Uncovering the Longitudinal and Physiological Associations between Self-Control, Delay of Gratification and Future Thinking

by

Samantha J. Watson

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Abstract

High self-control, better delay of gratification, and future thinking have long been linked theoretically and, more recently, empirically, yet evidence of the causal relationships between them is non-existent. The present research aimed firstly to elucidate the nature of the relationships between self-control, delay of gratification and future thinking, and secondly to investigate whether they are rooted in our physiology. In Study 1, a sample of 174 undergraduates completed a self-report survey three times with 2-month intervals in between. Longitudinal mediation path models were constructed to determine whether and how self-control would function as a mediator between delay of gratification at Time 1 and consideration of future consequences at Time 3. Results showed that delay of gratification predicted higher self-control, which in turn predicted higher concern for future consequences (CFC-F) and a lower concern for immediate consequences (CFC-I). Study 2 further explored this relationship by investigating whether temporal orientation grouping – high- vs. low-CFC – would predict subsequent levels of self-control and delay of gratification in a study of 71 undergraduates. Heart rate variability and cortisol were also examined. Results showed that by grouping participants in terms of CFC it was possible to predict subsequent levels of self-control and gratification delay abilities as expected. While there were no between-groups physiological differences, the methodology allowed for the novel discovery that cortisol was related to cognitive facets of self-control, while HRV was related to emotional functions associated with low self-control (i.e., worry and rumination). These results further highlight the importance of self-control in both our psychological and physiological functioning.

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CHAPTER I

INTRODUCTION

The ability to control one's emotion, cognition and behaviour is an important skill. Indeed, self-control is an essential ingredient of mental and physical wellbeing across time: self-control in the first decade of life predicts a wide range of outcomes later in life including income and financial security, physical and mental health, substance dependence, and social success (Moffitt et al., 2011). Two factors related to one's capacity for self-control are individual differences in the ability to delay gratification and to focus on future outcomes (e.g., Bembenutty & Karabenick, 2004; Fujita & Carnevale, 2012; Milfont & Schwarzenthal, 2014). A recent longitudinal study has shown that self-control is the causal mechanism underlying delay of gratification (Duckworth, Tsukayama, & Kirby, 2013). However, research investigating the associations between self-control, delay of gratification and future thinking is scarce, and systematic evidence of the causal, *directional* relationships between all three variables is non-existent, with most existing literature focusing on cross-sectional data.

Accordingly, the present thesis reports two studies aimed to address these gaps in the literature. As data collected at a single time point does not truly lend itself to the examination of directional and temporal relationships, the Study 1 will explore longitudinal data, allowing for the examination of the role of self-control in the relationship between delay of gratification and future thinking. Furthermore, recent research has found associations between aspects of our physiology and both self-control (Daly, Baumeister, Delaney, & MacLachlan, 2014) and self-regulatory functions (for instance, see Geisler & Kubiak, 2009; Shoal, Giancola, & Kirillova, 2003). As such, the Study 2 will also investigate whether the association between self-control, delay of gratification and future thinking is rooted in our physiology by investigating heart rate variability and levels of salivary cortisol.

Chapter two begins by reviewing relevant literature on self-control and delay of gratification, with a discussion of how these factors relate to psychological time. This is followed by a review of the research on time perspective. From here, aspects of human physiology are explored and integrated into the literature on self-control and time perspective. The two chapters that follow will concern the methodologies and results of Studies 1 and 2 respectively. The methodology sections will outline criteria for participation in the study, recruitment strategies, and a detailed consideration of the procedures used. They will also outline the measures used and ethical practices followed. The results sections will describe the analyses employed for correlational, meditational, and between-groups analyses, and the evaluation of the hypotheses tested. Finally, a discussion chapter will summarise the findings in light of the literature on self-control, delay of gratification, time perspective and psychophysiology in order to gain a further understanding of the relationships between psychological variables and aspects of our physiology.

CHAPTER II

LITERATURE REVIEW

Self-Control

What lies in our power to do, it lies in our power not to do.

–Aristotle.

Those who restrain desire do so because theirs is weak enough to be restrained.

–William Blake; The Marriage of Heaven and Hell.

Self-control is an essential function for achieving our goals, being successful in our endeavours, and resisting selfish and potentially deleterious impulses in order to perform appropriately in our environment. In response to a milieu of constant desires and temptations, we exercise our self-control. Self-control is our capacity for altering or overriding our own responses to bring them in line with social and moral standards and to reach our future goals, and is the conscious and deliberate part of self-regulation (Baumeister et al., 2007). To do so is essential for the cohesion of society. Poor self-control as early as childhood has been found to predict dire consequences in adulthood such as substance dependence, criminal convictions, and poor mental and physical health, all of which lead to excess societal costs in terms of health care, financial dependence, and crime (Moffitt et al., 2011). Self-control is also involved in the regulation of emotions, essential for overriding emotional responses that may be inappropriate for a certain situation (for example, controlling one's feelings of anxiety by taking deep breaths to reduce arousal; Tice & Bratslavsky, 2000).

And yet, we quite often do fail at bringing our behaviour in line with our goals, with attempts at self-control such as quitting smoking and losing weight often devolving into failure (Prochaska, DiClemente, & Norcross, 1992). Baumeister and colleagues have conceptualised self-regulation as a limited impulse-controlling resource that, like a muscle, gets tired and worn out after repeated acts of self-control: when this limited resource is depleted, an individual's subsequent ability to further exercise their self-control becomes compromised (Baumeister et al., 2007; Muraven & Baumeister, 2000). The depletion of the self-regulatory "muscle", enabling self-control, can be measured by examining behaviour on tasks such as delay of gratification tasks.

Delay of Gratification

Delay of gratification tasks involve an individual putting off getting access to immediate gratification in favour of larger future rewards. Being able to effectively delay gratification refers to one's preference for larger and more delayed rewards over smaller rewards that are more immediately available (Mischel, 1974, 1996). In the classic delay of gratification task, known colloquially as the marshmallow task (Mischel, Ebbesen, & Zeiss, 1972), children were given the choice to eat a small amount of a treat of their choice now, or to wait 15 minutes without giving in and receive a second treat. Although this task was originally designed to assess when the ability to delay gratification developed in children, performance on this task was found to predict success many years later (Shoda, Mischel, & Peake, 1990). Effortful self-control was recently found to be the mechanism underlying this ability to delay gratification in these tasks (Duckworth et al., 2013). Although such tasks are often used to provide a behavioural indication of delay of gratification, a recent self-report measure was developed – the Delaying Gratification Inventory (Hoerger, Quirk, & Weed, 2011). This measure covers five main domains of gratification delay involving food, physical pleasure, social interaction, money, and achievement. This measure was used in the present research, and has been shown to be positively related to both self-control and future thinking (Milfont & Schwarzenthal, 2014).

This ability to delay gratification involves an interaction between a "hot" emotional system and a "cool" cognitive system. The "hot" system quickly generates our reflexive reaction to approach or avoid different stimuli for survival, while the "cool" system generates our strategic and rational behaviour more slowly (Metcalfe & Mischel, 1999; Mischel & Ayduk, 2011). The ability to delay gratification and exercise effortful self-control depends on how well the “cool” system is able to cool down the “hot” system when it becomes activated by affect-arousing stimuli or situations.

Self-control, delay of gratification and future thinking. This ability to delay gratification as a child is also a powerful predictor of self-regulation in the pursuit of goals as an adult, along with many other adaptive life outcomes such as better personal and interpersonal competencies (Mischel & Ayduk, 2011; Moffitt et al., 2011). Deficits in gratification delay are associated with public health problems including obesity, substance abuse, financial debt and criminal convictions (Baumeister et al., 2007; Bembenutty & Karabenick, 2004; DeWall, Baumeister, Stillman, & Gailliot, 2007; Seeyave et al., 2009). But who is most able to resist the pressure to give in to temptation and persist for the delayed but greater reward?

A well-known phenomenon increasing the difficulty of effortful control over one’s impulses is *temporal discounting*. Temporal discounting refers to the tendency to subjectively discount the value of a reward or goal as the time delay between the present and an expected reward or goal increases (Mischel, 1974, 1996). From Mischel’s early delay of gratification work to today, this phenomenon of temporal discounting can be clearly seen (Mischel et al., 1972; Mischel & Ayduk, 2011; Mischel, 1974; Trope & Liberman, 2003, 2010): the delayed reward decreases in value as the length of the delay interval increases, and so too does the individual’s motivation to choose the delayed reward over immediate gratification. Clear links have been found between future time perspective and the ability to delay gratification in an academic setting (Bembenutty & Karabenick, 2004). In such a setting, it is often important to delay immediate rewards such as going out with friends in order to service a future benefit such as completing an assignment. If an individual has their future goals in mind they are more likely to be able to exercise self-control. In this way, future-oriented individuals are more likely to practise self-control and delay gratification, being less likely to be impulsive and engage in risky behaviour.

Individuals who have higher future orientation and higher self-control are also more likely to go to bed early and wake up earlier. In contrast, present-oriented individuals, more likely to be evening-types, may experience ‘social jetlag’ whereby they cannot easily adapt to the socially imposed rhythm that runs counter to their biological rhythm. This may result in a drain on their self-regulatory capacity and an accompanying impaired ability to exert self-control (Baumeister & Alquist, 2009; Milfont & Schwarzenthal, 2014).

Temporal discounting and the ability to delay gratification can be understood through Construal Level Theory (CLT; Liberman & Trope, 2008), and the way people mentally represent future events. As self-control requires us to act in a manner that is consistent with distant future goals when tempted by immediate rewards, it has been proposed that we must hold a higher-level construal of events in order to exercise self-control (Fujita & Carnevale, 2012; Fujita, Trope, Liberman, & Levin-Sagi, 2006; Trope & Liberman, 2010). More distant events are represented by higher-level, more abstract mental construals comprising the more general, simplified details of the event. Proximal events, on the other hand, are represented by lower-level, more concrete mental construals, made up of the event’s more specific and unambiguous details (Fujita et al., 2006; Maglio, Trope, & Liberman, 2015; Trope & Liberman, 2010). Because high-level construal enhances a person’s understanding of the broader implications of their choices *now* for their goals *in the future*, those with high-level mental representations about their current actions tend to be more self-controlled and more able to delay immediate gratification. In contrast, because low-level construal directs one’s attention to the concrete and direct parts of their present experience, those with low-level mental representations may exhibit more failures in self-control (Fujita & Carnevale, 2012; Fujita et al., 2006; Maglio, Trope, & Liberman, 2015).

Thus, a greater ability to delay gratification, with self-control at its heart, seems to imply a higher level of future thinking. With the importance of future thinking in mind, the review will now turn to a discussion of time perspective and will further explore its psychological correlates.

Psychological Time

Today is the tomorrow you worried about yesterday.

–Proverb, Author unknown.

Time, while indicated physically by the position of the sun or the hands of a clock, is also an invisible and subjective phenomenon that exists within an individual's own psychological experience (Boniwell & Zimbardo, 2004; Karniol & Ross, 1996; Lewin, 1951; McGrath & Kelly, 1986; Zimbardo & Boyd, 1999). The understanding and experience of time differs greatly not only between people, but also between events: some moments seem to stretch on for an eternity (e.g., dinner with the in-laws), while others flash by in a heartbeat (e.g., dinner with old friends). In psychological time, not limited by a linear flow like objective time, we can navigate non-linearly, backwards and forwards: we are able to remember past events, and project ourselves into the future to predict what is to come (Zimbardo & Boyd, 2008). Suddendorf and Corballis (1997) regarded the ability to monitor time as a fundamental developmental function allowing people to form expectations and learn from experiences, lying at the heart of cognitive functioning and essential for survival.

When Kurt Lewin first introduced his life space model, the focus was directed towards how an individual's thoughts about the past and future influence their behaviour and decision-making processes at present. Time perspective was defined here as the sum of an individual's views of their psychological past and future at any given time (Lewin, 1951). Drawing from Lewin's work, more recent research has focused on individual differences in time perspective, with the dimensions of time explained as psychological concepts fashioned and shaped by the individual as opposed to objective stimuli existing outside of the person (Block, 1990). In his writings, Block identified three main dimensions of psychological time: *time perspective* (a preference for relying on conceptions of past, present, or future time when making decisions and performing behaviours), *time succession* (the understanding of the temporal order of events and the relationships between them), and *time duration* (the experience of intervals between events and the persistence of events in time). This research focuses on time perspective.

Time Perspective

People differ greatly in how much they overemphasize and relate to one particular time perspective – past, present, or future – in their experiences (Block, 1990). Does one tend to engage more in reflecting on the past, analysing current circumstances, or planning for the future (Zimbardo & Boyd, 1999)? It is how individuals relate to and ascribe meaning to events that impacts how representations of past, present, and future affect one's thoughts and behaviours (Boniwell & Zimbardo, 2004; Karniol & Ross, 1996; Zimbardo & Boyd, 1999).

Over the past few decades, time perspective has become a particularly well-researched area of psychological time that is consistently found to be a strong predictor of our psychological functioning and behaviour (for recent reviews, see Stolarski, Fieulaine, & van Beek, 2015; Strathman & Joireman, 2005; Zimbardo & Boyd, 2008). A predominantly present time perspective and a concern with the immediate consequences of one's actions has been found to be associated with risk-taking (Zimbardo, Keough, & Boyd, 1997) substance abuse (Keough, Zimbardo, & Boyd, 1999), and a preference for staying up and waking up later (Nowack & van der Meer, 2013). Since Lewin's early conception of time perspective as an explanation for how individual's view their psychological past and future at any given time point (Lewin, 1951), particular attention has been paid to future time perspective.

Psychological markers of future time perspective. Future time perspective and a high consideration for the future consequences of one's actions is linked to a desire to work toward future goals and future gratification at the expense of present enjoyment where necessary (Karniol & Ross, 1996; Strathman, Gleicher, Boninger, & Edwards, 1994; Zimbardo & Boyd, 1999). A heightened ability to conceptualise future events and consider future consequences brings with it a more vivid awareness of the possible dangers and uncertainties the future holds (Boniwell & Zimbardo, 2004). As such, it is unsurprising that research has consistently found high scores on future time perspective to be predictive of positive outcomes in the domains of health (with less cigarette and alcohol use, Adams & Nettle, 2009; Strathman et al., 1994; and more frequent exercise, Ouellette, Hessling, Gibbons, Reis-Bergan, & Gerrard, 2005), wealth (with higher levels of fiscal responsibility, Joireman, Sprott, & Spangenberg, 2005), and even environmental sustainability (with higher levels of pro-environmental engagement, Arnocky et al., 2013; Joireman et al., 2004; Milfont & Gouveia, 2006; Strathman et al., 1994).

A recent study (Joireman, Shaffer, Balliet, & Strathman, 2012) found high concern with the present to be associated with a prevention-oriented goal pursuit strategy, where individuals focus on *avoiding* negative outcomes. In contrast, the relationship between a concern with the future and favourable outcomes for health and wellbeing is mediated by promotion orientation, where individuals focus on *achievement* of these positive outcomes as a strategy of goal pursuit. This is likely because these predominantly future thinkers have meaningful mental representations of future events. These individuals are drawn to behave in accordance with these representations, tending to rely on the expected consequences a present action might bring in their future (Milfont et al., 2012; Nowack & van der Meer, 2013).

This may be due to future time perspective helping to break down the psychological barriers preventing action in the interests of the future by reducing the psychological distance between the future and the present. As discussed previously, in accordance with Construal Level Theory (CLT; Liberman & Trope, 2008), to exercise self-control and act in a manner consistent with future goals we must hold higher-level construals of events, which enhance one’s understanding of the broader implications of their choices *now* for their goals *in the future*. CLT also helps us explain how future orientation may aid in reducing the psychological distance between the future and the present. CLT specifies four dimensions of psychological distance: spatial distance (here and there); temporal distance (now and later); social distance (the distance between the individual and a social target); and hypotheticality (the level of certainty that some event will occur). As an example, environmental issues such as climate change are perceived to be distant upon all four of these dimensions (see Lorenzoni & Pidgeon, 2006; Milfont, 2010; Spence et al., 2012). People tend to think of these environmental issues as too *uncertain* (hypotheticality); affecting *different* people or *other* nations to one's own (social distance); affecting *future* people as opposed to oneself (temporal distance); and occurring *far away* as opposed to close to home (spatial distance).

According to CLT, more psychologically distant events are represented by higher-level, more abstract mental construals comprising the more general, simplified details of the event. Psychologically close events, on the other hand, are represented by lower-level, more concrete mental construals, made up of the more specific and unambiguous details of the event (Maglio, Trope, & Liberman, 2015; Trope & Liberman, 2010). As future events become further away in time, decisions about them come to be based more on the simple end product, rather than the more complicated processes required to reach the end product. In this way, a future-focus may lead to a consideration for the more long-term benefits of one's behaviour, such as those created by health-conscious or sustainable behaviours. These future-focused individuals are less likely to have their actions toward the end goal obstructed from view by the often arduous and complicated means to the end.

As high future time perspective is associated with positive outcomes in many domains including health, wealth and environmental sustainability as previously noted, it comes as no surprise that high scores on measures of future time perspective also correlate with personality traits related to self-control including lower levels of impulsivity and a greater ability to delay immediate gratification (Joireman, Anderson, & Strathman, 2003; Joireman, Balliet, Sprott, Spangenberg, & Schultz, 2008; Strathman et al., 1994; Zimbardo & Boyd, 1999). Low levels of impulsivity and the ability to delay gratification are constructs associated with self-control, one's ability to change an automatic behaviour to align with a goal, to wait for a preferred reward while forgoing a less preferred reward now (Baumeister et al., 2007; Duckworth et al., 2013).

Psychological time has also been found to be related to an individual's *chronotype*, or whether they are more of a "morning type", preferring earlier bed and wake times, or an "evening type", preferring later bed and wake times (Milfont & Schwarzenthal, 2014; Nowack & van der Meer, 2013). Findings suggest that higher future time perspective is associated with being more of a morning type, while higher present time perspective is associated with being more of an evening type. Interestingly, this penchant for waking up earlier that seems to have a basis in our physiology has also been linked to higher levels of self-control (Baumeister & Alquist, 2009; Milfont & Schwarzenthal, 2014).

While it is clear that self-control underlies delay of gratification, an important correlate of future time perspective, whether self-control can explain future time perspective is unclear. As self-regulation and self-control have been found to have a basis in our physiology, it is likely that they lie at the causal root of future time perspective, however this hypothesis has only recently been tested (Milfont & Schwarzenthal, 2014), and only by using self-report measures of self-control at one time point. This study aims to further investigate the flow of causation by first utilizing longitudinal data, allowing for better testing of the mechanisms explaining the associations between self-control, delay of gratification, and future time perspective than cross-sectional data only. Self-control will then be investigated as a trait related to aspects of our physiology such as heart rate variability and salivary cortisol. The review will now turn to a discussion of relevant literature on the physiology of self-control.

Physiological Markers of Self-Control

In order for humans to function optimally as individuals or part of a larger group, self-control is adaptive and vital. Research suggests that the causes of self-control are deeply rooted in our physiology. A popular theory, the strength model of self-control, states that self-control, like a muscle, is dependent upon a limited self-regulatory resource: a single act of self-control can deplete this resource, making subsequent attempts at self-control more difficult as a result (a pattern called ego-depletion; Baumeister et al., 2007, and see a review by Muraven & Baumeister, 2000). Depletion of the self-regulatory resource following a thought suppression task has been shown to lead people to act more on impulse rather than acting deliberately and in line with their intentions (Baumeister, Bratslavsky, Muraven, & Tice, 1998; Hofmann, Rauch, & Gawronski, 2007). What's more, there is evidence to suggest that regular exercise of the self-control "muscle" can improve one's willpower. Early tests showed that practicing self-control (for example, by improving one's posture) for two weeks led to overall improvements in self-regulation as measured by greater handgrip stamina as compared to those who did not "exercise" (Muraven, Baumeister, & Tice, 1999). In another study, those who exercised self-control by sticking to a physical exercise program for two months not only had stronger self-control following a task designed to deplete self-control, they also showed more health-conscious behaviours (such as less smoking cigarettes, drinking alcohol, and eating junk food), less impulsive spending, less television-watching, and more academic study (Oaten & Cheng, 2006) – in other words, they showed a greater ability to delay immediate gratification.

Along with this theoretical evidence that self-control is dependent upon an exhaustible cognitive mechanism that functions like a muscle, recent research also suggests a link between self-control and physiological functioning (Appelhans & Luecken, 2006; Daly et al., 2014; Geisler & Kubiak, 2009; Reynard, Gevirtz, Berlow, Brown, & Boutelle, 2011;

Segerstrom & Nes, 2007). Using measures of physiology therefore gives us a chance to shed further light on the relationship between physiological functioning and self-control and delay of gratification. Using these measures also allows for the investigation of possible biological underpinnings of time perspective, all the while providing an opportunity to eliminate some of the biases involved with self-report measures. In this way, examining more objective psychophysiological variables may help us to better understand the relationship between self-control, delay of gratification, and future time perspective. The present research focuses on two such psychophysiological variables detailed below.

Salivary Cortisol

Along with identifying connections between self-control and cardiovascular functioning, research has also identified associations between self-control and cortisol; however research is in many cases contradictory. Some evidence has emerged pointing to the diurnal variation of cortisol as being important in predicting such outcomes as emotion regulation and health (Taylor et al., 2008; Urry et al., 2006). Recent research has also noted associations between self-control and the cortisol slope, a biomarker of adaptive neuroendocrine functioning (Daly et al., 2014). Cortisol levels follow a diurnal pattern, with levels peaking 30 minutes after waking and declining throughout the day (Haus, 2007; Posener, Schildkraut, Samson, & Schatzberg, 1996). People with a flat diurnal cortisol slope exhibit a slow rate of cortisol decline over the day with evening cortisol levels not markedly differing from morning levels, a pattern linked to cancer, fatigue, and early mortality (Saxbe, 2008). In contrast, people with the more typical steep slope of cortisol decline have substantially reduced cortisol levels in the afternoon and evening. A steep cortisol slope can be predicted by high levels of medial prefrontal cortex activity during emotion regulation tasks, a brain region involved in self-control (Cunningham-Bussel et al., 2009; Taylor et al., 2008). This medial prefrontal cortex activity may help to prevent large amounts of emotional reactivity and the associated stress-related cortisol upsurge due to a dampening of the amygdala's response to emotional stimuli.

One study found those with high self-control as measured by the Brief Self-Control Scale (Tangney, Baumeister, & Boone, 2004)—the same measure used in the present research—to have a steeper rate of cortisol decline across the day. This result suggests that in the afternoon and evening those who have high self-control would likely have lower levels of cortisol than those with low self-control (Daly et al., 2014). This normal cortisol decline points to an ability to adaptively cope with external and internal stressors, an ability facilitated by good self-control. A lack of cortisol decline, on the other hand, likely points to an inability to control one's internal state and cope with emotional turmoil in response to daily stressors. In support of this interpretation, other research has found higher levels of salivary cortisol to be related to higher risk taking and valuing immediate gratification over future consequences in an adolescent sample (Schechter & Francis, 2010), and highly elevated cortisol levels have been found to be associated with deficits in fluid functioning (Monk & Nelson, 2002).

Cortisol level has also been found to exhibit a strong relationship with chronotype, with morning types having higher cortisol levels immediately after waking than evening types (Randler & Schaal, 2010). As discussed previously, morning types tend to show higher self-control, greater delay of gratification abilities, and higher future time perspective than evening types (Milfont & Schwarzenthal, 2014; Stolarski, Ledzinska, & Matthews, 2013). Taken together, the extant empirical evidence suggests that a steeper cortisol slope – with higher morning cortisol levels and lower afternoon and evening cortisol levels – may be related to higher self-control, greater delay of gratification abilities, and a stronger future focus.

Conversely, research has also linked *lower* resting cortisol levels to behavioural inflexibility and low self-control (Shoal, Giancola, & Kirillova, 2003), elevated callous and unemotional traits in males (Loney, Butler, Lima, Counts, & Eckel, 2006), and elevated sensation seeking (associated with risk taking behaviour and impulsivity) in males (Rosenblitt, Soler, Johnson, & Quadagno, 2001). These conflicting results highlight the difficulty of investigating the associations between psychosocial variables and cortisol, with many factors possibly contributing to these observed variations in cortisol response including differences in methodology, gender and psychological variables (Kudielka, Hellhammer, & Wüst, 2009). As such, the present study wishes to examine whether individuals who differ in time perspective also differ at the level of their salivary cortisol, and further investigate the role of salivary cortisol in self-control.

Heart Rate Variability

Heart rate variability (HRV) is a well-known biomarker of self-regulatory effort. The capacity for self-regulation is likely linked to HRV as a result of a spatial overlap of the autonomic network and self-control systems including the amygdala, anterior cingulate, and medial prefrontal cortex in the brain (Appelhans & Luecken, 2006; Segerstrom & Nes, 2007). This network activates the vagus nerve, which controls the parasympathetic stimulation of the heart and acts to lower the heart rate. This vagal innervation mediates HRV, making HRV an indication of vagal tone: higher HRV corresponds to a stronger vagal tone.

The sympathetic and parasympathetic nervous systems comprising the autonomic nervous system coordinate in a similar way to the “hot” and “cool” systems of self-regulation described previously. Recall that the “hot” system was simple, reflexive, and accentuated by stress, while the “cool” system was cognitive, complex, and attenuating stress and enhancing self-control (Metcalfe & Mischel, 1999; Mischel & Ayduk, 2011). Here, the sympathetic nervous system is “hot”, activating and increasing the body’s metabolic activity in response to stressful “fight or flight” situations that may be physical or psychological in nature. The parasympathetic nervous system is “cool”, essential for recovery, rest, and repair, and acting to put a brake on the heart rate. Hence, high HRV is essentially an indication of one’s ability to mediate the control of the sympathetic nervous system (controlling the fight or flight response, and swift action in times of stress) over heart rate by using the parasympathetic nervous system to put on the brakes in stressful situations: it is an indicator of resilience, marking one’s ability to respond to and recover from exposure to psychological or physical stressors (Karim, Hasan, & Ali, 2011).

Vagal parasympathetic activity is indexed by the interval fluctuations between heartbeats. While the low frequency peak is often assumed to be dominantly associated with the function of the sympathetic nervous system, it is more complex than this, also receiving some parasympathetic contribution (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996). The high frequency component of this beat-to-beat variability, on the other hand, marks the fastest heart rate changes and is widely regarded to reflect parasympathetic nerve activity only, acting as one of the cleanest markers of cardiac vagal tone (Lane et al., 2009). The high frequency range correlates extremely strongly with other commonly used measures of HRV, with researchers finding associations of 0.7 and above between the high frequency range and measures such as the standard deviation of inter-beat-intervals and the root mean square of differences between inter-beat-intervals (Allen, Chambers, & Towers, 2007).

Low HRV indicates behavioural response inflexibility and longer recovery times following stressors. It has been associated with maladaptive behaviours (Thayer & Lane, 2000), hypervigilance (Thayer & Brosschot, 2005), and has been found to be particularly related to ineffective emotional regulation, high anxiety and depression (Appelhans & Luecken, 2006) . High HRV, on the other hand, is associated with more adaptive behavioural responses, greater adaptability to change, better impulse control, better performance on cognitive tasks (Thayer & Brosschot, 2005), and better affective and emotional regulation (Appelhans & Luecken, 2006). It is important to note, however, that some studies have not found this association between high HRV and better emotional regulation. For example, some have found no differences in the HRV of worriers and non-worriers (e.g., Davis, Montgomery, & Wilson, 2002; Knepp & Friedman, 2008). This lack of support for the dominant theory that those who use ineffective emotional regulation strategies are more autonomically rigid highlights the need for further research in this area.

The current research uses HRV to examine whether individuals who differ in future time perspective also differ at a physiological self-regulatory level, where higher levels of self-control may engage the vagus nerve leading to an increase in HRV. The present research also allows for further examination into the relationships between HRV and psychological variables including strategies for emotion regulation.

Aims and Hypotheses

The literature reviewed above indicates that relationships between and among self-control, delay of gratification and future orientation exist, but research linking all three factors simultaneously using longitudinal data, allowing for the inference of causal relationships, is lacking. The present research aims firstly to elucidate the direction and nature of the relationships between these key variables, and secondly to illuminate the biological underpinnings of these variables. The examination of psychophysiological data will provide the opportunity to eliminate some of the possible biases present in self-reported data.

Previous longitudinal research suggests that self-control is the underlying mechanism assessed by delay of gratification tasks requiring individuals to postpone immediate gratification in favour of future outcomes (Duckworth et al., 2013). As delay of gratification tasks measure the pursuit of future goals and a dilemma involving a choice between getting less now versus more later, it has long been theoretically linked to future time perspective (e.g., Joireman et al., 2008; Stolarski, Ledzinska, & Matthews, 2013; Zimbardo & Boyd, 1999), and yet only recently have self-control, delay of gratification and future thinking been empirically linked (Milfont & Schwarzenthal, 2014). As this recent study examined data from one time-point only, no conclusions about the true causal mechanisms involved could be drawn.

Using a longitudinal dataset with three times of measurement separated by 2 months each, Study 1 explores the directional relationships between self-control, delay of gratification and future thinking. Following on from previous literature, this study predicts that self-control, delay of gratification and future orientation will share positive associations with one another. Self-control is expected to be the main psychological mechanism underlying the association between delay of gratification and future thinking. Specifically, this study predicts that those with greater delay of gratification abilities at Time 1 will report higher levels of self-control at Time 2, resulting in greater concern for the future at Time 3.

Following from this, Study 2 first aims to further examine the nature of the relationships between self-control, delay of gratification and concern for the future explored in Study 1, by investigating whether future orientation at one time point can be used to predict subsequent levels self-control and delay of gratification. Individuals indicating high levels of concern for the future are expected to subsequently show higher levels of self-control and greater abilities to delay gratification.

The second aim of Study 2 is to explore behavioural differences between those indicating either high or low levels of concern for the future. Using computer-based simulations of cooperation and risk-taking behaviour, those indicating high levels of concern for future consequences are expected to behave in more cooperative and less risky ways.

The third and main aim of Study 2 is to examine physiological variables that may act as markers of self-control, delay of gratification, and temporal orientation. In line with previous literature, high self-control is expected to be associated with high heart rate variability. High heart rate variability is also expected to relate to lower use of maladaptive strategies of emotion regulation including rumination and worry. As self-control has been found to be associated with a steeper rate of daily cortisol decline, individuals with high self-control are expected to exhibit lower afternoon cortisol levels than individuals with low self-control. Literature examining the relationship between self-control and cortisol is in many cases contradictory, however, and thus the present research also wishes to further elucidate the nature of the relationship between self-control and cortisol. Due to a lack of research exploring the physiological basis of delay of gratification and temporal orientation, this research is also exploratory in nature.

CHAPTER III

STUDY 1

Introduction

While the extant literature examining the associations between self-control, delay of gratification and future thinking focuses primarily on data collected at a single time point, this kind of data does not truly lend itself to the examination of directional and temporal relationships. The present study examines longitudinal data, allowing for the investigation of directional, causal relationships.

In line with previous literature, it is predicted that self-control, delay of gratification, and future thinking will be positively associated with one another. Self-control has a basis in our physiology (Baumeister et al., 2007; Schechter & Francis, 2010), and a recent longitudinal study concluded that self-control is the psychological construct underlying the ability to delay gratification (Duckworth et al., 2013). It is thus predicted that self-control is the main psychological mechanism underlying delay of gratification abilities and the consideration of future consequences. The directional association between delay of gratification and concern for future consequences is not as clear. The first step of this study is to establish whether delay of gratification longitudinally influences future time perspective, or whether the opposite longitudinal effect holds. Regardless of the direction, self-control is expected to (partially or fully) explain the associations between these two constructs. That is, self-control will mediate the association between delay of gratification and consideration of future consequences such that participants indicating higher levels of gratification delay are expected to report higher self-control, leading to higher consideration of future consequences.

Method

Sampling Procedure

This study involved the analysis of a longitudinal dataset comprising survey data collected at three time points in 2014, with the first survey administered at the end of March (Time 1), the second at the end of May (Time 2), and the third at the end of July (Time 3). Time 1 and Time 3 data were drawn from a “mass testing” survey completed online by participants at the start of their introductory psychology courses in the first and second half of the year respectively. Time 2 data were drawn from an online survey conducted between the mass testing surveys.

Participants

A total of 174 students in introductory psychology courses at Victoria University of Wellington completed the surveys at all three time-points. The full dataset at Time 1 included 621 participants, Time 2 included 390 participants, and Time 3 included 529 participants. As Time 2 was an online survey that students elected to sign-up for near the end of the first semester in exchange for partial course credit, many individuals from Time 1 may not have wished to participate in this second wave due to a lack of interest or necessity (i.e. already having full credit from participating in other studies throughout the semester). Time 3 was completed in a different semester than Times 1 and 2, resulting in attrition due to many individuals not participating in the Semester 2 course. The majority of the remaining 174 participants were female (74.1% female, 25.9% male), with ages ranging between 17 and 39 years at Time 1 (M = 18.58, SD = 2.33). Participants consisted of 77.6% New Zealand European/Pakeha, 5.7% Maori, and 16.7% from other ethnic backgrounds (i.e., Asian or Pacific Islands), with 74.1% of participants born in New Zealand.

Procedure

Ethical approval was obtained from the School of Psychology Human Ethics Committee under delegated authority of the Victoria University of Wellington Human Ethics Committee before data were collected (reference number RM020759). Participants were given information about the survey and provided informed consent prior to the administration of the survey at all three time-points. The mass-testing surveys used at Time 1 and Time 3 took about 1 hour to complete as they included a battery of questions from other research projects. The survey administered at Time 2 took 30 minutes to complete. Please see Appendices A and B for copies of the information sheet and debriefing sheet used.

Measures

As part of a larger study, participants completed a number of measures relevant to the current research, described below.

Time perspective. Two measures were used to access future thinking: the Future subscale of the Zimbardo Time Perspective Inventory (ZTPI-F; Zimbardo & Boyd, 1999 - see Appendix C) and the Consideration of Future Consequences (CFC) Scale (Strathman et al., 1994 - see Appendix D). While the ZTPI-F measures a broader conceptualization of future time perspective, the CFC accesses the more specific consideration of the future consequences of one's behaviour (Joireman, 2014). These measures are detailed below.

The Future subscale of the Zimbardo Time Perspective Inventory (ZTPI-F; Zimbardo & Boyd, 1999) was used as a more general measure of time perspective. The ZTPI-F comprises 13 items assessing the distinct Future time perspective dimension, taken from the 56-item full version. Participants are asked to read a number of statements such as "I complete projects on time by making steady progress" and "I take each day as it is rather than try to plan it out" (reverse coded). Participants answer how characteristic or true of them each statement is on a 5-point Likert scale ranging from 1 (*very uncharacteristic*) to 5 (*very characteristic*). These 13 Future items have displayed good reliability, with a Cronbach's alpha of .77 and a test-retest reliability coefficient of .80 (Zimbardo & Boyd, 1999). The cross-cultural equivalence of the ZTPI-F has also been supported (Sircova et al., 2014).

The more specific time perspective measure was the 14-item version of the Consideration of Future Consequences Scale (CFC-14). Recent examinations of the factor structure of the original 12-item CFC scale (Strathman et al., 1994) found two distinct factors underlying the CFC construct – concern with immediate versus concern with future consequences (Joireman et al., 2012). As such, the CFC-14 was created using the 7 present-oriented and 5 future-oriented items of the original scale with two new items assessing a concern with future consequences added (Joireman et al., 2012). Following from this research, and more recent research supporting the distinction between the consideration of future and immediate consequences (Arnocky et al., 2013), the present research treats these two subscales as separate constructs and investigates responses on the Future (CFC-F) and Immediate (CFC-I) subscales separately. Participants responded to each item on a scale from 1 (*very uncharacteristic of me*) to 7 (*very characteristic of me*), with items assessing concern for future consequences (e.g., “I am willing to sacrifice my immediate happiness or well-being in order to achieve future outcomes”) and concern for immediate consequences (e.g., “My convenience is a big factor in the decisions I make or the actions I take”). Both subscales have shown high internal reliability (Cronbach’s *a*’s for CFC-I and CFC-F = .84 and .82 respectively; see Joireman et al., 2012).

Delay of gratification. Participants’ inclination to favour long-term rewards over short-term, immediate satisfaction was measured using the 10-item short form of the Delaying Gratification Inventory (DGI-10; Hoerger et al., 2011 - see Appendix E). The DGI is a 10-item scale measuring delay of gratification in five domains: food, physical pleasure, social interactions, money, and achievement. Participants rate how well each item describes them on a Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Examples of items include “I would have a hard time sticking with a special, healthy diet” and “I cannot be trusted with money”. The DGI-10 has shown good internal consistency reliability (*a* = .77) and high test-retest reliability (*r* = .87; Hoerger et al., 2011).

Self-control. Self-control was measured using the 13-item Brief Self-Control Scale (BSCS; Tangney et al., 2004 - see Appendix F). This scale taps five domains of self-control: self-discipline (5 items), deliberate/non-impulsive action (3 items), healthy habits (2 items), work ethic (2 items), and reliability (1 item). Participants rate items on a Likert scale from 1 (*not at all like me*) to 5 (*very much like me*). Examples of items include “I am good at resisting temptation”, and “I wish I had more self-discipline”. Previous research has found the BSCS to have high test-retest reliability (*r* = .87) and high internal consistency (*a* = .85; Tangney et al., 2004).

Statistical Analyses

Missing values constituted less than 2% of the dataset. EM (Expectation–Maximization) imputation (Lin, 2010) was used to estimate and impute this small amount of missing data. To test whether delay of gratification influenced time perspective across time or vice versa, a cross-lagged structural equation model design was utilised allowing for the evaluation of the temporal precedence between variables. Analyses were conducted using the software package Analysis of Moment Structures (AMOS) Version 20. To test whether self-control functioned as a longitudinal mediator between delay of gratification and the consideration of future and immediate consequences, longitudinal mediation analyses with structural equation modeling were conducted using AMOS. Separate path models with a bootstrap resampling of 2000 iterations and 95% bias-corrected confidence intervals were performed. These models stipulated delay of gratification as the independent variable, and self-control as a mediator on the dependent variable of the consideration of future or immediate consequences.

Results

Zero-Order Correlations

Zero-order bivariate correlations along with means, standard deviations and Cronbach's alphas of the variables are presented in Table 1. The values of skewness and kurtosis of all variables fell between -1 and +1, supporting the assumption of normal distribution of the data necessary for structural equation modelling. As expected, DGI score at Time 1 was positively associated at Time 2 with self-control ($r = .526$, $p < .001$), and CFC-F at Time 3 ($r = .309$, $p < .001$), and was negatively associated with CFC-I at Time 3 ($r = -.316$, $p < .001$).

Cross-Lagged Model

The cross-lagged path analysis in Figure 1 depicts a statistically significant path between the DGI at Time 1 and CFC-F at Time 2 (standardised path coefficient = .17, $p = .013$), while the standardised path coefficient between CFC-F at T1 and DGI at T2 is small and non-significant (.02, $p = .754$). Although the cross-lagged paths are significant from T2 to T3, the standardised path coefficient between the DGI and CFC-F (.27, $p < .001$) is stronger than the path coefficient between CFC-F and DGI scores (.14, $p = .016$). This cross-lagged path model shows that delay of gratification predicts consideration of future consequences across time better than consideration of future consequences predicts delay of gratification.

A less clear pattern was observed for CFC-I. Figure 2 shows statistically significant cross-lagged paths between DGI scores at Time 1 and CFC-I at Time 2 (-.16, $p = .025$), CFC-I at Time 1 and DGI at Time 2 (-.16, $p = .011$), DGI at Time 2 and CFC-I at Time 3 (-.26, $p < .001$), and CFC-I at Time 2 and DGI at Time 3 (-.22, $p < .001$). Given the results for CFC-F depicted in Figure 1, and the stronger Time 2 to Time 3 path coefficients for DGI in predicting CFC-I (see Figure 2), delay of gratification is also thought to predict consideration of immediate consequences better than the reverse pattern.

Table 1

Zero-order correlations among Delay of Gratification (DGI), Self-Control (S-C), Zimbardo's Time Perspective Inventory Future subscale (ZTPI-F) and Consideration of Future and Immediate Consequences (CFC-F and CFC-I) across all time points. Table includes Means, Standard Deviations (Std Dev), and Cronbach's Alphas (Alpha) for all measures.

	T1 DGI	T1 S-C	T1 ZTPI-F	T1 CFC-F	T1 CFC-I	T2 DGI	T2 S-C	T2 ZTPI-F	T2 CFC-F	T2 CFC-I	T3 DGI	T3 S-C	T3 ZTPI-F	T3 CFC-F	T3 CFC-I
T1 S-C	.546**														
T1 ZTPI-F	.483**	.518**													
T1 CFC-F	.343**	.294**	.481**												
T1 CFC-I	-.467**	-.477**	-.429**	-.491**											
T2 DGI	.671**	.420**	.397**	.247**	-.438**										
T2 S-C	**.526****	.752**	.502**	.314**	-.515**	.606**									
T2 ZTPI-F	.446**	.521**	.696**	.363**	-.393**	.514**	.554**								
T2 CFC-F	.324**	.268**	.404**	.504**	-.339**	.462**	.382**	.465**							
T2 CFC-I	-.377**	-.373**	-.340**	-.231*	.541**	-.547**	-.518**	-.490**	-.422**						
T3 DGI	.672**	.452**	.417**	.260**	-.444**	.679**	.573**	.478**	.420**	-.524**					
T3 S-C	.454**	.729**	.381**	.191*	-.480**	.492**	.749**	.458**	.281**	-.494**	.550**				
T3 ZTPI-F	.392**	.413**	.697**	.401**	-.324**	.448**	.479**	.735**	.441**	-.452**	.530**	.401**			
T3 CFC-F	.309**	.263**	.410**	.465**	-.422**	.455**	**.409****	.514**	.535**	-.481**	.528**	.384**	.529**		
T3 CFC-I	-.316**	-.316**	-.290**	-.365**	.439**	-.499**	**-.463****	-.435**	-.518**	.586**	-.503**	-.489**	-.434**	-.595**	
Mean	**3.52**	4.27	3.49	4.81	3.85	3.48	**4.16**	3.30	4.67	3.83	3.42	4.20	3.43	**4.67**	**3.82**
Std Dev	**0.50**	0.62	0.52	0.80	0.88	0.50	**0.63**	0.51	0.79	0.90	0.51	0.57	0.51	**0.86**	**0.84**
Alpha	**.70**	.83	.76	.79	.82	.70	**.85**	.74	.79	.82	.74	.81	.76	**.84**	**.82**

Note. ***p* < .001 **p* < .05 Descriptive statistics of and correlations between those variables included in mediation analyses have been bolded to increase clarity.

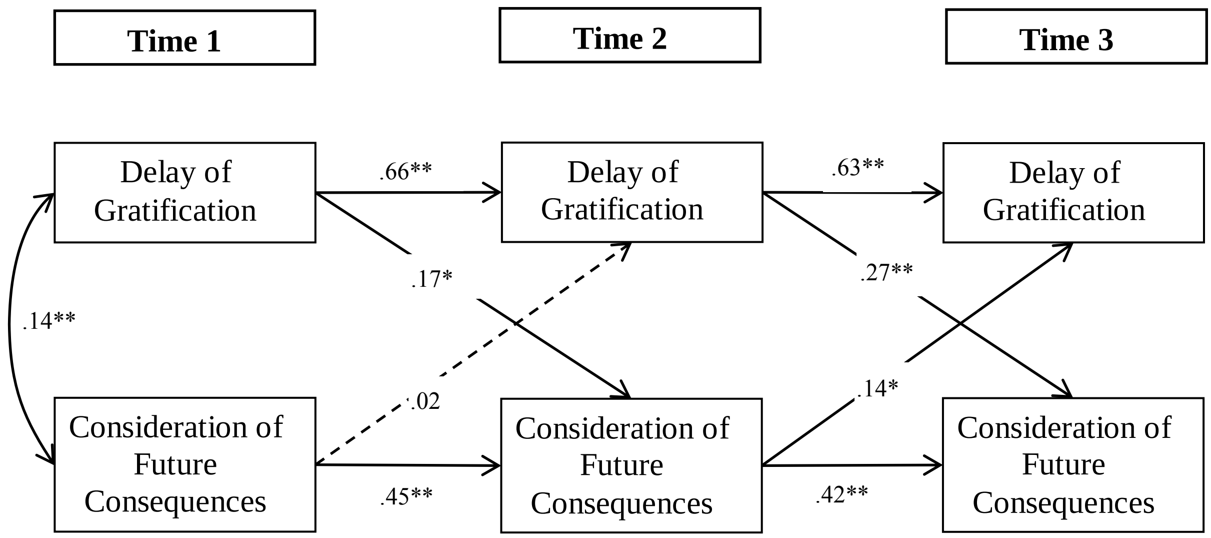

Figure 1. Cross-lagged path model with standardised regression weights linking delay of gratification and the consideration of future consequences at Time 1, Time 2 and Time 3. Dashed lines represent non-significant pathways ($p > .05$). $^*p < .05$, $^{**}p < .001$.

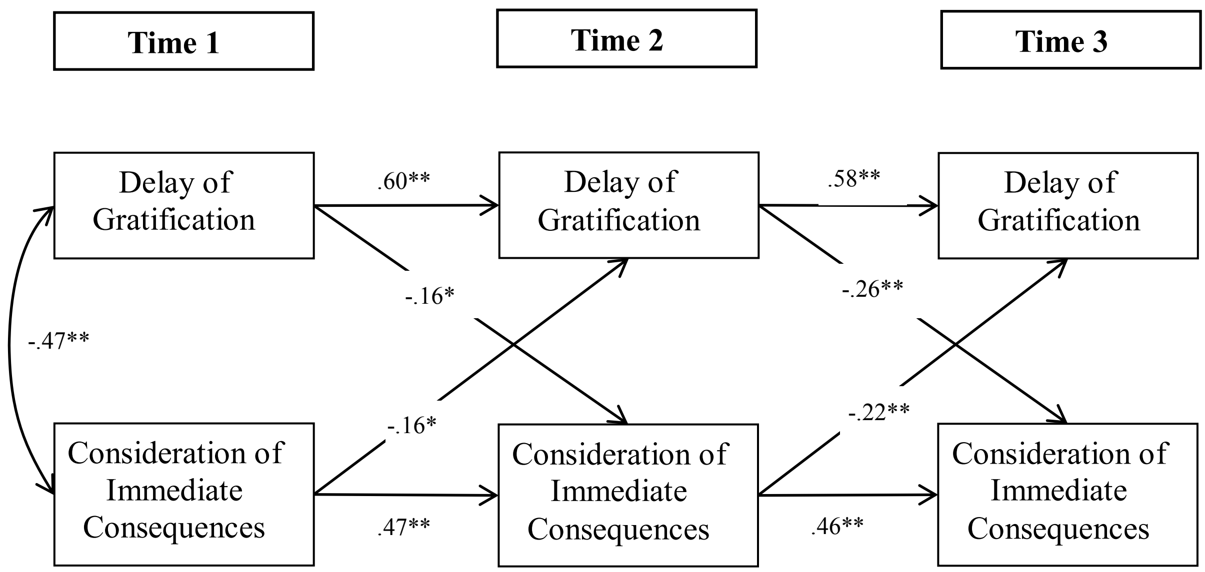

Figure 2. Cross-lagged path model with standardised regression weights linking delay of gratification and the consideration of immediate consequences at Time 1, Time 2 and Time 3. $^*p < .05$, $^{**}p < .001$.

The results also indicated less clarity about the directional relationships between the DGI and ZTPI-F, our other more general measure of time perspective (see Appendix G). Considering these findings, and the goal of the present research in investigating future time perspective in particular, subsequent analyses focus on the CFC measures.

Longitudinal Mediation

As shown in Table 1, it was established that the independent variable (delay of gratification) was directly associated with both the mediating variable (self-control; $r = .526$, $p < .001$) and the dependent variables (CFC-F and CFC-I; *r*'s = .309 and -.306, *p*'s < .001), and that the mediating variable predicted the dependent variables (*r*'s = .409 and -.493, *p*'s < .001). These results support the testing of the present theoretical mediation model (as per traditional mediation requirements; see Baron & Kenny, 1986).

Figure 3 depicts the longitudinal mediation analysis performed for the outcome variable of consideration of future consequences, while Figure 4 depicts the longitudinal mediation analysis for the consideration of immediate consequences. Following the recommendations of Jose (2013) and MacKinnon (2008), these models show that the independent variable was measured at Time 1, the mediating variable was measured at Time 2, and the outcome variables were measured at Time 3, with the Time 2 and Time 3 variables residualised and all possible concurrent covariances at a given time-point estimated. The *a* paths of the mediation analysis were estimated between delaying gratification at Time 1 and self-control at Time 2, the *b* paths were estimated between self-control at Time 2 and consideration of future or immediate consequences at Time 3, and the *c'* path was estimated between delaying gratification at Time 1 and the consideration of future or immediate consequences outcome variables at Time 3. Table 2 details the results of the two mediation analyses.

Table 2

Longitudinal standardised direct and indirect effects of delay of gratification, mediated by self-control, on the consideration of future and immediate consequences

IV	MV	DV	Total effect, 95% CI	Direct effect, 95% CI	Indirect effect, 95% CI	Ratio (%)	Sig.
DGI	Self-control	CFC-F	.051 (SE = .073) [-.087, .198]	.018 (SE = .076) [-.139, .159]	.033** (SE = .018) [.008, .078]	65	.004
		CFC-I	-.030 (SE = .074) [-.179, .112]	.009 (SE = .076) [-.147, .152]	-.039** (SE = .020) [-.090, -.009]	81	.006

Note. ** $p < .01$

Consideration of future consequences. The results based on 2000 bootstrapped samples for CFC-F indicated that the mediation model was statistically supported, with self-control fully mediating the relationship between delaying gratification and CFC-F (standardised indirect effect = .033, se = .018, 95% CI [.008, .078], $p = .004$) and the standardised total and direct effects of delay of gratification on CFC-F failing to reach significance (*p*'s = .472 and .865 respectively; see Table 2 for effect sizes). Computation of the size of the mediation effect based on standardised regression coefficients indicated that self-control accounted for 65% of the indirect effect. This result is consistent with expectations, and suggests participants who indicated higher levels of gratification delay were more likely to report higher self-control over time, and through higher levels of self-control these individuals were then more likely to consider future consequences.

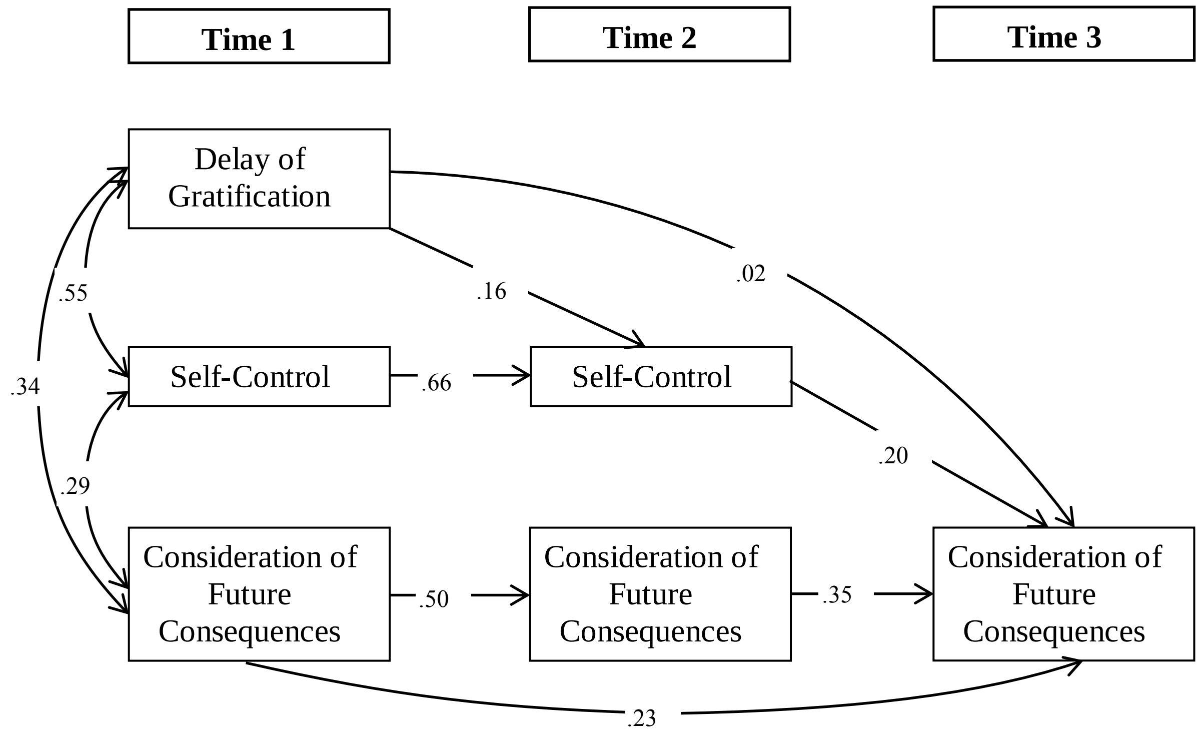

Figure 3. Standardised path model for the direct and indirect effects of delay of gratification on consideration of future consequences, mediated by self-control.

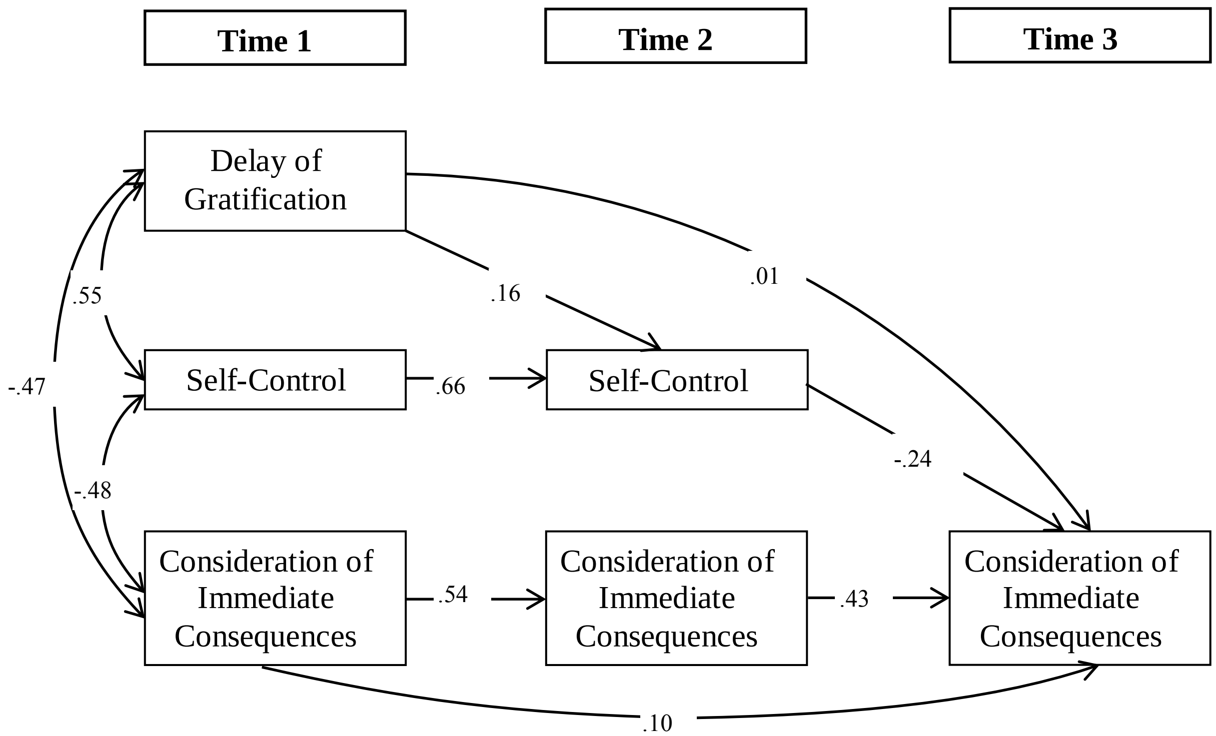

Figure 4. Standardised path model for the direct and indirect effects of delay of gratification on consideration of immediate consequences, mediated by self-control.

Consideration of immediate consequences. The mediation analysis for CFC-I also yielded a statistically significant result (standardised indirect effect = -.039, se = .020, 95% CI [-.090, -.009], *p* = .006). Self-control once again fully mediated the relationship between delay of gratification and CFC-I, with the standardised total and direct effects of delay of gratification on CFC-I failing to reach significance (*p*'s = .661 and .941 respectively; see Table 2 for effect sizes). Computation of the size of the mediation effect indicated that self-control accounted for 81% of the indirect effect. As above, these results suggest that those with a higher ability to delay gratification had higher levels of self-control over time, leading to a subsequent lower consideration of immediate consequences. This result is similarly consistent with expectations.[1]

Discussion

Study 1 investigated the longitudinal associations between the three related constructs of self-control, delay of gratification and future thinking (in particular, consideration of the consequences of one's behaviour). In line with predictions, self-control, delay of gratification, and the consideration of the consequences of one's behaviour were significantly associated with one another across time. Delay of gratification was found to influence consideration of future consequences across time rather than vice versa—with similar but less clear results for the temporal association between delay of gratification and consideration of immediate consequences.

Importantly, the results of the present longitudinal study provide to the author's knowledge the first empirical evidence that self-control fully mediates the relationship

[1] For the sake of completeness, a similar mediation model was conducted with ZTPI-F as the outcome variable. Although the ZTPI-F showed high correlations with delay of gratification and self-control, the mediation model was not supported. Specifically, the standardized direct self-control – ZTPI-F path was no longer significant (effect size = .051, se = .063, 95% CI [-.066, .172], *p* = .394); the standardized direct DGI – ZTPI-F path was no longer significant (effect size = -.014, se = .060, 95% CI [-.142, .100], *p* = .788); and the standardized indirect path between DGI and ZTPI-F including self-control as a mediator was also non-significant (effect size = .008, se = .012, 95% CI [-.009, .037], *p* = .307). The results provide further support for focusing on the CFC, and the pattern of results for the ZTPI-F will be further examined in the General Discussion.

between the delay of gratification and concern for future/immediate consequences across time. Those with a higher ability to delay gratification at Time 1 had higher levels of self-control at Time 2, leading to both a higher concern for future consequences and a lower concern with the immediate consequences of their behaviour at Time 3. Following from the results of Study 1, Study 2 aims to further investigate the role of self-control in delay of gratification and time perspective by utilizing survey measures, computer-based behavioural measures, and physiological measures.

CHAPTER IV

STUDY 2

Introduction

The present study has three main goals. The first goal is to further establish the associations between self-control, delay of gratification and consideration of future/immediate consequences observed in Study 1. Specifically, this study wishes to explore whether CFC scores can be used to predict subsequent self-control and delay of gratification levels. Two pre-selected extreme participant groups (i.e., high-CFC group = high CFC-F and low CFC-I scores; low-CFC group = low CFC-F and high CFC-I) are expected to differ after a period of six months on the measures of interest. The high-CFC group is expected to show higher self-control, higher delay of gratification scores, and higher future time perspective (accessed with the ZTPI-F) than the low-CFC group.

The second goal is to explore behavioural differences between the pre-selected groups by utilizing two online computer-based measures: a commons dilemma-type fishing simulation measuring cooperation and environmental conservation (Gifford & Gifford, 2000), and a measure of risk-taking behaviour (Lejuez et al., 2002). It is expected that the high-CFC group will act more cooperatively in the fishing simulation and will make less risky decisions than the low-CFC group.

The final and main objective of Study 2 is the examination of physiological markers (heart rate variability and cortisol) of self-control, delay of gratification and future time perspective. Recent research has found associations between high levels of self-control and high heart rate variability (Daly et al., 2014), with other research finding high heart rate variability to be an important predictor of adaptive behavioural responses, better impulse control, and better emotional regulation (Appelhans & Luecken, 2006; Thayer & Brosschot, 2005). High self-control is also related to a steeper rate of cortisol decline throughout the day

(Daly et al., 2014), suggesting that by the afternoon those high in self-control would have lower basal salivary cortisol levels than those with low self-control. As such, it is expected that higher self-control will be associated with higher heart rate variability and lower afternoon cortisol levels. Due to the relationship between self-control, delay of gratification and future thinking found in Study 1 and suggested in previous literature (see Milfont & Schwarzenthal, 2014), higher HRV and lower cortisol are also expected to be associated with higher scores on measures of future thinking and delay of gratification. As there is more research exploring the physiological basis of self-control, physiological associations with delay of gratification and future time perspective will be only exploratory.

To provide some indication of discriminant validity, we have also included rumination and worry measures, strategies of emotion regulation related to depression, anxiety, stress and anger (Garnefski & Kraaij, 2006; Martin & Dahlen, 2005). It is expected that those with higher self-control, higher heart rate variability and lower cortisol levels will have lower levels of emotional unrest, reflected in lower levels of rumination and worry. While most studies report associations between high HRV and lower levels of rumination and worry (for a review, see Appelhans & Luecken, 2006), as some studies have found no differences in the HRV of worriers and non-worriers and have found no support for the theory that worriers are more autonomically rigid (e.g., Davis et al., 2002; Knepp & Friedman, 2008), this research also aims to shed further light on the relationship between HRV and emotional functioning. Given the overall exploratory nature of the present study, other associations and between-group differences on psychological, physiological, and behavioural measures will also be explored.

Method

Study Design

This study used a between-subjects design with planned pairwise comparisons, with consideration of future/immediate consequences as measured at Time 1 during mass testing used as the independent between-subjects variable. The primary dependent variables were self-control, delay of gratification, future time perspective (accessed with a distinct measure), physiological measures of heart rate variability and levels of salivary cortisol (considered to be indices of self-regulatory capacity), and behavioural measures of cooperation and risk-taking. Levels of worry and rumination were also included in order to provide indication of discriminant validity, and also to ensure any effects of time perspective could not be better explained by perseverative cognition.

Participants

First-year psychology students at Victoria University of Wellington were given the opportunity to participate in exchange for course credit. These participants were pre-selected from previously obtained data.

Out of 715 students enrolled in a first-year psychology course, 168 completed the CFC Scale both at mass testing (Time 1 = March, 2014) and during another online survey (Time 2 = May, 2014). These datasets were the same as the Time 1 and Time 2 datasets used in Study 1.[2] These 168 students were then divided into two clusters, based on their CFC scores: those who were more present-oriented (*n* = 93) and those who were more future-

[2] Participant numbers differ between studies due to stringent outlier analysis strategies employed in the participant selection stage for Study 2 (Mahalanobis' Distance) that were later deemed inappropriate. The cluster analysis was conducted again to see if the participants selected would have had similar characteristics. A new dataset comprising data from Time 1 and Time 2 was created, including 337 students who completed the CFC scale at both times. Of these, 28 were identified as multivariate outliers by the simple visual analysis of boxplots, and were removed from further analysis. The remaining 309 students were then divided into two clusters based on their CFC scores: those who were more present-oriented (*n* = 182) and those who were more future-oriented (*n* = 127). Once again, subsequent *t*-tests provided a validity check for these clusters, showing that the clusters differentiate scores on a related but distinct measure of time perspective. At Time 1, participants in the future-oriented cluster scored higher ($M = 3.72$, $SD = 0.43$) on the future subscale of the ZTPI than participants in the present-oriented cluster ($M = 3.26$, $SD = 0.44$), $t(307) = -9.25$, $p < .001$, $r = .467$. The high CFC-group (n = 60, $M_{CFC} = 5.29$, $SD = 0.30$; $M_{age} = 18.7$, $SD = 1.61$; 68.3% female) and the low-CFC group (n = 60, $M_{CFC} = 3.54$, $SD = 0.23$; $M_{age} = 18.4$, $SD = 1.48$; 76.7% female) did not differ significantly by gender ($X^2(1, N = 120) = 1.05$, $p = .307$, $r = .093$) or age ($t(118) = -.826$, $p = .410$, $r = .076$). These results suggest that, had we drawn from this larger participant pool, the groups would have had similar characteristics to those actually used in the study.

oriented (n = 75). The future-oriented cluster included individuals exhibiting high CFC-F scores and low CFC-I scores (referred to as the high-CFC group), while the present-oriented cluster included individuals with high CFC-I scores and low CFC-F scores (referred to as the low-CFC group).[3]

Based on power analysis and time constraints, participants from each cluster were selected based on their total CFC scores in Time 1 and subsequently invited to partake in the present study.[4] In this way, two "extreme" groups were selected to participate in the lab study, whose scores on psychological and physiological variables could be compared subsequent to their participation.

Out of the 119 invited students, 85 students elected to take part in the lab study in exchange for course credit. The thirty-four students who did not elect to sign up for the study did not differ in terms of their membership in the time perspective groups ($X^2(1, N = 34) = 0.22$, $p = .643$), suggesting that they likely did not sign up for the study due simply to a lack of interest or necessity (i.e., already having full credit from participating in other studies).

Of the 85 participants, 10 participants taking antidepressants or anti-anxiety medication (including fluoxetine, venlafaxine, and citalopram), medicinal inhalers (such as Ventolin) and phenothiazines (antihistamine medications such as Phenergan) were removed from analysis due to the possible effects of these medications on cortisol (Nes, Segerstrom, & Sephton, 2005). Two further participants were removed due to poor quality heart rate data. Outlier analysis was completed by visually examining the heart rate data of each individual

[3] Subsequent t-tests provided a validity check for these clusters, showing that the clusters differentiate scores on a related but distinct measure of future time perspective. At Time 1, the high-CFC cluster scored higher (M = 3.73, SD = 0.48) on the ZTPI-F than the low-CFC cluster (M = 3.15, SD = 0.42), $t(164) = -8.33$, $p < .001$, $r = .541$. This pattern was mirrored at Time 2, with the high-CFC cluster scoring higher (M = 3.50, SD = 0.40) on the ZTPI-F than the low-CFC cluster (M = 3.00, SD = 0.44), $t(164) = -7.80$, $p < .001$, $r = .511$.

[4] One student was excluded prior to signing up due to having a personal relationship with the experimenter. The high-CFC group comprised the 59 students scoring the highest on the CFC ($M_{CFC} = 5.13$, $SD = 0.40$; $M_{age} = 18.2$, $SD = 1.27$; 67.8% female) and the low-CFC group comprised the 60 students scoring lowest on the CFC ($M_{CFC} = 3.68$, $SD = 0.30$; $M_{age} = 18.6$, $SD = 2.92$; 78.3% female). As a majority of first year psychology students are female, it was not completely possible to balance groups by sex when selecting participants. However, a chi-square test revealed no relationship between sex and CFC-group ($X^2(1, N = 119) = 1.68$, $p = .195$, $r = .119$), and a t-test revealed that the groups did not differ by age ($t(117) = 1.04$, $p = .301$, $r = -.096$).

for physiological impossibilities. Of the 73 cases remaining, two cases were identified as outliers and were removed[5]. The visual examination of distributions of the survey responses using histograms and boxplots revealed only a few outlying data points, but these were included in analyses due to the extreme nature of the chosen sample. In total, 71 participants were included in final analyses and all exclusions were conducted before any core analyses were conducted.

For the final sample of 71 participants, most were female (74.6 %), with ages ranging from 18 to 40 (M = 18.87, SD = 2.730), and with relatively even numbers of participants from each pre-selected time perspective group: the low-CFC group comprised 37 participants (M_{age} = 19.27, SD_{age} = 3.74, 81.1% female) and the high-CFC group comprised 34 participants (M_{age} = 18.44, SD_{age} = 0.56, 67.6% female). A chi-square test revealed no relationship between sex and CFC group (X^2(1, N = 71) = 1.69, p = .194, r = -.154), and an independent samples t-test revealed that these groups did not differ significantly by age (t(69) = 1.28, p = .203, r = -.153).

To validate this grouping, participants were asked to complete the CFC Scale again at the lab as part of a battery of questionnaires. As expected, participants in the high-CFC group had a higher score on the CFC-F (M = 5.22, SD = 0.55) compared to the low-CFC group (M = 4.25, SD = 0.82), t(69) = -5.821, p < .001, r = .574, and groups also differed in the predicted way on the CFC-I, with the high-CFC group scoring lower (M = 3.28, SD = 0.71) than the low-CFC group (M = 4.32, SD = 0.88), t(69) = 5.474, p < .001, r = -.550. The use of the CFC Scale in the lab was merely to confirm the grouping, and to avoid circularity will not be discussed further.

Procedure

[5] Both participants excluded as outliers had higher heart rates when sitting than when standing, an improbable pattern of results rendering their heart rate data unreliable.

This research was approved by the School of Psychology Human Ethics Committee under delegated authority of the Human Ethics Committee of Victoria University of Wellington, New Zealand (reference number RM020759).

Participants signed up online to participate in the 1 hour lab-based study where they completed a battery of online questionnaires, engaged in two online simulations (a simulation measuring cooperation behavior and a risk-taking simulation), had their heart-rate monitored, and had two saliva samples taken (one upon arrival and one upon the completion of all exercises). Participants were asked not to eat, drink, smoke or brush their teeth within 1 hour of their arrival at the lab to avoid contamination of the saliva samples (Nes et al., 2005). The experimenter was blind to which pre-selected time perspective group each participant was in. All participants completed the lab study in the afternoon, between the hours of 1:00 pm and 5:00 pm.

Upon their arrival at the lab, participants were given an information sheet outlining the nature and purpose of the research, and were given the opportunity to ask any questions before providing their informed consent to participate. All participants were advised that they could withdraw their consent at any time, without penalty, prior to the end of their participation. Participants then provided their first saliva sample, which was labelled with the participant’s study number (different to their Student ID number) by the experimenter and placed in a box out of the light. Participants were then given verbal instructions and a brief demonstration of how to fit their heart rate monitor, and they were instructed to fit their heart rate monitor chest strap under their clothes behind a screen. Once fitted, the participant sat at a computer and completed a number of questionnaires in a survey already loaded on-screen, with the measures and questions presented in a random order. On the completion of the online survey, participants completed an Orthostatic Challenge (i.e., 10 minutes of heart rate recording where participants were instructed to turn away from the computer and sit quietly with their legs and arms uncrossed for 4 minutes, then stand for 3 minutes, and then sit again for 3 minutes), an online fishing simulation, and an online risk simulation. Whether they completed the Orthostatic Challenge first or the simulations first, and which simulation was presented first, was random. After they had completed these three exercises, a second saliva sample was taken.

Participants were then thanked, debriefed, and awarded course credit. Saliva samples were frozen at -20 degrees Celsius the same day as collection and kept frozen for up to 3 months until analysis. The first one-minute of sitting heart rate data from the Orthostatic Challenge was removed from analysis to account for time required to relax, and the remaining 3 minutes were used in analyses.

If participants were interested in receiving a summary of the study findings after collation and analysis of the results, they were given the opportunity to sign up via email. Please see Appendices H, I and J for copies of the information sheet, consent form and debriefing sheet used.

Measures

Questionnaires. Participants completed an online questionnaire battery, including the same measures used in Study 1: time perspective (the CFC-14, Joireman et al., 2012; and the ZTPI-F, Zimbardo & Boyd, 1999), self-control (the BSCS; Tangney et al., 2004), and delay of gratification (the DGI-10; Hoerger et al., 2011). In addition, measures of rumination and worry were included to provide discriminant validity information, and further elucidate the relationship between these measures and HRV.[6]

[6]The questionnaire battery also included questions relating to pro-environmental concern and behaviour. The New Ecological Paradigm Scale is a measure of how much an individual endorses a pro-environmental viewpoint (Dunlap, Liere, Mertig, & Jones, 2000), and the Electricity Conservation Behaviour questionnaire is a measure of participant's habitual energy-conserving actions (Milfont & Sibley, 2012). No significant associations were found between these measures and the variables of interest, and as such they were excluded from analysis. Participants also completed demographic questions relating to age, sex, smoking status (smoker or non-smoker), alcohol consumption (the highest amount drank on a single occasion in the last month) and health (a single-item where people rated their health on a scale from 1 (*poor*) to 5 (*excellent*)). The inclusion of these questions enabled the effects of these variables to be controlled for in some analyses.

Rumination. Rumination was measured using the Ruminative Responses Scale (RRS; Nolen-Hoeksema & Morrow, 1991 - see Appendix K). The RRS is a 22-item scale assessing depressive rumination in thoughts, feelings, and behaviours. Participants rate on a scale from 1 (*almost never*) to 4 (*almost always*) how often they engage in ruminative responses when they are feeling down, sad or depressed, including items such as "think about how alone you feel" and "go away by yourself and think about why you feel this way". This scale has shown high internal reliability (*a* = .89; Nolen-Hoeksema & Morrow, 1991).

Recent research suggests that the RRS is made up of 3 distinct factors (Armey et al., 2009): brooding rumination (RRS-B, a 5-items measure of passive problem-focused thinking, strongly related to depression), reflective rumination (RRS-R, 5 items measuring active cognitive problem-solving) and depression-related items (RRS-D, 12-items very similar in content to items in the Beck Depression Inventory, BDI, a commonly used measure of depression; Treynor, Gonzalez, & Nolen-Hoeksema, 2003). As such, the present study will also investigate each of these three subscales separately.

Worry. Worry was measured using the Penn State Worry Questionnaire (PSWQ; Meyer, Miller, Metzger, & Borkovec, 1990 - see Appendix L). The PSWQ is a 16-item scale designed to assess pathological worry as a trait. Participants rate how typical each item is of them on a scale from 1 (*not at all typical of me*) to 5 (*very typical of me*). Examples of items include "Many situations worry me" and "When there is nothing more I can do about a concern, I do not worry about it." The PSWQ has shown high internal consistency (*a* = .93 to .95) and test-retest reliability (.93; Meyer et al., 1990).

Simulation tasks.

Cooperation behaviour. The FISH 4.0 was used to simulate cooperation behaviour (see Gifford & Gifford, 2000, for information on FISH 3 Microworld). The FISH is a fishing-based commons dilemma simulation that recreates in a laboratory setting some of the real-world conditions faced by fishers. In this way, FISH acts as a behavioural measure of cooperation and environmental conservation, where individuals must choose whether to harvest a small number of fish, resulting in long-term resource conservation, or a large amount of fish, resulting in large short-term gains at the expense of the commons and the other harvesters, risking the exhaustion of the resource (Gifford & Gifford, 2000). In this study, after reading through instructions and completing a practice run as a lone fisher in the ocean, participants fished in the same ocean as three computer fishers (with varying levels of greed) across four seasons. Fishers individually set out to fish, cast for fish as many times as they wished, and returned to port. Each season ended when all fishers chose to return to port, and fishers were paid for each fish they caught. If fish were left at the end of the season, spawning occurred, allowing fishers to return for another season (see Appendix M for further details).

As all measures of fishing behaviour correlated highly with one another (i.e., total number of fish taken and individual profit correlated perfectly, and they both correlated strongly with individual levels of restraint, $r = -.795$, $p < .001$), analyses in this study will focus on the total number of fish taken (fish total). Results reported below are virtually identical when individual profit and levels of restraint are considered. Due to some intermittent problems with loading FISH 4.0 in the laboratory, only 65 participants completed this simulation. Of these 65 participants, 34 were in the low CFC group ($M_{age} = 19.35$, $SD_{age} = 3.88$, 79.6% female) and 31 were in the high CFC group ($M_{age} = 18.48$, $SD_{age} = 0.57$, 67.7% female). Again, these groups did not differ significantly by sex ($X^2(1, N = 65) = 1.14$, $p = .285$, $r = -.133$) or age ($t(63) = 1.24$, $p = .221$, $r = -.154$).

Risk-taking behaviour. The Balloon Analogue Risk Task (BART; Lejuez et al., 2002) was used to simulate real-world risk-taking behaviour, a construct associated with impulsivity. In this task, each click of the mouse incrementally inflates an on-screen balloon allowing participants to earn money[7] for each click until the balloon either pops (meaning no money is earned on that balloon trial) or the participant chooses to cash-out (meaning they collect their earnings for that balloon trial, which could be done at any time; Lejuez et al., 2002). Thus, with each pump comes both greater potential reward and greater risk (the probability of a balloon pop increases with each pump). In this study, after reading through a set of instructions on-screen, participants had 20 balloons to inflate. Each pump made an inflating noise and accrued 5 cents, each explosion resulted in a “popping” sound effect and the loss of all money earned in that trial, and each collection transferred all money earned in that trial into the permanent bank, accompanied by a slot machine payoff sound effect (see Appendix N for further details).

As this task is a behavioural measure of risk-taking, the total number of balloon pumps – correlating strongly with total earnings (r = .893, p < .001) and also correlating with the number of popped balloons (r = .509, p < .001) – was used as a behavioural measure of risk-taking in analyses. Number of popped balloons was not considered as the best measure of risk-taking as it is an outcome of both risky behaviour and computer-generated probability. Results reported below are extremely similar when total earnings are considered.

Physiological measures.

Salivary cortisol. Salivary cortisol is an accurate and non-intrusive method of cortisol assessment that correlates with free blood cortisol levels (Kirschbaum & Hellhammer, 1994). Saliva was gathered at the beginning and end of the 1-hour lab session. While cotton buds are often used in research and are rated as easy to use by participants, salivary cortisol values may be significantly reduced if saliva is not immediately retrieved from the cotton (Mörelius, Nelson, & Theodorsson, 2006). Thus, in this study, participants spat a minimum of 1 mL of saliva directly into a small sterile plastic tube (Lewis, 2006) with milliliters marked on the

[7] In this study, no real money was earned, but participants were encouraged to think of their earnings as real money. Participation in the whole study was in exchange for course credit only.

side. The tube was then sealed by the experimenter using gloves and frozen at -20 degrees Celsius to ensure stability of the samples (losses may occur at room temperature; Garde & Hansen, 2005), in a private freezer used for lab purposes only. Previous studies have found cortisol concentrations to be elevated when anticipating a task, with lower and more habituated concentrations found when the task is no longer novel (Moss, Vanyukov, & Martin, 1995; Moss, Vanyukov, Yao, & Kirillova, 1999). Accordingly, the second sample collected at the end of the study was used in this study as an index of resting cortisol concentration.[8] As cortisol may be present in higher levels in women than in men (Swaab, Bao, & Lucassen, 2005), sex will be controlled for in the analyses.

Although there is diurnal variation in cortisol, with cortisol levels elevated in the morning and declining throughout the day (Haus, 2007; Posener et al., 1996) , the constraints of data collection did not fully allow for the standardization of the time of saliva collection. As noted above, all lab sessions were held in the afternoon between 1:00 pm and 5:00 pm, and given that cortisol levels decline gradually in the afternoon and evening compared to the steep decline in the morning for most individuals, collecting saliva samples in the afternoon reduces the potential effects of the time of collection. Nevertheless, time of saliva sampling was also controlled for in the analyses.

As salivary cortisol is thought to be of a similar concentration to circulating cortisol, investigating resting salivary cortisol concentration rather than cortisol reactivity was preferable for this study, because resting cortisol concentration is not as subject to individual differences as cortisol reactivity in response to novel stressors (Felker & Hubbard, 1998).

[8] This study wishes to acknowledge possible effects of task on cortisol levels, and tested post-hoc whether cortisol levels differed depending on whether participants completed the orthostatic challenge, the fishing simulation, or the BART immediately prior to providing their saliva sample. No difference in cortisol was found between those who completed the orthostatic challenge (n= 37, M = 15.14, SD = 7.18) or the simulations (n = 34, M = 15.50, SD = 7.07) immediately prior to saliva sampling, $t(69) = 0.375$, $p = .709$, $r = -.045$. Similarly, of those who completed the simulations immediately prior to saliva sampling, no difference in cortisol levels was found between those who completed the BART (n = 16, M = 14.81, SD = 8.02) or the fishing simulation (n = 18, M = 14.22, SD = 6.02) immediately prior to sampling, $t(32) = -0.239$, $p = .812$, $r = .042$.

Once all samples were collected, they were sent to Canterbury Health Laboratories (John G. Lewis, Steroid & Immunobiochemistry Laboratory, Christchurch, New Zealand) for analysis by enzyme-linked immunosorbent assay (ELISA: for further information about the procedure, see Appendix O). Cortisol values were returned in nanomoles per litre (nmol/L).

Heart rate variability (HRV). HRV was measured using a Polar WearLink® (Polar RS800CX) chest strap transmitter and a heart rate wrist monitor designed to measure heart rates ranging between 15-240 beats per minute (www.Polarusa.com). While there is some debate as to the validity of this system in certain situations (Quintana, Heathers, & Kemp, 2012; Wallén et al., 2012), the reliability and validity of the Polar monitors when measuring short-term resting HRV have been found to be acceptable (Nunan et al., 2008). Recordings were processed using software specializing in the analysis of HRV (Kubios HRV; http://kubio.uku.fi), developed by the Biosignal Analysis and Medical Imaging Group at the University of Kuopio, Finland (Tarvainen, Niskanen, Lipponen, Ranta-Aho, & Karjalainen, 2014). HRV is a measure of the beat-to-beat changes between consecutive heartbeats, as opposed to heart rate, which typically is a measure of the number of heartbeats per minute.

Artifacts in the physiological data, such as those created by ectopic beats and other sources of error, were corrected automatically by the program in order to prevent them from interfering with analysis. A manual check of the event series was also performed to ensure artifacts were not missed by the software's artifact correction algorithm (Tarvainen et al., 2014). HRV parameters were calculated from short-term recording intervals of 3 minutes, in keeping with recommendations of the Task Force (1996). While many studies investigate resting HRV in a supine lying position, participants in the present study were in the sitting position when their resting HRV was recorded for 3 minutes. Heart rate is less chaotic in both the sitting and lying positions compared to a standing position (Rajendra Acharya, Kannathal, Mei Hua, & Mei Yi, 2005), and for the purposes of this research the sitting position was deemed more user-friendly for the participant.

Power spectral analysis, a relatively new approach to HRV measurement, describes the quantity of HRV occurring at different frequencies (expressed in hertz, and computed as cycles/second) as indicated by the ECG signal, resulting in a power spectrum, or heart rate variance distribution at different frequencies. The fast Fourier transform and autoregressive modelling techniques are the two most common techniques used when extracting HRV fluctuations from sequential interbeat intervals. As both techniques have been found to yield similar results (Cerutti, Bianchi, & Mainardi, 1995; Task Force, 1996), the present study uses fast Fourier transform.

The high frequency range of the HRV spectrum (0.15-0.4 Hz) corresponding to respiration frequency and parasympathetic activation (with the parasympathetic nervous system responsible for repair and recovery), one of the cleanest markers of cardiac vagal activity (Lane et al., 2009), was extracted. As high correlations between all commonly used measures are noted in the literature (Allen et al., 2007), the measure of high frequency absolute power was selected as the measure of HRV for the present study and will henceforth be referred to as HRV. It should be noted that in this study, as in previous literature, all time-domain and frequency-domain measures highly intercorrelated. For example, the frequency-domain measure of high frequency absolute power and the time-domain measure of root mean squared successive beat-to-beat differences (rMSSD, a commonly used measure of vagally-mediated cardiac control) correlated strongly with one another (r = .844 to .946, p's $< .01$). The results reported below were almost identical when these other measures of HRV were considered. Raw heart rate values were natural log transformed prior to analysis to reduce skewness (see Appendix P for a table of correlations between measures and raw and natural log transformed values). [9]

Data analysis. Normality assumptions were examined using the Shapiro-Wilk test. All variables were normally distributed. Pearson's correlation analyses assessed relationships between the psychological and physiological variables, and independent-samples *t*-tests assessed differences between pre-selected CFC groups.

Results

Descriptive Statistics

Table 3 presents the descriptive statistics (including scale reliability, means and standard deviations) of participants' responses on all measures. All survey measures had good reliability except for the ZTPI-F and the DGI. Due to the overall poorer reliability of both the ZTPI-F and DGI in this study, results on these scales must be treated with caution.

Pre-Selected CFC Groups: Between-Group Differences

Table 3 presents the bivariate correlations between variables, including associations with pre-selected time perspective group. Independent samples *t*-tests were conducted to examine differences between the survey responses of those in the high-CFC and low-CFC groups. As expected, there was a significant difference in the ZTPI-F scores between high-CFC (M = 3.49, SD = 0.36) and low-CFC (M = 3.13, SD = 0.41) groups, $t(69)$ = -3.938, p < .001, r = .428; a significant difference in the DGI scores of those in the high-CFC (M = 3.76, SD = 0.37) and low-CFC (M = 3.34, SD = 0.38) groups, $t(69)$ = -4.795, p < .001, r = .500;

[9] This study also wishes to acknowledge possible effects of task on HRV, and tested post-hoc whether HRV would differ depending on whether participants completed the behavioural simulations prior to HRV measurement. No difference in HRV was found between those who had their resting HRV measured prior to the completion of the behavioural simulations (N = 34, M = 6.52, SD = 1.00) and those who had their resting HRV measured afterwards (N = 37, M = 6.54, SD = 1.24), $t(69)$ = 0.070, p = .944, r = -.008. Similarly, of those who completed the simulations before HRV measurement, no differences were found between those who completed the BART (N = 24, M = 6.64, SD = 1.19) or the fishing simulation (N = 13, M = 6.37, SD = 1.35) prior to measurement $t(35)$ = -0.619, p = .540, r = .104.

and a significant difference in self-control scores for the high-CFC (*M* = 3.03, *SD* = 0.50) and low-CFC (*M* = 2.69, *SD* = 0.44) groups, $t(69) = -3.012$, $p = .004$, $r = .341$.

These results support predictions and findings observed in Study 1 regarding the associations between self-control, delay of gratification and future thinking. Those in the high-CFC preselected group had higher self-control, higher abilities to delay gratification, and higher future focus than those in the low-CFC group. Furthermore, these results suggest that it is indeed possible to predict who will have higher self-control based on how great their concern for future consequences was six months prior to testing.

There were no between-groups differences on our measures of rumination or worry (*t*s < 1); at the same time, both rumination and worry were negatively related to self-control and also negatively related to delay of gratification (albeit non-significantly). These results provide evidence of discriminant validity by showing that rumination and worry are unrelated to future thinking but are related to two variables (self-control and delaying gratification) associated to future thinking. In other words, the findings suggest that while higher self-control is related to both greater future focus and lower maladaptive emotional responding, future time perspective is unrelated to rumination/worry. Considering these findings, further correlational analyses will investigate the relationships between rumination/worry and other variables across the dataset as a whole.

There were no significant differences in total number of fish taken in the fishing simulation or in total number of balloon pumps in the BART when comparing the high-CFC and low-CFC groups (*t*s < 1). Unexpectedly, participants in each pre-selected group did not differ in their performance on these behavioural measures of cooperation and risk taking, an issue further examined in the General Discussion. As no significant differences were observed between groups on these behavioural measures, and no significant associations

Table 3

Descriptive Statistics and Reliabilities

	Full Dataset					Low-CFC Group				High-CFC Group			
Variable	*N*	Scale	Mean	SD	*a*	*n*	Mean	SD	*a*	*n*	Mean	SD	*a*
ZTPI-F	71	1-5	3.30	0.43	.64	37	3.13	0.41	.63	34	3.49	0.36	.48
Self-Control	71	1-5	2.85	0.49	.75	37	2.69	0.44	.71	34	3.03	0.50	.74
DGI	71	1-5	3.54	0.43	.57	37	3.34	0.38	.53	34	3.76	0.37	.31
RRS	71	1-4	2.05	0.56	.92	37	2.06	0.61	.94	34	2.05	0.51	.89
PSWQ	71	1-5	3.00	0.82	.94	37	3.01	0.82	.94	34	3.00	0.82	.93
Cortisol	71	N/A	14.83	7.08	N/A	37	15.30	7.01	N/A	34	14.32	7.24	N/A
HRV	71	N/A	1192.61	1250.34	N/A	37	1163.07	1114.23	N/A	34	1224.76	1399.92	N/A
Fish taken	65	N/A	20.12	3.93	N/A	34	19.68	3.91	N/A	31	20.61	3.96	N/A
Balloon pumps	71	N/A	191.41	96.38	N/A	37	182.22	100.12	N/A	34	201.41	92.57	N/A

Table 4

Pearson Correlations between Scale Scores, Physiological Measures, and Behavioural Measures

Variable	CFC group	ZTPI-F	Self-Control	DGI	Rum	Worry	Cortisol	HRV	Fish taken
ZTPI-F	**.428****								
Self-Control	**.341****	**.495*****							
DGI	**.500*****	**.569*****	**.655*****						
Rumination	-.003	-.095	**-.348****	**-.218**†					
Worry	-.010	.101	**-.243***	**-.205**†	**.481*****				
Cortisol	-.069	**-.311****	**-.248***	**-.230**†	.154	.045			
HRV	-.012	-.079	-.148	-.071	**.254***	**.248***	-.010		
Fish taken	.120	.140	.159	-.126	.052	.023	-.137	.140	
Balloon pumps	.100	.106	-.051	.008	-.063	-.045	-.067	.028	.140

Note. ***$p < .001$ **$p < .01$ *$p < .05$ †$p < .09$

between these behavioural measures and each other or any other variables were observed (see Table 4), these measures will be excluded from further analyses.

Similarly, no significant differences in HRV and levels of cortisol were observed between the high-CFC and low-CFC groups (*t*s < 1). Individuals in these groups were not found to differ at a physiological level in this study. As no between-groups differences were observed for these physiological variables, but both shared significant associations with survey measures, the relationships between the physiological measures and other psychological variables will be further explored.

Correlational Analyses

Table 4 details the two-tailed Pearson correlations between all measures considered across all participants. As expected, a significant association was observed between rumination and worry (r = .481, p < .001), supporting the notion that those who ruminate more, worry more. Self-control was found to share negative associations with both rumination (r = -348, p = .003) and worry (r = -.243, p = .041). Further analysis of rumination results revealed that self-control was only related to the items of the RRS relating to brooding (r = -.389, p = .001) and depression (r = -.365, p = .002), while self-control was unrelated to the reflective subscale (r = -.118, p = .329). While not statistically significant, similar trends were found between delay of gratification and both rumination (r = -.218, p = .068) and worry (r = -.205, p = .086). These results suggest that those with low self-control (and lower delaying gratification scores) are more likely to display the maladaptive emotional responding associated with worry and rumination (in particular, brooding and depression).

As differences in rumination levels between males and females are consistently noted (Lopez, Driscoll, & Kistner, 2009; Susan Nolen-Hoeksema & Jackson, 2001), additional analyses were conducted to investigate the possible influence of sex on the relationship between rumination and worry and self-control. Rumination was associated with sex (r =

.329, p = .005) as was worry (r = .343, p = .003), indicating that females in this study (dummy coded as "1") had higher levels of rumination and worry than males. When the relationship between self-control and rumination was then subjected to a first-order partial correlation to explore the relationship controlling for the effect of sex, the first-order correlations with self-control retained their strength and significance (brooding: $r(68)$ = -.369, p = .002; depressive: $r(68)$ = -.343, p = .004), but the relationship between self-control and worry failed to reach significance when controlling for sex, $r(68)$ = -.212, p = .078, although it was still trending in the same direction.

In line with some previous literature (Daly et al., 2014), a significant and moderately negative correlation was found between self-control and cortisol (r = -.248, p = .037). Interestingly, a significant and stronger negative correlation was also found between cortisol and ZTPI-F scores (r = -.311, p = .008). A similar trend was also observed between salivary cortisol and the DGI (r = -.230, p = .053). Taken together, these results suggest that higher levels of cortisol are associated with lower levels of self-control and a broad future time perspective as measured by the ZTPI, and the ability to delay gratification.

Since cortisol has been found to be related to sex and time of day, additional analyses were conducted to investigate these associations. As has been found previously (Swaab et al., 2005), cortisol was significantly associated with participant sex (r = -.235, p = .049) and marginally significantly associated with time of day (r = -.221, p = .063), indicating that females in this study had lower cortisol levels than males, and those taking part later in the afternoon had lower cortisol levels than those participating earlier in the afternoon. When the relationship between cortisol and self-control was then subjected to a first-order partial correlation to explore the relationship controlling for the effects of sex and time of day, the first-order correlation was found to be statistically significant and slightly stronger than previously observed, $r(67)$ = -.297, p = .013. Even after controlling for sex and time of day, two variables known to influence cortisol levels, lower cortisol was a moderate predictor of higher self-control[10].

No significant associations were observed between cortisol and rumination (*r* = .154, *p* = .199) and worry (*r* = .045, *p* = .711).

As can be seen in Table 2, HRV was positively associated with both rumination (*r* = .254, *p* = .033) and worry (*r* = .248, *p* = .037), suggesting that those who ruminate and worry more have higher HRV. Further analysis of rumination results revealed that HRV was only related to the items of the RRS relating to depression (*r* = .313, *p* = .008), while HRV was unrelated to brooding rumination (*r* = .179, *p* = .136) and reflective rumination (*r* = .086, *p* = .475). No other significant associations were observed between HRV and survey measures (all *p*'s > .2). Cortisol and HRV were not significantly associated with one other (*r* = -.01, *p* = .931).

Due to the finding that sex was associated with rumination and worry in the present sample, as well as the findings of previous literature suggesting sex differences in rumination (Lopez et al., 2009; Susan Nolen-Hoeksema & Jackson, 2001) and HRV (Jensen-Urstad et al., 1997), additional analyses were conducted to investigate the possible influence of sex on the relationship between HRV and both depressive rumination and worry. When a partial correlation was computed between depressive rumination and HRV controlling for sex, the partial correlation was found to be statistically significant, *r*(68) = .328, *p* = .006. The partial correlation between worry and HRV when controlling for sex was also statistically significant, *r*(68) = .260, *p* = .030. These results indicate that relationships exist between HRV and depressive rumination and worry above and beyond the effects of sex.[11]

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[10]Although some literature has found associations between cortisol and smoking status (Badrick, Kirschbaum, & Kumari, 2007) and health (Daly et al., 2014) these associations were not found in the present study (*p*'s > .05). When entered as control variables along with sex, the partial correlation between cortisol and self-control was unchanged, *r*(66) = -.340, *p* = .006, indicating that this relationship exists above and beyond their effects.
[11]Although some literature has found associations between HRV and smoking status (Munjal et al., 2009) and health (Thayer, Hansen, Saus-Rose, & Johnsen, 2009), these associations were not found in the present study

These results reported above suggest an interesting distinction between the physiological markers of important psychological constructs. It seems that low cortisol level is the physiological marker of cognitive facets of self-control (here indexed by delay of gratification and future focus), while high HRV is a physiological marker of emotional regulation strategies (here indexed by depressive rumination and worry).

Discussion

The results of the present study indicate that an individual's level of concern for future consequences can be used to predict future levels of self-control, delay of gratification, and time perspective. Participants selected for their high CFC-F and low CFC-I scores had higher future time perspective, higher delay of gratification, and higher self-control than those selected for their low CFC-F and high CFC-I scores.

Importantly, while high self-control was found to be associated with low levels of rumination and worry, the benefits of self-control went further than subjective self-reports. High self-control was found to be associated with lower levels of cortisol in the afternoon, with a person's ability to delay gratification, closely related to self-control as observed in Study 1, showing a similar trend in relation to cortisol. Lower cortisol levels were also associated with higher levels of future time perspective: as future time perspective, delay of gratification and self-control share positive correlations with each other, and after self-control was found in Study 1 to be an important mechanism driving the relationship between these two variables, the fact that cortisol was also found to relate to time perspective in the present research should not be surprising. These results support the possibility that those high in self-control respond more adaptively to and cope better with external and internal sources of stress throughout the day, enabling them to avoid the emotional turmoil of worry and

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(p's > .05). When entered as control variables along with sex, the partial correlation between HRV and depressive rumination retained statistical significance, $r(66) = .326$, $p = .007$, as did the partial correlation between HRV and worry, $r(66) = .268$, $p = .027$. These results indicate that these relationships exist above and beyond their effects.

rumination, which in turn facilitates an afternoon decline in cortisol. However, further research is required to test this possibility.

Contrary to the findings of previous research and the expectations of the present study, heart rate variability was not found to be associated with self-control. However, lower heart rate variability was found to be associated with lower levels of rumination and worry. This result is counter-intuitive, as numerous previous studies have found *high* heart rate variability to be a marker of good self-control, emotional stability, and lower levels of negative affect.

GENERAL DISCUSSION

The extant literature has provided theoretical (Joireman et al., 2008; Stolarski, Ledzinska, & Matthews, 2013; Zimbardo & Boyd, 1999) and empirical (Milfont & Schwarzenthal, 2014) evidence for associations between higher self-control, a greater ability to delay gratification, and future thinking. Self-control has also been found to be the causal mechanism underlying delay of gratification abilities (Duckworth et al., 2013). Yet research investigating the nature of the relationship between these three variables is lacking. Using both a longitudinal dataset and a lab-based study, the goal of the present research was to explore whether self-control lay at the heart of the relationship between one's ability to delay gratification and have their actions in the present guided by future outcomes (Study 1), and whether one's level of future thinking could be used to predict psychological traits and aspects of our physiology measured at a later point (Study 2).

Self-Control Explains the Associations between Delay of Gratification and Future Thinking

The results of Study 1 showed firstly that the ability to delay gratification predicted a person's concern for future consequences longitudinally and secondly that this relationship was fully mediated by a person's self-control. A greater ability to delay gratification predicted higher levels of self-control over time, which in turn significantly predicted higher levels of concern for future consequences over time. This finding is consistent with the results of a previous longitudinal study showing self-control to be the main psychological mechanism underlying delay of gratification abilities across time (Duckworth et al., 2013). This finding also suggests that this role of self-control can be extended to explain why those who find it easier to delay immediate gratification also exhibit higher consideration for the future consequences of their behaviour (Joireman et al., 2008; Milfont & Schwarzenthal, 2014; Strathman et al., 1994).

Distinction between future and immediate factors. Although the present research was primarily interested in future thinking, the results of Study 1 suggest that higher delay of gratification and subsequent higher levels of self-control also led to a lower concern for immediate consequences over time. Self-control thus acts as a significant mediator between delay of gratification and concern for both future and immediate consequences. It is interesting to note that self-control accounted for more of the indirect relationship between delay of gratification and the consideration of *immediate* consequences as compared to future consequences (accounting for 81% of the indirect effect compared to 65%).

While not directly hypothesized, this result is consistent with some previous literature investigating the two-factor structure of the CFC scale. For example, a recent study by Arnocky and colleagues (2013) found that when included together in a regression analysis only CFC-Immediate (and not CFC-Future) predicted environmental concern and pro-environmental behavioural intentions. In particular, individuals with a high concern for immediate consequences had less environmental concern and pro-environmental motivation than those who had lower concern for the immediate. Some previous research has found those emphasizing immediate consequences to have lower self-control and a greater likelihood of engaging in risky behaviours such as compulsive buying than those who put less weight on immediate consequences; consideration of future consequences did not come in to play (Joireman et al., 2008; Joireman, Kees, & Sprott, 2010). The results of the present study finding self-control to be a stronger mediator of the directional relationship between delay of gratification and a concern for *immediate* consequences (compared to *future* consequences) provide further support for the understanding of present-thinking and future-thinking as two distinct yet related capacities, rather than polar opposites (see (Joireman et al., 2012).

Understanding the causal path. Another important result from Study 1 was the finding that the mediation model did not reach significance when run using the ZTPI-Future subscale as the outcome variable, even though the ZTPI-F showed high correlations with delay of gratification, self-control, and consideration of future and immediate consequences. This is potentially due to the idea that ZTPI-F includes items too closely related to delay of gratification and self-control (e.g., “Meeting tomorrow’s deadline and doing other necessary work comes before tonight’s play”) suggesting that delay of gratification abilities and levels of self-control account for a sizeable portion of the variance in ZTPI-F (also evidenced by the high correlations observed between the ZTPI-F and delay of gratification and self-control in previous literature; see Milfont & Schwarzenthal, 2014). This may also be due to the ZTPI-F being a more general measure of temporal orientation, whereas the CFC assesses a more specific aspect of future-oriented behavioural tendencies (Joireman, 2014). This result suggesting that the CFC-Future subscale was a more pure measure of future-oriented behavior and behavioural intentions provided support for the decision to use CFC subscale scores to select groups for Study 2.

At the same time, it is possible that the ability to delay gratification predicts self-control, which then predicts a more general time perspective as measured by the ZTPI-F, which in turn predicts the more specific concern for future consequences. Indeed, when a post-hoc longitudinal mediation analysis was performed between self-control and the CFC-F with ZTPI-F as the mediating variable, the mediation model was statistically supported: ZTPI-F mediated the relationship between self-control and the consideration of future consequences, with ZTPI-F accounting for 49% of the indirect effect[12]. These theoretical arguments and empirical findings suggest the following causal connection between these variables: delay of gratification → self-control → broad future time perspective →

[12] Standardized indirect effect = .074, se = .027, 95% CI [.030, .142], $p = .001$. The standardised total effect of self-control on CFC-F failed to reach significance (effect size = .025, $p = .742$), as did the standardised direct effect of self-control on CFC-F (effect size = -.049, $p = .514$).

consideration of future consequences. The present research was limited in its ability to properly test this causal hypothesis due to only using data collected at three time points. Future research should investigate this causal chain using longitudinal data from four time points.

From the theoretical perspective of the strength model of self-control. Perhaps one of the most interesting and parsimonious explanations for the pattern of results observed can be taken from the perspective of the strength model of self-control (Baumeister et al., 1998; Baumeister et al., 2007; Hofmann et al., 2007; Muraven & Baumeister, 2000). Self-control has long been understood as central to successful human development, with this constitutionally-based capacity for self-control enabling us to resist impulses and behave appropriately in the interests of our social standing, material wealth, and physical and mental health. Taken together, the present empirical results suggest that higher levels of self-control enable one to delay gratification and thus behave in a way consistent with the highly meaningful mental representations of future events held by dominantly future thinkers.

The direction of the relationship between delay of gratification and future orientation mediated by self-control is an important finding: while not explicitly tested, this result is reminiscent of the strength model of self-control (Baumeister et al., 2007; Muraven et al., 1999; Oaten & Cheng, 2006). As self-control underlies delay of gratification (Duckworth et al., 2013), exercising the self-control "muscle" with repeated acts of gratification delay would strengthen the self-control muscle. As it has been found that an individual's targeted efforts to control their behavior in one facet of their life lead to improvements in other areas (Muraven et al., 1999; Oaten & Cheng, 2006), these repeated acts of gratification delay might help to strengthen one's ability to show concern for and act in the interests of future consequences, even in the face of tempting immediate gratification. The extant literature has found results supporting this conjecture, with repeated exercise of this self-control muscle linked to the performance of behaviours associated with future thinking such as taking better care of one's health and being more fiscally responsible (Muraven et al., 1999; Oaten & Cheng, 2006). What's more, the depletion of the self-control muscle has been found to lead to more discounting of future outcomes among individuals high in CFC-I (Joireman et al., 2010), suggesting that those high in CFC-I are more susceptible to depletion and subsequent failures in self-control than those low in CFC-I. This also supports the notion that those who practice gratification delay and have higher self-control would also have lower concern for the immediate, consistent with the findings of the present research. While this theoretical argument was not experimentally tested in here, the investigation of the strength model of self-control in the context of future thinking is an interesting avenue for future research.

Physiological Markers of Self-Control, Delay of Gratification and Future Thinking

Having established the longitudinal associations between the three core variables of interest, Study 2 hypothesised that, by preselecting two groups based on CFC scores (with one group comprising those scoring highest in CFC-future and lowest in CFC-immediate, and the other group comprising those scoring lowest in CFC-future and highest in CFC-immediate), it would be possible to predict participants' levels of self-control, delay of gratification abilities[13], scores on a more general measure of time perspective, and even aspects of their physiology.

In line with hypotheses, the high-CFC group had significantly higher self-control, delay of gratification, and broad future time perspective scores than the low-CFC group. These results suggest that levels of self-control, abilities to delay gratification, and levels of future thinking are persistent and stable across time, upholding the predictive capabilities of Study 1's longitudinal mediation model. However, no behavioural or physiological differences were observed between these two groups.

[13] Due to low internal reliability, DGI scores may not be reliable, although results on this measure trend in the expected direction.

Before discussing the results relating to physiological measures, the lack of behavioural differences between groups must first be noted. While behavioural differences were expected, no behavioural differences were observed between these groups on computer simulations of cooperation and environmentalism (FISH) or risk-taking (BART). These measures also showed no associations with any other variables investigated in this study. It is likely that this null result had to do with the lack of tangible reward offered: many studies using these measures – particularly the BART – use a tangible reward such as cash or desirable vouchers. For the FISH task, the null result may also be related to the fact that participants were fishing against computer programs. Future research using these behavioural simulations should compare results of undergraduates given no reward aside from course credit with those given a tangible financial reward, and should also compare results of those fishing against computer programs with those fishing against other human fishers.

The two CFC groups also did not differ on either physiological measure. This could be due to the idea that self-control is more deeply rooted in our physiology than our consideration of the future/immediate consequences of our behaviours. Indeed, both physiological measures used in this lab study were found to be related *only* to aspects of self-regulation, with cortisol associated with self-control and its more cognitive aspects including a general future orientation and to some extent delay of gratification, and HRV associated with aspects of emotional regulation including depressive rumination and worry. Irrespective of a person's consideration of future/ immediate consequences, high self-control and to some extent high delay of gratification abilities were associated with lower levels of afternoon salivary cortisol, with lower levels of cortisol also found to be related to future time perspective. Associations were observed between HRV and both depressive rumination and worry, with higher levels of depressive rumination and worry associated with higher HRV.

Cortisol, HRV, and the cognitive and emotional aspects of self-control. It is clear from Table 4 that both cortisol and HRV show similar directional relationships to worry and rumination and self-control, however cortisol is more related to the cognitive aspects (self-control, delay of gratification, and broad future orientation) while HRV is clearly more related to the emotional aspects (rumination and worry). This idea is outlined in Figure 4 below. Figure 4 depicts a Venn diagram distinguishing emotional and cognitive functioning, with self-control intersecting both these domains. The figure also presents HRV as the foundation of the emotional functioning domain, while cortisol is the foundation of the cognitive functioning domain.

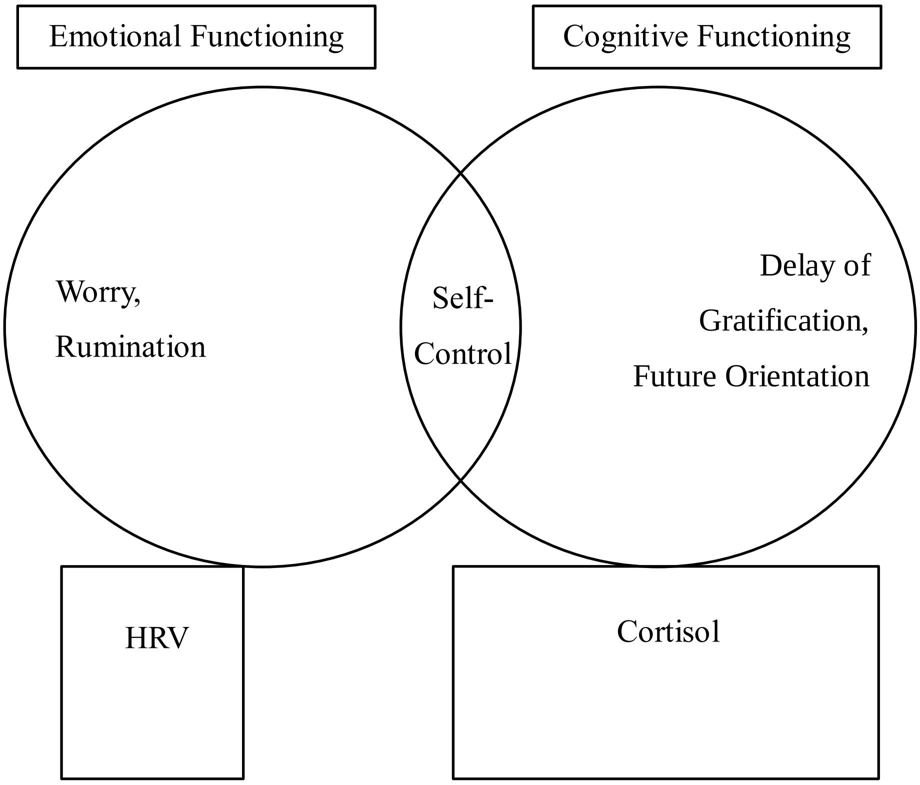

Figure 5. Venn diagram displaying the nomological relationships between key variables. Self-control is shown to relate to both emotional functions (emotional regulation techniques: worry, rumination) and cognitive functions (delay of gratification, future orientation). Heart rate variability (HRV) acts as a physiological “pillar” supporting emotional aspects of self-control, while cortisol underlies self-control and related aspects of cognitive functioning.

The finding that HRV and cortisol seem to underlie different aspects of self-regulation supports the idea that emotional regulation and cognitive and behavioural control are similar yet different constructs. Just as we must control our thoughts and behaviours such as how much we delay immediate gratification and how much we think about the future over the present, we must also regulate our emotions, shaping which emotions we have, when we have them, and how we experience and express them (Gross & Thompson, 2007). The very fact that in the present research self-control was associated with both the way we cognitively function (as seen in associations with gratification delay and future orientation) and our emotional functioning (as seen in associations with rumination and worry), and yet these aspects of cognitive and emotional functioning did not associate, also supports this notion of divergence between these constructs.

While self-control in general is our capacity for altering our own responses to bring them in line with social and moral standards and to reach our future goals, research has also found that emotion regulation is a specific form of self-control which may be central in the failure of other types of self-control (Tice & Bratslavsky, 2000). One salient example of people tending to give priority to short-term mood repair over their long-term goals is the often vicious cycle of dieting: limiting food intake may lead to negative affect, and a subsequent self-control breakdown in the form of an eating binge in a bid to make oneself feel better (Heatherton, Striepe, & Wittenberg, 1998).

Taken together, these results provide evidence of discriminant validity by showing that rumination and worry are related to self-control but are unrelated to future thinking, a strong correlate of self-control. These results also suggest that emotional control and general self-control and cognitive functioning have different physiological underpinnings. The following discussion explores this divergence.

HRV and salivary cortisol. The fact that HRV and cortisol were not found to relate in the present study warrants further discussion. Both have often been found to be associated with self-control, and both have been proposed as biological markers of self-regulation, but the lack of association found between self-control and HRV in the present study suggests cortisol and HRV may be biomarkers of distinct aspects of self-regulation. Rumination and worry, strategies of emotional regulation, were related to self-control and HRV, and yet HRV was unrelated to both self-control and cortisol. This curious result points to the possibility that HRV is a more specific marker of emotional regulation than broad-spectrum self-control, which appears to be indexed by cortisol (see Figure 4). In developing the BSCS, Tangeney and colleagues (2004) found some evidence linking high self-control to high levels of emotional stability (r = 0.50), a result suggesting that, while self-control is involved in emotion regulation, it is by no means the only mechanism by which we regulate and stabilize our emotions. What's more, Baumeister and colleagues have identified self-control as being important for controlling our thoughts, impulses, performance, and emotions (Baumeister et al., 2007; Muraven & Baumeister, 2000), again suggesting that while cortisol may relate to all of these facets of self-control, HRV may only be related to emotional control.

Cortisol and self-control, delay of gratification and future time perspective. The hypothesis that salivary cortisol would be associated not only with self-control but also with measures of future thinking was partially supported. Cortisol was found to positively associate with self-control scores and the ZTPI-F but not with CFC scores across time as evidenced by a lack of association between cortisol and CFC-grouping. This result could be due to the fact that the ZTPI-F is closely linked to self-control and delay of gratification, as mentioned above. Indeed, one recent study posits a strong overlap between items on the ZTPI-F and the BSCS (Milfont & Schwarzenthal, 2014). This suggests that the ZTPI-F is not merely a measure of future orientation but is more general, measuring aspects closely related to self-control including planning and goal-directed behaviour.

This cortisol result, while at odds with some literature finding *high* cortisol to be predictive of *better* functioning (Loney et al., 2006; Rosenblitt et al., 2001; Shoal et al., 2003), is nevertheless supported by recent literature finding an association between a steeper rate of cortisol decline across the day and high self-control (Daly et al., 2014). This finding in the present study was independent of sex, and was also independent of the time in the afternoon the individual was participating. Male or female, whether saliva was collected at 2:00 pm (the end of the day's first session) or 5:00 pm (the end of the day's final session), those with higher self-control, higher delay of gratification, and higher future orientation all had lower levels of cortisol. This result suggests that good self-control enabled a healthy pattern of neuroendocrine functioning and resilience against stress-related upsurges in cortisol. Accordingly, those lower in self-control may be more susceptible to feeling the stress of common stressors, preventing cortisol decline throughout the day and resulting in higher levels of afternoon cortisol. These results provide a good theoretical starting point. Future research should aim to further examine these conjectures, by measuring cortisol levels at least twice throughout the day – morning and evening – to truly further examine the relationship of these psychological variables to the cortisol slope in an undergraduate non-clinical sample.

HRV and emotional regulation. From the present results, it is clear that HRV is measuring emotional response. While the present study expected to find higher HRV to be associated with lower levels of emotional unrest, we appeared to find the opposite, with higher HRV correlating with higher levels of depressive rumination and worry. HRV also exhibited no relationship with reflective rumination, a construct thought to reflect a more positive, adaptive emotional response.

Most literature suggests an association between high HRV and lower levels of rumination and worry. The autonomic nervous system is a key system involved in generating the varying levels of physiological arousal associated with the emotions we experience (Levenson, 2003). A more rigid autonomic system is associated with a lower capacity for altering our physiological and emotional responses as the demands of our situation change, and this lower flexibility has traditionally been associated with lower HRV. Higher parasympathetically mediated HRV has often been found to be associated with regulated emotional responding as indexed by reduced distress when exposed to an unsettling film (Fabes, Eisenberg, & Eisenbud, 1993), higher social competence in children (Fabes, Eisenberg, Karbon, Troyer, & Switzer, 1994), and the use of constructive coping strategies by university students when stressed (Fabes & Eisenberg, 1997). Worry and rumination are associated with both anxiety and depression, which both share associations with deficits in emotional regulation such as maladaptive management and poor understanding of emotions, heightened emotional intensity, and negative reactivity to emotions (Mennin, Holaway, Fresco, Moore, & Heimberg, 2007).

What could explain the pattern of findings observed in our data? Some studies have found no differences in the HRV of worriers and non-worriers and have found no support for this theory that worriers are more autonomically rigid (e.g., Davis et al., 2002; Knepp & Friedman, 2008). Other studies have found the opposite, with Eisenberg and colleagues finding higher HRV to be an indicator of high social competence, the use of constructive coping strategies, and low emotionality across time for school-age boys only; HRV in girls instead acted as an index of nonconstructive coping and poorer emotional regulation (Eisenberg, Fabes, Murphy, Maszk, Smith, & Karbon, 1995). It is entirely possible that, due to bias against the publication of negative or null results that exists in many fields of science including psychology and medicine (e.g., Dickersin, Chan, Chalmers, Sacks, & Smith, 1987;

Ferguson & Heene, 2012; Hubbard & Armstrong, 1992), contradictory HRV results such as those found in the present study (i.e., positive associations between HRV and emotional unrest) are simply not often published.

It is also worth considering that perhaps depressive rumination and worry are associated with high HRV as they are adaptive emotional responses, particularly for our undergraduate student sample at this time of year coming up to finals. It has been suggested that mild-to-moderate depression is associated with enhanced rationality and an ability to see reality more clearly (Keedwell, 2008; Reznek, 2010), while a more severe depression is associated with a breakdown in our capacities for reason (Clark & Beck, 1999). It is quite possible that mild-to-moderate levels of worry and depression are associated with high HRV, while severe worry and depression are associated with low HRV and autonomic rigidity. Further research would benefit from analyzing the nature of the relationship between HRV and these strategies of emotional regulation traditionally seen as maladaptive, with a particular focus on depression.

Further Limitations and Future Directions

Along with the limitations and avenues for future research mentioned above, a few other limitations are also apparent. The reliability and generalizability of the findings may be compromised by the use of relatively small sample sizes and the nature of the sample: first year psychology students are not a fully representative sample, although we often wish they were. Future research should aim to recruit a more general population sample through the use of flyers both on campus (to recruit a broader university sample) and throughout the city, and through the use of social media. By utilizing these recruitment strategies, it would also be possible to investigate whether the same pattern of association between these variables holds across a sample with a broader age-range. As one striking feature of adulthood seems to be the emergence of substantial individual differences in delay behaviour (Lee, Lou, Wang, &

Chiu, 2008) – a difference which follows a general rise in gratification delay capacities from childhood to adolescence – differences in the nature of the relationship between these variables are also likely to exist at different stages of development. Potential cross-cultural differences should also be acknowledged, and investigated or controlled for in further analyses.

The present research may also be limited by only investigating responses on the future subscale of the ZTPI. While another measure of time perspective investigating concern for both the future and immediate consequences of actions was used (CFC-F and CFC-I), this measure is more specifically focusing on behaviour rather than the more general time perspective measured by the ZTPI. As in Study 2 where participants were clustered into extreme groups using the CFC-scale, it would be interesting to investigate whether there would be differences in self-control, emotional regulation, behaviour and physiology depending on how *balanced* a person's time perspective (i.e., those who endorse various time perspectives relatively evenly vs. those who strongly endorse one perspective in particular). Indeed, it would be surprising if this ability to switch flexibly between different perspectives to match the present situational demands (Boniwell & Zimbardo, 2004) did not rely on self-control, as self-control is by definition our capacity for altering our responses to bring them in line with social and moral standards and to reach our future goals (Baumeister et al., 2007).

Another potential limitation was the use of the self-report measure of delay of gratification. While the use of scales was more parsimonious for conducting the longitudinal mediation analyses of Study 1, the DGI-10 was not found to be a reliable measure for the lab study, Study 2 (Cronbach's a = .57). Further exploration into the effects observed in Study 1 could consider utilising the longer 35-item DGI, and a delay of gratification task conducted in a lab situation (for example, a response suppression task).

Finally, one notable limitation in the analysis of HRV in this study is that a reliable measure of physical fitness was not included. Studies have found that individuals who engage in regular exercise training and have good physical fitness have higher vagally-mediated HRV than controls who have not trained (Rossy & Thayer, 1998). By not taking a reliable measure of physical fitness, this study was unable to control for its possible influence on HRV. However, no associations were observed between HRV and smoking status and self-reported health in the present sample. This suggests that the inclusion of a physical fitness measure may also have had no effect on the sample as a whole.

Conclusions

While many of these findings were consistent with prior research, the present results fill an important gap in the literature, aiding in the understanding of the directional relationship between self-control, delay of gratification, and future orientation. We demonstrated that self-control is an important causal mechanism by which delay of gratification leads to higher concern for future consequences across time. Other mediators between delay of gratification and future orientation no doubt exist, and future longitudinal research would do well to continue investigating these other pathways.

The results of this research also showed that it was possible to predict a person's level of self-control and delay of gratification abilities from previously indicated levels of concern for future and immediate consequences. Finally, lower levels of afternoon cortisol were indicative of higher self-control, higher future time perspective scores, and greater abilities to delay gratification, and higher levels of HRV were indicative of greater use of the emotional regulation techniques depressive rumination and worry. These findings provide a good theoretical starting point, and future research should further investigate the role of self-control in future thinking, emotional regulation, behaviour, and aspects of our physiology longitudinally across the lifespan.

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Appendix A

Study 1 Information Sheet from Time 2

Samantha Watson: samantha.watson@vuw.ac.nz
MSc Student in Psychology
School of Psychology
Victoria University of Wellington

Dr. Taciano Milfont: taciano.milfont@vuw.ac.nz
Senior Lecturer
School of Psychology
Victoria University of Wellington

Welcome to this study: Investigating the Markers of Time Perspective

Purpose of this research:

• This research will examine the connections between self-control, psychological time, and pro-environmental behaviour.
• This study is interested in your opinions, attitudes and behaviours on a variety of social issues as well as psychological variables such as time perspective and self-control .

Who is conducting the research?

• Samantha Watson is a Masters student in the School of Psychology at Victoria University of Wellington. Dr Taciano Milfont is responsible for supervising this project. This research has been approved by the School of Psychology Human Ethics Committee under delegated authority of the VUW Human Ethics Committee (approved 22/05/2014; Reference number: 0000020759).

What is involved if you agree to participate?

• If you agree to participate in this study, you will complete an online survey questionnaire asking you about your opinions on a variety of social issues, and includes questions about you.
• We anticipate that the study will take no longer than 30 minutes to complete.
• During the research you are free to withdraw at any point before your survey has been completed.

Privacy and Confidentiality

• We will retain electronic data in anonymous form indefinitely (999 years).
• You will never be identified in the research project or in any other presentation or publication. The information you provide will be coded by number only, and your email address and name will be stored in a separate file.
• In accordance with the requirements of some scientific journals and organisations, your data - without identifying details - may be shared with other competent researchers.
• Your survey responses may be used in other, related studies, which would require separate ethics approval. No other such research has been approved at this time.

What happens to the information that you provide?

• The overall findings will be part of a Masters thesis that will be submitted for assessment. The overall findings may be submitted for publication in a scientific journal, or presented at scientific conferences.
• If you would like to know the results of this study, you will be offered the opportunity to enter your preferred email address at the end of this survey. You will be emailed a link to the results when they are available. Your email address will be kept in a separate file from your data, and will be destroyed when results are available (estimated: March 2015). If you have any further questions regarding this study please contact us via email.

Appendix B

Study 1 Debriefing Sheet from Time 2

TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI
VICTORIA
UNIVERSITY OF WELLINGTON

Thank you for participating in this study. Application number: 0000020759

Research has shown that how we monitor our personal use of common resources, think about the effects that our usage has on the environment, and our level of awareness of the usage patterns of others are related to how likely we are to act pro-environmentally (Gifford & Wells, 1991). This research investigates the relationships between psychological time (how you subjectively experience the passage of time, and whether you live more in the present moment or think more about the future), self-control, and pro-environmental actions.

Future time perspective has consistently been found to play an important role in influencing pro-environmental attitudes and behaviours, with future-focused individuals appearing to care more about and act to address environmental issues (Milfont, Wilson, & Diniz, 2012). While little is known about the role of self-control in time perspective and pro-environmentalism, studies have found those who can delay immediate gratification in favour of a preferred reward in the future have higher levels of self-control (see research using the "marshmallow task": Duckworth, Tsukayama, & Kirby, 2012).

By looking at the relationships between psychological time, self-control, and pro-environmentalism, it is hoped that we can shed light on the role of self-control in time perspective and pro-environmentalism.

Thank you again for participating in this research. This research project is being conducted by Samantha Watson, a Masters student, and her supervisor, Dr. Taciano L. Milfont, from the School of Psychology, Victoria University of Wellington. If you have any questions regarding your involvement in this research, or issues regarding the research in general, please do not hesitate to contact me via e-mail at Samantha.Watson@vuw.ac.nz.

Please note: None of the procedures or questions included in this study are intended to cause any upset. However, if you are feeling upset then it may help to consult your family doctor or a psychological counselling service.
Kelburn Campus Student Counselling Service: 04-463 5310

References:

Duckworth, A. L., Tsukayama, E., & Kirby, T. A. (2012). Is it really self-control? Examining the predictive power of the delay of gratification task. *Personality and Social Psychology Bulletin, 39*(7), 843-855.

Gifford, R., & Wells, J. (1991). FISH: A commons dilemma simulation. *Behaviour Research Methods, Instruments, & Computers, 23*(3), 437-441.

Milfont, T. L., Wilson, J., & Diniz, P. (2012). Time perspective and environmental engagement: A meta-analysis. *International Journal of Psychology, 47*(5), 325-334.

Appendix C

Zimbardo Time Perspective Inventory – Future Subscale (13 items)

Please read each of the following statements and, as honestly as you can, answer the following question: **How characteristic or true is this of you?**

1 Very uncharacteristic	**2 Uncharacteristic**	**3 Neutral**	**4 Characteristic**	**5 Very characteristic**

Meeting tomorrow's deadline and doing other necessary work comes before tonight's play.	1	2	3	4	5
I complete projects on time by making steady progress.	1	2	3	4	5
I am able to resist temptations when I know that there is work to be done.	1	2	3	4	5
When I want to achieve something, I set goals and consider specific means for reaching those goals.	1	2	3	4	5
I keep working at difficult uninteresting work if it will help me get ahead.	1	2	3	4	5
It upsets me to be late for appointments.	1	2	3	4	5
I believe that a person's day should be planned ahead each morning.	1	2	3	4	5
I meet my obligations to friends and authorities on time.	1	2	3	4	5
I make lists of things to do.	1	2	3	4	5
Before making a decision, I weight the costs against the benefits.	1	2	3	4	5
If things don't get done on time, I don't worry about it.	1	2	3	4	5
There will always be time to catch up on my work.	1	2	3	4	5
I take each day as it is rather than try to plan it out.	1	2	3	4	5

Appendix D

Consideration of Future Consequences Scale (14 items)

For each of the statements shown, please indicate whether or not the statement is characteristic of you.

1———2———3———4———5———6———7

Very uncharacteristic of me	**Neutral**	**Very characteristic of me**

		Subscale
I consider how things might be in the future, and try to influence those things with my day to day behaviour.	1 2 3 4 5 6 7	F
Often I engage in a particular behaviour in order to achieve outcomes that may not result for many years	1 2 3 4 5 6 7	F
I only act to satisfy immediate concerns, figuring the future will take care of itself.	1 2 3 4 5 6 7	I
My behaviour is only influenced by the immediate (i.e., a matter of days or weeks) outcomes of my actions.	1 2 3 4 5 6 7	I
My convenience is a big factor in the decisions I make or the actions I take.	1 2 3 4 5 6 7	I
I am willing to sacrifice my immediate happiness or well-being in order to achieve future outcomes.	1 2 3 4 5 6 7	F
I think it is important to take warnings about negative outcomes seriously even if the negative outcome will not occur for many years.	1 2 3 4 5 6 7	F
I think it is more important to perform a behaviour with important distant consequences than a behaviour with less important immediate consequences.	1 2 3 4 5 6 7	F
I generally ignore warnings about possible future problems because I think the problems will be resolved before they reach crisis level.	1 2 3 4 5 6 7	I
I think that sacrificing now is usually unnecessary since future outcomes can be dealt with at a later time.	1 2 3 4 5 6 7	I
I only act to satisfy immediate concerns, figuring that I will take care of future problems that may occur at a later date.	1 2 3 4 5 6 7	I
Since my day to day work has specific outcomes, it is more important to me than behaviour that has distant outcomes.	1 2 3 4 5 6 7	I
When I make a decision, I think about how it might affect me in the future.	1 2 3 4 5 6 7	F
My behaviour is generally influenced by future consequences.	1 2 3 4 5 6 7	F

Appendix E

Delaying Gratification Inventory (10 items)

Please indicate the extent to which you *agree* or *disagree* with each of the following statements using the 5-point scale below.

1	**2**	**3**	**4**	**5**
Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**

I would have a hard time sticking with a special, healthy diet.	1	2	3	4	5
I try to spend my money wisely.	1	2	3	4	5
I have given up physical pleasure or comfort to reach my goals.	1	2	3	4	5
I try to consider how my actions will affect other people in the long-term.	1	2	3	4	5
I cannot be trusted with money.	1	2	3	4	5
I do not consider how my behaviour affects other people.	1	2	3	4	5
I cannot motivate myself to accomplish long-term goals.	1	2	3	4	5
I have always tried to eat healthy because it pays off in the long run.	1	2	3	4	5
When faced with a physically demanding chore, I always tried to put off doing it.	1	2	3	4	5
I have always felt like my hard work would pay off in the end.	1	2	3	4	5

Appendix F

Brief Self-Control Scale (13 items)

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

1————2————3————4————5

Not at all like me | **Neutral** | **Very much like me**

I am good at resisting temptation.	1	2	3	4	5
I have a hard time breaking bad habits.	1	2	3	4	5
I am lazy.	1	2	3	4	5
I say inappropriate things.	1	2	3	4	5
I do certain things that are bad for me, if they are fun.	1	2	3	4	5
I refuse things that are bad for me.	1	2	3	4	5
I wish I had more self-discipline.	1	2	3	4	5
People would say that I have iron self-discipline.	1	2	3	4	5
Pleasure and fun sometimes keep me from getting work done.	1	2	3	4	5
I have trouble concentrating.	1	2	3	4	5
I am able to work effectively toward long-term goals.	1	2	3	4	5
Sometimes I can't stop myself from doing something, even if I know it is wrong.	1	2	3	4	5
I often act without thinking through all the alternatives.	1	2	3	4	5

Appendix G

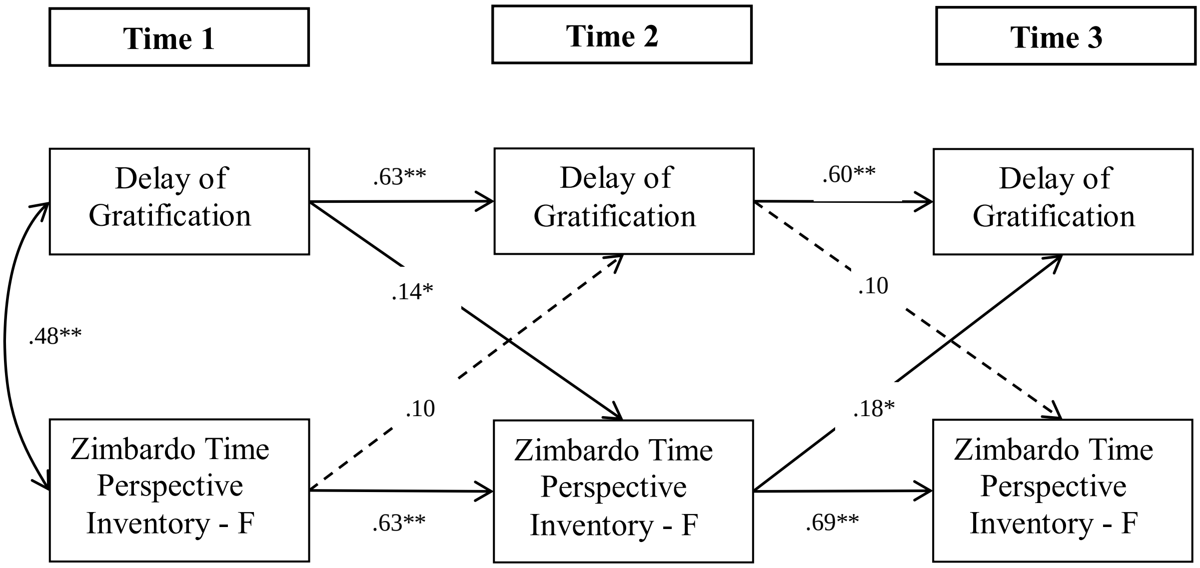

Figure G1. Cross-lagged path model with standardised regression weights linking delay of gratification and the consideration of future consequences at Time 1, Time 2 and Time 3. Dashed lines represent non-significant pathways ($p > .05$). $*p < .05$, $**p < .001$.

As can be seen in the Figure G1, this cross-lagged path model presents a less clear pattern of results than those seen in Figures 1 and 2. Here, neither variable reliably predicts the other across time.

APPENDIX H

Lab Study Information Sheet

TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI
VICTORIA
UNIVERSITY OF WELLINGTON

Samantha Watson: samantha.watson@vuw.ac.nz
MSc Student in Psychology
School of Psychology
Victoria University of Wellington

Dr. Taciano Milfont: taciano.milfont@vuw.ac.nz
Senior Lecturer
School of Psychology
Victoria University of Wellington

Welcome to this study: Investigating the Markers of Future Time Perspective

What is the purpose of this research?

- This research will examine the connections between self-control, psychological time, and pro-environmental behaviour in relation to basic physiological measures (heart rate, cortisol level in saliva, an indicator of stress even at low stress levels).
- This lab study is interested in your opinions, attitudes and behaviours on a variety of social issues as well as psychological variables such as time perspective and self-control.

Who is conducting the research?

- Samantha Watson is a Masters student in the School of Psychology of Victoria University of Wellington. Dr. Taciano Milfont is responsible for supervising this project.
  - This research has been approved by the School of Psychology Human Ethics Committee under delegated authority of the VUW Human Ethics Committee (Approved 22/05/2014; Application # 0000020759).

What is involved if you agree to participate?

- If you agree to participate in this study your heart rate will be measured during the study using a chest-belt monitor against your skin which you may put on yourself, and you will provide saliva samples for analysis of salivary cortisol levels, both of which have been implicated in self-control and impulsivity.
- You will complete an online survey questionnaire asking you about your opinions on a variety of social issues, and includes questions about you. You will also be given links to an online resource dilemma simulation and an online risk simulation.
- We anticipate that the study will take you no more than one hour to complete in total.
- During the research you are free to withdraw at any point before your survey has been completed.

Privacy and confidentiality

- We will keep your consent forms up to five years post-publication, and will retain electronic data in anonymous form indefinitely (999 years).
- Saliva samples will be destroyed during the analysis process.
- You will never be identified in this research project or in any other presentation or publication. The information you provide will be coded by number, and your name will be stored in a separate file.
- In accordance with the requirements of some scientific journals and organisations, your data - without identifying details - may be shared with other competent researchers.
- Data without identifying names may also be used in other, related studies, which would require separate ethics approval. No physiological information will be correlated with variables not covered in the current lab study. No other such research has been approved at this time.

What happens to the information that you provide?

- The overall findings will be part of a Masters thesis submitted for assessment. The overall findings may be submitted for publication in a scientific journal, or presented at scientific conferences.
- If you would like to know the results of this study, please write your email address on the sheet provided and you will be emailed a link when the results are available. Your email address will be kept separate from your data, and will be destroyed when results are available (estimated: March 2015). If you have any further questions regarding this study please contact us via email.

APPENDIX I

Lab Study Consent Form

Statement of consent

I have read the information about this research and any questions I wanted to ask have been answered to my satisfaction. I understand that I can withdraw my consent at any time, without penalty, prior to the end of my participation.

I understand that my name and student ID will be removed from the dataset and that my data will never be linked with my name.

I agree that a copy of an anonymous database containing my data can be kept indefinitely by Dr. Taciano L. Milfont, and that this anonymous database may also be shared with other competent professionals and used in similar research.

I agree to have my heart rate measured.

I agree to have my salivary cortisol levels measured via saliva samples. Saliva samples will be stored in a freezer dedicated to research purposes only. I understand that these samples of my cortisol levels will be coded by number and not by my name. I understand that this material will be destroyed during the analysis process.

I agree to participate in this research.

Name: ___________________________________

Student ID: _______________________________

Signature: ________________________________

Date: ____________________________________

APPENDIX J

Lab Study Debriefing Sheet

TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI
VICTORIA
UNIVERSITY OF WELLINGTON

Thank you for participating in this study. Application number: 0000020759

Research has shown that how we monitor our personal use of common resources, think about the effects that our usage has on the environment, and our level of awareness of the usage patterns of others are related to how likely we are to act pro-environmentally (Gifford & Wells, 1991). This research investigates the relationships between psychological time (how you subjectively experience the passage of time, and whether you live more in the present moment or think more about the future), self-control, and pro-environmental actions.

Future time perspective has consistently been found to play an important role in influencing pro-environmental attitudes and behaviours, with future-focused individuals appearing to care more about and act to address environmental issues (Milfont, Wilson, & Diniz, 2012). While little is known about the role of self-control in time perspective and pro-environmentalism, studies have found those who can delay immediate gratification in favour of a preferred reward in the future have higher levels of self-control (see research using the "marshmallow task": Duckworth, Tsukayama, & Kirby, 2012). What's more, aspects of physiology such as heart rate and cortisol have been found to be related to impulsivity and self-control (for instance, see Geisler & Kubiak, 2009, and Shoal, Giancola, & Kirillova, 2003).

By looking at the relationships between psychological time, self-control, and pro-environmentalism, it is hoped that we can shed light on the role of self-control in time perspective and pro-environmentalism.

Thank you again for participating in this research. This research project is being conducted by Samantha Watson, a Masters student, and her supervisor, Dr. Taciano L. Milfont, from the School of Psychology, Victoria University of Wellington. If you have any questions regarding your involvement in this research, or issues regarding the research in general, please do not hesitate to contact me via e-mail at Samantha.Watson@vuw.ac.nz. If you would like to know the results of the study and did not provide your email address, please email the experimenter and a link to the results will be emailed to you once they are available. Your email address will be kept separate from your data, and will be destroyed when results are available (estimated: March 2015).

Please note: None of the procedures or questions included in this study are intended to cause any upset. However, if you are feeling upset then it may help to consult your family doctor or a psychological counselling service.
Kelburn Campus Student Counselling Service: 04-463 5310

References:

Duckworth, A. L., Tsukayama, E., & Kirby, T. A. (2012). Is it really self-control? Examining the predictive power of the delay of gratification task. *Personality and Social Psychology Bulletin, 39*(7), 843-855.

Geisler, F. C., & Kubiak, T. (2009). Heart rate variability predicts self-control in goal pursuit. *European Journal of Personality, 23,* 623-633.

Gifford, R., & Wells, J. (1991). FISH: A commons dilemma simulation. *Behaviour Research Methods, Instruments, & Computers, 23*(3), 437-441.

Milfont, T. L., Wilson, J., & Diniz, P. (2012). Time perspective and environmental engagement: A meta-analysis. *International Journal of Psychology, 47*(5), 325-334.

Shoal, G. D., Giancola, P. R., & Kirillova, G. P. (2003). Salivary cortisol, personality and aggressive behaviour in adolescent boys: A 5-year longitudinal study. *American Academy of Child & Adolescent Psychiatry, 42*(9), 1101-1107.

Appendix K

Ruminative Responses Scale (22 items)

People think and do many different things when they feel depressed. Please read each of the items below and indicate whether you almost never, sometimes, often, or almost always think or do each one when you feel down, sad, or depressed. Please indicate what you *generally* do, not what you think you should do.

1	2	3	4
Almost Never	**Sometimes**	**Often**	**Almost Always**

					Subscale
think about how alone you feel	1	2	3	4	D
think “I won’t be able to do my job if I don’t snap out of this”	1	2	3	4	D
think about your feelings of fatigue and achiness	1	2	3	4	D
think about how hard it is to concentrate	1	2	3	4	D
think “What am I doing to deserve this?”	1	2	3	4	B
think about how passive and unmotivated you feel.	1	2	3	4	D
analyze recent events to try to understand why you are depressed	1	2	3	4	R
think about how you don’t seem to feel anything anymore	1	2	3	4	D
think “Why can’t I get going?”	1	2	3	4	D
think “Why do I always react this way?”	1	2	3	4	B
go away by yourself and think about why you feel this way	1	2	3	4	R
write down what you are thinking about and analyze it	1	2	3	4	R
think about a recent situation, wishing it had gone better	1	2	3	4	B
think “I won’t be able to concentrate if I keep feeling this way.”	1	2	3	4	D
think “Why do I have problems other people don’t have?”	1	2	3	4	B
think “Why can’t I handle things better?”	1	2	3	4	B
think about how sad you feel.	1	2	3	4	D
think about all your shortcomings, failings, faults, mistakes	1	2	3	4	D
think about how you don’t feel up to doing anything	1	2	3	4	D
analyze your personality to try to understand why you are depressed	1	2	3	4	R
go someplace alone to think about your feelings	1	2	3	4	R
think about how angry you are with yourself	1	2	3	4	D

Appendix L

Penn State Worry Questionnaire (16 items)

Instructions: Rate each of the following statements on a scale of 1 (“not at all typical of me”) to 5 (very typical of me”). Please do not leave any items blank.

1	2	3	4	5
Not at all typical of me				Very typical of me

If I do not have enough time to do everything, I do not worry about it.	1	2	3	4	5
My worries overwhelm me.	1	2	3	4	5
I do not tend to worry about things.	1	2	3	4	5
Many situations make me worry.	1	2	3	4	5
I know I should not worry about things, but I just cannot help it.	1	2	3	4	5
When I am under pressure I worry a lot.	1	2	3	4	5
I am always worrying about something.	1	2	3	4	5
I find it easy to dismiss worrisome thoughts.	1	2	3	4	5
As soon as I finish one task, I start to worry about everything else I have to do.	1	2	3	4	5
I never worry about anything.	1	2	3	4	5
When there is nothing more I can do about a concern, I do not worry about it anymore.	1	2	3	4	5
I have been a worrier all my life.	1	2	3	4	5
I notice that I have been worrying about things.	1	2	3	4	5
Once I start worrying, I cannot stop.	1	2	3	4	5
I worry all the time.	1	2	3	4	5
I worry about projects until they are all done.	1	2	3	4	5

Appendix M

FISH 4.0: Introduction and Script Used

A brief introduction taken from Page 1 of the Manual for FISH 4.0 (Gifford & Aranda, 2014):

> "FISH 4.0 is a microworld exercise designed by University of Victoria professor Dr. Robert Gifford and programmed by Dr. Jorge Aranda for studying the resource management decision-making of individuals and small groups. It is especially useful for conducting studies that examine situations often called commons dilemmas, resource dilemmas, or social dilemmas. These situations focus on valuable, limited, common pool resources in which individuals make decisions whether to cooperate (harvest little, resulting in modest short-term gain but long-term conservation of the resource) or defect (harvest a large amount, resulting in large short-term gains but endangering or even extinguishing the common resource (Gifford & Gifford, 2000). FISH 4.0 can be run with either all human fishers, or both human and computer-simulated fishers."

Preparatory FISH Information seen by participants prior to fishing in the experimental simulation:

> FISH simulates fishing in an ocean. You and the other fishers are the only fishers in this ocean. All the fishers see the same ocean that you do. At the beginning, the number of fish will be displayed on the screen. Once the simulation begins, you and the other fishers may catch as many of these fish as you like. Once you have taken as many fish as you want, you return to port with your catches, and the first season ends. Then the fish spawn for the next season, if any are left to spawn (if no fish are left, they cannot spawn). For every fish left at the end of one season, two fish will be available to be caught in the next season. However, because the ocean can support only so many fish, the total number of fish will never exceed the original number of fish. Fishing can go on this way for many seasons, but all fishing permanently ceases any time that all the fish are caught.
>
> You can make money fishing. You will be paid $3 for every fish you catch. (For now, this is 'play' money...but please treat it as if it were real money.)
>
> Your job is to consider all these factors, and the other fishers, and make your own decisions about how to fish. Fish however you wish.
>
> Please ask if anything is unclear. We want you to fully understand the rules before you start fishing.
>
> If you are sure you understand all the above, you are ready to fish. Click on the Go Fishing button when you are ready to begin the first season. (There may be a brief wait while the other fishers are loading.)

FISH manual Reference:

Gifford, R., & Aranda, J. (2014). *Manual for FISH 4.0.* University of Victoria, British Columbia, Canada.

Appendix N

Further Information About the Balloon Analogue Risk Task (BART)

PLEASE NOTE: Samantha Watson has a 1-year license with Inquisit Web by Millisecond Software (account valid until April 16th 2015). The BART is an Active Web Script on her account. Any BART data collected will only be recorded to and accessible from this account.

BART SCRIPT:

- INSTRUCTIONS:
  - Now you're going to see 20 balloons, one after another, on the screen. For each balloon, you will use the mouse to click on the button that will pump up the balloon. Each click on the mouse pumps the balloon up a little more.
  - BUT remember, balloons pop if you pump them up too much. It is up to you to decide how much to pump up each balloon. Some of these balloons might pop after just one pump. Others might not pop until they fill the whole screen.
  - You get MONEY for every pump. Each pump earns $0.05. But if a balloon pops, you lose the money you earned on that balloon. To keep the money from a balloon, stop pumping before it pops and click on the button labelled ~"Collect $$$~".
  - After each time you collect $$$ or pop a balloon, a new balloon will appear.
  - At the end of the experiment, you will need to take note of the amount earned on the game.
  - Click the left mouse button to see the summary.
- SUMMARY
  - * You make $0.05 for each pump.
  - * You save the money from a balloon when you click ~"Collect $$$"~.
  - * You lose money from a balloon when it pops.
  - * There are just 20 balloons.
  - * You will need to take note of the exact amount you earned on the game.
  - Click the left mouse button to begin.
- AFTER TASK MESSAGE
  - Congratulations!
  - You have earned $_________.
  - The task is now complete. Take note of how much money you earned, as you will be required to enter this information in the Qualtrics survey. Click the left mouse button to continue.

DESCRIPTION (taken from website: http://www.impulsivity.org/measurement/BART): The BART is a computerized measure of risk taking behaviour. The BART models real-world risk behaviour through the conceptual frame of balancing the potential for reward versus loss. In the task, the participant is presented with a balloon and offered the chance to earn money by pumping the balloon up by clicking a button. Each click causes the balloon to incrementally inflate and money to be added to a counter up until some threshold, at which point the balloon is over inflated and explodes. Thus, each pump confers greater risk, but also greater potential for reward. If the participant chooses to cash-out prior to the balloon exploding then they collect the money earned for that trail, but if balloon explodes earnings for that trial are lost. Participants are not informed about the balloons breakpoints; the absence of this information allows for testing both participants' initial responses to the task and changes in responding as they gain experience with the task contingencies. Risk taking is a related, but phenomenologically distinct process from impulsivity.

SCORING: The primary score used to measure BART performance is the adjusted average number of pumps on unexploded balloons, with higher scores indicative of greater risk-taking propensity (Bornovalova et al. 2005; Lejuez et al. 2002). In the original version of the task, each pump was worth $.05 and there were 30 total balloons across a range of different contingencies. Balloon breakpoints range from 1-8, 1-32, or 1-128 pumps. For example, for a 1-128 breakpoint, the probability that a balloon would explode on the first pump is 1/128. If the balloon did not explode on the first pump, the probability that the balloon would explode on the second pump is 1/127, and so no. According to this algorithm, the average break point for the 1-128 breakpoint would be the midpoint of the range, or 64 pumps.

METHODOLOGICAL CONSIDERATION: **We are using a total of 20 balloons instead of the default 30 balloons**, with each pump worth $0.05. This is imaginary money only. No real money will be given. Participants are only rewarded with IPRP credit for participating.

- REASONING: Study design often limits the administration time for any single task and there is interest in knowing the most appropriate task duration that maximizes quality of data while minimizing participant burden. Studies have varied the number of balloon trials, with the most common duration being 30 trials. In studies using 30 balloons, the score across all balloons is typically more reliable than any single 10 balloon block. However under time constraints, using fewer balloons may be necessary. Research indicates that correlations with the total score are acceptable for the first 10 balloons (~.6) and are good for balloons 11-20 (~.8) with little change for balloons 21-30 (~.8). Thus, an argument can be made for any choice between 10 and 30 balloons to balance time research testing time constrains.

PSYCHOMETRIC PROPERTIES OF THE BART: **Reliability:** Reliability has been well established across many samples and testing conditions. Adults tend to show modest increases in risk-taking across the blocks. Analyses have revealed reasonably robust test-retest correlations (T1/T2 $r = .77$). **Validity:** BART performance appears to be related to early engagement in substance use as well as to risk behaviours related to substance use. The relationship between BART score and risk behaviour may be moderated by other variables: in one study, the relationship between BART and risk-taking was only found in adolescents who were low in the ability to tolerate distress.

BART instrument reference:

Lejuez, C. W., Read, J. P., Kahler, C. W., Richards, J. B., Ramsey, S. E., Stuart, G. L., Strong, D. R., & Brown, R. A. (2002). Evaluation of a behavioral measure of risk taking: The Balloon Analogue Risk Task (BART). *Journal of Experimental Psychology: Applied, 8*, 75-84. PubMed ID 12075692

Reliability study citations:

White, T. L., Lejuez, C. W., & de Wit, H. (2008). Test-retest characteristics of the Balloon Analogue Risk Task (BART). Experimental and clinical psychopharmacology, 16(6), 565.

Lejuez, C. W., Read, J. P., Kahler, C. W., Richards, J. B., Ramsey, S. E., Stuart, G. L., ... & Brown, R. A. (2002). Evaluation of a behavioral measure of risk taking: the Balloon Analogue Risk Task (BART). Journal of Experimental Psychology: Applied, 8(2), 75.

Validity study citations:

Aklin, W. M., Lejuez, C. W., Zvolensky, M. J., Kahler, C. W., & Gwadz, M. (2005). Evaluation of behavioral measures of risk taking propensity with inner city adolescents. Behaviour research and therapy, 43(2), 215-228.

Fernie, G., Cole, J. C., Goudie, A. J., & Field, M. (2010). Risk-taking but not response inhibition or delay discounting predict alcohol consumption in social drinkers. Drug and alcohol dependence, 112(1), 54-61.

Crowley, T. J., Raymond, K. M., Mikulich-Gilbertson, S. K., Thompson, L. L., & Lejuez, C. W. (2006). A risk-taking "set" in a novel task among adolescents with serious conduct and substance problems. Journal of the American Academy of Child & Adolescent Psychiatry, 45(2), 175-183.

MacPherson, L., Magidson, J. F., Reynolds, E. K., Kahler, C. W., & Lejuez, C. W. (2010). Changes in Sensation Seeking and Risk-Taking Propensity Predict Increases in Alcohol Use Among Early Adolescents. Alcoholism: Clinical and Experimental Research, 34(8), 1400-1408.

MacPherson, L., Reynolds, E. K., Daughters, S. B., Wang, F., Cassidy, J., Mayes, L. C., & Lejuez, C. W. (2010). Positive and negative reinforcement underlying risk behavior in early adolescents. Prevention Science, 11(3), 331-342.

Appendix O

Email Correspondence Between the Researcher and Steroid Biochemist John G. Lewis Regarding the Analysis of Salivary Cortisol

After requesting further information regarding the method of salivary cortisol analysis, the following reply was received:

> "The method of cortisol analysis was by enzyme-linked immunosorbent assay (ELISA) with conditions as in the attached paper except using extracted saliva samples and differing standards. Saliva (250uL) was extracted with 1 mL of dichloromethane and 0.5 mL evaporated to dryness. The dried extract was reconstituted in 125uL of assay buffer and 50uL used in duplicate/well. Cortisol standards were prepared from a stock solution (1mg/mL in ethanol) by dilution to 1ug/mL followed by a further 1 in 10 dilution in assay buffer which formed the top standard of 280 nmol/L. Further standards were prepared by dilution in assay buffer to yield cortisol standards of 56; 28; 14; 7 and 3.5 nmol/L. In addition 4 zero points were used with other conditions and reagents as described in the attached paper." (J. G. Lewis, personal communication, 28 January 2015).

The conditions and reagents described in the paper attached to the email correspondence (Lewis, Manley, Whitlow, & Elder, 1992) include an incubation buffer (phosphate-buffered saline), an assay buffer to prevent further absorption of protein (PBS containing 0.1% Tween 20 and 0.1% gelatin) and substrate solution (*o*-phenylenediamine, Na_2HPO_4, and a citric acid buffer).

ELISA method citation:

Lewis, J. G., Manley, L., Whitlow, J. C., & Elder, P. A. (1992). Production of a monoclonal antibody to cortisol: Application to a direct enzyme-linked immunosorbent assay of plasma. *Steroids*, *57*(2), 82-85.

Appendix P

HRV Correlations, Raw and Natural Log Transformed Values, Means and Standard Deviations

Bivariate Correlations between Psychological Variables, Behavioural Measures, Cortisol, and Three Measures of HRV and their Log Transformed (l.n.) Values: Standard Deviation of Inter-Beat-Intervals (SDNN), the Root Mean Square of Differences between Inter-Beat-Intervals (RMSSD), and the High Frequency Range (HF).

	CFC-group	ZTPI-F	DGI	S-C	Rum	Worry	Fish Taken	Balloon Pops	Cortisol	SDNN	RMSSD	HF	SDNN l.n.	RMSSD l.n.	HF l.n.
SDNN	.054	.014	-.001	-.061	**.216**†	**.325***	.067	.082	.052						
RMSSD	.014	-.079	-.070	-.129	**.247***	**.257***	.176	.066	-.042	**.863****					
HF	.025	-.110	-.063	-.141	**.219**†	**.265***	.187	-.012	.006	**.807****	**.931****				
SDNN l.n.	.017	-.002	-.034	-.086	**.217**†	**.309***	.070	.104	.059	**.961****	**.834****	**.749****			
RMSSD l.n.	-.006	-.069	-.089	-.134	**.259***	**.250***	.157	.085	-.047	**.844****	**.946****	**.844****	**.883****		
HF l.n.	-.012	-.079	-.071	-.148	**.254***	**.248***	.140	.028	-.010	**.763****	**.885****	**.870****	**.796****	**.946****	
Mean	-	3.30	3.54	2.85	2.05	3.00	20.12	191.41	14.83	60.32	46.21	1192.61	4.02	3.69	6.53
Std Dev	-	0.43	0.43	0.49	0.56	0.82	3.93	96.38	7.08	25.17	25.95	1250.34	0.41	0.55	1.12

Note. ****p*** $< .001$ ***p*** $< .05$ †*p* $< .09$. Statistically significant relationships have been bolded for clarity. HF was used as the measure of HRV in the present study, with HF l.n. used in analyses to reduce skewness.