.83$, $p = .070$, $R^2 = .20$, and a main effect of *k* was not found. *b* = 0.09, *p* = .744, 95% CI [-0.47, 0.66]. However, a main effect of GQ-6 was shown, *b* = 0.24, *p* = .007, [0.07, 0.42], in addition to a main effect of TDM, $b = 0.31$, $p = .015$, [0.06, 0.55].[12] No other significant main nor interaction effects were found, as can be seen in Table 26.

When SDT amount forgone was substituted into the model as the criterion variable, the overall model was significant, $F(10, 70) = 3.30$, $p = .002$, $R^2 = .32$. However, contrary to predictions, no main effect of *k* emerged, $b = 0.48$, $p = .799$, 95% CI [-3.29, 4.26]. [13] A significant interaction between *k* and cognitive load condition was shown, $b = 8.59$, $p = .029$, [0.90, 16.27]. To decompose this effect, a regression analysis using *PROCESS* macro (model 1; Hayes, 2018) was conducted with *k a*s predictor, cognitive load condition as moderator, and SDT amount forgone as criterion. The interaction remained significant, $b = 7.61$, $p = .047$, [0.12, 15.10]. However, an analysis of conditional effects revealed that neither of the simple slopes proved significant. The effect of *k* on altruism was not significant for the low cognitive load condition, $b = -3.55$, $p = .202$, [-9.05, 1.95], nor for the high cognitive load condition, $b = 4.06$, $p = .113$, [-0.98, 9.10]. A main effect of covariate TDM was found $b = 3.15$, $p < .001$, [1.52, 4.78]. No other significant main effects nor interactions were found, as shown in Table 27.

Summary

Experiment 2 comprised the second attempt in the current research program to replicate DeSteno et al.'s (2014) effect of gratitude condition on *k.* The predicted effect did not emerge and, as such, Experiment 2 represents the second replication failure. Previously demonstrated main effects of both state and trait gratitude (DeSteno et al., 2014; Dickens & DeSteno, 2016)

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[12]When covariates I7, GQ-6, and TDM were excluded from the model, the results did not appreciably differ. The overall model was not significant, $F(7, 77) = 0.38$, $p = .911$, $R^2 = .03$, and no main effect of *k* emerged, $b = 0.09$, $p = .762$, 95% CI [-0.51, 0.70].

[13] Without including covariates I7, GQ-6 and TDM, the overall model was no longer significant, $F(7, 73) = 1.60$, $p = .149$, $R^2 = .13$. A significant main effect of cognitive load condition emerged, $b = 13.49$, $p = .043$, 95% CI [0.43, 26.54] in addition to the significant interaction between cognitive load and *k* that was also found when the covariates were included, $b = 9.74$, $p = .022$, [1.45, 18.04].

were also not replicated for the second time in this Experiment 2. Whereas the first experiment demonstrated a tenuous effect at trend level statistical significance of cognitive load on *k* using the *N*-back task, this effect was no longer present in Experiment 2 when the digit span task was used to manipulate cognitive load condition. Furthermore, the main effect of the I7 on *k* that was shown in the first experiment did not emerge in the second.

General Discussion

The primary aim of this program of research was to replicate DeSteno et al.'s (2014) research study demonstrating the relationship between gratitude and delay discounting, and to test whether the effect was contingent upon level of cognitive load. The predicted effect did not emerge in either of the two experimental studies comprising this program of research. Further, no interaction between gratitude and cognitive load was observed in the prediction of *k.* The current research does not provide evidence for an affective pathway to lower *k.*

The importance of replication studies in the field of experimental psychology cannot be understated. While original studies demonstrate novel findings, additional studies showing the same significant results are essential to help differentiate a true effect from a potentially false positive (Moonesinghe et al., 2007; Simons, 2014). Further, replication studies allow for the examination of multiple experiments in aggregate using meta-analytic testing which leads to stronger conclusions (Stroebe, 2016).

A replication failure is said to occur when a significant effect demonstrated in an original study does not emerge in a replication study. Replication failures are common in psychological research (Bohannon, 2015; Pashler & Harris, 2012) although the true rate of replication failure has been contested (e.g., Gilbert et al., 2016). There is ongoing debate surrounding culpability for the unimpressive rates of reproducibility in psychology (Fabrigar et al., 2020). Some attribute replication failures to problems with the original studies. For example, flawed research practices leading to the overreporting of false positives has been postulated as one explanation (John et al., 2012). Others have ascribed blame to the replication studies, citing the inflation of random error by using different populations or procedures (Cesario, 2014; Gilbert et al., 2016). Rather than subscribing to a stance on either one side of this dichotomy, Fabrigar et al. (2020) recommend a systematic examination of the reasons underlying replication failures on a case-by-case basis. Specifically, they recommend a comparison of the original and replication studies with reference to a research validity typology outlined by Cook and Campbell (1979). Cook and Campbell outlined four categories of validity intended to guide the evaluation of experimental research methodology. These four types of validity, namely statistical conclusion validity, internal validity, construct validity, and external validity, have become a mainstay in the evaluation of methodological quality in psychological research.

According to Fabrigar et al. (2020), replication failures occur when the replication study differs from the original study in one or more of these four domains. The current study failed to replicate previously demonstrated effects of gratitude, cognitive load, trait impulsivity, and heart rate variability on discounting rate in either one or both studies. Each of these replication failures are discussed with the intention of highlighting differences between original and replication studies in one or more of the four categories of validity.

Gratitude and Delay Discounting

Gratitude was operationalized in the current research program in three ways: namely, manipulated gratitude condition, state gratitude, and trait gratitude. Contrary to previous findings (DeSteno et al., 2014; Dickens & DeSteno 2016), the effect of gratitude on *k* was not replicated for any of the three gratitude variables in either of the two studies of the current research program.

Following the initiation of data collection for the current program of research, a study was published by researchers outside of the DeSteno group. This study, conducted by Patalano et al. (2018), aimed to replicate DeSteno et al.'s (2014) results showing a significant relationship between gratitude condition and delay discounting. Using a sample of university students, Patalano et al. replicated DeSteno et al.'s procedure to manipulate gratitude condition; participants were randomized to either the gratitude or neutral condition, instructed to recall a memory congruent with the assigned condition, and asked to write about their memory in detail for a duration of 5 minutes. Patalano et al. used the same manipulation check questionnaire items employed by DeSteno et al. to discern state gratitude and evaluate the success of the gratitude manipulation. Discounting rate was measured following the gratitude induction and manipulation check. Rather than the MCQ, Patalano et al. used a discounting task comprised of 240 decisions (120 unique), a fixed immediate financial reward of $10, and 12 delayed financial reward options ranging from $11 - $30. There were 10 different delay intervals. Patalano et al. found state gratitude to be significantly higher in the gratitude condition compared to the neutral condition, thus supporting the success of the gratitude manipulation. As in the current program of research, however, no significant effect of gratitude condition on *k* was found (Patalano et al., 2018).

Four studies to date have experimentally examined the relationship between gratitude condition and delay discounting. The first study, conducted by DeSteno et al. (2014), found a significant predictive relationship whereas no relationship was shown in the three subsequent studies, namely Patalano et al. (2018) and the two studies of the current research program.

Statistical Conclusion Validity

The first of Cook and Campbell's (1979) four validity categories is related to statistical inference. A study is said to have statistical conclusion validity if accurate conclusions are drawn about statistically significant covariation between variables (Cook & Campbell, 1979). Statistical conclusion validity can be threatened by low statistical power, violated statistical assumptions, the error rate problem, poor reliability of measures, poor reliability of treatment implementation, random irregularities in the experimental setting, or random heterogeneity of respondents (Cook & Campbell, 1979).

Statistical power is influenced by a collection of variables including effect size and sample size (Hallahan & Rosenthal, 1996). The replication failures in the current research program and in the study by Patalano et al. (2018) are unlikely to have resulted from low power due to inadequate sample size. Prior to the initiation of data collection for the studies in the current research program, power calculations were conducted based on previously published effect sizes. The number of participants recruited for each experiment in the current research program exceeded the calculated sample size required to achieve 80% power. Furthermore, of the four studies, sample size was lowest in the study by DeSteno et al. (2014). DeSteno et al.'s valid sample had 25 participants in each condition which was sufficient to detect the effect of gratitude on delay discounting. Patalano et al.'s (2018) valid sample had 40 and 44 participants in the neutral and gratitude groups, respectively. In Experiment 1 of the current research program, the gratitude and neutral conditions comprised 71 and 66 participants, respectively. In Experiment 2, the groups comprised 44 and 45 participants. Given that the three studies that failed to replicate the significant effect had larger sample sizes than the original study, the likelihood of the three failed replications representing a type II error is low.

The assumptions of regression-based statistical testing were systematically reviewed and comprehensively reported in the current research. As outlined previously, no assumptions were violated in the relevant analyses. It is not customary for detailed information regarding the assumptions of statistical tests to be divulged in journal publications. As such, the assumptions for the analyses conducted by DeSteno et al. (2014) and Patalano et al. (2018) could not be evaluated.

The error rate problem refers to the inflation of error rates resulting from multiple comparisons, particularly in instances where theoretically guided research questions are not specified a priori. Colloquially referred to as statistical ‘fishing,’ this approach is not considered best practice when corrections for multiple comparisons are not utilized or when findings are presented as if they were predicted a priori. Nevertheless, this approach can produce type 1 errors and has been shown to be prevalent in psychological research (John et al., 2012). The possibility of an inflated error rate giving rise the significant result found by DeSteno et al. (2014) cannot be ruled out with certainty. However, given the continuity of this group’s research program and the number of theoretical articles published in years prior that align with their predictions, it is highly unlikely that their published findings resulted from the error rate problem.

The current research managed reliability of the MCQ by measuring response consistency and implementing an exclusion rule for response consistency based on previous studies. Patalano et al. (2018) reported high reliability for the discounting task used in their study. DeSteno et al. (2014) did not report on MCQ reliability.

Variability in treatment implementation is unlikely to have influenced statistical conclusion validity in any of the studies. In all four studies, the instructions for the gratitude induction were presented to the participant electronically which enabled the standardization of the treatment implementation across participants. Similarly, the issue of random irrelevancies in the experimental setting is not likely to have influenced results. This factor is more relevant for experiments taking place in field settings which can be highly variable. The studies reviewed here were all laboratory-based and thus took place in a highly controlled and standardized environment.

Random heterogeneity of respondents refers to individual variation in study participants on factors external to the experimental design. Inherent differences in participants between the two conditions within an experiment could lead to biased results. All studies used random assignment to conditions which minimizes, but does not eliminate, this threat to validity. In both experiments in the current research program, extraneous variables with known or possible links to delay discounting were measured and tested in preliminary analyses to account for this possibility. The results of these preliminary analyses did not provide support for significant differences between the gratitude and neutral conditions in trait impulsivity, trait gratitude, deficits in executive function, or resting HRV in either of the two experiments. Like any research study, however, the possibility that unmeasured sources of respondent heterogeneity in any of the four studies could have influenced results leading to a type 1 error in DeSteno et al. (2014) or a type II error in the remaining three studies, cannot be ruled out.

Internal Validity

Internal validity is the plausibility of a directional and causal relationship between two variables (Cook & Campbell, 1979). The four experimental studies under review utilized random assignment to conditions and appropriate control groups. In all four studies, the predictor variable, gratitude, was experimentally manipulated and temporally preceded the measured variables, discounting. Taken together, these factors strengthen the ability to make causal inferences between variables, thus supporting the internal validity of the studies (Fabrigar et al., 2020).

Construct Validity

In psychological research, operational variables are typically used to infer the nature of relationships between conceptual variables (Fabrigar et al., 2020). Conceptually, the four studies under review aimed to provide information about the causal relationship between gratitude and delay discounting. These constructs, however, can be operationalized in different ways. Construct validity refers to the level of correspondence between operationalized variables and the conceptual variables they are intended to represent (Fabrigar et al., 2020). All four studies used the same gratitude induction procedure and same set of questions to measure the level of induced state gratitude. However, while the two studies in the current research program and the study by DeSteno et al. (2014) used the MCQ to measure discounting, Patalano et al. (2018) used a different discounting measure. Although the discounting task used by Patalano et al. has been successfully used to measure discounting rate in other studies, it does represent a methodological deviation from DeSteno et al. and thus introduces the possibility of a threat to construct validity.

Another methodological difference between DeSteno et al.'s (2014) study and the additional three studies pertains to reimbursement for participation and the hypothetical nature of the financial rewards on the discounting task. In the current research program and in the study by Patalano et al. (2018), participants made choices between hypothetical rewards for the discounting task. Participants did not actually receive their preferred amount of money at the selected temporal distance. Participants were aware that they were indicating hypothetical preferences when responding to the questions. By contrast, participants in the study by DeSteno et al. were randomly selected to receive a reward that aligned with one of their choices on the MCQ (i.e., they would receive the value of money they selected at the temporal distance they selected – immediately or after a period of delay). The rationale provided by DeSteno et al. for this method of reimbursement was to incentivize participants to indicate their actual preferences. The three replication studies differ from the DeSteno et al.'s study in that the selections made on the MCQ were purely hypothetical.

Although it is possible that this methodological difference could explain why DeSteno et al.'s (2014) study alone was able to show a significant gratitude effect on discounting, it is unlikely. Numerous studies have demonstrated that results on measures of delay discounting do not differ whether real or hypothetical rewards are used (Chabris et al., 2008; Crean et al., 2000; Baker et al., 2003; Johnson & Bickel, 2002; Johnson et al., 2007; Hinson et al., 2003; Lagorio & Madden, 2005; Madden et al., 2003; Reed & Martens, 2011).

All four studies provided course credit in undergraduate psychology courses in exchange for participation. In Experiment 1 of the current study, a subset of participants was randomly selected to each win a gift card valued at $100, regardless of their responses on the MCQ. Given the lack of empirical support for the use of real rewards to incentivize accurate responding, the decision was made to instead use financial reimbursement to promote study recruitment. At the time of data collection, Experiment 1 was competing with numerous other studies within a limited participant pool. Recruitment of a larger sample size to maximize statistical power was therefore prioritized rather than using financial reimbursement to provide real rewards related to responses on the MCQ. Recall that in Experiment 2, financial reimbursement was provided to every participant and was built into the procedure of evaluating altruistic behaviour. Consequently, the methodology of Experiment 2 did not allow for the provision of real rewards aligned with MCQ responding. Other methods were used to encourage accurate responding in both experiments of the current research program. Participants were informed that there were no right or wrong answers and were encouraged to answer honestly. The influence of socially desirable responding was minimized by ensuring privacy during the completion of the MCQ; participants responded to questions alone in a room without any researchers or other participants present.

The distinction between real and hypothetical rewards on the discounting task cannot be definitively ruled out as an explanatory factor for the failed replications. Given the abundance of empirical evidence demonstrating that this variable does not affect discounting rates, it is unlikely to account for the failed replications.

Another important point to be made is that direct procedural replications do not ensure protection against threats to construct validity; contextual changes and sample differences can introduce construct validity problems if they produce changes in the psychological properties of manipulations or measures (Fabrigar et al., 2020). Comparison of sample characteristics across studies is challenging and not all variables with the potential to influence results can be accounted for. Nonetheless, the general demographics of the samples across the four studies appear to be quite similar. All studies were completed at universities in North America. The current research program was conducted in Canada whereas the studies by DeSteno et al. (2014) and Patalano et al. (2018) occurred in the United States. All samples were predominantly comprised of young adult undergraduate students. Both men and women participated the studies, all of which had a greater proportion of female participants relative to male participants. A majority of participants who participated in the studies of the current research program as well as that of DeSteno et al. were of European descent. No variables related to race or ethnicity were reported by Patalano et al. While not an exhaustive list of sample characteristics, the samples recruited across the four studies appear to be relatively similar in terms of the variables that were reported: namely age, student status, sex, and ethnicity. As such, significant differences in sample characteristics between studies is unlikely explain the replication failures. With respect to the manipulation of gratitude, all four studies demonstrated significantly greater state gratitude in the gratitude condition compared to the neutral condition. This shows that the intended effect of the manipulation was comparable across studies.

When the effect sizes of the gratitude manipulation are taken into consideration, differences between the four studies emerge. In DeSteno et al.'s (2014) study, the effect size for the difference in state gratitude between conditions was quite large (Glass's delta = 1.82). In Patalano et al.'s (2018) study, the effect size was medium (Hedges' $g = 0.43$). In Experiment 1 of the current research, a large effect size was shown (Hedges' $g = 0.82$). Experiment 2 showed a medium effect size (Hedges' $g = 0.56$). Nevertheless, the effect sizes found in the current research program were more similar to the effect size shown by Patalano et al. than that of DeSteno et al. [14]

One possibility is that both the current research and Patalano et al. (2018) were unable to replicate the effect of gratitude on discounting because the gratitude manipulation did not produce a large enough effect. Indeed, one method recommended to increase statistical power is to administer a stronger treatment (Hallahan & Rosenthal, 1996). In the context of the current research, this would entail altering the gratitude manipulation to induce a stronger effect on state gratitude. Research suggests that in vivo gratitude inductions produce larger effect sizes than the

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[14]Hedges' g was used to calculate the effect sizes for Experiments 1 and 2 in the current research program and the study by Patalano et al. (2018) due to unequal sample sizes. The effect size for Patalano et al.'s study was calculated using the means, standard deviations, and sample sizes reported in the published article. Glass's delta was used to calculate the effect size for the difference in state gratitude between gratitude conditions in the study by DeSteno et al. (2014) due to equal sample sizes and unequal variances. The effect size was calculated from open-source data published here: https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/24885

method of autobiographical recall used in the current study (Ma et al., 2017). Further, there are published in vivo protocols that have been successfully used to manipulate state gratitude (e.g., Bartlett & DeSteno, 2006; DeSteno et al., 2010). One potential avenue of future research could be to pilot test autobiographical and in vivo gratitude manipulation protocols. Depending on the resulting effect sizes, a follow up study could include investigating the influence of an in vivo gratitude manipulation on discounting rate.

It is important to remember, however, that DeSteno et al. (2014) demonstrated the gratitude effect on discounting using autobiographical recall, and that the three later studies exactly replicated the gratitude manipulation procedure. Furthermore, the large effect size of state gratitude obtained by DeSteno et al. does not appear to be driven by a more successful gratitude manipulation. Across the four studies, mean state gratitude reported in the gratitude groups ranged from 4.34 (Patalano et al., 2018) to 4.80 (DeSteno et al., 2014). Although the highest gratitude level was reported in DeSteno et al.'s (2014) study, the mean level of gratitude is quite similar to that of Experiment 2 in the current research program ($M = 4.74$). Rather, the large effect size for state gratitude reported by DeSteno et al., appears to stem from a low level of state gratitude in the neutral condition ($M = 2.91$). State gratitude in the neutral condition of DeSteno et al.'s study was much lower than state gratitude reported in the three subsequent studies ($M = 3.90 – 4.21$). This point is of particular interest because it cannot be the result of variability in the success of the gratitude manipulations across studies. It is the control group, or the neutral condition, in DeSteno et al.'s study that differs from the other controls groups. Given the small sample size used by DeSteno et al., the low level of state gratitude in their control group, and the inability to replicate the result in three subsequent experiments, it could be that the significant effect resulted from unique sample characteristics rather than the gratitude manipulation itself. Further study is required before any conclusions can be drawn to this effect. Future research in this avenue should aim to maximize group differences in state gratitude which will likely require the adoption of a different gratitude manipulation procedure.

External Validity

External validity refers to the generalizability of results to additional contexts and populations (Cook & Campbell, 1979). Replication failures can occur when the sample used in the original study is different than the sample used in the replication study, and one or more factors that differentiate the samples moderate the relationship between the predictor and criterion variables. Given the similarity in sampled populations across the studies in terms of demographic characteristics and population from which recruitment took place (i.e., undergraduate university students), there is no reason to suspect a problem with external validity as the cause of the failed replications.

Although there are no clear threats to validity among the different studies investigating the influence of gratitude on discounting rate, there are a number of possibilities that warrant further investigation. First, the use of hypothetical versus actual rewards on the discounting task may have introduced a threat to construct validity given the methodological difference between the replication failures and the original study showing a positive result. Second, despite efforts to replicate the original procedure, repeating a study in a new context with different participant introduces the possibility of changes in the psychological properties of measures or manipulations which could have given rise to a construct validity problem (Fabrigar et al., 2020). Finally, the effect size of the gratitude manipulation itself among the replication studies warrants further investigation. Although this may well be an artefact stemming from heterogeneity of participants in the sample of the original study, it is also possible that the replication studies did not induce a large enough effect of gratitude which would reflect statistical conclusion validity problems. As mentioned, future research should aim to maximize the effect of the gratitude manipulation using alternative procedures.

State Gratitude and Delay Discounting

The relationship between state gratitude and delay discounting shown by DeSteno et al. (2014) was not replicated in either of the two experiments in the current research program. The sample size used in the current research was adequate to detect an effect of state gratitude. Using the same measures, DeSteno et al. detected a significant relationship using a sample size of 75 participants. The sample sizes used in the current research were 137 and 89, both of which exceed the sample size used by DeSteno et al. In addition to sample size, restriction of range in the criterion variable is another factor that can influence statistical power (Hallahan & Rosenthal, 1996). The mean level of state gratitude reported by DeSteno et al. ($M = 3.85$) is lower but not exceedingly different from the mean found in Experiment 1 ($M = 4.48$) and Experiment 2 ($M = 4.15$) of the current research. However, DeSteno et al. reported a larger standard deviation ($SD = 1.23$) than either of the current studies ($SD = 0.69, 0.60$). It is possible that the reduced variability in state gratitude observed in the current research resulted in restriction of range and thereby reduced statistical power to detect a significant effect (Hallahan & Rosenthal, 1996). This would reflect a threat to statistical conclusion validity. Another possibility, however, is that the standard deviation reported by DeSteno et al. was inflated because of the low level of state gratitude observed in their neutral condition, as discussed previously. If this observation reflects unique characteristics of participants in the neutral condition in DeSteno et al., a threat to statistical conclusion validity due to random heterogeneity in respondents could be deduced. On the other hand, if restriction of range in the subsequent three studies is the culprit, the threat to statistical conclusion validity would be present for the replication studies and would stem from inadequate statistical power.

Trait Gratitude and Delay Discounting

Dickens and DeSteno (2016) found a significant relationship between mean daily gratitude and delay discounting. The current research aimed to replicate this finding using a measure of trait gratitude rather than the daily questionnaires used by Dickens and DeSteno over a 3-week period. Trait gratitude did not predict discounting rate in either Experiment 1 or 2 of the current research. Dickens and DeSteno showed a significant effect using a sample of 105 participants. Although Experiment 2 relied on a slightly smaller sample (89 participants), Experiment 1 used a larger sample (137 participants). The characteristics of the sample used by Dickens and DeSteno were fairly similar to those of the samples used in the current research program. The sample used in the study by Dickens and DeSteno comprised undergraduate students recruited from a university in the United States. More than half of the sample consisted of individuals of European descent and a majority of participants were woman.

Like the current research, Dickens and DeSteno (2016) measured delay discounting using the MCQ. As mentioned, Dickens and DeSteno measured participants experience of gratitude daily for 3 weeks whereas the current research employed a questionnaire administered once that provides of index of gratitude as a personality trait. Given this methodological change, it is possible that the current research was tapping into a different construct than the mean daily level of gratitude measured by Dickens and DeSteno. Thus, a possible reason for the replication failure of Dickens and DeSteno could be a threat to construct validity that resulted from the current research's different operationalization of trait gratitude compared to the original study.

McCullough et al. (2004) provide an overview of gratitude, distinguishing between gratitude as a trait, a mood, and an emotion. The emotion of gratitude is described as an intense and transient psychological state that arises in response to an environmental stimulus and is relatively brief in duration (McCullough et al., 2004). In the current research as well as the studies by DeSteno et al. (2014) and Patalano et al. (2018), the emotion of gratitude is the target construct induced by the emotion manipulation and measured by the manipulation check questions. The GQ6 is the scale used to measure trait gratitude in the current research. Trait gratitude is a stable predisposition that determines the threshold at which the emotion of gratitude is experienced (McCullough et al., 2002; 2004). For example, in two people who experience the same situation, one may experience an affective state of gratitude while the other does not because of different thresholds for what is required to induce an affective state of gratitude. This individual difference is thought to comprise a difference in trait gratitude. Finally, the grateful mood is an intermediary between the emotion and the trait. The grateful mood is more stable across days than the grateful emotion but fluctuates in response to daily events more than trait gratitude (McCullough et al., 2004). One explanation for the inability of the current research to replicate the relationship between mean daily gratitude levels and delay discounting that was demonstrated by Dickens and DeSteno (2016) is that their study tapped into a grateful mood whereas the current research measured trait gratitude. Dickens and DeSteno showed a relationship between the emotion of gratitude (self-reported state gratitude following a gratitude induction) and mean daily gratitude levels and the current research showed a relationship between the gratitude emotion and trait gratitude (ranging from $r = .21 – .39$ across the three analyses). It can be expected that there is a relationship between trait gratitude and the mood of gratitude as well. However, it is possible that delay discounting is related to the mood of gratitude and not to the trait. Another possibility is that the 3-week daily questionnaire completion provided a more accurate index of this trait than the onetime questionnaire used in the current study, which relies on participant recollection of typical affective states over time. In any case, further study is required to clarify the relationship between delay discounting and the emotion, mood, and trait of gratitude.

Cognitive Load and Delay Discounting

High cognitive load condition was expected to increase discounting rate in the current research program. Experiment 1 produced some evidence of this effect; the high cognitive load condition led to increased *k,* and this effect was significant at a trend level. However, this tenuous effect of cognitive load condition was dependent on the inclusion of trait impulsivity in the model. Furthermore, the effect was not replicated in Experiment 2 when the *N*-back task was replaced with the digit span task to manipulate cognitive load. Possible explanations for the failed replications are differences in sample size, sample characteristics and methodology. These aspects are discussed highlighting possible threats to statistical conclusion validity, construct validity, and external validity.

Sample Size

As previously discussed, sample size is an important factor in ensuring adequate power to detect a significant effect (Hallahan & Rosenthal, 1996). Adequate statistical power is important to ensure statistical conclusion validity (Fabrigar et al., 2020). In the current research, statistical power analyses were performed based on published effect sizes for the relationship between cognitive load condition and discounting rate. Sample sizes for both experiments exceeded the calculated samples required to detect a significant effect. Nevertheless, the sample size used in Experiment 2 of the current research (N = 89) was smaller than the sample size used in Experiment 1 (N = 137). When paired with the methodological change involving the task used to manipulate cognitive load, the smaller sample size used in Experiment 2 may have been a contributing factor to the failure to replicate the cognitive load effect shown in Experiment 1.

It should also be noted that some of the previous studies that have demonstrated the effect of cognitive load condition on discounting rate have done so using large samples. Bailey et al. (2018) used a sample of 129 participants and a within-groups design whereas Finn et al. (2015) relied on a sample of 542 participants and a between-groups design. However, the use of large sample size has not been the case for all studies and does not appear to be essential. Recall that Hinson et al. (2003) reported on four experiments demonstrating the effect of cognitive load condition on discounting rate, the dose-dependent aspect of cognitive load, the interaction of cognitive load with individual difference variables, and the effect of cognitive load on discounting rate for real rewards. The sample sizes used by Hinson et al. ranged from 20 to 50 participants and all four experiments used a within-groups design. Of particular relevance, Hinson et al.'s fourth experiment demonstrated a significant effect of cognitive load condition on discounting rate using a sample size of 20 participants. A between-groups design was used in the current research in both experiments the number of participants in each cognitive load conditions was well beyond 20 participants (40 to 72).

Sample Characteristics

Characteristics of the samples used by the different studies that have evaluated the influence of cognitive load on discounting rate vary, specifically with reference to gender and clinical status. The varied nature of the samples may account for replication failures by introducing problems of external validity or construct validity. These threats to validity may be present in the studies showing an effect of cognitive load (i.e., producing a type 1 error) or in the failed replication studies (i.e., a type II error).

Recall that Hinson et al. (2003), Finn et al. (2015), Bailey et al. (2018), and the current Experiment 1 demonstrated either a significant or trending effect of cognitive load that increased discounting rate. The current Experiment 2 did not find a significant effect of cognitive load. Aranovich et al. (2016) also did not find an overall effect of cognitive load on discounting rate. However, they did show a significant correlation between working memory capacity and the change in discounting rate from baseline to after the cognitive load administration. These results were inferred to mean that the influence of cognitive load on discounting rate depends on individual working memory capacity.

Most studies predominantly included young adult participants. Aranovich et al. (2016) used a slightly older sample with a mean age of 33.6. Hinson et al. (2003), Bailey et al. (2018), and the current research primarily recruited from undergraduate student populations whereas Finn et al. (2015) and Aranovich et al. recruited community samples. Aranovich et al., Bailey et al., Finn et al., and the current research all included both male and female participants. Hinson et al. did not report descriptive information related to the gender distribution of their samples. The two experiments of the current research included more women than men. Conversely, the samples used by Aranovich et al., Bailey et al., and Finn et al. included more men than women. Further, Bailey et al. found a significant interaction between cognitive load and gender; the significant effect of cognitive load on discounting rate was not present in women. This finding may shed light on a possible problem with external or construct validity in the current research, given the large proportion of women in the current research, the tenuous effect of cognitive load in the current Experiment 1, and the failed replication in Experiment 2. Much of the delay discounting literature has suggested no reliable sex differences (Daugherty & Brase, 2010; Dennhardt, & Murphy, 2011; Finn et al., 2015; Jarmolowicz et al., 2014; Kirby & Marakovic, 1995; Kirby & Petry, 2004; Koff & Lucas, 2011; Kollins, 2003; Olson et al., 2007). Consequently, it is not likely that the difference in gender representation across studies led to a change in the psychological properties measured by the MCQ. However, it is possible that the greater proportion of women in the current research result in a change in the psychological properties of the cognitive load manipulation which would represent a problem with construct validity (Fabrigar et al., 2020). In the current research, all models predicting discounting rate were run with and without the inclusion of gender as a covariate. Gender was not a significant predictor of discounting rate in any of the models, nor did the results appreciable differ when gender was omitted. For this reason, the original models without the inclusion of gender were retained and reported. Gender is therefore unlikely to have led to a construct validity problem in the current research, but given Bailey et al.'s finding, further research is required to clarify the interaction between cognitive load and gender in the prediction of discounting rate.

Another way in which the samples across the studies differed was in terms of clinical status. A primarily nonclinical sample was used in the current research as well as in Hinson et al. (2003), and in Aranovich et al. (2016). Aranovich et al. screened participants using a structured clinical interview and included only participants without a history of significant psychiatric illness. The samples used in the current research did include individuals reporting diagnoses of depression (10.9 to 18.0%), ADHD (4.4 to 2.2%), and traumatic brain injury (3.6 to 3.4%). No data was collected with reference to other clinical diagnoses. No clinical information was reported in Hinson et al. In contrast, the sample used in Finn et al. (2015) consisted entirely of a clinical population. All participants exhibited some form of externalizing psychopathology including alcohol or substance use disorders, antisocial personality disorder, or conduct disorder. Bailey et al. (2018) used a sample of individuals with alcohol use disorder in addition to healthy controls. The relationship between psychopathology and delay discounting is well-documented (e.g., Amlung et al., 2019; Jackson & MacKillop, 2016; MacKillop et al., 2011), but the interaction between psychopathology and cognitive load in the prediction of discounting rate is less clear. In their study, Bailey et al. found a moderating effect of clinical group. Specifically, the effect of cognitive load condition on discounting rate was not significant among the alcohol use disorder group (Bailey et al., 2018). This is different that Finn et al.'s results which showed no significant interaction between externalizing pathology (including alcohol use disorder) and cognitive load in the prediction of discounting rate. Given the mixed findings, the variation in sample compositions across studies cannot be ruled out as having introduced a validity threat in either the studies showing positive results or failed replications. If the variation in clinical status led to a change in the psychological properties of the cognitive manipulation and the influence of the manipulation on discounting rate, this would represent a threat to construct validity (Fabrigar et al., 2020). On the other hand, if clinical status is a moderator of the relationship between cognitive load and discounting rate, a threat to external validity would explain the replications failures (Fabrigar et al., 2020).

Methodological Differences

Perhaps the most likely explanation for the inconsistent pattern of results linking cognitive load to discounting rate are the different ways in which cognitive load was manipulated across studies. Methodological differences can account for replication failures by introducing threats to statistical conclusion validity and construct validity.

Recall that Experiment 1 of the current research manipulated cognitive load using two variations of the *N*-back task whereas Experiment 2 used two variations of a digit span task. Finn et al. (2015), Hinson et al., (2003), and Bailey et al. (2018) all used digit span tasks. Both Bailey et al. and Finn et al. used digit spans consisting of three digits, Hinson et al. used a digit span with five digits, and the current Experiment 2 used a digit span with seven digits. Greater effects cognitive load effects have been observed using digit spans of six to eight digits compared to shorter sequences (Baddeley et al., 1984).

The procedure used by Hinson et al. was similar to that of the current Experiment 2. Like Experiment 2, in Hinson et al., a string of digits was presented, the participant completed the decision task, and then they completed the recall. In the current Experiment 2, participants were asked to recall the full seven-digit sequence. In Hinson et al., participants were shown a single digit from the five-digit string and were asked to recall the digit that was to right of it in the original sequence. The cognitive load manipulation procedures used by Bailey et al. and Finn et al. differed in that participants also had to count backwards from the presented number by threes for 10 seconds before making their choice between reward options on the discounting task.

In the current study, a sequence of digits was presented for the participant to memorize, and they were asked to recall it immediately before and after completing the delay discounting task. Although a digit sequence of this length is adequate to load working memory (Baddeley et al., 1984) other studies used multiple sequences, interspersed between trials of the primary task (Aranovich et al., 2016; Bailey et al., 2018, Finn et al., 2015; Hinson et al., 2003). Moreover, Hinson and Whitney (2006) showed that the discounting rate in Hinson et al.'s (2003) study was initially the same between the digit load and control conditions. Discounting rate remained consistent across blocks of trials in the control condition whereas it increased over consecutive blocks in the digit load condition (Hinson & Whitney, 2006). This finding supports the idea that the effects of several subsequent digit sequences accumulate to produce a larger working memory load. The current research used a single digit sequence so that the 27 questions of the discounting task could be presented without interruption, like the procedure employed by DeSteno et al. (2014). In doing so, however, it is possible that the digit load was not sufficiently taxing on working memory resources to produce an observable effect on discounting rate. Put simply, there may be variability in the strength of the different procedures used to manipulate cognitive load across the different studies.

Further to this, the successful manipulation of cognitive load in the second experiment would have required working memory maintenance of the digit span between presentation and recall. However, the possibility of the digit span having been maintained in long-term memory cannot be ruled out. In this case, given the large capacity of long-term memory, a meaningful difference in cognitive resources between the two cognitive load conditions would not have been expected during the completion of the MCQ.

While a trending effect of cognitive load was observed for discounting rate in the first experiment, the effect was tenuous and dependent on the inclusion of covariate trait impulsivity in the model. Aranovich et al. (2016) also used a *N*-back task to manipulate cognitive load. In their study, the *N*-back trials were interspersed between delay discounting task trials. It is possible that switching back and forth between a cognitive load task and answering discounting questions would produce a more potent cognitive load effect. However, Aranovich et al. was also unable to find an overall effect of cognitive load condition on discounting rate without accounting for baseline variables.

It is possible that the large degree of variability in method of manipulating cognitive load across the studies resulted in different psychological effects. This would indicate an issue of construct validity, whereby the operational definition of cognitive load manipulation used in individual studies does not align with a single conceptual construct (Fabrigar et al., 2020). In other words, the different cognitive load manipulation procedures may not all be manipulating the same thing.

The other possibility mentioned is that the cognitive load manipulation procedures across studies are manipulating the same construct, but they differ in strength. This would present an issue of statistical conclusion validity present in the failed replication studies. The strength of a manipulation procedure is an aspect of statistical power (Hallahan & Rosenthal, 1996). It could be that certain manipulation procedures require larger sample sizes to detect a significant effect because of differences in the strength of the manipulation. In the current research, the cognitive load manipulation procedure used in Experiment 1 (the *N*-back task) was replaced with a digit span task in Experiment 2 which may have been less potent in terms of its influence on discounting rate. This methodological change was necessary in order to evaluate the impact of the gratitude induction on discounting rate without adding a lengthy period of delay before measuring discounting rate. Further study is required to specifically investigate the impact of different types of cognitive load procedures on discounting rate.

In summary, the inconsistent results in the literature as well as within the current research program, may be understood by considering threats to statistical conclusion validity, construct validity, and external validity. The variation in sample characteristics across studies, particularly with reference to gender and clinical status, could have led to problems with either construct validity or external validity. The former would apply if the change in sample characteristics influenced the psychological properties of the cognitive manipulation whereas the latter would apply if the relationship was present for some groups and not for others. Methodological differences in terms of the task type and specific procedure used to manipulate cognitive load across the studies is another factor that may explain observed replication failures. Statistical conclusion validity may be a concern if the different manipulation procedure differed in strength. A manipulation procedure with a less potent effect may reduce the power of study to detect a significant statistical effect. Construct validity would be the issue if the different manipulation procedures tapped into either separate constructs, or different aspects of one multifaceted construct. The latter appears to be the case for another predictor variable, trait impulsivity.

Impulsivity and Delay Discounting

Impulsivity emerged as a significant predictor of discounting rate in Experiment 1 of the current research. However, this effect was not replicated in Experiment 2. Numerous studies have shown positive correlational relationships between self-report measures of impulsivity and discounting rate (Bobova et al., 2009; Coffey et al., 2003; de Wit et al., 2007; Hinson et al., 2003; Kirby et al., 1999; Kirby & Finch, 2010; Kirby & Petry, 2004; Koff & Lucas, 2011) although the consistency and strength of such findings has varied (Crean et al., 2000; de Wit et al., 2007; Koff & Lucas, 2011; Reynolds et al., 2006; Patalano et al., 2018).

The inconsistent findings can likely be explained by problems with construct validity. Reynolds et al. (2006) first proposed that self-report measures of impulsivity measure a different construct than impulsive decision-making tasks such as delay discounting paradigms which are further separated from impulsive disinhibition tasks. MacKillop et al. (2016) built upon this idea, distinguishing impulsive choice, impulsive action, and impulsive personality traits as independent facets of a multidimensional construct. Impulsive personality traits reflect self-regulatory ability according to self report; self-report measures of impulsivity (e.g., Barratt Impulsiveness Scale, I7) are indices of impulsive personality. The impulsive choice facet is related to discounting rate and impulsive action reflects the inability to inhibit responses. Importantly, MacKillop et al. (2016) showed a significant but weak correlation between impulsive choice and impulsive personality (*r* = .10). Understanding impulsivity as a multifaceted constructed with largely unrelated individual facets can help to reconcile the inconsistent relationship between self-report measures of impulsivity and discounting rate in the published literature as well as within the current research.

Heart Rate Variability and Delay Discounting

None of the hypotheses involving HRV and delay discounting were supported in the current research program; neither resting HRV nor HRV reactivity predicted discounting rate. Regarding the former, the current research represents the second known replication failure since the original study was published showing a significant result; Daly et al. (2009) found a significant relationship between resting HRV and discounting rate, the latter of which was measured using the MCQ. This effect was not replicated in a study by Steenergen et al. (2020) who measured discounting rate using the Adjusting Immediate Amount Task nor in the current Experiment 1 using the MCQ.

These two replication failures can most likely be attributed to issues of construct validity. In the only study that found positive results, resting HRV was operationalized using the SDNN variable. This was obtained from day long recordings obtained from participants wearing portable cardiac monitoring devices. While the SDNN variable can be used to infer vagal tone, the general recommendation is that recordings of 24 hours in duration are used (Malik, 1996). This was not the case in Daly et al. who reported that cardiac activity was “continuously tracked from waking to sleeping” (Daly et al., 2009, p.664). Further, the variability indicated by the SDNN variable increases alongside recording length (Malik et al., 1996). Because of individual variability in waking and sleep times, the reported information implies that there could be variability in recording lengths between participants. This flags a construct validity issue because, rather than representing greater HRV, elevations in the SDNN variable when variable recording lengths are used could be influenced by numerous confounding variables, most notably, the number of hours slept. Both failed replications studies (i.e., the current Experiment 1 and Steenbergen et al., 2020) used the RMSSD variable to operationalize HRV. Consequently, the original study and the two replications may have obtained different results owing to the measurement of different constructs.

In the current research, the ECG recordings were obtained following best practices outlined by Laborde et al. (2017) and based on the recommendations of the Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology (Malik, 1996). The ECG recordings took place while participants were seated with their feet flat on the floor and their knees at a 90° angle. Clear instructions were provided prior to onset of the study and the commencement of the ECG recording was not announced to the participants. The 5-minute baseline recording took place while the participant engaged in a sustained attention task with minimal cognitive demand; participant fixed their gaze on a fixation cross presented on a large computer screen. Further, participants were seated in the same position for at least 5 minutes prior to the onset of the baseline recording. The baseline recording was 5 minutes in duration which is a sufficient recording length to capture the short-term components of HRV that are reflected by RMSSD and is the generally recommended recording length to ensure standardization across studies (Laborde et al., 2017; Malik,1996. The results of the current research, paired with the adherence to best practices, adds to the HRV and discounting literature by providing evidence that does not support a relationship between resting HRV and discounting rate. Inconsistency in findings can likely be attributed to issues with construct validity.

The absence of support for the hypothesized relationship between HRV reactivity and discounting rate, on the other hand, is not a replication failure. The current research is the first to have directly examined this hypothesis. The ECG recordings obtained during the completion of the MCQ were variable in length across participants and were usually less than 5 minutes in duration. While 5-minute recording durations are recommended for consistency across studies, valid and reliable measures of HRV can be obtained with shorter recordings, particularly when using RMSSD (Esco & Flatt, 2014; Laborde et al., 2017; Malik, 1996). Deviations from the recommended 5-minute duration are acceptable where required due to methodological considerations (Laborde et al., 2017; Malik, 1996). In the current research, a shorter ECG recording duration was used during the completion of the MCQ. This recording was used to calculate HRV reactivity. Ensuring a 5-minute ECG recording during the delay discounting task would have required an adaptation of the MCQ procedure; this was not undertaken in the current research in order to replicate the procedure used by DeSteno et al. (2014).

According to recommendations by the Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, time domain measures, especially indices of overall HRV, should have the same duration to facilitate comparison (Malik, 1996). While RMSSD is a time domain measure, it is not an index of overall HRV. Nevertheless, a constant recording duration would have been better suited to make strong conclusions about the relationship between HRV reactivity and discounting rate. Consequently, the results should be replicated using best practices for HRV data collection to draw more definitive conclusions.

Altruism and Delay Discounting

The current research did not find support for the hypothesized relationship between discounting rate and altruism. Discounting rate did not predict DG amount donated, which was a variable representing the amount of money donated by participants to a charitable organization. This result replicates the finding of Jones and Rachlin (2009) who showed that a discounting rate did not predict the amount of a hypothetical donation by participants. The results of the current research add strength and value to the findings by Jones and Rachlin because of the use of a real behavioural outcome. The current findings show that the previously demonstrated effects hold true even when there is real money at stake.

No published studies to date have demonstrated a link between discounting rate and the amount of money donated to charity. However, the current research did show significant effects of trait gratitude and prosociality in the prediction of DG amount donated. Regarding the former, previous research has shown an increase in altruistic behaviour following the induction of state gratitude through a contrived social situation (e.g., Bartlett & DeSteno, 2006; DeSteno et al., 2010). While state gratitude has been shown to produce larger effects on prosociality than trait gratitude (Ma et al., 2017), the current findings are also congruent with a number of studies that have shown the predictive ability of trait gratitude (e.g., Dewani et al., 2016; Li & Chow, 2015; McCullough et al., 2002). The effect of gratitude on prosociality is larger when it is reciprocal (i.e., carrying out a prosocial behaviour toward the subject of one's gratitude) although nonreciprocal effects of gratitude on altruism have been demonstrated empirically (Bartlett & DeSteno, 2006). The comparatively weaker association between prosociality and trait gratitude, paired with the smaller effect sizes seen when the measure prosocial behaviour is nonreciprocal as in the current study, may explain why gratitude did not emerge as a predictor for the second altruism variable, SDT amount forgone.

The absence of a relationship between discounting rate and performance on the SDT in the current research contradicts previous findings. Jones and Rachlin (2009) showed and replicated a correlation between these two variables, albeit with small effect sizes (r = .28 and r = .25). Wainwright et al. (2018) replicated the relationship but found an even smaller effect size (r = .14). Both studies used samples with similar characteristics as the current research. However, there are some differences between the studies that may have introduced issues with construct validity.

First, although all studies used the SDT to operationalize the criterion variable, the current study used a different variable derived from the measure. Because of the specific interest in altruistic behaviour rather than social discounting itself, the current study used only the furthest social distance (i.e., person # 100) whereas the previous two studies incorporated all social distances to calculate the criterion variable. Consequently, the different results obtained in the current research may have resulted from the measurement of different constructs.

Further, the current research introduced two major methodological differences by way of manipulating both gratitude and cognitive load. These aspects were not present in the previous studies. Inferential testing showed that gratitude did not interact with discounting to predict altruism. However, a significant interaction between cognitive load condition and discounting rate did emerge in the current research. The interaction suggested a positive association between cognitive demand, discounting, and altruism. However, after decomposing the interaction into simple slopes to identify the nature of the significant result, the effect of discounting rate on altruistic behaviour was not significant for either high or low cognitive load conditions. Consequently, the statistically significant interaction could not be translated into a meaningful effect. Nevertheless, this result suggests that the manipulation of cognitive load may have impacted the ability to observe a statistically significant effect of discounting rate on altruism. As such, the current findings should not be interpreted as evidence for absence of this effect. Future study is needed to clarify the relationship between discounting and altruism without the complicating addition of the cognitive load manipulation.

Strengths, Limitations, and Future Directions

The current research program exhibited a number of strengths. First, the research program comprised a multi-study investigation. The results of Experiment 1 informed the methodology employed in Experiment 2. When Experiment 1 failed to replicate the significant relationship between gratitude and delay discounting, procedural changes were adopted for Experiment 2 based on hypothesized reasons for the failed replication. The combination of multiple experiments testing the same primary hypotheses are a strength of the current research program.

Second, the current research program directly replicated the procedure used by DeSteno et al. (2014) to manipulate gratitude and measure delay discounting. The procedural fidelity to the original study that showed positive result is a strength that minimizes threats to external and construct validity and increase confidence in the findings.

Third, the current research comprised a mix of replication and novel hypotheses. As discussed, replication is an essential component of experimental research, particularly within the field of psychology. Individual studies evaluating novel hypotheses are important for generating new ideas and advancing research. Replication is critical because multiple replications are required to differentiate true effects from false positives, and strong conclusions are drawn from consolidated data that is systematically reviewed and analyzed in aggregate.

Fourth, the current research represents the first known study to evaluate the relationship between resting HRV and delay discounting using best practices and adhering the recommendations set forth by the Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology (Malik, 1996) and others (e.g., Laborde et al., 2017) for conducting HRV research.

The current research program is not without its limitations. First, the ECG recordings obtained during the completion of the MCQ were variable in length. The MCQ comprises a series of questions to which the participant responds at their own pace. Ensuring a consistent time to completion for all participants would have required an adaptation to the presentation of the items. In order to maximize fidelity to the procedure used by DeSteno et al. (2014) to investigate the relationship between gratitude and delay discounting, the decision was made not to adapt the MCQ. Consequently, the ECG recordings from which the RMSSD variables pertaining to HRV reactivity were derived are variable in length; the duration of the ECG recordings corresponds to the time it took for participants to complete the MCQ. The RMSSD variable is less susceptible than other HRV indices to reliability problems because of variable recording lengths (Malik, 1996). However, using ECG recordings of consistent lengths to derive HRV variables is considered best practice. While the procedure used in the current research does not invalidate the results, the findings should be replicated using best practices before strong conclusions can be drawn about the relationship between HRV reactivity and delay discounting.

A second limitation of the current research pertains to the use of hypothetical rewards on the MCQ. This represents a methodological change from the DeSteno et al.'s (2014) procedure. Specifically, DeSteno et al. incentivized accurate responding on the MCQ with the potential for participants to win real rewards corresponding to their MCQ responses. Informed by the literature base suggesting no differences in discounting rate whether hypothetical or real rewards are used (Chabris et al., 2008; Crean et al., 2000; Baker et al., 2003; Johnson & Bickel, 2002;

Johnson et al., 2007; Lagorio & Madden, 2005; Madden et al., 2003; Reed & Martens, 2011), the decision was made to use participant compensation for other purposes. In Experiment 1, compensation was used to promote participant recruitment in order to maximize sample size. In Experiment 2, compensation was involved in measuring one of the criterion variables. Nevertheless, this methodological change can be considered a limitation because it represents a departure from the procedure used in the study upon which the current research is based. Efforts were made to promote accurate responding. Participants were encouraged to answer accurately, informed that there were no right or wrong answers, and completed the MCQ in private, without researchers or other participants in the room.

A number of avenues that warrant further study have been highlighted in discussing the results of the current research program. Suggested directions for future research are summarized here. First, the sample used in the current research was overwhelming white, largely female, and mostly comprised of undergraduate university students. The results are therefore not representative of the Canadian population more generally. The restricted demographic characteristics of the sample used in this research is the result of relying on a convenience sample largely recruited within a university setting in northern Ontario. Future research should aim to expand findings to more diverse populations in terms of gender, race and ethnicity, geographical location, educational status, age, socioeconomic status, and clinical group.

Second, while not specifically related to delay discounting, other research has shown greater effects of gratitude on other outcome variables (e.g., altruism) in laboratory settings when in-vivo gratitude inductions were used compared to using recall to induce gratitude (Ma et al., 2017). While both in-vivo and recall gratitude inductions have shown to be effective to predict altruism (Ma et al., 2017), the in-vivo induction produces a larger effect. An in-vivo gratitude induction (e.g., Bartlett & DeSteno, 2006; DeSteno et al., 2010) may produce a more state gratitude effect in a laboratory setting. Delay discounting should therefore be examined using an in-vivo gratitude induction to rule out the possibility that the gratitude recall procedure did not produce a large enough effect in the current research nor in the study by Patalano et al. (2018).

Third, although numerous studies have found that discounting results do not differ according to whether real or hypothetical rewards are used (e.g., Hinson et al., 2003), this has not been directly compared in a study examining gratitude and delay discounting. In the study by DeSteno et al. (2014) participants were provided the opportunity to win a sum of money of a value and delay period equivalent to one of their choices on the delay discounting task. In contrast, the first of the studies in the current research provided an opportunity to win one a fixed sum of money and in the second, participants were all offered a fixed sum of money, the actual payment of which varied according to the amount they opted to donate to charity in the dictator game. Like the current research, Patalano et al. (2018) who also did not find a relationship between gratitude and discounting, used hypothetical rewards. Consequently, future research should attempt to rule out the possibility that the use of hypothetical rewards for the discounting task could have influenced the results.

Fourth, future study is required to clarify the effects of different cognitive load manipulation procedures on discounting rate. There is variability across studies in terms of the procedures used to manipulate cognitive load. It is unclear whether the replication failures stem from this methodological variability. Establishing a standard cognitive load procedure that reliably increases discounting rate would allow for the investigation of moderating variables and the exploration of effects in different populations.

Conclusions

The current program of research adds one small piece to the large body of literature required to make conclusions about the predictors and correlates of delay discounting. With respect to the primary hypothesis, the results of this study alone cannot confirm nor refute the relationship between gratitude and discounting. The systematic evaluation of possible threats to validity in original studies showing positive results as well as in the studies who have failed to replicate the findings as recommended by Fabrigar et al. (2020) is an important step in differentiating a true effect from a false positive. This process yields valuable information about different factors that may have contributed to an individual failed replication. Further, by examining validity threats across multiple studies within a specific area of research, hypotheses can be generated regarding explanations for inconsistent research findings. Applied to the current research, this process of evaluation highlighted numerous potential validity threats in previously published studies as well as within the current Experiments 1 and 2. Definitive conclusions about the true nature of the relationships between gratitude, cognitive load, and delay discounting, however, are reserved for future studies using more powerful techniques. Replication failures are common in psychological research (Bohannon, 2015; Pashler & Harris, 2012) and are not sufficient to conclude the absence of an effect (Stroebe, 2016). While the current research added an important piece to this body of literature, multiple replication studies are required before stronger conclusions can be drawn (Maxwell et al., 2015). Further, the nature of the relationship between gratitude, cognitive load, and delay discounting should be evaluated using meta-analytic techniques (Maxwell et al., 2015; Stroebe, 2016).

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Table 1

Experiment 1, Descriptive Statistics for Original and Natural Logarithmic Transformed Heart Rate Variability and k Variables

		Original Variable			ln Transformed Variable		
Variable	*N*	*M*	*SD*	$z_{skewness}$	*M*	*SD*	$z_{skewness}$
Resting RMSSD	129	40.79	25.45	**7.57**	3.54	0.58	0.12
RMSSD Reactivity	124	43.86	26.56	**7.71**	3.62	0.56	-0.08
k	137	0.02	0.04	**18.09**	-4.82	1.55	-0.92

Note. Bolded z_{skewness} values = significant degree of skew (absolute value > 1.96).

Table 2

Experiment 1, Means and Standard Deviations of k, According to Emotion and Cognitive Conditions

Variables	Gratitude		Neutral	
	High CL	Low CL	High CL	Low CL
	M (SD)			
k	0.018 (0.02)	0.023 (0.05)	0.029 (0.05)	0.024 (0.05)
ln *k*	-4.570 (1.25)	-5.005 (1.64)	-4.603 (1.44)	-5.057 (1.79)

Note. CL = cognitive load condition. ln *k* = natural logarithmic transformed *k.* Gratitude and high CL condition, *n* = 35. Gratitude and low CL conditions, *n* = 36. Neutral and high CL condition, *n* = 30. Neutral and low CL condition, *n* = 36.

Table 3

Experiment 1, Descriptive Statistics, Reliability Coefficients, and Normality Coefficients for Psychometric Variables

Variables	*N*	*M*	*SD*	Items	Min/Max	$Z_{skewness}$	α
I7	137	6.48	4.16	19	0.00-17.00	**2.43**	.83
GQ-6	137	35.29	5.15	6	18.06-42.00	**-5.78**	.78
BDEFS	137	164.64	35.68	89	99.00-288.77	**3.46**	.97
State Gratitude	137	4.48	0.69	3	1.67 – 5.00	**-7.57**	.82
Positive Affect	137	3.95	0.73	3	1.33 – 5.00	**-3.47**	.76

Note. α = Cronbach's alpha internal consistency. Bolded $Z_{skewness}$ values = significant degree of skew (absolute value > 1.96).

Table 4

Experiment 1, Pearson Intercorrelations Among Variables

Variables	1	2	3	4	5	6	7	8
1. I7	—	.02	.56*	-.15	.01	-.11	-.07	.22*
2. GQ-6		—	-.23*	.20*	.23*	-.15	-.13	.07
3. BDEFS			—	-.28*	-.18*	-.02	-.09	-.04
4. State Gratitude				—	.61*	.00	.06	-.05
5. Positive Affect					—	-.09	-.09	.05
6. Resting RMSSD						—	.86*	.02
7. RMSSD Reactivity							—	.07
8. *k*								—

Note. N = 137 (resting RMSSD, N = 129; RMSSD reactivity, N = 124).

*$p < .05$

Table 5

Experiment 1, Spearman Intercorrelations Among Variables

Variables	1	2	3	4	5	6	7	8
1. I7	—	-.10	.53*	-.10	.03	-.09	-.06	.21*
2. GQ-6		—	-.27*	.23*	.28*	-.10	-.05	.00
3. BDEFS			—	-.31*	-.16	-.02	-.08	-.03
4. State Gratitude				—	.53*	.00	.07	-.03
5. Positive Affect					—	-.07	-.07	.05
6. Resting RMSSD						—	.84*	.08
7. RMSSD Reactivity							—	.06
8. *k*								—

Note. $N = 137$ (resting RMSSD, $N = 129$; RMSSD reactivity, $N = 124$).

$^*p < .05$

Table 6

Experiment 1, Preliminary Analysis, Manipulation Check – Moderation Analysis with Gratitude Condition as the Predictor, Cognitive Load Condition as the Moderator, and State Gratitude as the Criterion

Variable	Coeff.	*SE*	*p*	95% CI
Gratitude Condition	0.53	0.11	< .001	0.31, 0.75
CL Condition	-0.14	0.11	.203	-0.36, 0.08
Gratitude Condition * CL Condition	0.11	0.22	.608	-0.32, 0.55
Constant	4.46	0.05	< .001	4.35, 4.57

Note. $N = 137$. CL condition = cognitive load condition.

Table 7

Experiment 1, Means and Standard Deviations of State Gratitude and Positive Affect Reported Separately by Gratitude Condition

	Condition	
	Gratitude	Neutral
Variable	*M (SD)*	
State Gratitude	4.73 (0.40)	4.21 (0.82)
Positive Affect	4.08 (0.65)	3.81 (0.80)

Note. Gratitude condition, *n* = 71. Neutral condition, *n* = 66.

Table 8

Experiment 1, Preliminary Analysis, Manipulation Check – Moderation Analysis with Gratitude Condition as the Predictor, Cognitive Load Condition as the Moderator, and Positive Affect as the Criterion

Variable	Coeff.	*SE*	*p*	95% CI
Gratitude Condition	0.27	0.12	.033	0.02, 0.52
CL Condition	-0.04	0.12	.730	-0.29, 0.20
Gratitude Condition * CL Condition	-0.02	0.25	.949	-0.51, 0.48
Constant	3.94	0.06	< .001	3.82, 4.06

Note. N = 137. CL condition = cognitive load condition.

Table 9

Experiment 1, Hypothesis 1 – Moderation Analysis with Gratitude Condition as the Predictor, Cognitive Load Condition as the Moderator, I7 as the Covariate, and k as the Criterion

Variable	Coeff.	*SE*	*p*	95% CI
Gratitude Condition	0.09	0.26	.716	-0.42, 0.61
CL Condition	0.49	0.26	.063	-0.03, 1.00
CL Condition * Gratitude Condition	0.05	0.52	.931	-0.98, 1.07
I7	0.09	0.03	.006	0.03, 0.15
Constant	-5.38	0.24	< .001	-5.85, -4.90

Note. $N = 137$. CL condition = cognitive load condition.

Table 10

Experiment 1, Hypothesis 2 – Moderated Moderation Analysis with GQ-6 as the Predictor, Gratitude Condition and Cognitive Load Condition as Moderators, I7 as the Covariate, and k as the Criterion

Variable	Coeff.	*SE (HC4)*	*p*	95% CI
GQ-6	0.02	0.02	.356	-0.02, 0.07
Gratitude Condition	0.12	0.26	.648	-0.40, 0.63
GQ-6 * Gratitude Condition	-0.08	0.05	.086	-0.17, 0.01
CL Condition	0.45	0.26	.086	-0.07, 0.97
GQ-6 * CL Condition	-0.03	0.05	.531	-0.12, 0.06
Gratitude Condition * CL Condition	0.05	0.51	.929	-0.97, 1.06
GQ-6 * Gratitude Condition * CL Condition	-0.07	0.09	.415	-0.25, 0.10
I7	0.09	0.03	.003	0.03, 0.15
Constant	-5.43	0.24	< .001	-5.91, -4.95

Note. N = 137. CL condition = cognitive load condition.

Table 11

Experiment 1, Hypothesis 2 – Moderated Moderation Analysis with State Gratitude as the Predictor, Gratitude Condition and Cognitive Load Condition as Moderators, I7 as the Covariate, and k as the Criterion

Variable	Coeff.	*SE*	*p*	95% CI
State Gratitude	-0.14	0.27	.606	-0.68, 0.40
Gratitude Condition	0.16	0.30	.597	-0.43, 0.75
State Gratitude * Gratitude Condition	-0.42	0.54	.438	-1.48, 0.65
CL Condition	0.51	0.30	.094	-0.09, 1.10
State Gratitude * CL Condition	-0.16	0.54	.772	-1.23, 0.91
Gratitude Condition * CL Condition	0.08	0.60	.891	-1.11, 1.27
State Gratitude * Gratitude Condition * CL Condition	-0.24	1.08	.822	-2.38, 1.89
I7	0.09	0.03	.007	0.02, 0.15
Constant	-5.33	0.26	< .001	-5.84, -4.82

Note. N = 137. CL condition = cognitive load condition.

Table 12

Experiment 1, Hypothesis 3 – Moderated Moderation Analysis with Baseline RMSSD as the Predictor, Gratitude Condition and Cognitive Load Condition as Moderators, I7 as the Covariate, and k as the Criterion

Variable	Coeff.	*SE*	*p*	95% CI
Baseline RMSSD (*ln*)	0.14	0.26	.589	-0.37, 0.65
Gratitude Condition	0.08	0.28	.785	-0.48, 0.63
Baseline RMSSD (*ln*) * Gratitude Condition	-0.62	0.52	.231	-1.65, 0.40
CL Condition	0.55	0.28	.054	-0.01, 1.10
Baseline RMSSD (*ln*) * CL Condition	0.47	0.52	.371	-0.56, 1.49
Gratitude Condition * CL Condition	0.02	0.56	.970	-1.09, 1.14
Baseline RMSSD (*ln*) * Gratitude Condition * CL Condition	-1.18	1.04	.259	-3.23, 0.88
I7	0.09	0.03	.013	0.02, 0.15
Constant	-5.36	0.26	< .001	-5.87, -4.84

Note. N = 129. CL condition = cognitive load condition.

Table 13

Experiment 1, Hypothesis 3 – Moderated Moderation Analysis with MCQ RMSSD as the Predictor, Gratitude Condition and Cognitive Load Condition as Moderators, I7 and Baseline RMSSD as the Covariates, and k as the Criterion

Variable	Coeff.	*SE*	*p*	95% CI
MCQ RMSSD (*ln*)	0.45	0.49	.361	-0.52, 1.41
Gratitude Condition	0.15	0.28	.600	-0.41, 0.70
MCQ RMSSD (*ln*) * Gratitude Condition	-0.61	0.53	.256	-1.66, 0.45
CL Condition	0.65	0.28	.020	0.10, 1.21
MCQ RMSSD (*ln*) * CL Condition	0.39	0.53	.465	-0.66, 1.44
Gratitude Condition * CL Condition	0.19	0.56	.727	-0.91, 1.30
MCQ RMSSD (*ln*) * Gratitude Condition * CL Condition	-1.18	1.07	.271	-3.29, 0.93
I7	0.09	0.03	.005	0.03, 0.16
Baseline RMSSD (*ln*)	-0.21	0.47	.660	-1.15, 0.73
Constant	-4.68	1.73	.008	-8.10, -1.25

Note. N = 124. CL condition = cognitive load condition.

Table 14

Experiment 2, Descriptive Statistics for Original and Natural Logarithmic Transformed k Variables

Variable	*N*	Original Variable			ln Transformed Variable		
		M	*SD*	$z_{skewness}$	*M*	*SD*	$z_{skewness}$
k	89	0.02	0.05	**14.59**	-4.78	1.57	1.35

Note. Bolded z_{skewness} values = significant degree of skew (absolute value > 1.96).

Table 15

Experiment 2, Descriptive Statistics, Reliability Coefficients, and Normality Coefficients for Psychometric and Altruism Variables

Variables	*N*	*M*	*SD*	Items	Min/Max	$Z_{skewness}$	α
I7	89	6.69	4.17	19	0.00-16.00	-1.42	.81
GQ-6	89	34.54	5.62	6	18.00-42.00	**-3.48**	.79
BDEFS	89	175.73	41.01	89	99.00-276.00	1.24	.97
State Gratitude	89	4.15	0.60	3	2.33-5.00	**-2.29**	.72
Positive Affect	89	3.58	0.72	3	2.00-5.00	0.26	.74
TDM	85	5.74	3.77	9	0.00-9.00	**-2.29**	.96
DG Amount Donated	89	5.19	4.27	—	0.00-10.00	0.00	—
SDT Amount Forgone	81	25.12	29.81	—	-5.00 – 85.00	**4.40**	—

Note. α = Cronbach's alpha internal consistency. Bolded $Z_{skewness}$ values = significant degree of skew (absolute value > 1.96).

Table 16

Experiment 2, Means and Standard Deviations of k, According to Emotion and Cognitive Conditions

Variables	Gratitude		Neutral	
	High CL	Low CL	High CL	Low CL
	M (SD)			
k	0.034 (0.06)	0.020 (0.03)	0.026 (0.05)	0.022 (0.05)
ln *k*	-4.595 (1.66)	-4.770 (1.53)	-4.880 (1.81)	-4.861 (1.41)

Note. CL = cognitive load condition. ln *k* = natural logarithmic transformed *k.* Gratitude and high CL condition, $n = 19$. Gratitude and low CL conditions, $n = 25$. Neutral and high CL condition, $n = 21$. Neutral and low CL condition, $n = 24$.

Table 17

Experiment 2, Pearson Intercorrelations Among Variables

Variables	1	2	3	4	5	6	7	8	9
1. I7	–	-.10	.59*	-.04	.08	-.23*	.01	-.03	-.31*
2. GQ-6		–	-.28*	.37*	.35*	.10	-.02	.31*	.18
3. BDEFS			–	-.17	-.22*	-.10	-.05	.09	-.08
4. State Gratitude				–	.47*	.17	.07	.07	.16
5. Positive Affect					–	-.15	.12	-.02	-.02
6. TDM						–	.08	.27*	.45*
7. *k*							–	.03	.08
8. DG AD								–	.24*
9. SDT AF									–

Note. *N* = 89 (TDM, *N* = 85; DG AD, *N* = 85; SDT AF, *N* = 81). DG AD = DG Amount Donated. SDT AF = SDT Amount Forgone.

*p < .05

Table 18

Experiment 2, Spearman Intercorrelations Among Variables

Variables	1	2	3	4	5	6	7	8	9
1. I7	—	-.11	.57*	-.03	.13	-.26*	.01	-.04	-.34*
2. GQ-6		—	-.31*	.42*	.35*	.11	.00	.26*	.08
3. BDEFS			—	-.17	-.23*	-.12	-.10	.09	-.06
4. State Gratitude				—	.46*	.12	.09	.07	.11
5. Positive Affect					—	-.13	.13	-.01	-.15
6. TDM						—	.10	.29*	.42*
7. *k*							—	.05	-.04
8. DG AD								—	.28*
9. SDT AF									—

Note. N = 89 (TDM, N = 85; DG AD, N = 85; SDT AF, N = 81). DG AD = DG Amount Donated. SDT AF = SDT Amount Forgone.

*$p < .05$

Table 19

Experiment 2, Preliminary Analysis, Manipulation Check – Moderation Analysis with Gratitude Condition as the Predictor, Cognitive Load Condition as the Moderator, and State Gratitude as the Criterion

Variable	Coeff.	*SE*	*p*	95% CI
Gratitude Condition	0.37	0.12	.004	0.12, 0.61
CL Condition	0.00	0.12	.997	-0.24, 0.25
Gratitude Condition * CL Condition	0.33	0.25	.177	-0.15, 0.82
Constant	4.15	0.06	< .001	4.03, 4.28

Note. $N = 89$. CL condition = cognitive load condition.

Table 20

Experiment 2, Preliminary Analysis, Manipulation Check – Moderation Analysis with Gratitude Condition as the Predictor, Cognitive Load Condition as the Moderator, and Positive Affect as the Criterion

Variable	Coeff.	*SE*	*p*	95% CI
Gratitude Condition	0.29	0.15	.061	-0.01, 0.59
CL Condition	-0.05	0.15	.741	-0.35, 0.25
Gratitude Condition * CL Condition	0.43	0.30	.156	-0.17, 1.04
Constant	3.57	0.08	< .001	3.43, 3.73

Note. $N = 89$. CL condition = cognitive load condition.

Table 21

Experiment 2, Means and Standard Deviations of State Gratitude and Positive Affect Reported Separately by Gratitude Condition

	Condition	
	Gratitude	Neutral
Variable	*M (SD)*	
State Gratitude	4.33 (0.47)	3.98 (0.66)
Positive Affect	3.71 (0.72)	3.44 (0.70)

Note. Gratitude condition, *n* = 44. Neutral condition, *n* = 45.

Table 22

Experiment 2, Hypothesis 1 – Moderation Analysis with Gratitude Condition as the Predictor, Cognitive Load Condition as the Moderator, I7 as the Covariate, and k as the Criterion

Variable	Coeff.	*SE*	*p*	95% CI
Gratitude Condition	0.19	0.34	.585	-0.49, 0.87
CL Condition	0.08	0.34	.820	-0.60, 0.76
CL Condition * Gratitude Condition	0.19	0.69	.781	-1.18, 1.56
I7	0.00	0.04	.982	-0.08, 0.08
Constant	-4.78	0.32	< .001	-5.43, -4.14

Note. $N = 89$. CL condition = cognitive load condition.

Table 23

Experiment 2, Hypothesis 2 – Moderated Moderation Analysis with GQ-6 as the Predictor, Gratitude Condition and Cognitive Load Condition as Moderators, I7 as the Covariate, and k as the Criterion

Variable	Coeff.	*SE*	*p*	95% CI
GQ-6	0.00	0.04	.892	-0.08, 0.07
Gratitude Condition	0.16	0.35	.656	-0.54, 0.86
GQ-6 * Gratitude Condition	-0.07	0.07	.322	-0.21, 0.07
CL Condition	0.12	0.35	.725	-0.58, 0.83
GQ-6 * CL Condition	0.03	0.07	.642	-0.11, 0.17
Gratitude Condition * CL Condition	0.24	0.71	.734	-1.17, 1.66
GQ-6 * Gratitude Condition * CL Condition	-0.12	0.14	.377	-0.40, 0.15
I7	0.00	0.04	.954	-0.08, 0.08
Constant	-4.78	0.34	< .001	-5.45, -4.10

Note. $N = 89$. CL condition = cognitive load condition.

Table 24

Experiment 2, Hypothesis 2 – Moderated Moderation Analysis with State Gratitude as the Predictor, Gratitude Condition and Cognitive Load Condition as Moderators, I7 as the Covariate, and k as the Criterion

Variable	Coeff.	*SE*	*p*	95% CI
State Gratitude	-0.16	0.32	.617	-0.80, 0.48
Gratitude Condition	0.36	0.36	.314	-0.35, 1.08
State Gratitude * Gratitude Condition	-1.51	0.64	.021	-2.79, -0.24
CL Condition	0.36	0.36	.322	-0.36, 1.07
State Gratitude * CL Condition	-1.27	0.64	.052	-2.54, 0.01
Gratitude Condition * CL Condition	0.74	0.73	.310	-0.70, 2.18
State Gratitude * Gratitude Condition * CL Condition	-1.60	1.27	.212	-4.13, 0.93
I7	-0.01	0.04	.740	-0.09, 0.07
Constant	-4.51	0.33	< .001	-5.17, -3.85

Note. $N = 89$. CL condition = cognitive load condition.

Table 25

Experiment 2, Hypothesis 2 (HC3) – Moderated Moderation Analysis with State Gratitude as the Predictor, Gratitude Condition and Cognitive Load Condition as Moderators, I7 as the Covariate, and k as the Criterion, Examined using Heteroscedasticity Consistent Standard Error Estimator

Variable	Coeff.	*SE (HC3)*	*p*	95% CI
State Gratitude	-0.16	0.40	.692	-0.96, 0.64
Gratitude Condition	0.36	0.42	.386	-0.47, 1.20
State Gratitude * Gratitude Condition	-1.51	0.81	.064	-3.12, 0.09
CL Condition	0.36	0.42	.401	-0.49, 1.20
State Gratitude * CL Condition	-1.27	0.81	.121	-2.88, 0.34
Gratitude Condition * CL Condition	0.74	0.88	.400	-1.00, 2.48
State Gratitude * Gratitude Condition * CL Condition	-1.60	1.61	.323	-4.81, 1.60
I7	-0.01	0.05	.766	-0.10, 0.08
Constant	-4.51	0.37	< .001	-5.25, -3.78

Note. $N = 89$. CL condition = cognitive load condition.

Table 26

Experiment 2, Hypothesis 3 – Moderated Moderation Analysis with k as the Predictor, Gratitude Condition and Cognitive Load Condition as Moderators, I7, GQ-6, and TDM Covariates, and DG Amount Donated as the Criterion Variable

Variable	Coeff.	*SE*	*p*	95% CI
k	0.09	0.28	.744	-0.47, 0.66
Gratitude Condition	-0.65	0.96	.503	-2.56, 1.27
k * Gratitude Condition	-0.39	0.59	.508	-1.56, 0.78
CL Condition	0.06	0.90	.944	-1.74, 1.86
k * CL Condition	0.08	0.58	.887	-1.08, 1.25
Gratitude Condition * CL Condition	-2.73	1.82	.139	-6.36, 0.90
k * Gratitude Condition * CL Condition	0.96	1.14	.401	-1.31, 3.23
GQ-6	0.24	0.09	.007	0.07, 0.42
State Gratitude	-0.48	0.90	.591	-2.27, 1.30
TDM	0.31	0.12	.015	0.06, 0.55
Constant	-2.94	3.73	.432	-10.37, 4.48

Note. $N = 85$. CL condition = cognitive load condition.

Table 27

Experiment 2, Hypothesis 3 – Moderated Moderation Analysis with k as the Predictor, Gratitude Condition and Cognitive Load Condition as Moderators, I7, GQ-6, and TDM Covariates, and SDT Amount Forgone as the Criterion Variable

Variable	Coeff.	*SE*	*p*	95% CI
k	0.48	1.89	.799	-3.29, 4.26
Gratitude Condition	-9.95	6.36	.123	-22.63, 2.74
k * Gratitude Condition	0.44	3.99	.913	-7.52, 8.40
CL Condition	8.44	6.04	.167	-3.61, 20.48
k * CL Condition	8.59	3.85	.029	0.90, 16.27
Gratitude Condition * CL Condition	-7.10	12.12	.560	-31.27, 17.08
k * Gratitude Condition * CL Condition	4.86	7.56	.522	-10.22, 19.94
GQ-6	0.32	0.57	.577	-0.82, 1.46
State Gratitude	7.53	6.22	.230	-4.87, 19.93
TDM	3.15	0.82	< .001	1.52, 4.78
Constant	-35.98	27.09	.189	-90.02, 18.06

Note. $N = 81$. CL condition = cognitive load condition.

Figure 1

Timeline of Experimental Procedures for the Laboratory Session in the First Experiment

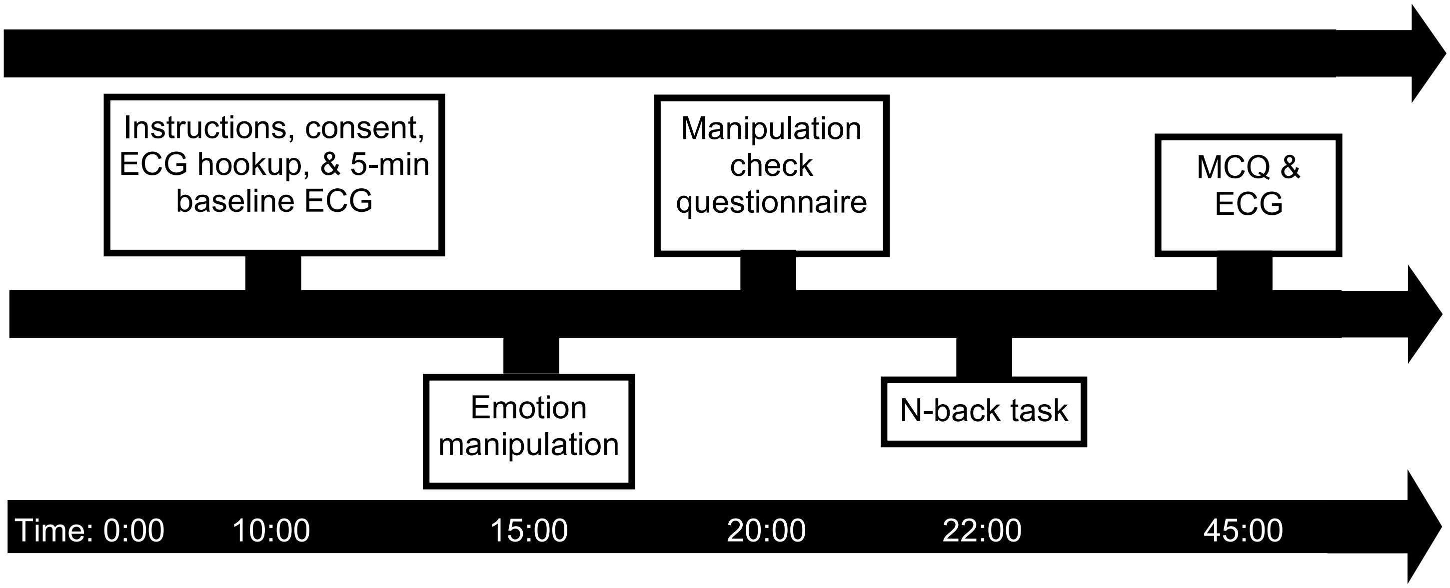
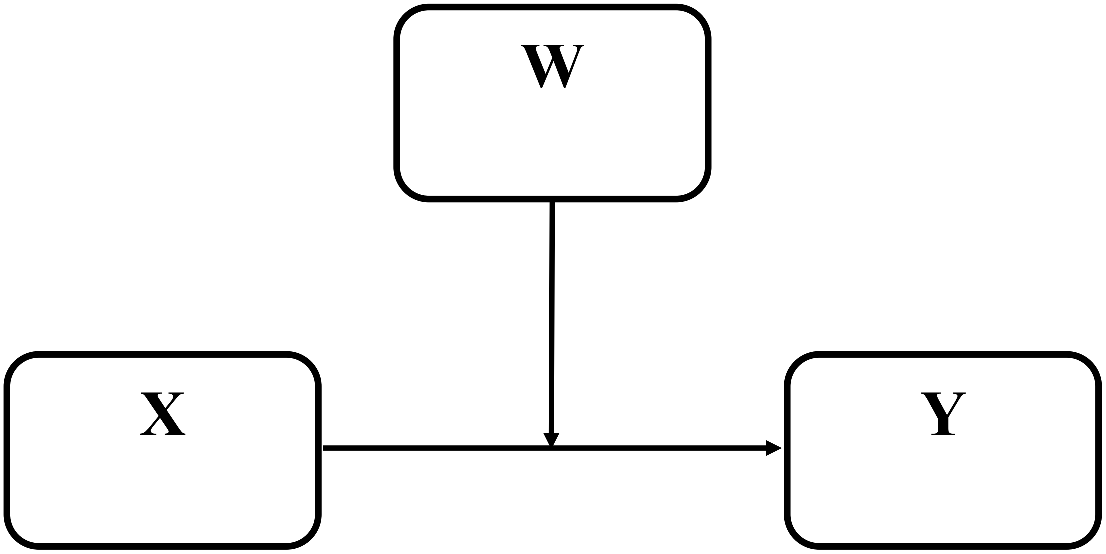


Figure 2

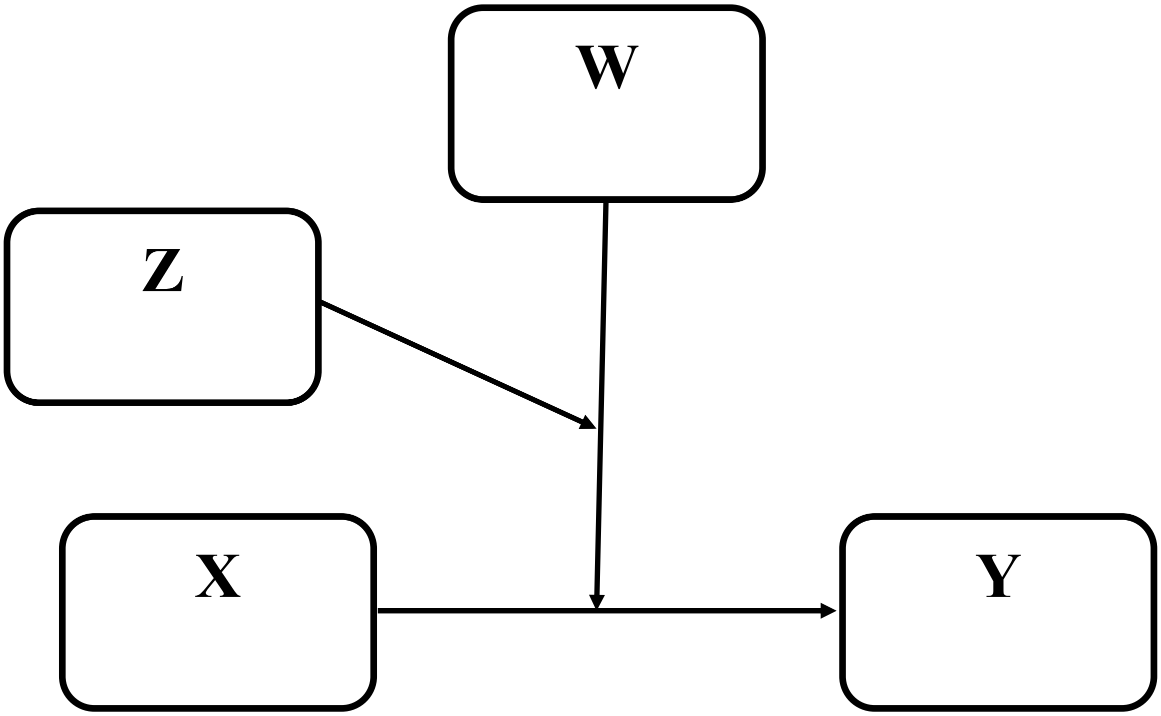
Conceptual Model Depicting Simple Moderation



Note. This figure depicts *PROCESS* (Hayes, 2018) model 1. X = predictor variable, W = moderating variable, Y = criterion variable.

Figure 3

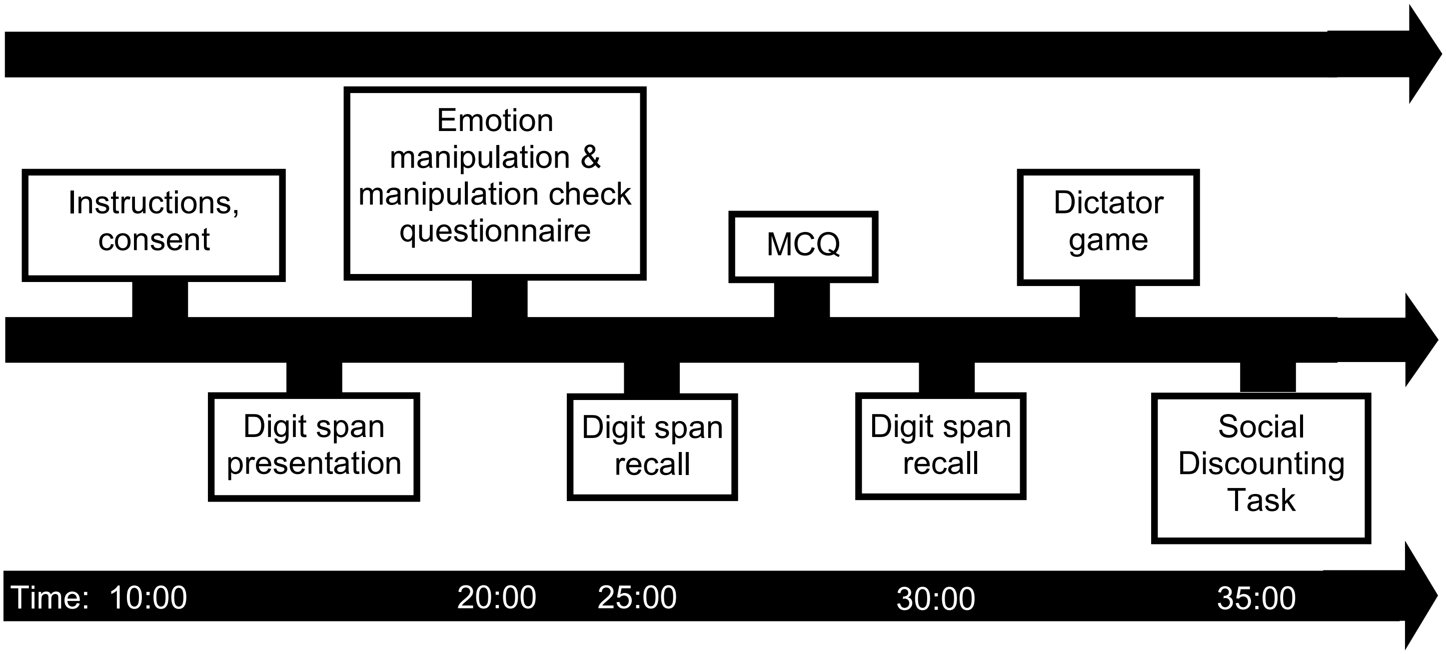
Conceptual Model Depicting Moderated Moderation



Note. This figure depicts *PROCESS* (Hayes, 2018) model 3. X = predictor variable, W = moderating variable 1, Z = moderating variable 2, Y = criterion variable.

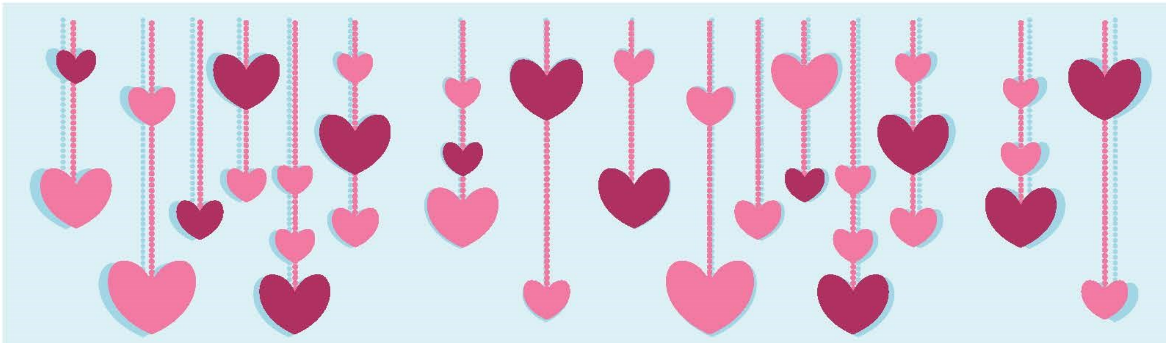
Figure 4

Timeline of Experimental Procedures for the Laboratory Session in the Second Experiment



Appendix A

Experiment 1: Recruitment Poster



WIN ONE OF 5 PREPAID $100 GIFT CARDS

We are looking for volunteers to take part in a study of Personality, Heart Function, and Decision-Making. Participants must fluent in English, age 18+, nonsmokers, and not currently taking antidepressant, hypertensive, or cold medication.

As a participant in this study, you would be asked to:

1) Complete an online questionnaire: https://www.surveymonkey.com/r/3Y66HLY?c=
2) Attend a 60-minute laboratory session at Lakehead University

During the laboratory visit, you would be fitted with electrodes to record electrical activity of your heart and face as you engage in three tasks:

a. Recall the details of a personal experience in your life
b. Engage in a computerized cognitive task involving shape discrimination and memory
c. Answer a series of questions regarding personal preference about the receipt of hypothetical financial rewards

For more information or to volunteer for this study, please contact:

Brittany Mascioli

Bmasciol@lakeheadu.ca

If you are a Lakehead student enrolled in a Psychology course eligible for bonus points, participation in this study is worth 2.5 Bonus points.

This study has been reviewed by, and received ethics clearance through, the Research Ethics Boards at Lakehead University (REB #1466658) and Confederation College (REB #0078)

LAKEHEAD UNIVERSITY | PSYCHOLOGY | THE MONEY STUDY

Appendix B

Experiment 1: Participant Information Letter

Dear Potential Participant:

This study will be of interest to people who are 18 years of age and older, nonsmokers, not currently taking any cold, antidepressant, or hypertensive medications, and fluent in English. Thank you for your interest in participating in our research study **The Money Study.** This study is being conducted by student researcher Brittany Mascioli under the supervision of Dr. Ron Davis in the Department of Psychology at Lakehead University. The purpose of this project is to examine whether certain personality traits and emotions influence electrical activity of the heart and face and decision-making related to hypothetical financial rewards.

If you are eligible and agree to participate, you would first complete some questionnaires that ask you about certain attitudes, behaviours, and emotions. This questionnaire can be completed online, and can comfortably be completed, at your own pace, in under 60 minutes. Next, you would sign up to attend a laboratory session in the Department of Psychology at Lakehead University. During this laboratory visit, you will be fitted with three ECG electrodes on your clavicle and lower rib to record heart activity as well as a bipolar EMG electrode above and below your right eye while you engage three tasks as follows:

1) Recall the details of a personal experience of gratitude or a random day in your life.
2) Engage in a computerized cognitive task involving shape discrimination and memory
3) Answer a series of questions regarding personal preference about the receipt of hypothetical financial rewards.

This laboratory session will take approximately 60 minutes of your time. A summary of the research findings may also be provided to you upon your request via email.

Your participation in this study is completely voluntary and you may withdraw from it at any time without penalty. However, your answers to the online questionnaires cannot be withdrawn once submitted, as your information on this questionnaire will be assigned a code unattached to your name and the researchers will not be able to identify your answers. In order to link your data from the online questionnaire to your data from the laboratory session, you will be asked to indicate your name on the online questionnaire. Your name will only be used for this purpose. Once the study is completed, you name will be removed from the data to ensure anonymity. All information that you provide will be kept completely confidential. Only Dr. Davis and Brittany Mascioli will be permitted to view your data. Dr. Davis is never aware of the identities of those who volunteer to participate in this study. As such, he will only be permitted to view the data from the study once the data is anonymized. All of the information that you provide will be securely stored at Lakehead University for 5 years as per University regulations. When publishing the results from this study in research journals and conferences, your data will be presented in aggregate form and your identifying information will be kept confidential. Please note that the online survey tool used in the study, SurveyMonkey, is hosted by a server located in the USA. The US Patriot Act permits U.S. law enforcement officials, for the purpose of anti-terrorism investigation, to seek a court order that allows access to the personal records of any person without the person's knowledge. In view of this we cannot absolutely guarantee the full confidentiality and anonymity of your data. With your consent to participate in this study, you acknowledge this.

A risk associated with your participation in this study is the possibility that thinking about personal issues while completing the questionnaires (e.g., time-management) and/or recalling the details of a personal experience of your choosing, may arouse a degree of distress as might normally occur when thinking about these topics in your daily life. You may choose not to answer any question asked in the questionnaires without penalty or consequence.

If you are registered in a Psychology undergraduate course eligible for bonus points, your participation by way of questionnaire completion and attending the laboratory visit would lead to 3 bonus points credited to your final grade in that course. Please feel free to contact Brittany Mascioli and/or Dr. Ron Davis with any questions that you might have. If at any point during or after this study you would like to speak to a mental health professional, feel free to contact the Student Health and Counseling Centre at (807) 343-8361. The Student Health and Counselling Centre is located in the Prettie Residence at Lakehead University. Alternatively, you can contact Crisis Responses Services at (807) 346-8282 or Postsecondary Student Helpline at 1-866-925-5454 or www.good2talk.ca

This study has been approved by the Lakehead University Research Ethics Board. If you have any questions related to the ethics of the research and would like to speak to someone outside of the research team please contact Sue Wright at the Research Ethics Board at 807-343-8283 or research@lakeheadu.ca

Sincerely,

Brittany Mascioli bmasciol@lakeheadu.ca
Dr. Ron Davis ron.davis@lakeheadu.ca (XXX) XXX-XXXX

Appendix C

Experiment 1: Participant Consent Form

By providing my name and signature below, I indicate that I have read the “Participant Information Letter” and that I have had the opportunity to receive satisfactory answers from the researchers concerning any questions that I might have about my participation in **The Money Study**. I understand and agree to the following:

1. I understand all of the information on the “Participant Information Letter”;
2. I agree to participate in this study;
3. I am a volunteer and can withdraw at any time from this study without penalty or consequence;
4. I may choose not to answer any question asked in the questionnaires without penalty or consequence;
5. There are no anticipated physical risks associated with participation in this study. I understand that the act of completing the questionnaire about personality traits, emotions, and decision-making may elicit feelings of distress. This distress is no more than would be experienced in daily life when thinking about these topics. Should I experience any personal distress or discomfort during or following my participation, I know that I may personally contact the Student Health and Counseling Centre at Lakehead University (Thunder Bay campus) located in the Prettie Residence in person or by telephone at 807-343-8361 to speak to a mental health professional;
6. My personal information will be securely stored in a double-locked research office in the Department of Psychology at Lakehead University Thunder Bay Campus for 5 years as per University regulations;
7. Dr. Ron Davis is never aware of the identities of those who participate in this study;
8. My personal information will remain anonymous should any publications or public presentations come out of this project;
9. I may receive a summary of this research upon completion if I so request;
10. I give my permission to be contacted by telephone and/or email for the purpose of participation in this study; and
11. I understand and agree to this “Consent to Participate”

___________________________ ___________________________

Full Name (*please print*) Date

____

Signature (*please sign*)

□ Please check this box if you would like to receive a summary of this research upon its completion. Please provide an email address as to where this research summary should be sent. You will not be identified directly or indirectly through this process.

Email address: ____

Appendix D

Demographic Questionnaire

1. What is your age?
    - 18 – 25
    - 26 – 35
    - 36 – 45
    - 46 – 55
    - 56 – 65
    - 66 or over

2. What is your gender?
    - Female
    - Male
    - I define myself as _________________________
    - Prefer not to say

3. Which of the following best describes your current relationship status?
    - Married/Common law
    - Widowed
    - Divorced/Separated
    - Single
    - In a relationship

4. What is your ethnicity?
    - Caucasian/White
    - Aboriginal/First Nation
    - South Asian
    - Hispanic
    - African-Canadian/Black
    - East Asian
    - Middle Eastern
    - If none of these adequately describes your ethnicity, how would you identify yourself? _________________________

5. Are you currently enrolled as a student at Lakehead University?
    - Yes
    - No

    If so, what is your current year of study?
    - 1
    - 2
    - 3
    - 4

- Other ________

6. Are you currently enrolled as a student at Confederation College?

   - Yes
   - No

   If so, what is your current year of study?

   - 1
   - 2
   - 3
   - 4
   - Other ________

7. List the name(s) of prescribed medication(s) that you are currently taking: ________________________________
8. List the name(s) of over-the-counter medication(s) that you are currently taking: ________________________________
9. Do you smoke cigarettes or use other tobacco products?
   - Yes
   - No

10. Have you ever been diagnosed with any of the following? (check all that apply)
    - Attention-deficit/hyperactivity disorder (ADHD)?
    - Depression
    - Traumatic brain injury
    - Hypertension
    - Heart condition (please specify)_________________

Appendix E

Eysenck Impulsiveness Questionnaire

Please answer each question by indicating “Yes” or “No". There are no right or wrong answers and no trick questions. Work quickly and do not think too long about the exact meaning of the question.

1. Would you enjoy water skiing?
2. Usually do you prefer to stick to brands you know are reliable, to trying new ones on the chance of finding something better?
3. Would you feel sorry for a lonely stranger?
4. Do you quite enjoy taking risks?
5. Do you often get emotionally involved with your friends’ problems?
6. Would you enjoy parachute jumping?
7. Do you often buy things on impulse?
8. Do unhappy people who are sorry for themselves irritate you?
9. Do you generally do and say things without stopping to think?
10. Are you inclined to get nervous when others around you seem to be nervous?
11. Do you often get into a jam because you do things without thinking?
12. Do you think hitch-hiking is too dangerous a way to travel?
13. Do you find it silly for people to cry out of happiness?
14. Do you like diving off the highboard?
15. Do people you are with have a strong influence on your moods?
16. Are you an impulsive person?
17. Do you welcome new and exciting experiences and sensations, even if they are a little frightening and unconventional?
18. Does it affect you very much when one of your friends seems upset?
19. Do you usually think carefully before doing anything?
20. Would you like to learn to fly an aeroplane?
21. Do you ever get deeply involved with the feelings of a character in a film, play or novel?
22. Do you often do things on the spur of the moment?
23. Do you get very upset when you see someone cry?
24. Do you sometimes find someone else’s laughter catching?
25. Do you mostly speak without thinking things out?
26. Do you often get involved in things you later wish you could get out of?
27. Do you get so ‘carried away’ by new and exciting ideas, that you never think of possible snags?
28. Do you find it hard to understand people who risk their necks climbing mountains?
29. Can you make decisions without worrying about other people’s feelings?
30. Do you sometimes like doing things that are a bit frightening?
31. Do you need to use a lot of self-control to keep out of trouble?
32. Do you become more irritated than sympathetic when you see someone cry?
33. Would you agree that almost everything enjoyable is illegal or immoral?
34. Generally do you prefer to enter cold sea water gradually, to diving or jumping straight in?
35. Are you often surprised at people’s reactions to what you do or say?

36. Would you enjoy the sensation of skiing very fast down a high mountain slope?
37. Do you like watching people open presents?
38. Do you think an evening out is more successful if it is unplanned or arranged at the last moment?
39. Would you like to go scuba diving?
40. Would you find it very hard to break bad news to someone?
41. Would you enjoy fast driving?
42. Do you usually work quickly, without bothering to check?
43. Do you often change your interests?
44. Before making up your mind, do you consider all the advantages and disadvantages?
45. Can you get very interested in your friends' problems?
46. Would you like to go pot-holing?
47. Would you be put off a job involving quite a bit of danger?
48. Do you prefer to 'sleep on it' before making decisions?
49. When people shout at you, do you shout back?
50. Do you feel sorry for very shy people?
51. Are you happy when you are with a cheerful group and sad when the others are glum?
52. Do you usually make up your mind quickly?
53. Can you imagine what it must be like to be very lonely?
54. Does it worry you when others are worrying and panicky?

Appendix F

Barkley Deficits in Executive Function Scale

Instructions: How often do you experience each of these problems? Please circle the number next to each item that best describes your behavior DURING THE PAST 6 MONTHS.
All items are on a Likert scale with 1= Never or Rarely, 2= Sometimes, 3= Often, and 4= Very Often

1. Procrastinate or put off doing things until the last minute
2. Poor sense of time
3. Waste or mismanage my time
4. Not prepared on time for work or assigned tasks
5. Fail to meet deadlines for assignments
6. Have trouble planning ahead or preparing for upcoming events.
7. Forget to do things I am supposed to do
8. Can't seem to accomplish the goals I set for myself
9. Late for work or scheduled appointments
10. Can't seem to hold in mind things I need to remember to do
11. Can't seem to get things done unless there is an immediate deadline
12. Have difficulty judging how much time it will take to do something or get somewhere
13. Have trouble motivating myself to start work
14. Have difficulty motivating myself to stick with my work and get it done
15. Not motivated to prepare in advance for things I know I am supposed to do
16. Have trouble completing one activity before starting into a new one
17. Have trouble doing what I tell myself to do
18. Difficulties following through on promises or commitments I may make to others
19. Lack self-discipline
20. Have difficulty arranging or doing my work by its priority or importance; can't "prioritize" well
21. Find it hard to get started or get going on things I need to get done
22. I do not seem to anticipate the future as much or as well as others
23. Can't seem to remember what I previously heard or read about
24. I have trouble organizing my thoughts
25. When I am shown something complicated to do, I cannot keep the information in mind so as to imitate or do it correctly
26. I have trouble considering various options for doing things and weighing their consequences
27. Have difficulties saying what I want to say
28. Unable to come up with or invent as many solutions to problems as others seem to do
29. Find myself at a loss for words when I want to explain something to others
30. Have trouble putting my thoughts down in writing as well or as quickly as others
31. Feel I am not as creative or inventive as others of my level of intelligence
32. In trying to accomplish goals or assignments, I find I am not able to think of as many ways of doing things as others
33. Have trouble learning new or complex activities as well as others
34. Have difficulty explaining things in their proper order or sequence

35. Can't seem to get to the point of my explanations as quickly as others
36. Have trouble doing things in their proper order or sequence
37. Unable to "think on my feet" or respond as effectively as others to unexpected events
38. I am slower than others at solving problems I encounter in my daily life
39. Easily distracted by irrelevant events or thoughts when I must concentrate on something
40. Not able to comprehend what I read as well as I should be able to do; have to reread material to get its meaning
41. Cannot focus my attention on tasks or work as well as others
42. Easily confused
43. Can't seem to sustain my concentration on reading, paperwork, lectures, or work
44. Find it hard to focus on what is important from what is not important when I do things
45. I don't seem to process information as quickly or as accurately as others
46. Find it difficult to tolerate waiting; impatient
47. Make decisions impulsively
48. Unable to inhibit my reactions or responses to events or others
49. Have difficulty stopping my activities or behavior when I should do so.
50. Have difficulty changing my behavior when I am given feedback about my mistakes.
51. Make impulsive comments to others.
52. Likely to do things without considering the consequences for doing them.
53. Change my plans at the last minute on a whim or last minute impulse.
54. Fail to consider past relevant events or past personal experiences before responding to situations (I act without thinking).
55. Not aware of things I say or do.
56. Have difficulty being objective about things that affect me.
57. Find it hard to take other people's perspectives about a problem or situation.
58. Don't think or talk things over with myself before doing something.
59. Trouble following the rules in a situation.
60. More likely to drive a motor vehicle much faster than others (Excessive speeding).
61. Have a low tolerance for frustrating situations
62. Cannot inhibit my emotions as well as others.
63. I don't look ahead and think about what the future outcomes will be before I do something (I don't use my foresight).
64. I engage in risk taking activities more than others are likely to do.
65. Likely to take short cuts in my work and not do all that I am supposed to do.
66. Likely to skip out on work early if my work is boring to do.
67. Do not put as much effort into my work as I should or than others are able to do.
68. Others tell me that I am lazy or unmotivated.
69. Have to depend on others to help me get my work done.
70. Things must have an immediate payoff for me or I do not seem to get them done.
71. Have difficulty resisting the urge to do something fun or more interesting when I am supposed to be working.
72. Inconsistent in the quality or quantity of my work performance.
73. Unable to work as well as others without supervision or frequent instruction.
74. I do not have the willpower or determination that others seem to have.
75. I am not able to work toward longer term or delayed rewards as well as others.
76. I cannot resist doing things that produce immediate rewards, even if those things are not

good for me in the long run.

77. Quick to get angry or become upset.
78. Overreact emotionally.
79. Easily excitable.
80. Unable to inhibit showing strong negative or positive emotions.
81. Have trouble calming myself down once I am emotionally upset.
82. Cannot seem to regain emotional control and become more reasonable once I am emotional.
83. Cannot seem to distract myself away from whatever is upsetting me emotionally to help calm me down. I can't refocus my mind to a more positive framework.
84. Unable to manage my emotions in order to accomplish my goals successfully or get along well with others.
85. I remain emotional or upset longer than others.
86. I find it difficult to walk away from emotionally upsetting encounters with others or leave situations in which I have become very emotional.
87. I cannot re-channel or redirect my emotions into more positive ways or outlets when I get upset.
88. I am not able to evaluate an emotionally upsetting event more objectively.
89. I cannot redefine negative events into more positive viewpoints when I feel strong emotions.

Appendix G

Gratitude Questionnaire – 6

Using the scale below as a guide, indicate how much you agree with each statement.
1 _ strongly disagree
2 _ disagree
3 _ slightly disagree
4 _ neutral
5 _ slightly agree
6 _ agree
7 _ strongly agree

1. I have so much in life to be thankful for.
2. If I had to list everything that I felt grateful for, it would be a very long list.
3. When I look at the world, I don’t see much to be grateful for.
4. I am grateful to a wide variety of people.
5. As I get older I find myself more able to appreciate the people, events, and situations that have been part of my life history.
6. Long amounts of time can go by before I feel grateful to something or someone.

Appendix H

Manipulation Check Questionnaire

1. How grateful do you feel?

   1------------------2------------------3------------------4------------------5

2. How appreciative do you feel?

   1------------------2------------------3------------------4------------------5

3. How positive do you feel?

   1------------------2------------------3------------------4------------------5

4. How happy do you feel?

   1------------------2------------------3------------------4------------------5

5. How content do you feel?

   1------------------2------------------3------------------4------------------5

6. How amused do you feel?

   1------------------2------------------3------------------4------------------5

Appendix I

Monetary Choice Questionnaire

For each of the next 27 choices, please indicate which reward you would prefer: the smaller reward today, or the larger reward in the specified number of days.

1. Would you prefer $54 today, or $55 in 117 days?
2. Would you prefer $55 today, or $75 in 61 days?
3. Would you prefer $19 today, or $25 in 53 days?
4. Would you prefer $31 today, or $85 in 7 days?
5. Would you prefer $14 today, or $25 in 19 days?
6. Would you prefer $47 today, or $50 in 160 days?
7. Would you prefer $15 today, or $35 in 13 days?
8. Would you prefer $25 today, or $60 in 14 days?
9. Would you prefer $78 today, or $80 in 162 days?
10. Would you prefer $40 today, or $55 in 62 days?
11. Would you prefer $11 today, or $30 in 7 days?
12. Would you prefer $67 today, or $75 in 119 days?
13. Would you prefer $34 today, or $35 in 186 days?
14. Would you prefer $27 today, or $50 in 21 days?
15. Would you prefer $69 today, or $85 in 91 days?
16. Would you prefer $49 today, or $60 in 89 days?
17. Would you prefer $80 today, or $85 in 157 days?
18. Would you prefer $24 today, or $35 in 29 days?
19. Would you prefer $33 today, or $80 in 14 days?
20. Would you prefer $28 today, or $30 in 179 days?

21. Would you prefer $34 today, or $50 in 30 days?

22. Would you prefer $25 today, or $30 in 80 days?

23. Would you prefer $41 today, or $75 in 20 days?

24. Would you prefer $54 today, or $60 in 111 days?

25. Would you prefer $54 today, or $80 in 30 days?

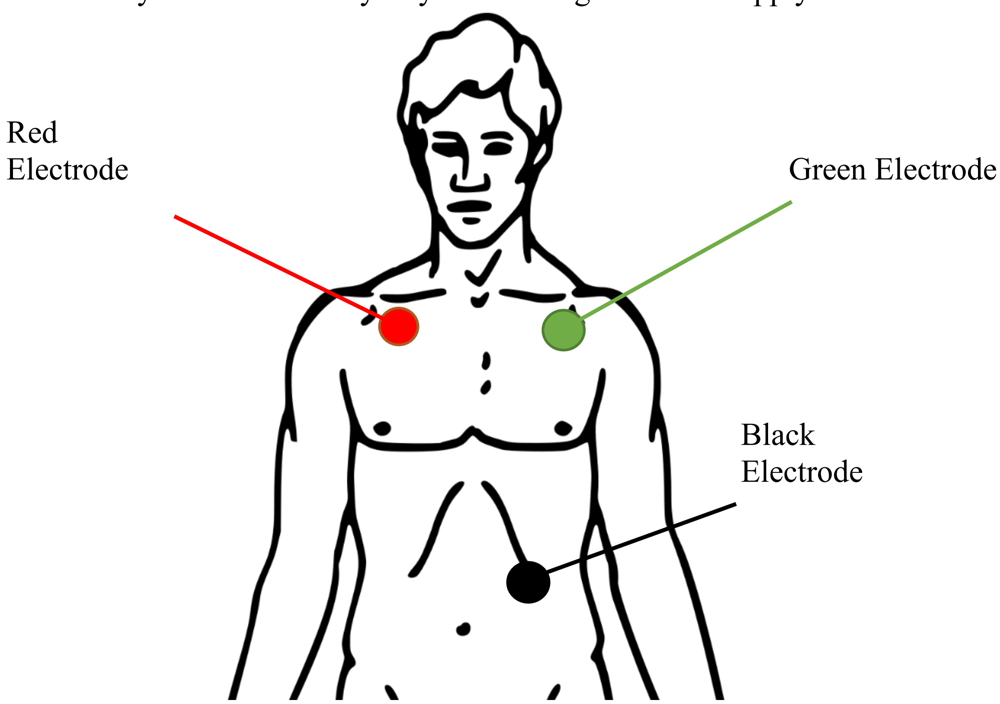
26. Would you prefer $22 today, or $25 in 136 days?

27. Would you prefer $20 today, or $55 in 7 days?

Appendix J

Heart Rate Electrode Placement

As part of this experiment, we are interested in collecting information on your heart rate. In order to do this, we will be asking you place electrodes on your skin in the locations below. For your privacy, we will be in the other room while you are applying these electrodes. However, there should be no need for you to remove any of your clothing in order to apply the electrodes.



Please Follow These Steps:

1. Use the alcohol napkin to clean the areas that you will be placing the electrodes.

2. Peel back the protective covering from the red electrode. The surface will now be very sticky, so try not to catch it on your clothes. Place the electrode approximately 1 inch below your collarbone and 2 inches from your right armpit.

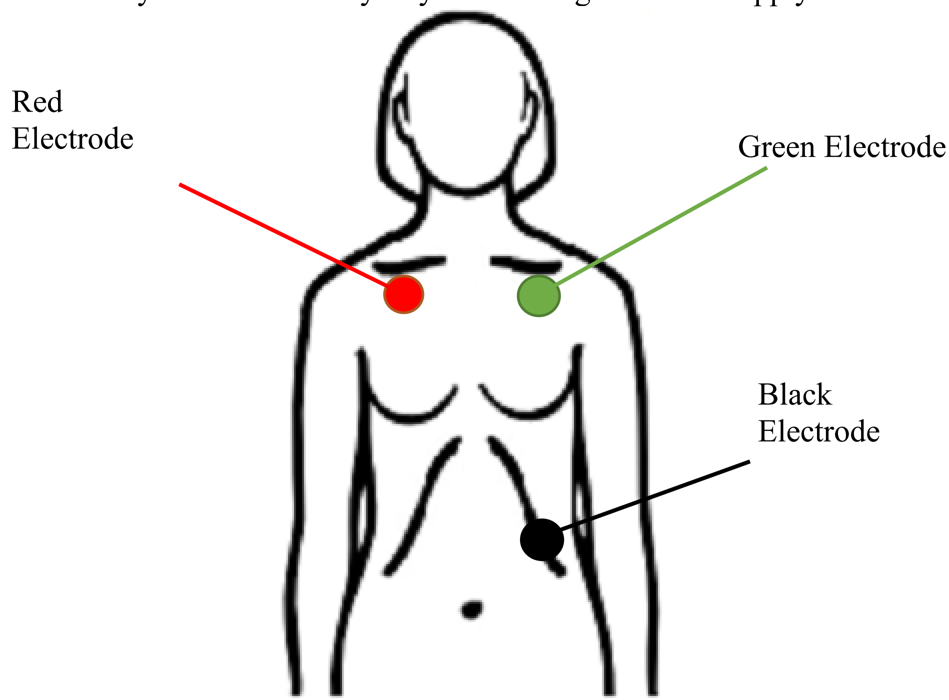
3. Peel back the protective covering on the black electrode. Place the electrode below your left ribcage. It sometimes helps to find you lowest left rib with your fingers and then place the electrode approximate 1 inch below this.

4. Peel back the protective covering on the green ground electrode. Place the electrode directly opposite the black electrode on the left side of the body.

This line is 1 inch long

Heart Rate Electrode Placement

As part of this experiment, we are interested in collecting information on your heart rate. In order to do this, we will be asking you place electrodes on your skin in the locations below. For your privacy, we will be in the other room while you are applying these electrodes. However, there should be no need for you to remove any of your clothing in order to apply the electrodes.



Please Follow These Steps:

1. Use the alcohol napkin to clean the areas that you will be placing the electrodes.

2. Peel back the protective covering from the red electrode. The surface will now be very sticky, so try not to catch it on your clothes. Place the electrode approximately 1 inch below your collarbone and 2 inches from your right armpit.

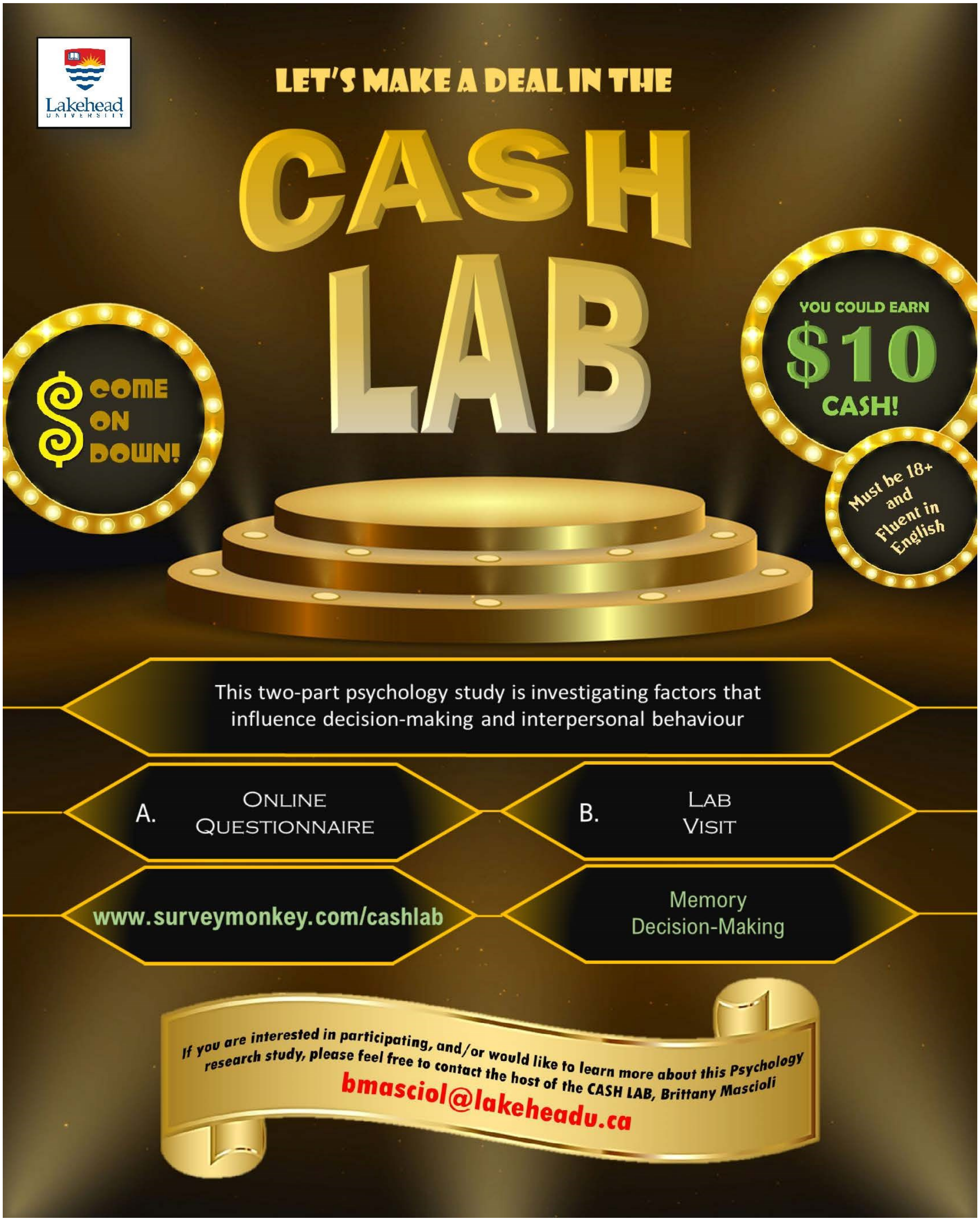
3. Peel back the protective covering on the black electrode. Place the electrode below your left ribcage. It sometimes helps to find you lowest left rib with your fingers and then place the electrode approximate 1 inch below this.

4. Peel back the protective covering on the green ground electrode. Place the electrode directly opposite the black electrode on the left side of the body.

This line is 1 inch long

Appendix K

Experiment 2: Recruitment Poster



Appendix L

Experiment 2: Participant Information Letter

Dear Potential Participant:

This study will be of interest to people who are 18 years of age and older and fluent in English.

Thank you for your interest in participating in our research study **Cash Lab.** This study is being conducted by student researchers Brittany Mascioli and Allison Payette under the supervision of Dr. Ron Davis in the Department of Psychology at Lakehead University. The purpose of this project is to examine whether certain personality traits and emotions influence electrical activity of the heart and face, decision-making related to hypothetical financial rewards, and interpersonal behaviour.

If you are eligible and agree to participate, you would first complete some questionnaires that ask you about certain attitudes, behaviours, and emotions. This questionnaire can be completed online, and can comfortably be completed, at your own pace, in under 60 minutes. Next, you would sign up to attend a laboratory session in the Department of Psychology at Lakehead University. During this laboratory visit, you will be fitted with three ECG electrodes on your clavicle and lower rib to record heart activity as well as a bipolar EMG electrode above and below your right eye while you engage in three tasks as follows:

1) Recall the details of a personal experience in your life.
2) Engage in a memory task.
3) Answer a series of questions regarding personal preference about the receipt of hypothetical financial rewards.

This laboratory session will take approximately 60 minutes of your time. A summary of the research findings may also be provided to you upon your request via email.

Your participation in this study is completely voluntary and you may withdraw from it at any time without penalty. However, your answers to the online questionnaires cannot be withdrawn once submitted, as your information on this questionnaire will be assigned a code unattached to your name and the researchers will not be able to identify your answers. In order to link your data from the online questionnaire to your data from the laboratory session, you will be asked to indicate your name on the online questionnaire. Your name will only be used for this purpose. Once the study is completed, you name will be removed from the data to ensure anonymity. All information that you provide will be kept completely confidential. Only Dr. Davis, Brittany Mascioli, and Allison Payette will be permitted to view your data. Dr. Davis is never aware of the identities of those who volunteer to participate in this study. As such, he will only be permitted to view the data from the study once the data is anonymized. All of the information that you provide will be securely stored at Lakehead University for 5 years as per University regulations. When publishing the results from this study in research journals and conferences, your data will be presented in aggregate form and your identifying information will be kept confidential. Please note that the online survey tool used in the study, SurveyMonkey, is hosted by a server located in the USA. The US Patriot Act permits U.S. law enforcement officials, for the purpose of anti-terrorism investigation, to seek a court order that allows access to the personal records of any person without the person's knowledge. In view of this we cannot absolutely guarantee the full confidentiality and anonymity of your data. With your consent to participate in this study, you acknowledge this.

A risk associated with your participation in this study is the possibility that thinking about personal issues while completing the questionnaires (e.g., time-management) and/or recalling the details of a personal experience of your choosing, may arouse a degree of distress as might normally occur when thinking about these topics in your daily life. You may choose not to answer any question asked in the questionnaires without penalty or consequence.

If you are registered in a Psychology undergraduate course eligible for bonus points, your participation by way of questionnaire completion and attending the laboratory visit would lead to 2.5 bonus points credited to your final grade in that course. Please feel free to contact Brittany Mascioli and/or Dr. Ron Davis with any questions that you might have. If at any point during or after this study you would like to speak to a mental health professional, feel free to contact the Student Health and Counseling Centre at (807) 343-8361. The Student Health and Counselling Centre is located in the Prettie Residence at Lakehead University. Alternatively, you can contact Crisis Responses Services at (807) 346-8282 or Postsecondary Student Helpline at 1-866-925-5454 or www.good2talk.ca

This study has been approved by the Lakehead University Research Ethics Board and the Confederation College Research Ethics Board. If you have any questions related to the ethics of the research and would like to speak to someone outside of the research team please contact Sue Wright at the Research Ethics Board at 807-343-8283 or research@lakeheadu.ca

Sincerely,
Brittany Mascioli bmasciol@lakeheadu.ca
Dr. Ron Davis ron.davis@lakeheadu.ca (XXX) XXX-XXXX

Appendix M

Experiment 2: Participant Consent Form

By providing my name and signature below, I indicate that I have read the "Participant Information Letter" and that I have had the opportunity to receive satisfactory answers from the researchers concerning any questions that I might have about my participation in **Cash Lab.** I understand and agree to the following:

1. I understand all of the information on the "Participant Information Letter";
2. I agree to participate in this study;
3. I am a volunteer and can withdraw at any time from this study without penalty or consequence;
4. I may choose not to answer any question asked in the questionnaires without penalty or consequence;
5. There are no anticipated physical risks associated with participation in this study. I understand that the act of completing the questionnaire about personality traits, emotions, and decision-making may elicit feelings of distress. This distress is no more than would be experienced in daily life when thinking about these topics. Should I experience any personal distress or discomfort during or following my participation, I know that I may personally contact the Student Health and Counseling Centre at Lakehead University (Thunder Bay campus) located in the Prettie Residence in person or by telephone at 807-343-8361 to speak to a mental health professional;
6. My personal information will be securely stored in a double-locked research office in the Department of Psychology at Lakehead University Thunder Bay Campus for 5 years as per University regulations;
7. Dr. Ron Davis is never aware of the identities of those who participate in this study;
8. My personal information will remain anonymous should any publications or public presentations come out of this project;
9. I may receive a summary of this research upon completion if I so request;
10. I give my permission to be contacted by telephone and/or email for the purpose of participation in this study; and
11. I understand and agree to this "Consent to Participate"

____________________________ ____________________________

Full Name (*please print*) Date

____

Signature *(please sign)*

☐ Please check this box if you would like to receive a summary of this research upon its completion. Please provide an email address as to where this research summary should be sent. You will not be identified directly or indirectly through this process.

Email address: ____

Appendix N

Triple Dominance Measure

In this task we ask you to imagine that you have been randomly paired with another person, whom we will refer to simply as the "Other." This other person is someone you do not know and that you will not knowingly meet in the future. Both you and the "Other" person will be making choices by circling either the letter A, B, or C. Your own choices will produce points for both yourself and the "Other" person. Likewise, the other's choice will produce points for him/her and for you. Every point has value: the more points you receive, the better for you, and the more points the "Other" receives, the better for him/her.

Here's an example of how this task works:

	A	B	C
You Get	500	500	550
Other Gets	100	500	300

In this example, if you choose A you would receive 500 points and the other would receive 100 points; if you chose B, you would receive 500 points and the other 500; and if you chose C, you would receive 550 points and the other 300. So, you see that your choice influences both the number of points you receive and the number of points the other receives. Before you begin making choices, please keep in mind that there are no right or wrong answers -- choose the option that you, for whatever reason, prefer most. Also, remember that the points have value: the more of them you accumulate the better for you. Likewise, from the "other's" point of view, the more points s/he accumulates, the better for him/her.

For each of the nine choice situations, select A, B, or C, depending on which item you prefer most:

1.
   a) You get $480; Other gets $80
   b) You get $540; Other gets $280
   c) You get $480; Other gets $480

2.
   a) You get $560; Other gets $300
   b) You get $500; Other gets $500
   c) You get $500; Other gets $100

3.
   a) You get $520; Other gets $520
   b) You get $520; Other gets $120
   c) You get $580; Other gets $320

4.

a) You get $500; Other gets $100
b) You get $560; Other gets $300
c) You get $490; Other gets $490

5.

a) You get $560; Other gets $300
b) You get $500; Other gets $500
c) You get $490; Other gets $90

6.

a) You get $500; Other gets $500
a) You get $500; Other gets $100
b) You get $570; Other gets $300

7.

a) You get $510; Other gets $510
b) You get $560; Other gets $300
c) You get $510; Other gets $110

8.

a) You get $550; Other gets $300
b) You get $500; Other gets $100
c) You get $500; Other gets $500

9.

a) You get $480; Other gets $100
b) You get $490; Other gets $490
c) You get $540; Other gets $300

Appendix O

Social Discounting Task

The following experiment asks you to imagine that you have made a list of the 100 people closest to you in the world ranging from your dearest friend or relative at position #1 to a mere acquaintance at #100. The person at number one would be someone you know well and is your closest friend or relative. The person at #100 might be someone you recognize and encounter but perhaps you may not even know their name. You do not have to physically create the list—just imagine that you have done so. Next you will be asked to make a series of judgments based on your preferences. For each question, you will be asked if you would prefer to receive an amount of money for yourself versus an amount of money for yourself and the person listed. Please indicate your preference for each question.

Imagine you made a list of the 100 people closest to you in the world ranging from your dearest friend or relative at #1 to a mere acquaintance at #100. Now imagine the following choices between an amount of money for you and an amount for the #___ person on the list. Indicate which you would choose for each question.

1.
   a. $155 for you alone.
   b. $75 for you and 75 for the #1 person on the list.
2.
   a. $145 for you alone.
   b. $75 for you and 75 for the #1 person on the list.
3.
   a. $135 for you alone.
   b. $75 for you and 75 for the #1 person on the list.
4.
   a. $125 for you alone.
   b. $75 for you and 75 for the #1 person on the list.
5.
   a. $115 for you alone.
   b. $75 for you and 75 for the #1 person on the list.
6.
   a. $105 for you alone.
   b. $75 for you and 75 for the #1 person on the list.
7.
   a. $95 for you alone.
   b. $75 for you and 75 for the #1 person on the list.
8.
   a. $85 for you alone.
   b. $75 for you and 75 for the #1 person on the list.
9.
   a. $75 for you alone.

b. $75 for you and 75 for the #1 person on the list.

10.
   a. $155 for you alone.
   b. $75 for you and 75 for the #2 person on the list.

11.
   a. $145 for you alone.
   b. $75 for you and 75 for the #2 person on the list.

12.
   a. $135 for you alone.
   b. $75 for you and 75 for the #2 person on the list.

13.
   a. $125 for you alone.
   b. $75 for you and 75 for the #2 person on the list.

14.
   a. $115 for you alone.
   b. $75 for you and 75 for the #2 person on the list.

15.
   a. $105 for you alone.
   b. $75 for you and 75 for the #2 person on the list.

16.
   a. $95 for you alone.
   b. $75 for you and 75 for the #2 person on the list.

17.
   a. $85 for you alone.
   b. $75 for you and 75 for the #2 person on the list.

18.
   a. $75 for you alone.
   b. $75 for you and 75 for the #2 person on the list.

19.
   a. $155 for you alone.
   b. $75 for you and 75 for the #5 person on the list.

20.
   a. $145 for you alone.
   b. $75 for you and 75 for the #5 person on the list.

21.
   a. $135 for you alone.
   b. $75 for you and 75 for the #5 person on the list.

22.
   a. $125 for you alone.
   b. $75 for you and 75 for the #5 person on the list.

23.
   a. $115 for you alone.
   b. $75 for you and 75 for the #5 person on the list.

24.
   a. $105 for you alone.
   b. $75 for you and 75 for the #5 person on the list.

25.
   a. $95 for you alone.
   b. $75 for you and 75 for the #5 person on the list.
26.
   a. $85 for you alone.
   b. $75 for you and 75 for the #5 person on the list.
27.
   a. $75 for you alone.
   b. $75 for you and 75 for the #5 person on the list.
28.
   a. $155 for you alone.
   b. $75 for you and 75 for the #10 person on the list.
29.
   a. $145 for you alone.
   b. $75 for you and 75 for the #10 person on the list.
30.
   a. $135 for you alone.
   b. $75 for you and 75 for the #10 person on the list.
31.
   a. $125 for you alone.
   b. $75 for you and 75 for the #10 person on the list.
32.
   a. $115 for you alone.
   b. $75 for you and 75 for the #10 person on the list.
33.
   a. $105 for you alone.
   b. $75 for you and 75 for the #10 person on the list.
34.
   a. $95 for you alone.
   b. $75 for you and 75 for the #10 person on the list.
35.
   a. $85 for you alone.
   b. $75 for you and 75 for the #10 person on the list.
36.
   a. $75 for you alone.
   b. $75 for you and 75 for the #10 person on the list.
37.
   a. $155 for you alone.
   b. $75 for you and 75 for the #20 person on the list.
38.
   a. $145 for you alone.
   b. $75 for you and 75 for the #20 person on the list.
39.
   a. $135 for you alone.
   b. $75 for you and 75 for the #20 person on the list.
40.

a. $125 for you alone.
b. $75 for you and 75 for the #20 person on the list.

41.
a. $115 for you alone.
b. $75 for you and 75 for the #20 person on the list.

42.
a. $105 for you alone.
b. $75 for you and 75 for the #20 person on the list.

43.
a. $95 for you alone.
b. $75 for you and 75 for the #20 person on the list.

44.
a. $85 for you alone.
b. $75 for you and 75 for the #20 person on the list.

45.
a. $75 for you alone.
b. $75 for you and 75 for the #20 person on the list.

46.
a. $155 for you alone.
b. $75 for you and 75 for the #50 person on the list.

47.
a. $145 for you alone.
b. $75 for you and 75 for the #50 person on the list.

48.
a. $135 for you alone.
b. $75 for you and 75 for the #50 person on the list.

49.
a. $125 for you alone.
b. $75 for you and 75 for the #50 person on the list.

50.
a. $115 for you alone.
b. $75 for you and 75 for the #50 person on the list.

51.
a. $105 for you alone.
b. $75 for you and 75 for the #50 person on the list.

52.
a. $95 for you alone.
b. $75 for you and 75 for the #50 person on the list.

53.
a. $85 for you alone.
b. $75 for you and 75 for the #50 person on the list.

54.
a. $75 for you alone.
b. $75 for you and 75 for the #50 person on the list.

55.
a. $155 for you alone.

b. $75 for you and 75 for the #100 person on the list.

56.

a. $145 for you alone.
b. $75 for you and 75 for the #100 person on the list.

57.

a. $135 for you alone.
b. $75 for you and 75 for the #100 person on the list.

58.

a. $125 for you alone.
b. $75 for you and 75 for the #100 person on the list.

59.

a. $115 for you alone.
b. $75 for you and 75 for the #100 person on the list.

60.

a. $105 for you alone.
b. $75 for you and 75 for the #100 person on the list.

61.

a. $95 for you alone.
b. $75 for you and 75 for the #100 person on the list.

62.

a. $85 for you alone.
b. $75 for you and 75 for the #100 person on the list.

63.

a. $75 for you alone.
b. $75 for you and 75 for the #100 person on the list.