Submitted on Time: Measuring, Predicting, and Reducing Procrastination

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Abstract

Procrastination is the volitional delay of an intended task, despite believing that delay will be harmful. While not all delay is attributable to procrastination, procrastination is fundamentally characterised by delay. As much as 90% of the population have experience with procrastination, with around 20% in the general population and 50% of university students reporting problematic levels of chronic procrastination. Compared to their non-procrastinating peers, chronic procrastinators report lower levels of wellbeing, higher rates of depression, higher rates of alcohol and other drug use for coping, and poor health adjustment. Procrastinators tend to have lower salaries, shorter durations of employment, and a greater likelihood of being unemployed or underemployed. There is also a direct economic impact on the workforce, with office workers found to spend an average of 1.5 hours per work day procrastinating.

Despite its prevalence, the variability of tasks, time available, subjectivity, and individual differences render procrastination difficult to observe as it happens. Consequently, while correlates, antecedents, effects, and types of procrastination have been widely investigated, progress in this field is limited by several factors. In particular, few studies have accurately quantified delay associated with procrastination over time. As a consequence, there is limited evidence supporting the ability of trait measures of procrastination to predict delay, and few interventions aimed at reducing procrastination have been clearly associated with reduced delay. Recent developments in smartphone technology and Experience Sampling Method (ESM) applications have enabled intensive longitudinal observations of such dynamic

phenomena with relative ease; however, such methodology and statistical modelling of delay have yet to be reliably applied to the study of procrastination.

To address the challenge of observing delay associated with procrastination, I conducted three studies of students enrolled in a 1st year psychology course: a small pilot study (*N* = 24) and two larger scale replications (*Ns* = 80 and 107) focusing on intensive longitudinal measurement of delay, procrastination scale validation, and an intervention to reduce procrastination respectively. Participant ages ranged from 17.38 to 65.85 years (*M* = 23.85, *SD* = 9.49) and 75% identified as female. Each study included a baseline survey of demographic and trait procrastination and personality variables, an ESM phase comprised of 28 SMS surveys over 14 days in the lead-up to submission of an assignment worth 30% of the course grade, and the collection of assignment submission date and mark from the course convenor. Participants in the ESM phase were randomly allocated into either an intervention or control condition, with participants in both conditions reporting their assignment progress, completion intent, and affect regarding their assignment progress. Participants in the intervention, but not the control, condition were messaged at the end of each ESM survey with open reflection prompts designed to reduce procrastination. Studies 1 and 3 also included follow up interviews with a small subsample of participants (*N* = 8) to garner first-hand perspectives of participation in the ESM component of the studies.

Through the application of multilevel model analyses, the presence of quantified delay curves in all three studies provides firm evidence that regular self-reporting of task progress using ESM is a robust and reliable method for measuring behavioural delay. The use of multilevel modelling in quantifying delay enabled the inclusion of mixed effects, where the predictive ability of several procrastination scales could be assessed. A trait measure of passive procrastination was found to reliably predict behavioural delay, whereas no association was found between a measure of active procrastination, a type of procrastination purported to be adaptive and deliberate, and delay. The intervention prompting regular reflection on factors thought to be related to procrastination that was embedded into the ESM phase of each study was found to significantly reduce delay in Studies 1 and 3, but not in Study 2. Between-study differences in this intervention effect were likely related to contextual differences as participants in Study 2 were aware that the research pertained to procrastination whereas those in the other studies were not informed of the focus on procrastination. In the follow-up interviews, participants reported that regularly reporting task progress, as well as the intervention reflection prompts, may have assisted with the reduction of procrastination. Analyses conducted into the relationships between trait procrastination, neuroticism, and state affect and delay revealed that neuroticism (emotional stability) moderated the relationship between trait procrastination and affect, and affect mediated the relationship between trait procrastination and task delay. Moreover, cross-lagged panel model analyses of inter-temporal changes in affect and delay showed that participants who reported greater task progress at an earlier time were likely to report higher positive affect at a subsequent time, whereas those reporting higher positive affect at an earlier time tended to report lower progress at a subsequent time.

Overall, the research offers three specific unique contributions to the body of knowledge. First, the use of ESM surveys of task progress is demonstrated to be a reliable method for measuring behavioural delay associated with procrastination. This is evidenced by the presence of accelerating delay curves, where assignment progress increases in a hyperbolic trajectory prior to a submission date. The reliable observation and modelling of delay is an oft-cited limitation of the field; thus, the replicated validation of this as a reliable method constitutes a valuable contribution. Second, multilevel mixed effects modelling is used to assess the ability of scales measuring different aspects of trait procrastination to predict behavioural delay, indicating that some trait procrastination measures are more predictive of behaviour than are others. The statistical method employed, and the use of task progress rather than study duration as the outcome, enabled the construct validity of the contentious 'active' form of procrastination to be challenged. This approach is proposed also to be a suitable method for assessing the behavioural efficacy of targeted interventions for reducing procrastination. Third, sending regular reflection prompts to randomly selected ESM recipients resulted in a significant reduction in behavioural delay in two of the three studies. This use of low-intensity reflection prompts delivered at a high-frequency demonstrates smartphone use can be an effective medium for reducing procrastination without the need for intensive approaches requiring considerable commitment from both practitioners and participants. This intervention design sets an example for reducing delay in academia, with the method likely capable of being extended, with adaptation, to procrastination in other areas such as health behaviour change, personal finance, and collective action.

Statement of Originality

This work has not previously been submitted for a degree or diploma in any university. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made in the thesis itself.

(Signed)_________[redacted]__________(Date)___17/09/2020___

Jason Wessel

Preface

Publications During Candidature

Papers

Wessel, J., Bradley, G. L., & Hood, M. (2019). Comparing effects of active and passive procrastination: A field study of behavioral delay. *Personality and Individual Differences, 139*, 152-157. https://doi.org/10.1016/j.paid.2018.11.020

Wessel, J., Bradley, G. L., & Hood, M. (2020). *A low-intensity, high-frequency approach to reducing procrastination* [Manuscript submitted for publication].

Conference Presentations

Wessel, J., Bradley, G. L., & Hood, M. (January, 2019). *Using covert System 2 nudges to reduce procrastination: A tale of three studies.* Poster presented at the TAPMI-Max Planck-SOTON Winter School on Bounded Rationality, Manipal, India.

Publications Included in this Thesis

Wessel, J., Bradley, G. L., & Hood, M. (2019). Comparing effects of active and passive procrastination: A field study of behavioral delay. *Personality and Individual Differences, 139*, 152-157. https://doi.org/10.1016/j.paid.2018.11.020

Wessel, J., Bradley, G. L., & Hood, M. (2020). *A low-intensity, high-frequency approach to reducing procrastination* [Manuscript submitted for publication].

Acknowledgement of Papers Included in this Thesis

Section 9.1 of the Griffith University Code for the Responsible Conduct of Research (“Criteria for Authorship”), in accordance with Section 5 of the Australian Code for the Responsible Conduct of Research, states:

To be named as an author, a researcher must have made a substantial scholarly contribution to the creative or scholarly work that constitutes the research output, and be able to take public responsibility for at least that part of the work they contributed. Attribution of authorship depends to some extent on the discipline and publisher policies, but in all cases, authorship must be based on substantial contributions in a combination of one or more of:

- conception and design of the research project
- analysis and interpretation of research data
- drafting or making significant parts of the creative or scholarly work or critically revising it so as to contribute significantly to the final output.

Section 9.3 of the Griffith University Code (“Responsibilities of Researchers”), in accordance with Section 5 of the Australian Code, states:

Researchers are expected to:

- offer authorship to all people, including research trainees, who meet the criteria for authorship listed above, but only those people.
- accept or decline offers of authorship promptly in writing.
- include in the list of authors only those who have accepted authorship
- appoint one author to be the executive author to record authorship and manage correspondence about the work with the publisher and other interested parties.

- acknowledge all those who have contributed to the research, facilities or materials but who do not qualify as authors, such as research assistants, technical staff, and advisors on cultural or community knowledge.
- Obtain written consent to name individuals.

Included in this thesis are papers in Chapters 2 and 3, which are co-authored with other researchers. Additionally, Chapter 5 is presented as a manuscript ready for submission to a journal with minor adjustments (e.g., removal of references to previous chapters). My contribution to each co-authored paper is outlined at the front of the relevant chapter. The bibliographic details for these papers including all authors, are:

Chapter 2: Wessel, J., Bradley, G. L., & Hood, M. (2018). Comparing effects of active and passive procrastination: A field study of behavioral delay. *Personality and Individual Differences, 139*, 152-157. https://doi.org/10.1016/j.paid.2018.11.020

For articles published in *Personality and Individual Differences*, authors retain the right to include articles in a thesis or dissertation, provided it is not published commercially. Permission is not required.

Chapter 3: Wessel, J., Bradley, G. L., & Hood, M. (2020). *A low-intensity, high-frequency approach to reducing procrastination* [Manuscript submitted for publication].

Currently under a second round of review. Presented in Chapter 3 is an updated manuscript incorporating suggested minor revisions by anonymous reviewers.

Appropriate acknowledgements of those who contributed to the research but did not qualify as authors are included in each paper.

(Signed)__________[redacted]__________(Date)___17/09/2020___

Jason Wessel

(Countersigned) _____[redacted]________(Date)___17/09/2020___

Principal supervisor: Graham Bradley

At the beginning of Chapter 2, Chapter 3, and Chapter 5 the contributions of others to the manuscripts are detailed.

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I am grateful for my supervisors: Graham Bradley and Michelle Hood. Graham, working with you has been a privilege. Though I doubt you ever intended it, the quality of your insight, acumen, modesty, and good humour has set a standard which I will spend my career striving to match. Thank you for giving me the space to make my own mistakes, and knowing when to reel me back to narrow my focus. Under different supervision, this thesis would look very different, and not for the better. Michelle, your earnest and always sincere advice was invaluable. Thank you for your prompt and thoughtful comments. Your breadth of knowledge provided crucial links to literature at opportune times. There is much I would have missed without your recommendations. Together, I cannot imagine having had wiser counsel.

To my girlfriend, who became my fiancé, then wife, and mother of my son (Finn) over the course of my candidature: Ellen, I would never have started this journey were it not for you. Your unwavering belief in me is infectious. Though I certainly did not complete this thesis with the same poise you completed yours, having you as a role model has been, and still is, a privilege I could never take for granted. Now it is complete, I would promise you more down-time, but I think you realised long before me that I will forever be compelled to chase new projects. For all things past, present, and future, I am eternally grateful for your support and patience.

Thank you to my friends and colleagues. Over these past few years you have acted as sounding boards, challenged my thinking, and shown great faith in me. I would particularly like to thank Blake Redding and Matthew Burgess for your role modelling and guidance in professional practice and research excellence.

Though I have never been one to procrastinate on the big things in life, I expect the understanding I have collected in thesis will haunt me as I procrastinate on

many smaller things like doing the dishes, going to the gym, and gift shopping. Unfortunately, I can no longer feign as much ignorance, and regrettably admit that I should know better. For those considering the study of procrastination, take that as my only warning.

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Introductory Chapter

0.1 Overview

In general, to procrastinate is to voluntarily delay performing an intended task, despite believing delay will be harmful (Corkin et al., 2011; Howell & Watson, 2007; Nguyen et al., 2013; Steel, 2010a). For the purpose of this thesis, procrastination is understood to result from an interaction of situational and dispositional factors. Procrastinators may be more inclined to delay performing intended tasks, but they are unlikely to delay all tasks equally. At its core, procrastination is a failure of self regulation, where the opportunity to act is present, but the individual elects to pursue other less important, although perhaps more enjoyable, tasks (Steel, 2007). Delay, therefore, is endemic to procrastinaiton; however, not all delay is procrastination. In order for delay to be associated with procrastination, there needs to be elements of intention to complete an action, the volition to do so, and an expectation of harm if action is delayed. Otherwise, delay as a discrete observable action may be a result of adaptive and necessary sequencing among competing priorities. Trait measures of procrastination that assess tendencies to delay intended actions or to leave tasks to the last minute and understanding of harm if delayed may be sufficient proxies for more objective measurement of behavioural delay. However, in recent years this definition has been expanded by some researchers to include forms of delay that are not contingent on a belief or experience of harm (e.g., Choi & Moran, 2009; Chu & Choi, 2005; Ferrari, 1992). Adopters of this broader definition tend to ‘type’ the motivation of procrastinators into those with an adaptive approach and those knowingly inducing harmful delay. The dichotomy of adaptive and/or harmful procrastination has been labelled as ‘arousal’ and ‘avoidant’ (e.g., Ferrari, 1992; Steel, 2007), ‘active’ and ‘passive’ (Choi & Moran, 2009; Chu & Choi, 2005), or ‘intentional’ and 'unintentional' (Fernie et al., 2017). Procrastination, at least in its harmful form, has been extensively discussed in terms of personality, self-efficacy, self-regulatory failure, impulse control, task interest, task complexity, availability of distractors, and duration before required task completion (Abbasi & Alghamdi, 2015; Bullard & Manchanda, 2017; Dewitte & Schouwenburg, 2002; Ferrari, Johnson & McCown, 1995; Steel, 2007; Tice & Baumeister, 1997; van Eerde, 2003a). The range of tasks, goals, and behaviours that are vulnerable to delay are many and varied.

Among American adults, as many as 20% identify as having problems with procrastination (Harriott & Ferrari, 1996), while Nguyen et al. (2013) found that 25% consider procrastination to be one of their defining traits. A meta-analysis by Steel (2007) reported 80 to 95% of college students procrastinate, 75% identify as procrastinators, and 50% procrastinate consistently and problematically. For example, Pychyl et al. (2000) surveyed students 40 times over five days, finding that students procrastinated over a third of the time. While prevalent among humans, procrastination has been observed also among other species (Ainslie, 1974; Mazur, 1996; Steel, 2007). For example, Mazur (1996) found pigeons delay pecking a trigger for food, even when the alternative requires them to peck more and wait longer, while Bowman et al. (1996) found that primates delayed, progressing faster and making fewer errors on a task the closer they came to receiving a reward.

The impact of procrastination is considerable. Student procrastinators, for example, suffer greater anxiety, and, in some studies, receive significantly lower grades on both written assignments and exams compared to non-procrastinators (e.g., Tice & Baumeister, 1997). Procrastination in online courses poses significant barriers to completion, with completion rates as much as 40 to 50% lower in online courses compared to face-to-face higher education courses (Patterson, 2014). Among workers, higher procrastination is associated with lower income, shorter employment duration, and a higher likelihood of underemployment (Nguyen et al., 2013), with white-collar workers reporting higher levels of chronic procrastination than blue-collar workers (Gupta et al., 2012; Hammer & Ferrari, 2002). Several studies have also observed group-level procrastination, with the rate of productivity among business teams found to increase as available work time decreases (Waller et al., 2002). Office workers have been found to spend up to 1.5 hours per work day procrastinating, costing employers an estimated average of USD$8,875 per employee per year (D'Abate & Eddy, 2007). The economic impact of such dilatory behaviours extends beyond the office to a range of personal finance issues as well, with procrastinators less likely to redeem gift certificates (Ferrari, 1993) and as many as 80% of Americans delaying saving so long that an adequate retirement income is unlikely (Byrne et al., 2006).

Procrastination has been linked also to greater health-care costs due to delayed diagnosis and treatment. Arndt et al. (2002) found that 1 in 6 women diagnosed with breast cancer had delayed seeking a medical opinion for over 3 months, compared to the median duration of 16 days. Greater delays in seeking medical attention are associated with poorer prognosis and more invasive treatments (Arndt et al., 2002) and poorer adjustment to and management of hypertension and cardiovascular disease (Sirois, 2015). Research also suggests that anxiety brought about by procrastination can have negative impacts on the immune system, specifically through poorer well-being and a vulnerability to stress (Sirois et al., 2003; Tice & Baumeister, 1997). Relationships have also been observed between procrastination and the increased use of drugs and alcohol for coping with stress (Sirois & Pychyl, 2002; cited in Sirois et al., 2003). Thus, procrastination might both cause and exacerbate illness, likely inflating health-related costs. Delaying intended behaviour may contribute also to collective action issues, such as responses to climate change (Gifford, 2011; Keller et al., 2007; Malott, 2010). Consequently, the potential economic, social, and environmental benefits associated with reducing maladaptive dilatory behaviour are considerable.

Four broad areas of procrastination research are examined, extended, and discussed in this thesis – (1) measurement of procrastination and changes in delay over time, (2) the ability of trait procrastination measures, including those designed to predict delay curves over time, and those relating to different 'types' of procrastination (e.g., arousal and avoidant, active and passive) to predict behavioural delay, (3) interventions designed and proposed to mitigate procrastination, and (4) the inter-temporal (between time) relationships between procrastination, delay, and affective states such as guilt, anxiety, and stress. Extant research has largely focused on these four foci in isolation. No known approach has simultaneously considered measurement of delay over time, how trait-level measures of procrastination differ in their ability to predict changes in delay over time, whether interventions are more or less effective in light of these variables, and how the trait variables relate to state delay and affect. However, with the prevalence of smartphone technology, it is possible to study this complex and multifaceted phenomenon with increasing ease and precision. Given the prevalence and broad impacts of procrastination, the ability of trait measures to predict delay and the strategies that aid procrastinators, whether self-identified or not, warrants thorough investigation.

This thesis addresses these areas of procrastination research by integrating a battery of demographic and trait measures with intensive (twice daily) longitudinal surveys of task progress and associated affect, and by examining the effectiveness of an intervention with regular prompts for individuals to reflect on their goal, in a single study design. Results from a small-scale pilot study are presented and discussed in the Chapter 1. These results informed an expansion of the research design to a larger sample in Study 2 presented in Chapter 2. Differences in intervention outcomes between Studies 1 and 2 were considered to be related to methodological differences. Thus, Study 3, presented in Chapter 3, was undertaken to more closely follow the methodology of Study 1. Findings from qualitative interviews with research intervention and control participants from Studies 1 and 3 are presented in Chapter 4. A series of analyses examining the inter-temporal relationships between state delay and affect in the context of procrastination and emotional stability trait variables are presented in Chapter 5. Finally, a summary of all studies, findings, strengths, limitations, contribution to the body of knowledge, and future directions are presented in Chapter 6.

0.2 Review of Procrastination Literature

0.2.1 Measuring and Predicting Procrastination

One of the core barriers to measuring, and, therefore, predicting future procrastination is the lack of collective agreement on what procrastination is. The definition of procrastination has included harmful delay for thousands of years (Steel, 2007); however, researchers have only recently begun to explore the possibility of an adaptive form of procrastination. In a grounded theory approach to disentangling motivations for procrastination, participants in a study by Schraw et al. (2007) described not only the many disadvantages of procrastination, but also the advantage of reaching optimal performance under the pressure of time. As such, subjective perceptions in the general population appear to include a positive type or component of procrastination. The recognition of an adaptive form of procrastination arguably requires a broader definition that more closely reflects the pure Latin translation from "'pro,' meaning 'forward, forth, or in favour of,' and 'crastinus,' meaning 'of tomorrow'" (Steel, 2007, p. 66). In recent years, there has been apparent discord in the literature, with inconsistent language used to describe the differences between procrastination types, and authors preferencing different measures to discriminate between the types. In order to understand the full implications of procrastination, it is important to consider the likely consequences and possible motives both for and against the delaying of behaviour. There is some evidence suggesting that not all who delay a behaviour, whether labelled as procrastination or not, are adversely affected (Choi & Moran, 2009; Chu & Choi, 2005; Ferrari, 1992).

0.2.1.1 Arousal and Avoidant Procrastination. Procrastination has been measured using more than a dozen different scales. Two of the earliest and most widely used measures of procrastination, the General Procrastination Scale (GPS; Lay, 1986) and Adult Inventory of Procrastination (AIP; McCown & Johnson, 1989), were not originally designed to differentiate between types of procrastination. The possibility of multiple approaches to procrastination was popularised by Ferrari (1992) after he found the two original scales did not adequately correlate with one another. Ferrari (1992) compared the extent to which the GPS and AIP were correlated with sensation seeking, need for cognition, and self-esteem scales. A factor analysis revealed these five scales loaded onto two primary factors: arousal and avoidance, with GPS scores loading onto sensation-seeking (i.e., arousal) and AIP scores loading onto need for cognition and self-esteem (i.e., avoidance). The number of days taken to return completed questionnaires and attendance at optional study review sessions were used as verification that the GPS and AIP procrastination scales were related to behavioural delay. Course test scores were also obtained, but no relationship between procrastination and test score (performance) was found. Both

AIP and GPS were positively correlated with behavioural delay in the return of questionnaires, reinforcing the validity of the scales as measures of delay, implying those who delay do so due to arousal or avoidant tendencies (Ferrari, 1992). In a later study, Ferrari (1993) demonstrated further differences between arousal and avoidant procrastinators operationalised as scores on the GPS and AIP, respectively. Among a sample of last-minute Christmas shoppers, arousal procrastinators (high GPS scores) most often blamed work matters for their delay, while avoidant procrastinators (high AIP scores) most often blamed themselves and their own poor time management. To further reconcile the apparent difference in motivation for procrastination, Steel (2010a) conducted a factor analysis of responses to the AIP and GPS from over 4,000 participants. At odds with Ferrari's (1992) findings, Steel found a high correlation between the scales and dismissed the likelihood of multiple types of (or motivations for) procrastination. However, the idea of different types of procrastination did not cease with Steel's dismissal.

0.2.1.2 Active and Passive Procrastination. Chu and Choi (2005) distinguished between individuals able to harness the pressure of a proximal deadline to perform at a heightened level without adverse consequences and individuals who respond to proximal deadlines with higher anxiety and stress. Deeming the two responses to time pressure 'active' and 'passive' procrastination respectively, they explained that "active procrastinators are persistent and able to complete tasks at the last minute [while] passive procrastinators […] are more likely to give up and fail to complete tasks" (p. 247). With the development and validation of Active and Passive Procrastination Scales (APS & PPS; Choi & Moran, 2009; Chu & Choi, 2005), active procrastination was found to be correlated positively with self-efficacy, GPA, life satisfaction, task coping, and purposive use of time and negatively with both stress and depression.

The validity of these two ‘types’ of procrastination has been supported by subsequent research. Seo (2013) found passive procrastinators in a Korean sample to be more likely than active procrastinators to submit assignments late, suggesting that if there is behavioural delay in the progress of the assignment, active procrastination does not impede timely submission. In a sample of 152 Australian university students, Habelrih and Hicks (2015) found active and passive procrastination were not correlated. In addition, these authors found that active procrastination was correlated positively with psychological well-being, autonomy, environmental mastery, personal growth, positive relations, purpose in life, and self-acceptance, whereas passive procrastination was correlated negatively with psychological well-being, autonomy, environmental mastery, personal growth, and purpose in life. Most recently, Kim et al. (2017) discovered active and passive procrastination have distinctly different relationships with four of the Big-5 personality factors, with passive procrastination related positively to neuroticism and negatively to conscientiousness, agreeableness, and extraversion. Conversely, active procrastination was correlated negatively with neuroticism and positively with extraversion, but had no association with conscientiousness. Kim et al. also found GPA was correlated negatively with passive procrastination, but not active procrastination. They used an objective measure of GPA (official GPA from the university administration) rather than the more common self-reported GPA, demonstrating robust construct validation.

0.2.1.3 Discord of ‘Types’ in Procrastination Literature. Steel’s (2010a) meta-analytic review and factor analysis of avoidant and arousal procrastination made no reference to active and passive procrastination and associated measures developed by Chu and Choi (2005) and Choi and Moran (2009). As such, Steel's (2010a) assertion that there is only one (maladaptive) type of procrastination is at odds with this other conceptualisation and operationalisation of procrastination as well as with some of the more recent evidence supporting this.

Thus, there remains conflicting motivations for behavioural delay in the literature. There are those (such as Corkin et al., 2011; Ferrari, 2010; Pychyl et al., 2000; and Steel, 2010a) who have argued that procrastination is maladaptive by definition, reasoning that deliberate procrastination is more accurately described as 'active delay' (Corkin et al., 2011). In contrast, others (such as Choi & Moran, 2009; Chu & Choi, 2005; or Seo, 2013) have argued procrastination is a behavioural pattern that can be engaged with or without volition (active or passive). In any respect, there is discord in the literature as to whether procrastination can be both adaptive and maladaptive. This is a disagreement that no study presently reviewed has adequately reconciled. Moreover, no study to date has investigated how those who score highest on measures of the different types of procrastination differ in delay on tasks over time. In other words, no study has closely examined the extent to which scales purportedly measuring each procrastination type are able to predict procrastination, operationalised as behavioural delay in task progress, in real life.

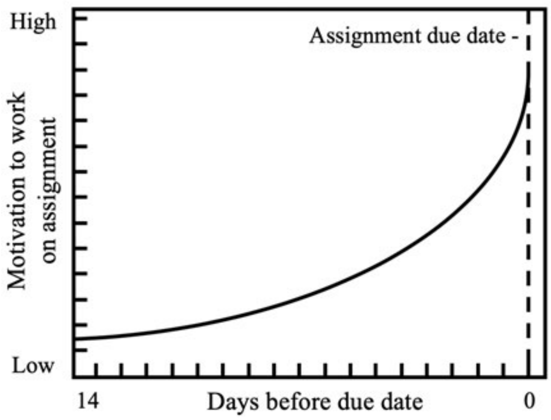
For the purpose of this review, I adopt the term *trait procrastination*, or more simply, procrastination, to refer to what some of the above authors have termed either avoidant or passive procrastination. Where an adaptive form such as arousal or active procrastination is referenced, or the measure of avoidant or passive procrastination is used to contrast the adaptive form, the 'type' will be explicitly stated. Otherwise, the term *procrastination* should be interpreted as including an expectation of harm. The rationale for this is that those unintentionally avoiding what they feel to be an important task may be in a position to be helped by further understanding of the mechanisms involved. Evidence of the positive relationship between active procrastination, positive affect, and performance suggest those who intentionally delay need no such help. Nonetheless, it is important to remain cogniscent of the behavioural patterns of active procrastination. If, as claimed, the patterns of delay in the two purported types of procrastination are assumed to be behaviourally indistinguishable, they can likely only be distinguished by differences in the underlying motivation and affect associated with dilatory, or delay, behaviour. Adequately predicting procrastination, therefore, requires a deeper interrogation of the concurrent relationship between trait measures and both behavioural delay and concurrent affect.

0.2.1.4 Measuring Procrastination and Delay over Time. In certain circumstances, it may be advantageous to delay an intended behaviour in favour of more immediate pursuits. As Bernstein (1996) explains: "Once we act, we forfeit the option of waiting until new information comes along. As a result, not acting has value. The more uncertain the outcome, the greater may be the value of procrastinating" (p. 14). For example, a student may delay commencing an assignment until later in the course when greater content has been covered (Steel & Klingsieck, 2016). Even when students complete an assignment early, they are likely to intentionally delay submission, allowing time for a later final revision 'just in case' (Gregory & Morón-García, 2009). More common in the discourse of procrastination, however, is delaying due to giving in to the temptation of immediate rewards. In this example, a student may delay commencing an assignment to fulfil social engagements, indulge in media, or pursue a hobby. A preference for immediate rewards is broadly shared across species (Bowman et al., 1996; Mazur, 1996; Steel, 2007), with some authors arguing procrastination evolved in early human history (Lyons & Rice, 2014). In support of this evolutionary argument, Gustavson et al. (2014) have found genetic evidence of procrastination's heritability in twins.

According to the principle of hyperbolic discounting (also referred to as temporal discounting), the proximity of a reward or preferred behaviour determines its allure (Ainslie, 1974; Frederick et al., 2002). For instance, when offered $50 today or $100 in one year, many people opt to take the $50 today (Kirby, 1994). In contrast, when provided the option of $50 in five years or $100 in six years, many opt to delay for the $100 (Kirby, 1994). The difference between the two scenarios is not the monetary value or duration of delay between the two potential pay-offs (they both represent a 100% increase over one year); it is the proximity of the nearest pay-off. In essence, the further the potential pay-off, the more one psychologically discounts the value of that pay-off. It is theorised (e.g., Ainslie, 1975; König & Kleinmann, 2005; Steel, 2007) that the discounting of a delayed reward when an immediate reward is available, compared to a delayed reward when a somewhat less-delayed reward is available, is not temporally linear. Rather, the slope of this discounting rises more rapidly as the delay to initial reward decreases, following the shape of a hyperbolic (or accelerating) curve. In the context of academic procrastination, one can imagine a student preferring to socialise until closer to the assessment due date, at which time the preference to complete an assignment overtakes the otherwise stable preference to socialise. The assessed value in completing the less-favoured task (assignment writing) increases in comparison to other available actions (socialising) as the due date approaches, or conversely, the value of the less immediate reward (completing the assignment) is discounted when the payoff (submitting the assignment) is further away. See Figure 0.1 for an example of a hyperbolic curve in assignment writing motivation prior to deadline, adapted from Steel (2007). The research presented in this thesis investigates the presence of a curvilinear hyperbolic trajectory relating to observations of behavioural delay.

Figure 0.1

Hyperbolic Curve of Motivation to Write an Assignment, where a Generally Less Favourable Activity (Assignment Writing) is Preferenced Above a Generally More Favourable Activity (e.g., Socialising) Only as the Deadline Approaches. Adapted from Steel (2007)



0.2.1.5 Behavioural and Temporal Measurements of Procrastination. Fundamentally, to understand procrastination, it is important to measure not only the accompanying consequences and affect, but also the delayed behaviour itself. As delay can be described not just by the rate of behavioural initiation, but also by rate of task progress over time, it is appropriate to observe this temporal delay in progress when operationalising procrastination. While a number of authors have utilised submission of a survey or assessment piece as a behavioural indicator of procrastination (e.g., Howell et al., 2006), there remains a widely acknowledged dearth in the procrastination research literature of studies that include monitoring of delay behaviour over time (e.g., Habelrih & Hicks, 2015; Steel, 2007; Steel et al., 2001; van Eerde, 2003a).

Only a few concerted attempts have been made to measure not just the consequences of procrastination over time (e.g., Tice & Baumeister, 1997) but behavioural delay itself. Three examples of procrastination tracking are discussed here, each of which serves to highlight some of the problems associated with this research endeavour. In the first example, Dewitte and Schouwenburg (2002) assessed how predicted study behaviour differed from observed study behaviour in procrastinators and non-procrastinators. Students were emailed weekly over 11 weeks and asked how many hours they intended to study over the next 7 days, as well as how many hours they studied over the previous 7 days. Hours of study completed increased as the exam date approached in line with the hyperbolic discounting curve hypothesised by earlier theorists. However, this was the case for both procrastinators and non-procrastinators, with high procrastinators both predicting and reporting studying for more hours than non-procrastinators. This resulted in a deeper hyperbolic delay curve identified in those low in procrastination, compared to the curve observed in those high in trait procrastination.

Several factors may help explain this seemingly counter-intuitive finding. First, Dewitte and Schouwenburg (2002) reported study hours as the primary dependent variable, asking students to record all hours spent studying behaviour, not study hours related to a single study goal (such as the exam that the authors discussed). There are several problems with this approach. First, recording all study hours disallows discrimination of specific task procrastination; that is, how many hours were spent studying for an exam relative to the time until the exam day. Second, as people tend to be more efficient users of time when motivation is higher (Waller et al., 2002), it is possible that procrastinators do study for longer but with less efficiency than non-procrastinators. The measure selected to operationalise trait procrastination may have also confounded their results. As they used the GPS measure that has been linked to arousal procrastination by Ferrari (1992) and associated with sensation seeking, those classified as high in procrastination may have recorded higher amounts of time spent studying compared to those who were high in an avoidant type of procrastination, even if that logged study time was not used effectively. Finally, as Dewitte and Schouwenburg surveyed the students weekly, requiring them to retrospectively recall the number of hours spent studying over the previous week, memory effects might have adversely affected the accuracy of reported study hours.

The second example is also a study investigating progress on multiple course assessments, with Moon and Illingworth (2005) electronically monitoring undergraduate student online test completion. Students were required to complete five online tests throughout a semester, with one week to complete each test. Behavioural delay was assessed by the difference between date of test availability and date of test completion. As with Dewitte and Schouwenburg (2002), Moon and Illingworth found test submission delay of both high and low trait procrastinators followed the same pattern over time – that is, the majority of both high and low procrastinators completed the test closest to the date of closure. As their measure was a single score (i.e., submitted on date x), the authors were unable to account for the amount of time devoted to preparing for the test or other time demands. Therefore, the test completion date is likely to have been a poor proxy for procrastination, and not sensitive to legitimate competing priorities. The authors also did not account for different types of behavioural delay (i.e., active or avoidant).

The third example perhaps goes furthest of any study reviewed in addressing the lack of longitudinal research into procrastination and delay curves. Steel et al.

(2018) embedded a series of demographic and personality-based questionnaires in an online course. The course consisted of 19 chapters, for each of which students were required to review study questions, concept previews, and practice quizzes, prior to sitting a final exam. Following a fixed start date, the first 18 chapters were described as self-paced; however, students were penalised with half-marks if they did not complete a chapter quiz on schedule. A supervised final exam was set at the end of the 19th chapter. The fixed enrolment and final exam dates provided a defined start and finish time scale, with student progress throughout the course chapters enabling the authors to plot observed delay longitudinally as a percentage of the course chapters completed at a given date. In doing so, they found delay was significantly correlated with trait procrastination (r = .41). This method overcame some of the limitations of Dewitte and Schouwenburg's (2002) and Moon and Illingworth's (2005) studies and identified a significantly correlation between observed and trait procrastination.

There were, however, some limitations of Steel et al.'s (2018) study that limit its implications for future research. First, students were penalised with half marks for completing quizzes late. This intermittent staggering of incentives to complete is likely to have broken down the larger goal of completing the course for students, and subsequently is likely to have reduced the degree to which all students, particularly those high in trait procrastination, delayed during the course (Ariely & Wertenbroch, 2002; Steel, 2007). As a consequence, the degree of delay reported is likely to have been conservative, and may not reflect how students naturally delay on complex tasks. Second, the authors equated behavioural delay with observed procrastination; however, they did not control for demographic variables such as study load and work, family, and caring commitments, each of which may have affected delay without being considered procrastination. Third, observed delay was positively correlated with trait procrastination, but delay was quantified as a single area-under-the-curve metric, with mixed between- and within-person effects of trait procrastination and delay curves not statistically modelled. In comparing within- and between-person variables, use of a mixed effects model is recommended to control for error in both within- and between- person measurement (Heck et al., 2010). In other words, Steel et al. (2018) may have over-estimated the statistical probability of observed effects. Fourth, this study design was built around a very specific course structure (described above), limiting the generalisability of the findings not just to other complex tasks, but also to other courses such as traditional face-to-face courses and self-paced Massive Open Online Courses (MOOCS) where interim incentives (or disincentives to delay) are not available. Moreover, in an online-course context where attrition rates can be as high as 94% (Evans et al., 2016), the authors make no note on attrition rates in their sample, and may have inadvertently excluded problem procrastinators from their analysis through attrition.

Procrastination has both dynamic and specific properties, in that motivation to complete a complex target behaviour changes over time, and the strength of motivation and rate of behaviour change are dependent on the individual's relationship to the specific goal. While attempts were made in these three studies to account for these challenges, it is questionable how well each method isolated and operationalised naturalistic study behaviour and, therefore, adequately quantified behavioural delay.

0.2.1.6 Measuring Procrastination with Experience Sampling Method (ESM). Aided by recent developments in personal digital technology, Experience Sampling Method (ESM), also known as ecological momentary assessment, or an intensive longitudinal approach, has been used to monitor within-person temporal changes with relative ease (Evans, 2016). ESM is a research procedure for capturing individual experiences in the moment through the high frequency use of multiple, often random, surveys or other observational procedures (Larson & Csikszentmihalyi, 2014). Beyond diary studies, which typically require detailed training sessions and an amplified level of participant commitment (Bolger et al., 2003), experience sampling research *in vivo* has not been practical until recent years. With the advent of smartphones, ESM has allowed the widespread use of short yet frequent ‘experience’ surveys to shed light onto lived experience with relative ease outside of a lab environment (Krieke et al., 2016; Smith et al., 2017; Torous et al., 2014). Memory-loss effects of less frequent surveying strategies (e.g., Dewitte & Schouwenburg, 2002) are likely to be reduced by ESM questions relating to the specific instance or time point/period in which they are asked. For example, in an irritable bowel syndrome population, Mujagic et al. (2015) found patients reported higher abdominal pain in an end-of-day diary than they did during the two daily ESM surveys. The authors concluded that patients tended to retrospectively report peak pain, rather than average pain, supporting the assertion that ESM may be a more valid measurement tool than relying on recall.

An important advantage of ESM is its capacity for mapping experiential changes within individuals over time, allowing data on person-level changes to be compared between individuals. Shared person-level changes within individuals can then be combined into groups, and group-level differences can be analysed on a multi-level basis (see Evans, 2016; Larson & Csikszentmihalyi, 2014). A common example of this approach is found in the education sector, where researchers gather experiential data over multiple time points, which are nested within students, who are nested within classrooms, and, in some studies, nested within schools (Zirkel et al., 2015).

In accord with these recent advances, empirical research in this thesis used multi-level modeling techniques to analyse data obtained through ESM.

ESM has some history of use in procrastination research; however, past studies have mostly focused on the affective correlates of procrastination as deadlines approach, rather than monitoring dilatory behaviour. Moreover, ESM has not been used to overcome the failure of past studies to take multiple measures over time of progress on a well-defined focal task. In the earliest example found, Pychyl et al. (2000) used paper-based ESM, requiring 45 students to carry a pager and a folder with 40 questionnaires at all times before an essay, project, or exam. Participants were paged at random intervals eight times per day to complete a survey over the five days before the due date of their assignment or exam. The authors were primarily interested in the relationship between affect and procrastination over the five days, finding self-reported procrastination correlated with guilt, but not with positive or negative affect more generally (e.g., happy for positive affect, and depressed for negative affect). No reports of study efforts or progress were recorded, and, although multiple procrastination scales that might have discriminated between adaptive and harmful procrastination were used, these were not discussed in terms of different procrastination types. Hence Pychyl et al. drew no conclusions regarding differences in affect or task progress between either those with varying levels of trait procrastination or those with different procrastination types.

Reinecke and Hofmann (2016) have more recently used ESM to administer six questionnaires over three days directly to participants' mobile phones. Their research differentiated between media use for recovery and media use for procrastination.

While they found that procrastination-based media use affected well-being negatively, they did not target a particular goal or intended behaviour and, consequently, did not include a behavioural measure of procrastination. Similarly, Smith et al. (2017) used ESM to administer two questionnaires per day over three days to investigate the relationship between self-reports of perfectionism and procrastination. They did not quantify delay or predict it on the basis of personality measures. In summary, therefore, no known study, to date, has used rigorous behavioural measurement of delay over time alongside measures of active or avoidant procrastination.

0.2.1.7 Temporal Motivation Theory (TMT). Without specifying a method for accurately obtaining data for modelling, Steel and König (2006) proposed the Temporal Motivation Theory (TMT) as a model for predicting how motivation, and, therefore, its inverse, delay, is likely to change over time. Central to this theory are four variables: expectancy, value, delay sensitivity, and delay. In the context of TMT, *expectancy* relates to the expected probability that the desired outcome will be achieved, and *value* relates to how much the expected outcome is valued. Expectancy and value in TMT, largely derived from Vroom's (1964) expectancy theory, have a long history of varied application (van Eerde & Thierry, 1996). However, the TMT conceptualisation of value differs slightly from Vroom's (1964) concept of valence, which generally refers to all possible affective orientations towards an outcome (van Eerde & Thierry, 1996). Instead, value in TMT refers to the extent to which individuals do not discount the value of unpleasant tasks, find pleasure in achievement, and are less prone to boredom (Steel, 2007).

Delay sensitivity relates to levels of distractibility, impulsiveness, and lack of self-control (Steel 2007; Steel et al., 2018; Wu et al., 2016), such that individuals high in delay sensitivity prefer activities that are more immediately enjoyable and have a sooner promise of reward. Delay sensitivity can be thought of as similar to impulsivity, with delay sensitivity predominantly reviewed in terms of impulsivity in Steel's (2007) meta-analysis, and the term impulsivity used instead of delay sensitivity in Steel and colleagues' (2018) applied study of TMT. However, whereas impulsivity, as a broader construct, implies more than temporal changes in avoidance (e.g., non-planning, motor impulsivity, and attention impulsivity; Spinella, 2007), delay sensitivity specifically implies that an impulsive person becomes less distracted by their impulses as the time remaining to complete a less-desirable task decreases. Delay sensitivity, therefore, differs from the fourth variable of TMT, *delay*, in that delay relates specifically to the time remaining before action or completion of a task is required; for example, time remaining to an assignment deadline.

TMT posits that high task expectancy and perceived value of an outcome will counter the effects of delay sensitivity and delay that would otherwise lead to individuals postponing tasks until the latest practicable moments. At the crux of TMT is a simplified equation for understanding task motivation, where motivational strength is inversely related to the likely extent of procrastination:

$$\textit{Motivation} = \frac{\textit{Expectancy x Value}}{\textit{1 + Delay sensitivity x Delay}}$$

Where expectancy and value are likely to be relatively stable in relation to a specific task, and delay sensitivity is likely to be relatively stable as a trait variable, delay or duration to a deadline is a dynamic environmental factor. As all of these variables can be measured, the procrastination equation is expected to provide a dynamic numeric value for latent task motivation. If task expectancy and perceived value are high, and delay sensitivity and delay (time remaining) are low, then motivation to act should be high, and procrastination behaviour (task delay) low. As the equation denominator changes temporally as delay or proximity to deadline reduces, task motivation, or at least the internally experienced compulsion to act, should increase in a hyperbolic curvilinear fashion similar to that depicted in Figure 0.1. TMT is the only theory that considers both the multi-faceted and dynamic nature of procrastination, explicitly articulating the hyperbolic interaction between time and behavioural delay associated with trait level variables.

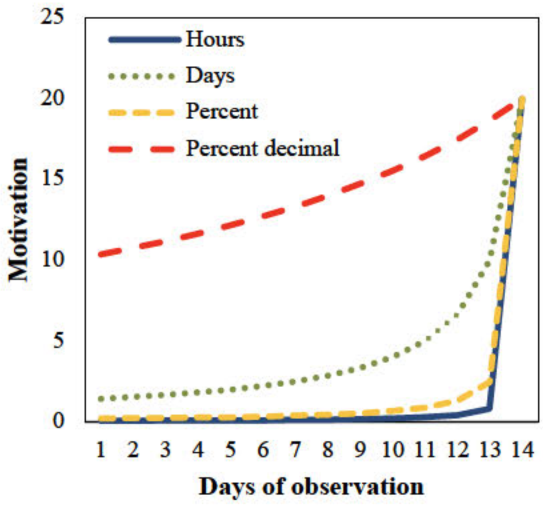
No study identified in the present review has empirically tested the predictive components of expectancy, value, or delay sensitivity, nor the full temporal motivation (procrastination) equation, despite several of TMT's core variables having been examined. Thus, the full theory has not been exhaustively tested. This is due to several of the theory's limitations.

0.2.1.8 Limitations of TMT. Despite being first proposed over a decade ago, there is little evidence currently as to the predictive ability of TMT. Though Steel et al. (2018) alluded to examining evidence of TMT in the title of the paper, they only operationalised delay (i.e., measured task delay longitudinally) and did not operationalise expectancy, value, or delay sensitivity, or use the TMT equation to predict motivation or procrastination. That TMT remains generally untested may, in part, be due to the aforementioned difficulty in accurately tracking motivation across individuals, tasks, and contexts. As discussed earlier, it is clear that harmful delay afflicts diverse life domains (e.g., study, work, health, and personal achievement). Career-driven professionals may not procrastinate at work, yet may readily admit to perennially neglecting their personal health. Similarly, a student may repeatedly procrastinate on an assignment, yet generally complete employment tasks promptly. As such, it is difficult to conceive that trait procrastination scales (e.g., those discussed in section 0.2.1) can have sufficient specificity to return a predictive measure of task specific motivation, and, therefore, accurately predict task delay. Steel (2010a; 2010b; 2011) has provided a tri-factor scale to measure expectancy, value, and delay sensitivity; however, the items are trait-based, and like other measures, are not task specific, and as such, may not provide additional predictive specificity over alternative trait measures of procrastination. While academic self-efficacy may equate for a large amount of variance in task expectancy in academic settings (Steel, 2007; van Eerde, 2003a), TMT conceptualises value as a singular construct, arguable simplifying a variable considered by others to be multi-dimensional and/or domain-specific (Wu & Fan, 2017). TMT also largely neglects contextual social, cognitive, affective, and attentional processes, such as those that underpin intentional delay and perceived task priority in the complicated ecosystem of tasks in which people must operate on a daily basis (Fernie et al., 2017; Solomon & Rothblum, 1984).

Steel and König (2006) do not provide clear instruction on how delay is to be weighted. Specifically, with the procrastination equation's dynamic formula, choices around units of delay can have substantially different effects on the curvature of the hyperbolic trajectory of motivation or delayed action. Assuming static values for individual expectancy, value, and delay sensitivity (e.g., each of 20), higher units for delay over the period modelled relate to sharper trajectory increases as a deadline looms near. For example, a unit of delay measured in days (i.e., 1 day = 1) over 14 days has a substantially shallower curvature of the hyperbolic trajectory compared to a unit of delay measured in hours (i.e., 1 hour = 1) over the same 14 days (see Figure 0.2). As durations of time available for a task are likely to vary considerably dependent on the task, it may be pragmatic to quantify delay as a percentage of available duration. However, using a percentage of time available to enable the TMT formula to apply across a spectrum of task durations relates to substantially different modelled trajectory if the full integer (e.g., 80% time remaining = 80), or a decimal (e.g., 80% time remaining = 0.80) is employed.

Figure 0.2

TMT Motivation Trajectories with Fixed Expectancy, Value, and Delay Sensitivity Values, Changing Only the Unit of Time in the TMT Formula, Presenting Hours, Days, Percentage of Total Available Time Elapsed (Max 100%), and Percentage of Total Available Time Elapsed Presented as a Decimal (Max 1)



Moreover, TMT is also limited in its prescriptive utility. If motivation is indeed predicted by a dynamic equation, TMT does not provide guidance as to how this numeric value of motivation can be used. Perhaps it is that interventions to aid maladaptive procrastinators are best introduced once motivation is over a certain level or once the hyperbolic slope surpasses a certain angle. Or perhaps interventions are most effective the earlier they are introduced, and, as Steel (2007) suggests, the four elements of TMT provide a system for targeting antecedents of individual procrastination. For example, receiving constructive and supportive feedback, or exposure to successful role models, may effectively increase *expectancy*. Perhaps task *value* can be increased through reflection and visualisation relating to goal attainment.

The impact of individual *delay sensitivity* might be mitigated by practicing smaller versions or 'chunks' of a task. Finally, the influence of temporal *delay* might be manipulated through the strategic imposition of earlier or more frequent (sub-goal) deadlines. Thus, while these and other options are plausible, the theory does not provide guidance on how or when to select between them.

In short, without more specific guidance on how expectancy, value, and delay sensitivity can be assessed against specific tasks of interest, how delay is to be quantified, or how one might leverage elements of the procrastination equation to assist in the reduction of maladaptive behavioural delay, it is not surprising there are, as yet, no accounts translating TMT to application in empirical research. Although Steel and König (2006) do not suggest such a direct link between the components of TMT and interventions, there are many others who recommend strategies for curbing harmful delay.

0.2.3 Reducing Procrastination

0.2.3.1 Empirically Evidenced Interventions. Research investigating anti-procrastination interventions is limited (Steel & Klingsieck, 2016). The available research tends either to measure the effects on participating individuals of whole intervention programs, or to measure changes in dilatory behaviour following *in situ* experimental manipulation of the approach required for task completion. These can be termed person-level interventions and naturalistic task interventions, respectively. Person-level intervention programs include time-management training (see Claessens et al., 2010; Häfner et al., 2014; Kachgal et al., 2001; van Eerde, 2003b) and internet-based cognitive behaviour therapy (Rozental et al., 2015). An example of the latter showed clinically significant change in procrastination scores for 25% of participants following 10 weeks of treatment (Rozental et al., 2015). While person-level intervention programs can make a demonstrable difference in dilatory behaviour (Häfner et al., 2014; Rozental et al., 2015), their efficacy is likely to depend on multiple factors. Success is dependent on the availability of skilled facilitators, the time participants can dedicate to attending, the dedication participants have to complete what can be intensive programs, and the opportunity provided to them by their institution or circumstances to attend. To feasibly reach all those purportedly afflicted by procrastination, we must look beyond such resource-intensive intervention programs.

Naturalistic task interventions, that is, intervention strategies that are integrated in the process of completing a task, may be more scalable to reach procrastinators without the need for extensive training. One of the more comprehensive naturalistic task interventions was aimed at reducing procrastination in scholarly writing. Boice (1989) encouraged academic staff to dedicate 30 minutes per day to writing, with weekly audits and encouragement to write from the researchers. This approach led to significant increases in academic (as opposed to teaching) output in the experimental group, without exception. Brooke and Ruthven (1984) and Lamwers and Jazwinski (1989) also found imposing interim deadlines was effective in reducing delay behaviour in what would have otherwise been a self-paced learning program. Ariely and Wertenbroch (2002) built on these studies exploring ways for student procrastinators to impose their own deadlines and whether interim deadlines were more helpful when self-imposed or imposed by others. All impositions of interim deadlines reduced procrastination, but task completion was steadiest when evenly staggered interim deadlines were imposed upon students from an external authority. Arguably, however, the efficacy of such interventions is likely to vary with the rationale for procrastination (e.g., arousal or avoidance). That is, when granting procrastinators the ability to set their own interim deadlines, perhaps arousal procrastinators would choose to set later deadlines in order to maximise the sense of time pressure. No intervention program or strategy appears to have taken into consideration this diversity of procrastination types.

0.2.3.2 Suggested interventions. While the procrastination literature contains many suggested intervention strategies, the empirical evidence of their efficacy is limited. Strategies are varied, yet most can be categorised into TMT's four hypothesised elements of procrastination; that is, those that seek to increase expectancy of success through high task performance, task completion, outcome success/goal achievement, or all the above; increase the salience or amount of perceived task value; attenuate the effects of individual impulsivity or sensitivity to delay; and address the use of time (i.e., delay). The use of strategies from within these four categories of procrastination interventions has also been suggested by Steel (2007). These intervention examples, although grouped in terms of expectancy, value, and delay sensitivity, should not be seen as mutually exclusive.

Expectancy of success can be enhanced by providing actors with evidence or examples of other like-individuals who have started the behavior early and successfully completed it on time. The persuasive power of social comparison has been repeatedly demonstrated (see Chen et al., 2016). A particularly compelling example of the effects of providing "social proof" evidence can be found in Goldstein et al.'s (2008) experiment on the reuse of hotel towels. Hotel guests given the message "the majority of guests reuse their towels" were more likely to reuse their towels than those told about the benefits to the environment of reuse (44% and 25%, respectively). Further, Goldstein et al. (2008) demonstrated a message pertaining to a more specific social norm (i.e., "the majority of guests in this room reuse their towels") increased towel reuse by a further 5%.

It should be noted that social "proof" differs from social comparison, and, may not be as effective at reducing procrastination. Social proof relates to the behaviour of one person having the potential to influence the behaviour of another as evidence or "proof" of what is possible (Goldstein et al. 2008), while social comparison more often relates to how individuals self-evaluate compared to others (Festinger, 1954). Delaval et al. (2015) integrated social comparison performance feedback for students in an undergraduate statistics course, progress and performance was provided in comparison to that of others in the course through an online learning portal. While exam performance improvements were observed for students exposed to social comparison data if they connected to the training portal early, no effect was identified in those who connected later. Therefore, effects for procrastinators were inconclusive, with the authors proposing procrastinators who delayed their connection to the portal were not able to be observed for long enough to gauge the full effect of the social comparison condition.

Other lessons from social comparison studies suggest that comparison can be motivating when individuals are slightly below average, but demotivating when they are either well below or well above average (Locke & Latham, 1990). This suggests that social comparison is unlikely to be broadly applicable, and social proof, where an ideal standard is ambitious albeit vague, is likely to be more effective. This evidence suggests that the application of social proof-based interventions to increase expectancies within the procrastination domain is both plausible and promising, and, thus, warrants investigation.

To amplify perceived *value* in pursuing a task or goal, Steel and Klingsieck (2016) recommend the use of mental contrasting visualisations. This involves the vivid imagining of future goal attainment both independently and in comparison to the current state or to the alternative of not achieving the goal (Kappes et al., 2012). High procrastination has been related to a poorer ability to vividly imagine future scenarios, with procrastinators less likely to consider the implications of their current behaviour (Rebetez et al., 2016). Experimental research on visualisation of future states has been shown to be effective in reducing procrastination on financial planning. When presented with a digitally aged picture of their current selves, individuals made larger contributions to retirement savings, thereby reducing the otherwise common tendency towards hyperbolic temporal discounting (Hershfield et al., 2011). Visualising a future self or situation as a form of mental time-travel (Díaz-Morales & Ferrari, 2015); for example, imagining one's self as having not started the day before a major task must be completed may have the effect of enhancing the affective relationship with that future self, and, depending on the implications of the goal of task completion, either increasing or decreasing the perceived present value of the task.

To mitigate the impact of individual *delay sensitivity* or impulsivity, the management of potential distractors (Abbasi & Alghamdi, 2015; Steel, 2010b) and the use of short productivity 'sprints' (Cirillo, 2013; Tambini et al., 2010) have both been recommended. The suggestion of removing potential distractions, particularly modern ones such as email, social media, and unfettered internet use, before one has a chance to be distracted by them, is common (Meier et al., 2016; Reinecke et al., 2016; van Eerde, 2018; Wieber & Gollwitzer, 2010). Indeed, there are anecdotal examples of those who self-limit access to distractions, like Margaret Attwood, a prolific author yet self-confessed procrastinator, who keeps a 'to don't' list, where she records the things she will *not* do while working (Grant, 2020). However, I could not find any empirical studies assessing the efficacy of self-limiting access to distractions outside of self-regulatory skills training, which includes stimulus control techniques (van Eerde & Klingsieck, 2018). The use of implementation intentions, that is, the pre-planning of when, where, and how one will engage in a task or manage distractions that may be attractive to those sensitive to delay (Gollwitzer & Brandstätter, 1997), is also commonly recommended as a strategy for reducing procrastination (e.g., Howell & Watson, 2007). Forming such intentions is not only likely to reduce the apparent duration of delay by making upcoming action seem more proximate, but also encourage commitment to intentions that may curb impulsive behaviour. While there is evidence of implementation intentions increasing the probability of follow-through in job seekers (van Hooft et al., 2005) and individuals keeping an appointment (Owens et al., 2008), they have not been shown to be effective in specifically reducing procrastination (Owens et al., 2008; Gustavson & Miyake, 2017). Further, although pre-planning what one will do in the event of a distraction may have the potential to combat impulses for distraction, it is unlikely to be sufficient in isolation if procrastinators are concurrently experiencing low task expectancy and value.

Regarding the use of short productivity sprints, Ferrarri (2010) describes procrastinators as often seeing a forest and forgetting it is made of trees. That is, procrastinators may experience feeling overwhelmed when considering the enormity of the task ahead of them, and, as a consequence, may delay taking the first step. To combat this, Ferrari recommended that instead of focusing on the whole forest, the procrastinator should consider only the first tree, and if the first tree is too large a task, then consider only a branch. Breaking a task (i.e., a 'forest') down into smaller achievable steps (i.e., ‘trees’ or ‘branches’) is likely to lead to the experience of quick wins, potentially overcoming some of the distractibility experienced by those who are more impulsive and building momentum (Abbasi & Alghamdi, 2015). This strategy has been referred to as chunking (Ferrari, 2010), success spiralling, or island hopping (Steel, 2010b). It should be noted that the experience of ‘quick wins’ may also help to build expectancy of success and improve affect relating to the task, thereby increasing perceived intrinsic value.

Of all potential methods for intervening to reduce procrastination, altering the time individuals have to complete a task, that is altering the actual duration of *delay*, may be the most pragmatic. In the role of an administrator, manager, or parent, artificially altering the influence of *delay* through the imposition of additional deadlines, or progress-based milestones, has been found to be effective in reducing procrastination (Ariely & Wertenbroch, 2002; Steel & König, 2006; Stellman & Greene, 2015). Notably, these additional deadlines are likely most effective when equally staggered and set by an authority, compared with being staggered at varying intervals or set by the student, employee, or child (Ariely & Wertenbroch, 2002). While this strategy is likely to be effective in certain contexts, such as imposing multiple interim deadlines to keep students in an online course progressing steadily (e.g., Steel et al., 2018), it might not always be feasible in other contexts.

A superordinate factor that is relevant to these individual procrastination factors is *metacognition*. Metacognition in regards to procrastination relates to the degree to which individuals pause to consider their task progress and associated thoughts and behaviours. Metacognition may, for example, take the form of considering whether avoidance behaviour is being self-corrected to achieve the task on time, or an appropriate amount of time or effort is being spent on planning, or less important tasks are distracting from task performance (Corkin et al., 2011; Wolters, 2004). The use of metacognitive strategies has been linked to lower levels of trait procrastination, leaving authors to conclude that reflection on one's procrastination may lead to self-correcting behaviours (Corkin et al., 2011; Howell & Watson, 2007; Steel & Klingsieck, 2016; Rozental et al. 2015; van Eerde, 2000).

The wide body of literature on metacognitive *beliefs* about procrastination predominantly relates to the perceived positive and negative consequences of procrastination (e.g., de Palo et al., 2017; Fernie et al., 2016; Fernie et al., 2017, Hosseini & Khayyer, 2009). A positive metacognitive belief about procrastination may be, for example, that procrastination allows creativity while a negative belief may be, for example, that procrastination makes the procrastinator feel bad (de Paolo et al. 2017). However, authors who have suggested metacognitive *reflection* as a potential strategy for reducing procrastination have generally referred to metacognition about task completion, rather than positive or negative beliefs about procrastination. For example, Corkin et al. (2011) found use of metacognitive strategies to be negatively correlated with trait procrastination (r = -.31), including after controlling for self-efficacy, which is an indicator of expectancy (Steel, 2007). This suggests that use of metacognitive strategies in interventions may aid in the reduction of procrastination, over and above that achievable through expectancy-based interventions. It is important to consider how metacognition is operationalised in procrastination interventions. Corkin et al. (2011) used an adjusted version of the Motivated Strategies for Learning Questionnaire (Wolters, 2004), which operationalises metacognitive strategies as awareness of an upcoming task and consideration of potential barriers to completion of the task. Based on this, interventions seeking to leverage metacognitive strategies should include prompts to encourage consideration of personal barriers to timely task completion.

0.2.4 Relationship Between Affect and Procrastination

As mentioned earlier, expectation of harm is integral to the definition of maladaptive types of procrastination, although many scholars would argue it is relevant to all types of procrastination (e.g., Corkin et al., 2011; Steel, 2010). The harm often relates to effects on task performance (Tice & Baumeister, 1997; van Eerde, 2003a); however, there is a considerable body of research concerning experiential harm in the form of negative affect, including guilt, anxiety, and stress.

Outside of academic settings, trait or chronic procrastination has been associated with generalised depression, anxiety, and stress (Sirois, 2007; 2014; van Eerde, 2003a). In academic contexts, procrastinators are likely to self-report low self-esteem, and high rates of depression and test anxiety, including anxiety-related physical symptoms such as headaches, dry mouth, and hand trembling (Rothblum et al., 1986; Solomon & Rothblum, 1984). Tice and Baumeister (1997) have shown procrastinators are likely to experience temporal changes in negative affect. That is, a procrastinator's experience of negative affect may not be perpetually heightened, but instead fluctuates relative to a critical event that increases the person's susceptibility to procrastinating. In two longitudinal studies, Tice and Baumeister found student procrastinators reported lower levels of stress and symptoms of ill health in the early part of the semester, but higher levels in the later part of the semester, with higher general levels of stress and illness than non-procrastinators over the course of the semester. Although no known research has formally drawn the link, it logically follows that frequent and chronic procrastinators' generally heightened momentary experiences of negative affect could culminate in the longer-term experiences of illness (e.g., Sirois, 2007) and/or psychopathology (e.g., van Eerde, 2003a).

Moreover, the small, but widely recognised link between procrastination and neuroticism or low emotional stability (Johnson & Bloom, 1995; Schouwenburg & Lay, 1995; Steel, 2007) may be affect the role that affective variability plays in mediating the relationship between individual levels of trait procrastination and task delay. That is, it is possible that those high in trait procrastination but low in neuroticism may experience fewer negative affective consequences during delay than do their high procrastination-high neuroticism peers. Understanding the nature of these relationships, should assist scholars to more appropriately tailor interventions for reducing procrastination.

However, to date, there remain a number of limitations in the studies that have explored the relationship between affect and delay. Some researchers have measured state affect relating to a critical event, such as an examination period, but have not measured delay behaviour relative to the same event (e.g., Lay et al., 1989; Rothblum et al., 1986; Steel et al., 2001). Others have measured delay relating to a critical event, but use general measures of positive and negative affect, and are, therefore, unable to associate procrastination with feelings relating to delayed activity prior to that specific event (e.g., Krause & Freund, 2014; Pychyl et al., 2000; Tice & Baumeister, 1997). In addition, the temporal ordering of affect and delay is not fully understood. On the one hand, delaying a task in favour of something less important but more pleasant, when one knows the importance of doing the original task sooner rather than later (i.e., recognises the potential harm of delaying), may increase feelings of stress, anxiety, and guilt. On the other hand, increased feelings of stress, anxiety, and guilt may influence one to delay an unpleasant task. As van Eerde (2003) has noted, there is no compelling empirical evidence showing whether negative affect causes delay, delay causes negative affect, or there is a bi-directional relationship. The simultaneous and fully cross-lagged measurement of affect relating to task delay and delay relating to a critical event has the potential not only to aid in a deeper understanding of procrastination in vivo, but also in designing future interventions to reduce procrastination.

0.3 The Research Program

0.3.1 Overview

Previous attempts to accurately measure, predict, and intervene to reduce procrastination have largely been conducted in isolation from one another. That is, studies exploring measurement tend not to attempt reduction, and those attempting reduction, tend not to verify accuracy of prediction. This thesis reports three studies with similar designs, all of which incorporated aspects of measurement validation, prediction, and intervention. All three studies used a baseline survey of demographic and trait variables, twice-daily surveys (ESM) to measure affect and behaviour such as assignment progress, random allocation of participants to intervention and control conditions, delivery of brief reflection prompts designed to reduce procrastination in the intervention condition, collection of data pertaining to assignment submission times and marks, and follow-up interviews (Studies 1 and 3 only). The research used a consistent set of well-controlled strategies to observe and model behavioural delay, associate delay trajectories with predictive trait-based procrastination scales, and, through a randomised control design, introduce and assess the efficacy of a novel intervention to reduce procrastination. The design used in all three studies is outlined in detail in the next chapter (see Chapter 1, Figure 1.1 for a visual representation of the study design). The consistency across the three studies enabled replication of major findings around measurement, prediction, and reduction of procrastination. Moreover, methodological and procedural changes highlighted the importance of the context in the delivery of interventions via ESM as well as the type of procrastination measured, with differences in outcomes across the three studies discussed.

0.3.2 Thesis Structure and Outline

Following this introductory chapter, Chapter 1 presents the first of the three studies undertaken with a smaller sample (*N* = 24 producing potentially 672 observations over 14 days) in order to pilot and establish the efficacy of the ESM method. The chapter presents a broad and exploratory series of analyses that confirmed the combined use of ESM and the measurement of assignment progress as a viable method of modelling behavioural delay associated with procrastination, and provides summary evidence that behavioural delay can be effectively reduced through inclusion in the ESM surveys of brief reflection prompts based on the mechanisms of expectancy, value, delay sensitivity, and metacognition. Chapter 1 introduces some of the complexities of longitudinally measuring behavioural delay and the roles of several potential covariates that informed Studies 2 and 3. The qualitative interview component (*N* = 8) yielded informative feedback that confirmed the feasibility and potential applications of a larger scale replication.

Chapter 2 is presented as a published journal article (Wessel et al., 2019), following a linking or prelude section that contextualises the paper in the broader thesis. Chapter 2 presents results of Study 2, which was a larger replication (*N* = 80) of Study 1 designed to enable comparison of active and passive trait procrastination against assignment completion trajectories. The main contribution of Chapter 2 to both the thesis and the body of knowledge is evidence that those highest and lowest in active procrastination do not differ in delay trajectory whereas high levels of passive procrastination was a very strong predictor of behavioural delay. This finding fundamentally challenges the construct validity of active procrastination. This paper was the first to present multilevel mixed effects modelling of curvilinear assignment completion trajectories, and, as such, describes the statistical methodology in detail. As Chapter 2 has been published as a stand-alone document, it repeats some elements of the literature presented in this Chapter, as well as providing greater depth relating to the debate around active and passive procrastination.

The positive effects of the intervention introduced in Study 1 in reducing procrastination did not replicate in Study 2. Differences in the intervention effect between Studies 1 and 2 are considered to be due to differences in contextual factors, which are discussed with evidence in the associated Chapter 3 prelude. Chapter 3, in which the primary focus is the intervention to reduce procrastination, is also presented as a published journal article (Wessel et al., 2020). Chapter 3 presents data from Study 3, which was a more faithful, yet larger ($N = 107$) replication of the Study 1 protocol. The paper presented as Chapter 3 discusses the design and effect of the high-frequency, low-intensity intervention; namely, open questions embedded at the end of each ESM survey designed to prompt regular participant reflection on their task expectancy, value, delay sensitivity, and metacognition. Results indicated participants randomly allocated to the intervention condition reported earlier and more linear progress in assignment progress over the two weeks leading up to its submission deadline compared to those in the control group who were only asked to report progress in each ESM survey. By modelling dilatory behaviour from repeated measurements of task progress, the research provides a basis for assessing the efficacy of both person-based intervention programs, whether they are discrete and separate from either tasks such as time management training or internet-based cognitive behaviour therapy, and naturalistic task intervention strategies that can be integrated into an academic system or program (Marquez, 2016; Melton et al., 2015). Similar to Chapter 2, Chapter 3 is presented as a stand-alone article so there is some repetition of the literature presented in this Chapter. However, more depth is provided around the development of intervention questions and their mapping onto elements considered to relate to procrastination.

Interviews with a subsample of participants ($N = 8$) following the ESM phases of Studies 1 and 3, from both intervention and control conditions, are thematically analysed and results presented in Chapter 4. These interviews elucidated personal experiences associated with participation in the study that focused on their assignment completion and provide rich detail from the perspective of both intervention and control participants, in particular, as to the delivery, advantages, and limitations of such programs. The analysis explicates individual experiences with high frequency surveys and their perceptions of motivation changes that occurred through regular progress reporting and, for the intervention participants, questions designed to prompt reflection relating to expectancy, value, delay sensitivity, and metacognition. Implications for the design of naturalistic task interventions, as opposed to generalised person-based interventions, are discussed.

Chapter 5 uses the data from Study 3 to examine the role affect plays in the experience of delay for procrastinators and non-procrastinators, as negative affect has been highlighted as integral in the definition of procrastination as outlined in this introductory chapter. The use of high frequency ESM surveys measuring both task progress and affect towards progress provides an intensive longitudinal data structure where trajectories of behavioural delay, changes in affect over time, and the inter-temporal (cross-lag) effect between the two can be investigated. The research presented in this thesis is the first to concurrently measure trait procrastination and neuroticism (presented in Chapter 5 as emotional stability), as well as state delay and affect as they relate to progress (or lack thereof) on a single critical task. In Chapter 5, relationships between trait and state variables are examined, and evidence presented that higher delay at one time relates to lower positive affect at a subsequent time, while higher positive affect at one time relates to higher delay at a subsequent time. Chapter 5 has been prepared as a stand-alone paper, that will subsequently be submitted to a journal for publication. Consequently, there is again slight but necessary repetition of key content from this introductory chapter and the statistical methodology presented in Chapter 2.

The General Discussion chapter, Chapter 6, reflects on the overall research program. In conclusion, I argue that the novel design of the three Studies and the specific research questions addressed across Chapters 1-5 represent unique and significant contributions relating to the measurement, prediction, and reduction of procrastination. While the three studies operationalised procrastination in relation to behavioural delay on an academic task, the approach to reducing procrastination through both frequent measurement of goal progress and reflection prompts is likely to extend to other fields of application. For example, those seeking to lose weight who have struggled to maintain exercise and dietary discipline may benefit from an application prompting frequent weigh-ins followed by open-ended questions targeting weight loss expectancy, value, delay sensitivity, and metacognition. This is likely to apply also to other common health behaviour change challenges. Similarly, this high-frequency, low-intensity approach may be effective when applied to perennial challenges in personal financial planning and inaction on collective issues such as climate change where most people agree more needs to be done, but delay individual action.

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Chapter 1: Study 1 (Pilot)

1.0 Overview

Study 1 was conducted as a small-scale pilot ($N = 24$) of a novel study protocol comprised of a large baseline questionnaire that included demographic items and personality and procrastination scales, followed by frequent and brief ESM surveys (i.e., twice daily over 14 days) and follow-up interviews. The study aimed to test whether tracking self-reported assignment progress over two weeks would identify the hypothesised delay curve, confirm the relationship between personality and delay based on prior procrastination research, assess the ability of trait procrastination scales and a dynamic procrastination equation to predict delay, and pilot a novel intervention to reduce delay. ESM surveys included questions on percentage of assignment completed at the time of responding, intended progress in the next 24 hours, and affect towards assignment progress (e.g., guilty or relaxed). For the ESM component of the study, students were randomly allocated to either an intervention or control condition. In the intervention condition, each ESM survey concluded with one of four open questions, selected at random each survey. Intervention questions were designed to prompt reflection on the target assignment in the four areas previously proposed to reduce procrastination (reviewed in section 0.2.3.2 of the introductory chapter). In prompting reflection on *expectancy*, participants were informed of, and then asked to repeat what other students who are successful in the task do, with the aim that this would provide a basis for social proof regarding the benefits of not procrastinating (e.g., Goldstein et al., 2008). To prompt reflection on *value*, participants were asked to visualise future consequences of task delay (e.g., Rebetez et al., 2016) and report anticipated feelings. To address *delay sensitivity*, participants were prompted to reply with the next achievable step of the task ahead of them (e.g., Abbasi & Alghamdi, 2015; Rozental & Carlbring, 2013). Finally, to prompt *metacognition*, participants were asked to consider and report a potential barrier to timely completion (e.g., Corkin et al., 2011; Steel & Klingsieck, 2016).

All participants were students enrolled in a first-year psychology course, where ESM surveys and intervention prompts related to a mid-term assignment (laboratory report) worth 30% of the course grade. As all participants were working toward the same task and deadline, progress reports provided an intensive longitudinal view of participants' dilatory behaviours in pursuit of that goal (i.e., submission of the assignment). Using a mixed effects multilevel modelling approach, rates of assignment progress towards completion were found to fit a hyperbolic trajectory. Similar to trajectories found by Dewitte and Schouwenburg (2002), modelling revealed assignment progress of those high in trait procrastination over two weeks was more linear than those low in the same trait measure. No significant differences in progress trajectory based on trait conscientiousness or neuroticism were identified. However, the absence of significant effects might have reflected a lack of power due to the small sample size as moderate effect sizes were identified and graphed trajectories showed notable differences. Most importantly, participants allocated to the intervention condition (n = 16) reported substantially less delay than those allocated to the control condition (n = 8). Follow-up interviews did not reveal substantial subjective differences in perceived influence of participation in the study between those in the intervention or the control conditions, with interviewees from both conditions reflecting that regular reporting of actual progress and intended progress is likely to have increased their motivation to complete the assignment earlier. Frequent progress reporting required of all participants may have led to an observer effect, where heightened awareness of their progress over the two-week ESM period may have increased motivation in the control condition and subsequently reduced potential between-condition differences in behavioural delay.

1.1 Introduction

The propensity to procrastinate is considered to be personality-related (Schouwenburg & Lay, 1995). That is, levels of procrastination differ between individuals, and those differences are thought to persist over time and across a range of situations. Many authors have sought to understand procrastination by its relationship with other personality traits, namely the big-five factors (Costa & McCrae, 1992). Of the big-five, trait procrastination is most consistently associated with both conscientiousness and neuroticism. Reviews and meta-analyses have identified a strong negative correlation between procrastination and conscientiousness (e.g., Ferrari et al., 1995; Steel, 2007; van Eerde, 2003). This is perhaps to be expected when facets of conscientiousness include achievement striving and self-discipline, both of which are conceptually aligned and firmly correlated with procrastination (r = -.53 and -.49 respectively; Lay, 1997). On the other hand, meta-analyses have identified a weak yet positive correlation between procrastination and neuroticism (Steel, 2007; van Eerde, 2003). However, Steel (2007) has argued this relationship is more likely an artefact of higher rates of negative self-appraisal among those high in neuroticism, and neuroticism is unlikely to be related to observed behavioural delay. The cited evidence for this assertion, however, operationalised delay through postponement of self-paced quizzes, which may be insensitive to reasons for delay other than procrastination. This weak positive relationship may also be explained by a curvilinear relationship between procrastination and neuroticism, where higher levels of neuroticism can lead to task avoidance, yet among those scoring in the highest percentiles of neuroticism, the reverse effect may occur, with higher degrees of anxiety leading to over-cautious earlier completion of tasks (McCown et al., 1987).

Few studies have adequately modelled behavioural delay relating to procrastination, with fewer exploring the relationship between delay and personality-based correlates such as conscientiousness and neuroticism. In the validation of a novel approach for measuring and modelling behavioural delay, not only is it necessary to identify statistically significant levels of delay, but in order to establish convergent validity of the delay measure as indicative of procrastination, the inclusion of potential covariates is also warranted.

Hypothesis 1. Participants, in general, will display a hyperbolic curve in productivity (i.e., delay) as a deadline approaches.

Hypothesis 2. Conscientiousness will be negatively associated with behavioural delay.

Hypothesis 3. Emotional stability will be negatively associated with behavioural delay.

In addition, no known study has empirically assessed the ability of various procrastination types to predict delay curves. For example, it is not known whether those who self-report procrastinating due to avoidant tendencies display progress on a complex task such as an assignment at the same rate as those who procrastinate due to arousal tendencies. If the goal of administering a trait procrastination measure is to predict and potentially circumvent future delay behaviour, then those measures purporting to predict delay should first be assessed for their predictive validity.

Hypothesis 4. Higher scores on (a) arousal procrastination and (b) avoidant procrastination will be associated with behavioural delay.

Temporal Motivation Theory (TMT; Steel & König, 2006) was briefly introduced in the previous chapter (section 0.2.1.7). TMT posits that individuals are more likely to procrastinate if they have low *expectancy* of task success, hold low *value* for the task, and are more likely to indulge in proximal needs than work towards distant goals (i.e., *sensitive to delay*). Moreover, at the core of TMT is an equation which purports to predict curvilinear individual differences in motivation as a task deadline or payoff approaches. However, the authors of TMT do not provide guidance on how expectancy, value, and delay sensitivity should be measured (Steel & König, 2006). The only found method for quantifying the variables of TMT's procrastination equation was presented in the form of the Motivational Diagnostic Test (MDT) at the Seventh Biennial Procrastination Research Conference (Steel, 2011). Convergent construct validity of the MDT was established through a cross-sectional correlational study (N = 1,279), where expectancy, value, and delay sensitivity were correlated with a trait measure of procrastination (rs = -.29, -.59, and .63, respectively). TMT and the associated procrastination equation theoretically account for both individual and temporal differences in motivation in a way no other theory of procrastination does. However, I know of no attempts to validate TMT empirically in a dynamic (i.e., longitudinal) context.

There are two core elements that are likely to determine the ability of TMT to predict procrastination: (1) the adequate operationalising of the components of TMT; namely, expectancy, value, and delay sensitivity, and (2) the procrastination equation (described in section 0.2.1.7). Regarding the former, with no known direct empirical evidence testing the predictive ability to TMT, and only cross-sectional evidence of the convergent validity of the MDT, in order to test TMT in the field, alternative measures of expectancy, value and delay sensitivity ought to be utilised. Moreover, although Steel (2011) demonstrated convergent validity between trait procrastination and the components of TMT, the MDT scales for expectancy and value predominantly target self-efficacy and persistence in the absence of intrinsic motivation, respectively, as stable trait variables. As such, individual scores of expectancy and value in the MDT do not differ relative to the task or goal. Individual tendencies to procrastinate, however, are likely to differ relative to the perceived expectancy of task success and value in the predicted outcome (Steel, 2007; van Eerde & Thierry, 1996).

In order to address the potential limitation of using the MDT to operationalise expectancy and value in the TMT formula, this study included measures of expectancy and value (Zhu et al., 2012) designed to be tailored to a specific focal task. In the case of this study, a psychology laboratory report was used as the task. While expectancy and value are likely to be highly variable based on focal task, delay sensitivity may be a more stable individual trait. As discussed in the previous chapter, delay sensitivity is largely synonymous with impulsivity (Steel, 2007), with Steel (2011) referring directly to impulsivity in the construction of the MDT. In order to overcome the limited empirical support for the MDT impulsivity sub-scale, a widely used and well validated measure of impulsivity (e.g., Spinella, 2007) was utilised as an alternative. The additional expectancy, value, and impulsivity scales are combined in this study into an alternative composite of the TMT formula and referred to hereafter as the EVI.

Hypothesis 5. Higher motivation scores as determined by the (a) MDT and (b) EVI scales will be associated with less behavioural delay.

If expectancy, value, and delay sensitivity predict procrastination, then the design of interventions to reduce procrastination ought to consider methods for increasing expectancy and value, while decreasing sensitivity to delay. Indeed, many suggested approaches to reducing procrastination can be described as addressing either task expectancy or success, value, or delay sensitivity. These were discussed in these three categories in section 0.2.3.2 of the previous chapter, as was an additional approach: metacognitive reflections on task and delay behaviour. The specific method of delivering these proposed interventions, however, was not explicitly discussed. Those seeking to aid others in the reduction of procrastination need to consider how and when interventions are best delivered. For example, one might consider an intensive training or psychotherapeutical person-level intervention, where the intervention is delivered independently of a task on which an individual may be prone to procrastinating. Alternatively, one might consider a naturalistic task intervention, where an intervention is embedded in the task itself. In the case of a study proposing to measure task progress via subjective reports at a relatively high frequency, it is opportune to consider a naturalistic task intervention.

The challenge, then, is how to embed an intervention without placing unreasonable additional requirements on participants that may adversely affect participation rates (e.g., as happened with Rozental et al., 2015). Instead of providing extensive educational content that individuals may passively engage with (e.g., Rozental et al., 2015), providing individuals with short open-ended questions that prompt reflection on potential antecedents to procrastination may be a parsimonious approach. For example, to build *expectancy*, participants may be prompted to describe what others who are successful in the task do. This use of 'social proof' has been effective in changing behaviour in lieu of direct work with an individual to coach and reinforce experiences of success to build expectancy (Goldstein et al., 2008). Prompting individuals to visualise future favourable consequences of procrastinating may be an effective strategy for increasing perceived *value* to reduce delay (e.g., Rebetez et al., 2016). To dilute the effect delay has on those who are *sensitive to delay*, a prompt designed to shift focus to a more immediately achievable portion of the task may be beneficial (e.g., Abbasi & Alghamdi, 2015; Rozental & Carlbring, 2013). Finally, *metacognition* may involve reflection on a broad category of behaviours and strategies. To prompt metacognitive reflection, asking individuals to report their primary barrier to timely completion may be a parsimonious method for prompting respondents to consider variables around the task, their priorities, and their own behavioural, cognitive, and affective tendencies on a meta level (Corkin et al., 2011; Steel & Klingsieck, 2016; Wolters, 2004). While the singular responses to these brief reflection prompts may do little to reduce behavioural delay in the short-term, frequent repetition of these prompts may ensure delivery of subtle yet persistent increases in task expectancy, value, metacognitive reflection, and reduced sensitivity to delay.

Hypothesis 6. Brief yet frequent prompts targeting task expectancy, value, delay sensitivity, and general metacognitive strategies (the intervention) will reduce behavioural delay.

Procrastination is positively associated with both delayed task completion (e.g., assignment submission) and reduced performance (van Eerde, 2003). While the primary objective of delivering reflection prompts is to reduce behavioural delay, it seems reasonable that if an intervention is successful at that, then students will commence their assignments earlier, have more time overall to devote to successful completion, and, therefore, receive higher marks for performance.

Hypothesis 7. Members of the intervention group will (a) submit their assignments earlier and (b) receive higher assignment marks than will members of the control group.

Finally, behavioural delay and performance are not the only consequences of procrastination. Perhaps one of the most pernicious consequences of procrastination is the higher degree of negative affective states experienced by the procrastinator. That is, those who are knowingly procrastinating experience higher degrees of guilt, anxiety, and worry (Pychyl et al., 2000a; Sirois, 2007; Sirois 2014; van Eerde, 2003). The relationship between procrastination and negative affect is well established; however, no known study has simultaneously measured progress and affect relating to progress in the lead-up to a critical event such as a due date. In order for measured delay to be confidently associated with procrastination, delay is expected not only to differ between those higher and lower in trait levels of procrastination, but also to be associated with negative affective states such as guilt, anxiety, and worry.

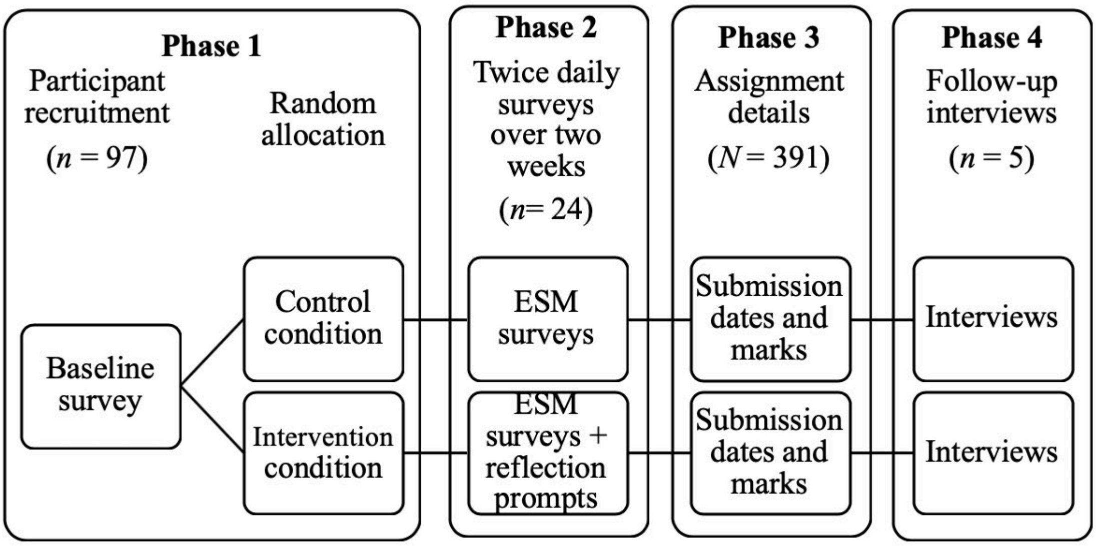
Hypothesis 8. Behavioural delay will be associated with higher levels of negative affect such as guilt, anxiety, and worry.

1.2 Design

The study comprised four phases (see Figure 1.1). In Phase 1, person-level questionnaires measured demographic and personality variables, trait-level propensity to procrastinate, individual impulsivity, and expectancy and value specific to completion of an undergraduate Lab Report. Following Phase 1, students were invited to volunteer to participate in a further ESM study (Phase 2). Volunteers were randomly allocated to intervention and control conditions. ESM surveys were directly distributed to all participants' smartphones over this phase. The primary focus of participants since the last survey (i.e., study or non-study related), percentage of assignment completed (i.e., progress), and affect towards assignment progress were assessed 2 times per day over the 14 days prior to the assignment due date for a total of 28 observations. In addition, at the end of each ESM survey, intervention condition participants received an open-ended question/prompt, randomly selected from a pool of four, expected to reduce delay on assignment progress by prompting reflection on either task expectancy, value, delay sensitivity, or metacognition. In Phase 3, the final assignment submission dates and marks were obtained for the study participants and for all members of the remaining class cohort to determine the effects of observation and intervention on the assessment. Last, in Phase 4, participants were invited to a follow-up interview to discuss their experiences with the ESM study. Figure 1.1 summarises these four research phases.

Figure 1.1

Four Phases of Study 1



1.2.1 Participants

Participants ($N = 94$) were students enrolled in a first-year undergraduate psychology course at a multi-campus urban university in south-east Queensland, Australia (24% of the entire course cohort). The majority of participants were female

(86.2%), with ages ranging from 17.23 to 43.15 years ($M = 20.42$, $SD = 5.96$). There were 74.5% who were enrolled full time, and 90% worked less than 20 hours per week. Most (79%) primarily spoke English at home. Of the 94 participants in Phase 1, 33 (35.1%) consented to participate in the ESM study (Phase 2). Participants in Phase 2 ($N = 33$; 8.4% of the entire course cohort) were generally representative of those who participated in Phase 1. Ages of those in Phase 2 ranged from 17.38 to 43.15 years ($M = 22.83$, $SD = 8.00$). Most Phase 2 participants were studying full-time (76%), 75% worked less than 20 hours per week, and most (87.5%) primarily spoke English at home.

Phase 2 (ESM) participants were randomly allocated to either an intervention or a control condition. Due to the relatively small sample size and the interest in the effect of interventions on different types of procrastinators, random allocation was weighted towards intervention condition, whereby a participant had a 2 in 3 chance of allocation to the intervention condition. This resulted in 64% of ESM participants allocated to the intervention condition ($n = 21$), compared to 36% allocated to the control condition ($n = 12$). Assignment mark and submission data (Phase 3) were collected for the entire class cohort ($N = 391$). All 33 Phase 2 participants were invited to a follow-up interview (Phase 4). Five students (15.2%) attended a follow-up interview (control $n = 3$, intervention $n = 2$).

1.2.2 Measures

Independent Variables

Phase 1

The Phase 1 person-level baseline questionnaire contained demographic items plus the following multi-item scales. Unless otherwise indicated, scale responses are made on a 5-point Likert scale (1 = *strongly disagree*; 5 = *strongly agree*). Higher scores indicate stronger endorsement of the construct.

NEO Personality Inventory – Revised (NEO-PI-R). Conscientiousness and Neuroticism subscales (9 and 8 items, respectively) from the NEO-PI-R scale (Costa & McCrae, 1992, 1994) were used. Conscientiousness facets are competence, order, dutifulness, achievement striving, self-discipline, and deliberation. The neuroticism subscale consists of anxiety, angry hostility, depression, self-consciousness, impulsiveness, and vulnerability. The internal reliabilities (Cronbach's α) of NEO-PI-R subscales are above .80, and test retest reliabilities are above .75 (Costa & McCrae, 1992).

Avoidant Procrastination. The Adult Inventory of Procrastination (AIP; McCown & Johnson, 1989) is a 15-item measure of avoidant procrastination with reported Cronbach's alpha of .79 and retest reliability (1 month) of .71. Items include "I am not very good at meeting deadlines" and "I don't get things done on time".

Arousal Procrastination. The General Procrastination Scale (GPS; Lay, 1986) is a 20-item measure of arousal procrastination with reported Cronbach's alpha of .82 and 1-month retest reliability of .80 (Ferrari, 1992). Items include "I am continually saying I'll do it tomorrow" and "When preparing to go out, I am seldom caught doing something at the last minute".

Motivational Diagnostic Test (MDT). The MDT was developed by Steel (2010a; Steel, 2011) to provide the values for the 'procrastination equation' posed by TMT (Steel, 2010a; Steel, 2011; Steel & König, 2006). The MDT is comprised of three 8-item sub-scales that assess expectancy, value, and delay sensitivity. Of the sub-scales, expectancy (E) and value (V) are multiplied together as the numerator in the procrastination equation, while delay sensitivity (DS) and delay (D; time) plus 1 are multiplied as the denominator to determine a motivation (M) score ($M = (E \times V) \div (DS \times (D + 1))$). In order to maintain consistent weighting with other sub-elements of the TMT formula (for which scores could range between 8 and 40), the value for D (time) was calculated on a sliding scale from 40 to 0, where 40 represents the first data collection point on the first day of the ESM protocol, and 0 represents the last ESM data collection point on the due date of the assignment. There is a perfect correlation between TMT scores (measured both through the MDT and EVI) at time 1 and the average trajectory across the total delay period. That is, as D (time) was the only dynamic element in the formula, and it changed at the same rate for all participants, between-person differences in MDT at one time were equal to between-person differences at all other times. Previous internal reliability values were not reported for the expectancy, value, and delay sensitivity subscales but with this sample, Cronbach's alphas were between .85 and .91.

EVI Expectancy and Value Scales (tailored). An 11-item expectancy-value scale was adapted from Zhu et al. (2012, see Appendix A). The scale is designed to be tailored to specific goals or tasks. Items are rated on a 5-point bipolar scale, with pole-descriptions dependent on the context of the question (1 = *Not good/Worst/Very poorly*, 5 = *Very good/Best/Very well*). The scale includes five items targeting expectancy in relation to the particular student assignment (e.g., "If you give 5 to the best student and 1 to the worst, what would you give yourself?"), and six items targeting value, again in relation to the particular student assignment (e.g., "How important do you think Psychology is for you?"). Zhu et al. reported that the scale Cronbach's alpha in a middle-school sample was .89.

EVI Impulsivity. As the MDT has limited empirical support, the 15-item short form of the Barratt Impulsiveness Scale (BIS-15; Spinella, 2007) was used as an alternative measure of delay sensitivity to the MDT delay sensitivity subscale. The BIS-15 includes sub-scale factors for attention impulsivity, motor impulsivity, and non-planning. Spinella (2007) reported that the Cronbach's alpha of the full BIS-15 was .79, and, as evidence of validity, total scores on it were highly correlated with the original 30-item Barratt Impulsivity Scale (BIS30; $r = .94$, $p < .001$). Questions include "I do things without thinking" and "I plan tasks carefully" [reversed]. Items are rated on a 4-point frequency scale (1 = *rarely/never*, 4 = *almost always*).

EVI Motivation. EVI motivation is a score constructed as an alternative form of the MDT based on the three EVI measures where items were specific to the task of assignment completion. D was the same delay or time metric explained under the MDT. The formula is the same also as that used to calculate MDT motivation ($M = (E \times V) \div (I \times (D + 1))$).

Phase 2

Intervention Questions/Reflection Prompts. At the end of each ESM survey, participants in the intervention condition were required to respond to a brief open question designed to prompt reflection on one of expectancy, value, delay sensitivity, and metacognition. The ESM software randomly allocated one of the following four reflection prompts each time: (1) "Our analyses suggest that students who do best in this course start early and submit their Lab Report the day before it's due. To demonstrate you have read the above statement, in the following box please repeat what students who perform the best do" (expectancy); (2) "I want you to imagine yourself the day before this assignment is due, and you haven't started working on it. How do you feel?" (value); (3) "Research has found breaking larger tasks (like completing an assignment) into smaller tasks (like brainstorming 3 dot-points) can help with motivation. What is your next small step?" (delay sensitivity); or (4)

"Thinking about a time you put off an intended task (like an assignment), what would have helped you complete the task earlier?" (general metacognition).

Dependent Variables

Twice a day for 14 days, all Phase 2 participants (those allocated to both intervention and control conditions) were asked to complete a short questionnaire that included the following measures.

Study and Non-Study Focus. As a source of construct validation, without explicitly implying a connection to procrastination, study and non-study focus was determined by a single question with multiple pre-determined response options. Participants were asked: "Since the last survey, what has been your primary focus?" (available answers: *study*, *sleep*, *work [paid or unpaid]*, *caring for others*, *house work*, *socialising [family or friends]*, *media [including social media and gaming]*, or *other*). Two variables were created from this measure: (1) study focus, taken as the percentage of responses over the ESM phase stating "study" as the primary focus, and (2) non-study focus, taken as the percentage of responses of either "house work", "socialising", or "media".

Assignment Progress. Assignment progress was the primary dependent variable for mapping assignment progress trajectories, and, therefore, delay. It was measured by the following question: "As of right now, what proportion of your [course code] Lab Report have you completed (0% - 100%)". Responses were made on a sliding scale from 0% to 100%. This measure of progress was adapted from items relating to study duration used by Dewitte and Schouwenburg (2002).

Delay. Delay was the primary dependent variable used in correlational and group mean difference analyses. Delay was taken as the average within-person modelled assignment progress trajectory across the 28 points of measurement in

Phase 2, as determined by an unconditional quadratic multilevel mixed effects model (see Tables 1.3 and 1.4). This average percentage assignment completed trajectory figure was then subtracted from 100 (i.e., from 100% completed) as an indication of behavioural delay. For example, if a participant had completed only a small proportion of their assignment over the first 13 days of observation, then completed 50% and 100% assignment on the 14th day, their average assignment progress (modelled) may be 15%, and their average delay 85%. As modelled trajectories were used to compute this variable, average delay values were able to be calculated for participants with missing data. The delay variable is, therefore, equivalent to the area over the reported progress curve.

Progress Intent. Progress intent over the next 24 hours was measured by asking the following question: "By this time tomorrow, what proportion of your [course code] Lab Report do you plan to have completed? (0% - 100%)". This item was also measured on a 0 to 100 sliding scale. This measure of intent was adapted from items relating to study intent used by Dewitte and Schouwenburg (2002).

Affect. Participants were asked how they felt about their progress on the target assignment at the time of completing each ESM survey, using a single sliding scale with "anxious/worried/guilty" as descriptive anchors of negative affect on one end, and "relaxed/comfortable" as anchors of positive affect on the other. Similar to the delay variable, average affect across the 28 ESM surveys was computed through an unconditional quadratic multilevel model to determine a single continuous variable use in the correlational analyses. The scale was centred for analyses, where higher positive scores indicated higher positive affect, and lower (negative) scores indicated higher levels of negative affect, specifically anxiety, worry, and guilt.

Phase 3

Assignment Details. Assessment mark and submission date were collected from university records for study participants as well as for the full class cohort not participating in the present study.

1.3 Results

Participants who responded to less than 40% of ESM surveys were removed from analysis due to incomplete data. One individual who responded to 100% of the ESM surveys, but did not report completing more than 30% of their assignment and had no assignment submission data from Phase 3 was also removed from further analyses. The small amounts of missing data present in the responses of the remaining 24 participants were handled through the Restricted Maximum Likelihood procedure (REML; Heck et al., 2010) in the multilevel mixed models used to analyse assignment progress trajectory data (described below).

Phase 1 results report relationships between independent variables, including data from dependent variables collected in Phase 3 (assessment details). These data are presented initially to assess relationships reported by previous research and to ensure relationships in this sample occur in the directions expected. Phase 2 results include analyses of covariates identified in Phase 1 (e.g., conscientiousness, EM, active, and avoidant procrastination types), and mean levels of delay and delay trajectories reported by ESM participants in Phase 2. Additionally, mean delay and delay trajectories are compared between participants in Phase 2 intervention and control conditions (H6). Phase 2 data are instrumental in addressing hypotheses 1-6 and 8. Results for Phase 3 are not reported in a separate section; rather, results pertaining to submission dates and assignment marks are included in the phase 1 and 2 analyses. Phase 4 was designed to gain participant perspectives of the ESM methodology. Results from this phase summarise the most common and most noteworthy responses received in the follow-up interviews.

1.3.1 Phase 1 Descriptive Statistics and Bivariate Correlations

All scales had adequate internal reliability ($\alpha \geq .70$: Nunnally, 1978). Correlations reported in Table 1.1 indicate associations between avoidant and arousal procrastination and other variables in the anticipated directions. Measures of arousal and avoidant procrastination were strongly positively correlated with each other. Both avoidant and arousal procrastination were correlated positively with a well validated measure of impulsivity (EVI). Conscientiousness was correlated negatively with both types of procrastination. However, neuroticism demonstrated a weak positive correlation with arousal procrastination, but was not correlated with avoidant procrastination. EVI motivation was correlated negatively with avoidant procrastination but not with arousal procrastination, while MDT motivation was correlated negatively with both procrastination types (motivation scores calculated using the procrastination formula). Conscientiousness was correlated positively with both the EVI and MDT motivation scores.

Table 1.1

Correlations for Phase 1 Composite Variables, Including Data from Phase 3 (N = 94)

		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
1.	Gender	—															
2.	Age	.07	—														
3.	Study load	-.01	**-.33**	—													
4.	Conscientiousness	-.08	**.22**	-.14	(.74)												
5.	Neuroticism	**.43**	-.07	.01	-.13	(.84)											
6.	Avoidant Procrastn.	.13	.15	-.01	**-.39**	.19	(.77)										
7.	Arousal Procrastn.	.15	-.01	.03	**-.53**	**.28**	**.57**	(.89)									
8.	MDT: Expectancy	**-.23**	.04	-.01	**.41**	-.17	-.13	.04	(.91)								
9.	MDT: Value	-.06	.16	-.12	**.50**	**-.34**	**-.20**	**-.57**	-.11	(.86)							
10.	MDT: Delay Sens.	-.01	-.10	.07	**-.46**	**.22**	**.28**	**.64**	.20	**-.67**	(.85)						
11.	MDT: Motivation	-.16	.14	.09	**.69**	**-.39**	**-.33**	**-.43**	**.51**	**.62**	**-.62**	(.88)					
12.	EVI: Expectancy	-.17	-.05	.18	.17	-.18	-.14	.11	**.57**	-.16	.11	**.33**	(.83)				
13.	EVI: Value	-.03	.10	-.05	.02	.02	-.12	**.28**	**.46**	-.23	.32	.12	**.53**	(.88)			
14.	EVI: Impulsivity	.15	.00	-.02	**-.45**	.13	**.40**	**.66**	**.01**	**-.55**	**.58**	**-.34**	.06	.19	(.81)		
15.	EVI: Motivation	-.17	-.05	.10	**.35**	-.14	**-.37**	-.17	**.55**	.08	-.10	**.44**	**.76**	**.66**	**-41**	—	
16.	Submission Date	-.10	-.00	.08	.06	.07	.05	.05	.02	.17	-.05	.11	.04	.01	.02	.02	—
17.	Assignment Mark	.03	.05	-.11	.15	.04	-.12	-.03	.16	-.19	.07	-.02	**.29**	.07	-.07	**.24**	**-.34**

Note. Cronbach's alpha coefficients are depicted in parentheses along the diagonal. Gender is coded as 0 = Male, 1 = Female. Study load is coded as 1 = 25% of the standard full-time study load, 2 = 50% study load, 3 = 75% study load, 4 = 100% study load, 5 = >100% study load. MDT: Motivation was computed as (MDT: Expectancy × MDT: Value) / (MDT: Delay Sensitivity × ((distance from due date)+1)). EVI motivation was computed as (EVI: Expectancy × EVI: Value) / (EVI: Impulsivity × ((distance from due date)+1)). Submission date of -1 = on or before 11/05/2017 4:00 pm, 0 = Due date 12/05/2017 4:00 pm, +1 = on or after 13/05/2017 4:00 pm.

Correlation coefficients with $p < .05$ (2-tailed) highlighted in bold. Correlations above ±.204 are significant at the $p < .05$ level; correlations between ±.27 and ±.33 are significant at the $p < .01$ level; correlations above ±.33 are significant at the $p < .001$ level. All tests are two-tailed.

Assignment mark was correlated positively with EVI: expectancy, but not with any other EVI scale scores. However, the calculated EVI: motivation demonstrated a positive correlation with assignment mark. MDT: motivation was not significantly correlated with assignment mark. No variables were significantly correlated with the assignment submission date.

1.3.2 Phase 2 Descriptive Statistics and Correlations

Table 1.2 presents descriptive statistics and correlations relating to the ESM phase. Subscales of MDT: motivation and EVI: motivation were not correlated with any Phase 2 variables and, thus, were excluded from further analyses. Correlations significant at the $p < .05$ (1-tailed) level are italicised in Table 1.2 to aid with interpretation of directional hypothesis.

Study focus was moderately correlated positively with study load and negatively with delay; however, study load was not correlated with delay. That is, those studying full-time were more likely to report their main focus had been study since the last ESM survey, and those who more frequently reported study had been their main focus were less likely to delay. Similarly, those in the intervention condition reported a lower level of average delay ($M = 44.8$, $SD = 20.2$) compared to those in the control condition ($M = 64.5$, $SD = 27.9$; Cohen's $d = 0.86$, $p = .03$; 1-tailed). Thus, Hypothesis 6 was supported. Delay, that is, the inverse of assignment progress, was also associated with higher levels of negative affect; namely, guilt, anxiety, and worry, supporting Hypothesis 8. Higher levels of delay during the two-week ESM period of observation was also related to later assignment submission. Assignment mark was not correlated with any variable analysed.

Table 1.2

Descriptive Statistics and Correlations for Demographic Variables and Phase 1, 2, and 3 Composite Variables for Participants in the ESM Phase of the Study (N = 24)

Phase		**Variable**	**Mean**	**SD**	**1.**	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	**8.**	**9.**	**10.**	**11.**	**12.**	**13.**	**14.**	**15.**
	1.	Gender	-	-	—														
	2.	Age	21.9	9.11	.15	—													
	3.	Study load	3.54	0.88	-.06	**-.59**	—												
	4.	Conscientious	32.1	4.44	.07	.17	-.17	—											
1	5.	Neuroticism	26.5	6.16	*.38*	.14	.09	-.24	—										
	6.	Avoidant Procr.	35.4	7.19	.04	.24	.16	*-.40*	.00	—									
	7.	Arousal Procr.	51.7	13.7	.02	.06	.27	**-.54**	.24	**.71**	—								
	8.	MDT: Motivation	2.32	1.13	-.03	.01	.05	**.69**	**-.43**	-.28	**-.47**	—							
	9.	EVI: Motivation.	0.97	0.34	-.24	-.25	.05	*.39*	-.17	-.16	-.07	**.49**	—						
	10.	Study focus	40.1	24.4	-.04	-.36	**.50**	.26	-.17	.00	.09	.12	.34	—					
	11.	Non-study focus	10.7	9.15	.08	.02	-.25	-.14	.24	-.26	-.21	.01	.16	-.08	—				
2	12.	Exp. cond.	0.67	0.48	.00	.32	.14	.12	-.21	.21	.06	.09	-.34	*.37*	.02	—			
	13.	Delay	51.4	24.3	.03	-.15	.06	-.19	.31	-.15	-.14	.02	-.13	**-.46**	.13	*-.39*	—		
	14.	Affect	0.07	2.48	-.23	-.02	.09	*.35*	-.26	-.25	*-.38*	*-.16*	.31	.25	.04	.10	**-.49**	—	
3	15.	Submission date	-1.02	1.81	.00	-.25	.14	.01	.34	-.15	-.12	-.03	-.10	.04	.13	-.06	*.40*	*-.35*	—
	16.	Assign. mark	71.5	13.1	.26	.28	-.24	.27	.08	.09	.22	-.06	.01	.19	-.04	.21	-.31	-.09	.02

Note. Exp. cond. is dummy coded, where *control condition* = 0 and *intervention condition* = 1. A higher submission date signifies later submission. Higher delay denotes a higher proportion of the assignment completed closer to the deadline. Higher affect indicates more positive average affect modelled over the two weeks of observation.

Correlation coefficients with $p < .05$ (2-tailed) highlighted in bold. Correlations above ±.41 are significant at the $p < .05$ level; correlations between ±.54 and ±.62 are significant at the $p < .01$ level; correlations above ±.63 are significant at the $p < .001$ level; Correlations above ±.35 are significant at the $p < .05$ level (1-tailed) and are italicised.

1.3.3 Phase 2 Multilevel Mixed Effects Models

Assignment progress reported in each ESM survey was the primary focus (DV) in a series of multilevel models. To determine whether progress towards assignment completion over the 14 days generally followed the hypothesised (H1) hyperbolic (or quadratic, in the nomenclature of trajectory modelling) form, progress trajectories were analysed using a single-level unconditional linear and growth curve mixed model in a multilevel framework (Heck et al., 2010; Muthén & Muthén, 2017).

The unconditional model examined the rate of progress on the assignment (as indicated by reports of the percentage completed at each of the 28 time points). The model included two time variables: Time (the linear effect) and Time^2 (the quadratic or hyperbolic effect). Coefficients represented units of percentage increase in assignment progress at the start of the two weeks (intercept), additional change over one day (slope), and additional change over one day squared (quadratic). Thus, the general form of the unconditional model (see Tables 1.3 and 1.4, model 1) was as follows:

$$Y_{ti} \text{ (Percentage completed)} = \Pi_{0i} + \Pi_{1i} (\text{Time}_{ti}) + \Pi_{2i} (\text{Time}^2{}_{ti}) + \varepsilon_{ti},$$

$$\Pi_{0i} = + \beta_{00} + \gamma_{0i},$$

$$\Pi_{1i} = + \beta_{10} + \gamma_{1i},$$

$$\Pi_{2i} = + \beta_{20} + \gamma_{2i},$$

where Π_{0i} is person i’s mean progress percentage at Time 1, Π_{1i} is person i’s linear growth rate, and Π_{2i} is person i’s quadratic curvilinear growth rate (or acceleration in assignment percentage completed). Mean percentage assignment completed, signified by unstandardised β_{00}, indicates the average percentage of assignment completed at Time 1 (2 weeks prior to the due date), while mean growth (linear) and the acceleration (quadratic) rates are signified by β_{10} and β_{20}, respectively.

Wald Z tests identified significant between-person differences in intercept, linear, and quadratic growth (Z = 3.28, 3.15, and 3.20 respectively, all ps < .003) in the unconditional model, suggesting additional covariates may explain the remaining variance in assignment progress trajectories (Heck et al., 2010).

Thus, in order to include conscientiousness, neuroticism, avoidant procrastination, arousal procrastination, MDT motivation, EVI motivation, and experimental condition participation as covariates that may explain this additional variance, the general form of models 2-8, respectively, was as follows:

$$Y_{ti} \text{ (Percentage completed)} = \Pi_{0i} + \Pi_{1i} \text{ (Time}_{ti}) + \Pi_{2i} \text{ (Time}^2{}_{ti}) + \varepsilon_{ti},$$

$$\Pi_{0i} = + \beta_{00} + \beta_{01} \text{ (Covariate)} + \gamma_{0i},$$

$$\Pi_{1i} = + \beta_{10} + \beta_{11} \text{ (Covariate)} + \gamma_{1i},$$

$$\Pi_{2i} = + \beta_{20} + \beta_{21} \text{ (Covariate)} + \gamma_{2i},$$

where mean percentage assignment completed, signified by β_{00}, indicates the average percentage of assignment completed at Time 1 (14 days prior to the due date), with covariates equal to zero (grand mean centered). A single covariate was included in each of these models (2-8), with the coefficient β_{01} reflecting differences in mean percentage assignment completed as a function of the particular covariate under analysis at the first observation (i.e., intercept). Mean growth (linear) and the acceleration (quadratic) rates are signified by β_{10} and β_{20}, respectively. Growth (linear) and the acceleration (quadratic) rates for participants scoring one standard deviation above covariate means are signified by β_{11} and β_{21}, respectively. These coefficients index the effect of the covariate (e.g., trait procrastination or intervention condition) on linear and quadratic growth. The single level and multilevel models with unstandardised trajectory (but not intercept) coefficients (β) are presented in Table 1.3. In Table 1.4, standardised coefficients (t) are reported for interpretability of effect sizes. Thus, instances of β in the above description can be interpreted interchangeably with instances of t reported in Table 1.4.

Table 1.3

Multilevel Mixed Effect Model Fit (AIC) and Growth Curve Unstandardised Estimates for Models 1-8 (N = 24)

Covariate model		AIC	Δ	β_{00}	β_{10}	β_{20}	β_{11}	β_{21}
1.	Unconditional	4,593.50	-	23.81^{***}	1.11	0.28^{*}	-	-
2.	Conscientiousness	4,586.47	-7.03	23.79^{***}	1.12	0.28^{*}	-0.84	0.08
3.	Neuroticism	4,586.58	-6.92	23.78^{***}	1.12	0.28^{*}	-1.60	0.08
4.	Avoidant Procrastination	4,582.11	-11.39	23.91^{***}	1.09	0.29^{*}	2.10	*-0.23*
5.	Arousal Procrastination	4,581.37	-12.13	23.86^{***}	1.10	0.28^{*}	1.90	-0.24^{*}
6.	MDT motivation	4,588.12	-5.38	23.80^{***}	1.11	0.28^{*}	-0.20	0.03
7.	EVI motivation	4,583.37	-10.13	23.85^{***}	1.10	0.29^{*}	-1.43	0.04
8.	Experimental condition	4,585.79	-7.71	23.80^{***}	1.19	0.28^{*}	2.00	-0.09

Note. AIC=Akaike Information Criteria; Δ denotes AIC change from the baseline unconditional model; β_{00} = intercept estimate; β_{10} = slope estimate; βt_{20} = quadratic estimate; β_{11} = covariate by slope interaction estimate; β_{21} = covariate by quadratic interaction estimate. Experimental condition is dummy coded as *control condition* = 0 and *intervention condition* = 1.

* $p < .05$. ** $p < .01$. *** $p < .001$. All statistical tests were two-tailed.

Table 1.4

Multilevel Mixed Effect Model Fit (AIC) and Growth Curve Standardized Estimates for Models 1-8 (N = 24)

	Covariate model	AIC	Δ	t_{00}	t_{10}	t_{20}	t_{11}	t_{21}
1.	Unconditional	4,593.50	-	4.76***	0.76	2.44*	-	-
2.	Conscientiousness	4,586.47	-7.03	4.77***	0.75	2.39*	-0.56	0.67
3.	Neuroticism	4,586.58	-6.92	4.66***	0.77	2.34*	-1.10	0.66
4.	Avoidant Procrastination	4,582.11	-11.39	4.74***	0.76	2.61*	1.47	*-2.05*
5.	Arousal Procrastination	4,581.37	-12.13	4.80***	0.77	2.63*	1.33	-2.18*
6.	MDT motivation	4,588.12	-5.38	4.66***	0.74	2.38*	-0.13	0.23
7.	EVI motivation	4,583.37	-10.13	5.09***	0.74	2.39*	-0.97	0.36
8.	Experimental condition	4,585.79	-7.71	4.66***	0.83	2.38*	1.40	-0.78

Note. t_{00} = standardised intercept coefficient; t_{10} = standardised slope coefficient; t_{20} = standardised quadratic coefficient; t_{11} = standardised covariate by slope interaction coefficient; t_{21} = standardised covariate by quadratic interaction coefficient.

* $p < .05$. ** $p < .01$. *** $p < .001$. All statistical tests were two-tailed.

As shown in Tables 1.3 and 1.4, the unconditional model supports a significant quadratic increase (i.e., delay) in assignment progress trajectory over the ESM period (model 1 β_{20} = 0.28, t_{20} = 2.44, p = .02), supporting Hypothesis 1. Covariate models thereafter slightly improved model fit as evidenced by negative AIC change values. No multilevel between-person covariate predicted variation in linear assignment progress trajectories from the sample mean over the two-week ESM period (H2-6). Arousal procrastination, included in model 5, was the only covariate related to quadratic change in assignment progress trajectory (2-tailed); however, this is in the opposite direction to that expected (model 5 β_{21} = -0.24, t_{21} = -2.18, p = .04

two-tailed, p = .98 one-tailed); that is, indicative of flattening of the assignment progress curve as the due date approached, rather than a hyperbolic increase in progress over time. Thus, Hypothesis 4a is not supported. Model 4, which included avoidant procrastination as the covariate, showed a similar quadratic effect size; however, this did not meet the threshold for two-tailed significance test (p = .053) and, as was the case with arousal procrastination, the effect was in the opposite direction to that anticipated so Hypothesis 4b was also not supported.

In order to present the models graphically, Phase 2 participants were split by the covariate group median for all continuous covariates (i.e., except experimental condition which is a categorical covariate). To illustrate the relatively even resultant group sizes, low and high scorer frequencies are presented in Table 1.5. The mean Phase 2 assignment progress modelled trajectory and mean responses (unconditional model), as well as trajectories split by those scoring in the bottom (low) and top (high) half of each covariate are presented in Figure 1.3, panels A to F.

Table 1.5

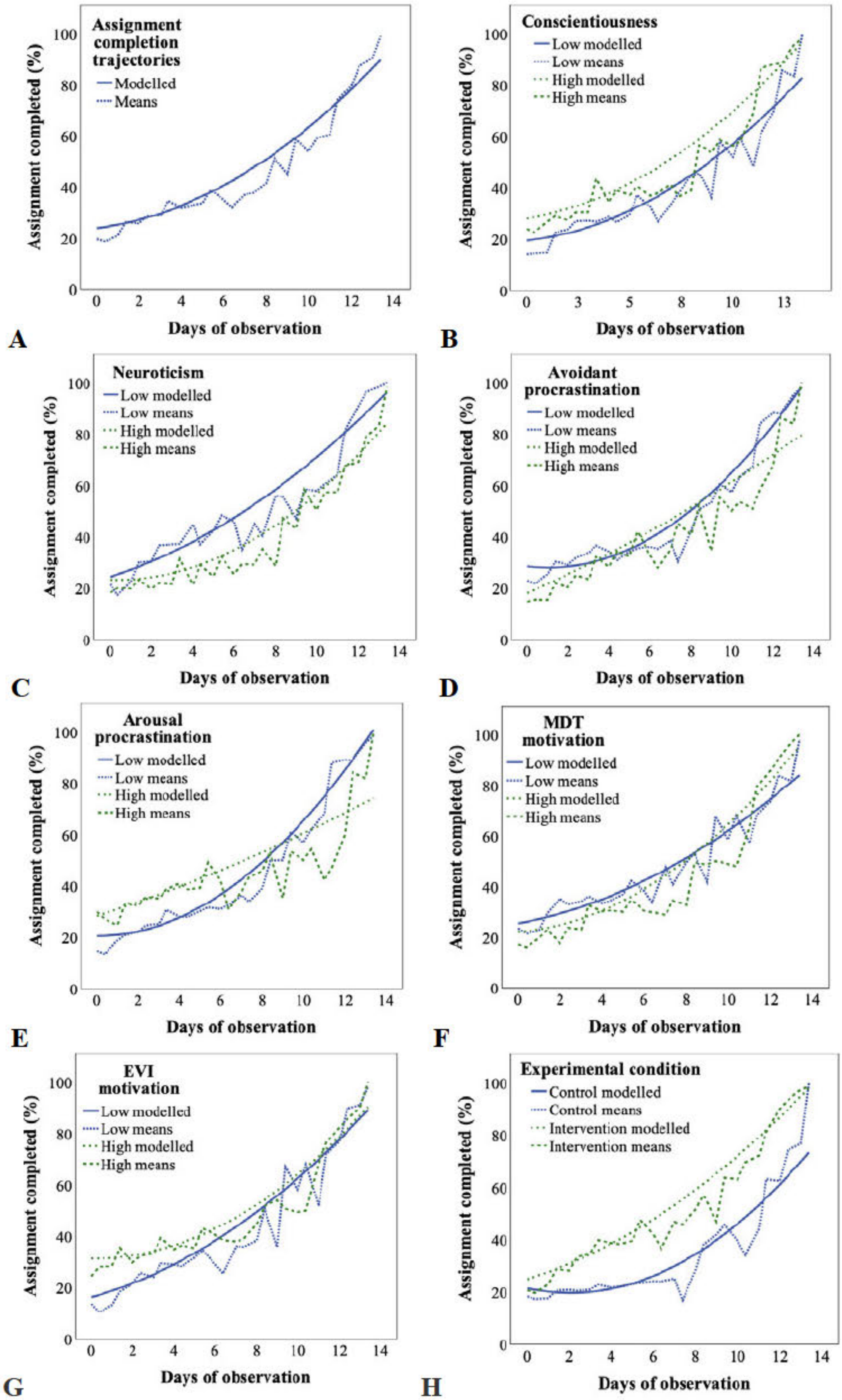
Median Split Half Frequencies of Multilevel Model Covariates for Phase 2 (ESM) Participants

Covariate	Low Scorers	High Scorers	Total
Conscientiousness	12	12	24
Neuroticism	11	13	24
Avoidant Procrastination	13	11	24
Arousal Procrastination	14	10	24
MDT motivation	12	12	24
EVI motivation	12	12	24
Experimental condition	8	16	24

Note. Experimental condition "low score" is the control condition and "high score" is the intervention condition.

Figure 1.3

Mean Assignment Progress Trajectories for all Phase 2 Participants Displayed for the Unconditional Model (Panel A), and Covariate Models 2-8 with Participants Median Split by Low and High Scores on Each Covariate (Panels B-H)



Differences between the high and low covariate groups were generally not statistically significant (Figure 1.3, panels B, C, D, F, and G). However, as this study utilised a very small sample, statistical power is limited. Consequently, in an endeavour to faithfully report study findings and inform future research directions, visual aspects of assignment progress trajectories are described here with reference to shape and directionality of trajectory and effect sizes (for Cohen's *d* of average modelled delay by covariate half, see Table 1.5). Between-group differences in affect are also described.

The general curvilinear trajectory is clearly seen in the unconditional model (Figure 1.3, panel A). This general curvilinear trajectory is evident also in all of the other models (panels B to H). Hypothesis 2 that there would be a negative association between conscientiousness and delay is illustrated in Figure 1.3 panel B, which shows that those higher in conscientiousness reported having consistently higher proportions of their assignments completed (i.e., less delay) across the two-week period (Cohen's $d = .47$). Similarly, as per Hypothesis 3 that neuroticism would be associated with higher delay is illustrated by delay trajectories being deeper for those higher in neuroticism (Cohen's $d = -.45$; illustrated in Figure 1.3, panel C). However, while trends support the hypotheses, neither of these relationships were statistically significant. Mean levels of delay by neuroticism quartiles were also investigated post-hoc to test the possibility of a curvilinear relationship between neuroticism and delay, where those in the highest and lowest quartiles of procrastination may be less likely to delay (McCown et al., 1987). There was no evidence of a curvilinear relationship between neuroticism quartiles and delay (Q1 $M = 43.2$, $SD = 31.3$; Q2 M = 45.0, $SD = 20.4$; Q3 $M = 46.2$, $SD = 22.2$; Q4 $M = 76.1$, $SD = 10.6$).

The modelled trajectory of the high avoidant procrastination group (Figure 1.3, panel D) appeared to follow a linear trend, while the low group appeared to follow the more typical quadratic trend. The effect size of the quadratic interaction between avoidant procrastination and percentage of assignment completed over time was only marginally smaller than that for arousal procrastination (t = -2.05 and -2.18, respectively). However, there was a slightly higher net difference in absolute levels of delay between those scoring low (M = 49.7, SD = 24.2) and high (M = 53.4, SD = 25.6) in avoidant procrastination, albeit with a small effect size (p = .36, Cohen's d = -.15). Unlike in arousal procrastination, high (M = 6.0, SD = 2.4) and low (M = 5.1, SD = 2.6) avoidant procrastination group mean differences in affect were not statistically significant (p = .39, Cohen's d = .36).

Only the covariate model with arousal procrastination returned a statistically significant (2-tailed) linear or quadratic difference from the Phase 2 group mean. Figure 1.3, panel E, displays a flatter modelled trajectory in the high arousal procrastination group than in the low arousal procrastination group. However, the direction of this effect is contrary to expectations, where higher arousal procrastination was expected to delay assignment progress (H4a), and thereby result in greater curvature in the progress trajectory. The underlying percentage of assignment completed means reported at each interval was highest among those high in arousal procrastination over the first seven days, before those in the low arousal procrastination group began to consistently report having completed higher proportions of their assignments in the second week. The net effect of this cross over is apparent in the near zero effect size in group delay differences between those high and low in arousal procrastination (Ms = 50.5 and 52.0, SDs = 32.1 and 18.2, respectively, p = .88, Cohen's d = .06). Those high in arousal procrastination reported lower levels of positive affect over the two-week period than did those low in arousal procrastination (*M*s = 4.3 and 6.5, *SD*s = 2.5 and 2.1, respectively, $p = .03$, Cohen's $d = .96$).

Neither of the procrastination formulae operationalised through the MDT or EVI measures significantly predicted behavioural delay (H5; Figure 1.3, panels F & G). There was no difference in delay between those scoring highest in MDT motivation ($M = 51.5$, $SD = 20.6$) and those who scored lowest in MDT motivation ($M = 55.3$, $SD = 28.5$, $p = .51$, Cohen's $d = -.01$). Those scoring highest in EVI motivation ($M = 48.7$, $SD = 28.2$) reported marginally lower levels of delay than those in scoring lowest in EVI motivation ($M = 54.1$, $SD = 20.7$, $p = .30$, Cohen's $d = .22$). Neither MDT or EVI motivation ware correlated with positive affect ($r = -.16$, $p = .47$ and $r = .31$, $p = .14$, respectively).

The statistically significant difference in mean levels of delay reported by those in the intervention and control conditions presented in section 1.3.2 above ($p = .03$, Cohen's $d = .86$) support a successful intervention effect (H6). Though no statistically significant differences in linear or quadratic trajectory were identified (see Table 1.3 model 6), Figure 6 panel H shows a trajectory approaching higher vertical linearity among those in the intervention condition, and a deeper delay curve in those in the intervention condition. These curves appear to generally fit the underlying means and show pronounced delay in assignment progress among control participants compared to intervention participants.

1.3.4 Phase 3 Group Mean Differences by Levels of Study Involvement

Table 1.6 below summarises four two-tailed between-samples *t*-tests analysing group differences on assignment submission date and marks between participants allocated to either the intervention or control condition with the broader course cohort who did not participants in the ESM phase. Mann-Whitney *U* tests were also applied in all cases to accommodate the large differences in group sizes and non-normal distributions. Those who participated in the intervention condition submitted their assignments significantly earlier (M = -1.10, SD = 2.10) than the broader cohort (M = 0.06, SD = 3.51), supporting Hypothesis 7a. Though a small to medium effect size was identified in mean assignment mark differences between intervention participants and class cohort (M = 73.40, SD = 9.91, and M = 68.30, SD = 14.5, respectively), the effect was non-significant and so Hypothesis 7b was not supported. No statistically significant differences in assignment submission date or marks were identified between control condition and class cohort (ps > .05).

Table 1.6

Independent Samples T-Tests and Mann-Whitney U Tests Comparing Assignment Mark and Submission Date Means of Those Not Participating in the ESM Phase of the Study (n = 359) Versus Those in the Intervention (n = 16), and Versus Those in the Control (n = 8) Condition, Excluding ESM Phase Participants Removed Due to Insufficient Data (n = 8)

Submission date		***Statistic***	***df***	***p***	***Cohen's d***
Intervention	*t*	1.30	373	0.19	0.33
	Mann-Whitney U	1858.00*		0.02	0.33
Control	*t*	0.74	365	0.46	0.26
	Mann-Whitney U	1394.00		0.89	0.26
Assignment mark		***Statistic***	***df***	***p***	***Cohen's d***
Intervention	*t*	-1.38	373	0.17	-0.35
	Mann-Whitney U	2405.00		0.27	-0.35
Control	*t*	0.13	365	0.90	0.05
	Mann-Whitney U	1364.00		0.81	0.05

* p < .05. All statistical tests were two-tailed.

1.3.5 Phase 4 Follow-up Interviews

All students who participated in the ESM study (Phase 2) were invited to a follow-up interview (Phase 4) to determine how invasive participants found the 28 surveys of the ESM study, whether the process lead to any specific realisations about their own behaviour, what they felt might help their procrastination, and, if in the intervention condition, their experiences with the additional intervention tasks. Five participants responded and interviews were conducted between 29 May and 2 June 2017. Interviews were semi-structured and conducted face-to-face in a private meeting room on campus or by phone. Interviews were audio-recorded and brief notes were taken by the interviewer. Interviews were scheduled for half an hour, ranged from 20:09 to 29:41 minutes, and had an average duration of 24:28 minutes. Two of the five were from the intervention group and three were from the control group. Two were male and three were female.

Interviews generally revealed a sampling frequency of two surveys per day for two weeks was not overly burdensome on participant time. One participant described having the two surveys – one in the morning and one in the evening – bracketed their day, resulting in an opportunity for reflecting on the progress they predicted or planned that morning. In general, participants in both control and intervention conditions found answering questions about the percentage of their laboratory report completed to be motivating**.** Participants in both conditions reported finding the questions relating to the percentage of their assignment they had completed so far and how much they planned to complete in the next 24 hours helpful. Participants reported using those questions to 'plan' what they were going to complete and then felt a level of self-imposed accountability to themselves to fulfil what they reported they would do.

When asked what might help reduce procrastination, one participant described breaking down larger tasks into smaller tasks, while another suggested a buddy system may be useful. Upon reflection of how helpful reporting percentage completed had been, one participant suggested the researchers send a graph showing progress during the study. Two variations of this idea arose, with one participant talking about sending a graph showing the rate of progress participants had predicted they would follow prior to the ESM phase around a week before the assignment was due, while another suggested that feeding back more recent plans (as opposed to a prediction made weeks prior) would be beneficial. One participant considered that if a social ‘leader board’ were used, it would only be motivating if the group average were slightly in front of where the individual was, while having the opposite effect on motivation if the group was behind them.

One of the control participants felt the ESM survey questions about per cent completed and levels of worry and guilt were enough of a motivator and did not think the intervention questions would have increased motivation. Another of the control participants thought questions aimed at deeper contemplation (i.e., as was prompted in the intervention condition) might be helpful. Participants generally reported feeling as though the intervention-specific questions were useful, with one participant, prompted by the social proof task, reporting their goal on all assignments was now to be in the position to submit a day early. Another participant in the control condition, when asked about whether the social proof question would be useful, thought it might have the opposite effect on him, demotivating him as he felt he already submits early. Several participants also described how they found random changes in the intervention reflection prompts between each survey helpful in promoting engagement, as they had to cognitively engage with intervention tasks and felt less inclined to repeat their last answer.

Participant estimation of percentage of assignment completed is unlikely to have been free of error. One participant reported that, on reflection, she may have at times under-estimated how much of her assignment she had completed. Another participant reported confidence in his abilities to estimate how much he had completed at any given time. This second participant went on to described the importance of not procrastinating in anticipation of when he does under-estimate how large and complex an assessment is.

A conclusion tentatively drawn from the interviews was that the benefits of twice daily prompting regarding progress and plans would likely lose its novelty. Nevertheless, participants suggested that if the prompts occurred less frequently, perhaps their benefits could be sustained. A detailed content analysis of these five interviews as well as an additional three interviews conducted following Study 3 is presented and discussed in Chapter 4.

1.4 Discussion

Procrastination is a pernicious problem that affects around 20% of the global adult population and 50% of students to a problematic extent (Harriott & Ferrari, 1996). Despite the size of the problem, few procrastination studies have longitudinally measured delay (Steel, 2007; van Eerde, 2003), most of which have failed to identify greater longitudinal delay among those higher in trait procrastination (e.g., Dewitte & Schouwenburg, 2002; Moon and Illingworth; 2005). Additionally, while many strategies for reducing procrastination are offered (see Steel, 2007 for a summary), there few empirical intervention studies which have demonstrated success, and successful interventions generally rely on resource and time intensive programs to reduce trait levels of procrastination, rather than assessing success against reduced delay (Boice, 1989; Rozental, 2015; van Eerde & Klingsieck, 2018). The present study sought to pilot a novel ESM-based approach for both measuring and reducing behavioural delay associated with procrastination. Results provide preliminary support for a novel ESM method for measuring and reducing delay.

Dilatory behaviour was found to follow a curvilinear trend through the application of a single-level unconditional linear model with second order (quadratic) growth factor. However, the observed rate of increase in activity over time as the completion date approached did not approach the level of curvature suggested by Steel and König (2006; see Figure 0.1 for example). This may be related to the addition of reflection prompts in the intervention condition, which significantly reduced the levels of delay in assignment progress over the 2-week period of observation. The pronounced delay curve apparent in the assignment progress trajectory of participants in the control condition (see Figure 1.3, panel F) is likely closer to the delay curve that would be seen in the general student population. However, feedback from the follow-up interviews suggests the high frequency of progress reporting may have contributed an additional level of motivation, possibly influencing what may have been a deeper hyperbolic curve in assignment progress if the control group had been unobserved. Of course, the dilemma posed by that is that the opportunity to measure progress and delay would have been lost. In summary, the statistical modelling process applied revealed a modest hyperbolic delay curve, which is likely to be a conservative approximation of the corresponding curve of assignment progress in the wider cohort of students. These results provide preliminary support for behavioural delay measured through regular progress reporting as an acceptable proxy for observed procrastination.

The two personality traits most commonly associated with procrastination, conscientiousness and neuroticism (Steel, 2007; van Eerde, 2003), were not statistically related to delay. However, given the moderate effect sizes it is possible that the lack of statistical significance was due to the small sample size and lack of statistical power. Consistent with prior research on conscientiousness, neuroticism, and procrastination (Steel, 2007; van Eerde, 2003), there were trends such that individuals who were higher in conscientiousness reported more early progress on their assignments, and those who were higher in neuroticism reported more delay.

Neither avoidant nor arousal procrastination measures predicted behavioural delay as expected in this sample. Although arousal procrastination (measured using the GPS; Lay, 1986) returned a statistically significant quadratic interaction with assignment progress over time, the effect was in the opposite direction to expected, whereby the model indicated those lower in arousal procrastination delayed less. It is possible that due to the small sample size and low power the unexplained between-person variance in assignment progress trajectories was too large to return reliable trajectories, even after controlling for between-person variables. This possibility is supported by the reported mean trajectories from arousal procrastinators following the expected deeper delay curve, but that curve not being followed by the *modelled* trajectory (see Figure 1.3, panel E). Similar to the results of Dewitte and Schouwenburg (2002), the inverse trajectory of the quadratic model could be due more to noise in the dependent variable. With such a small sample size, it would be premature to conclude that these measures of trait procrastination used here have low sensitivity to behavioural delay; however, as models using conscientiousness, neuroticism, and the experimental condition as covariates performed generally as expected, other trait measures of procrastination may be worth exploring to determine if the expected effects can be demonstrated.

No analyses conducted identified a relationship between either of the TMT formula-based measures of motivation (i.e., either using the MDT or EVI measures in the same TMT formula) and delay. In the Phase 1 sample, only the tailored EVI motivation score predicted assignment mark above chance levels, while only the tailored EVI expectancy was correlated individually with assignment mark. Neither motivation measure predicted submission date. While aspects of TMT, notably the hyperbolic nature of delay over time, was confirmed in this study, it is currently unclear how best to harness its utility as a predictive model given the usefulness of this formula was not supported.

The difference in assignment progress trajectories between participants in the control and intervention conditions was not statistically significant in the multilevel mixed effects model. However, a simple comparison of the delay means between intervention and control groups indicated those in the intervention condition reported significantly less delay. When plotted (see Figure 1.3 panel H), there was a trend evident for those in the intervention condition to progress in a more linear fashion, while those in the control condition completed their assignments in a more curvilinear fashion, similar to that anticipated by TMT (see Figure 0.1). This suggests that providing targeted prompts for participants to regularly reflect on task expectancy, value, delay sensitivity, and metacognition has the potential to significantly reduce task delay compared to a control condition that shared many features (e.g., regular surveying and progress reporting) with the intervention. These observable differences in both mean delays and plotted trajectories suggest the lack of power in this study resulted in statistical non-significance for the trajectories due to the more complex modelling requiring greater power to detect a significant difference. The potential efficacy of reflection on these domains also lends credibility to TMT as a theoretical model, but replication with a larger sample is needed to increase certainty.

Participation in the intervention condition, but not the control condition, was significantly related to earlier assignment submission. There were no statistically significant differences in assignment mark between the experimental conditions and remaining course cohort, although there was a moderate effect size difference, with students in the experimental condition receiving higher mean assignment marks than the remainder of the course cohort.

It is important to note here that delay in progress in the lead up to a due date is not equivalent to delay in timely submission relating to that due date. Gregory and Morón-García (2009) note that some individuals may finish a task early but postpone submission until closer to the deadline 'just in case'. Though those who are high in trait procrastination may often delay submission, those who are low in trait procrastination may also delay submission for different reasons such as leaving time for final revisions.

The experience of negative affective states such as guilt and worry relating to one's volitional delay (i.e., delay associated with procrastination) is likely to be an insidious and directly attributable negative consequence of procrastination. Those reporting higher levels of delay were also more likely to report higher levels of guilt, worry, and anxiety relating to their progress, with negative affect accounting for 24% of the variance in delay. This prompts further questions on the nature of this relationship across time. For example, how do temporal changes in affect relate to temporal changes in task delay? Does affect improve in response to progress over time, and does improved affect, in turn, promote more rapid progress? Modelling of the temporal relations between delay and affect could be more fully elucidated given a larger sample size. What can be concluded from these results is that affect and delay are related, and, thus, are critical to consider in unison to understand and ultimately aid in the reduction of procrastination.

1.4.1 Strengths and Limitations

To my knowledge, this study is the first to (1) use ESM to measure and compare behavioural delay as it relates to different trait measures of procrastination; (2) attempt to empirically validate the ability of the 'procrastination equation' as proposed by TMT to predict task delay; and (3) provide some empirical support for an intervention to reduce academic procrastination via brief but frequent targeted reflection prompts. However, the small sample size limited the statistical power, potentially explaining non-significant results of the multi-level analyses and preventing the ability to conduct more nuanced multivariate analyses. Nonetheless, the current results provide important preliminary findings that justified expansion of the current research and analytic methods to further explore the predictive ability of a range of procrastination scales and the effects of an embedded naturalistic intervention on behavioural delay.

There were potential limitations with some of the measures used. The scales used to determine avoidant and active procrastination (AIP and GPS, respectively) were not developed specifically as measures of different trait forms of procrastination. Therefore, it is possible that some of the non-significant or unexpected findings for these different forms of procrastination are due to measurement misspecification. Repeat measures of the percentage of assignment completed was an attempt to measure progress objectively, but it is acknowledged that this was subjectively reported. Consequently, assignment progress is likely to be heavily influenced by perception. The planning fallacy (Kahneman & Tversky, 1979) may provide one possible explanation of errors in these subjective reports. For example, Buehler et al. (1994) have found psychology students under-estimate how long it will take them to submit a complex assessment piece, even when asked to provide a worst-case scenario estimate. It is possible this optimistic view of the time required to complete a task may have similarly presented as optimism about the percentage of the assignment already completed. However, Pychyl et al. (2000b) found no significant difference in the extent of the planning fallacy between those high and low in trait procrastination who were preparing for an exam, suggesting that it is likely there was no systematic differences in the inaccuracy of reports of progress between the procrastination groups in this study.

Efforts were undertaken to operationalise the TMT equation in two different ways. The MDT, a scale designed by one of the theory's authors (Steel, 2011) was used, as well as a customised measure (the EVI) to overcome limitations of the MDT (i.e., not task-specific and not empirically validated). Nevertheless, neither measure was related to delay. It is important to note that Steel and König (2006) did not advise on how the TMT theory, and specifically this formula, could be used to predict task progress. Their dominant proposition was that TMT could be used as a model to predict when one might break through other preferences, such as socialising, to work on a less palatable task. Therefore, TMT may be more appropriately operationalised to predict action in what Pychyl (2006-2018) refers to as 'precipitative moments', where varied individuals have the same opportunities to act, but procrastinators more frequently fail to do so. In the context of this study, momentary progress on an assignment may be made in a constellation of precipitative moments over the course of two weeks. Unfortunately, capturing the process of conversion of such precipitation into action on a moment-by-available-moment basis is not possible with the present study design.

While exposure to the intervention prompts was associated with lower delay than in the control condition, follow-up interviews suggested that those in the control condition were also motivated to progress by the regular ESM surveys asking about their progress and plans. The methodology applied cannot determine the rate of progress in a genuine "no-intervention" condition (e.g., the remainder of the class cohort) because the only way to obtain ongoing information on completion was to survey students. It is unclear whether students who were not regularly questioned about their progress worked on their assignment according to the same hyperbolic curve.

Finally, the design of this study, although longitudinal, is limited in its ability to monitor whether intervention effects will continue to change behaviour beyond the ESM duration, in other academic works, or in other life domains. Procrastination is a broad phenomenon affecting individuals in many life domains. Though this study utilised a low-intensity, high frequency reflection prompt intervention framework that is not restricted to academic procrastination, as this study specifically focused on procrastination in an academic setting, findings may not be generalisable to other domains such as personal finance, health behaviour change, or collective action issues such as pro-environmental activities. Replication with other forms of procrastination is needed.

1.4.2 Next Steps

To overcome a number of these limitations, a larger study was designed to build upon these initial findings and explore additional research questions. As the use of ESM and this study design appeared adequate to assess the predictive ability of procrastination scales, this was replicated. Considering the modest effect size of the intervention in this study, a larger scale replication was undertaken and expected to return significant results in the multilevel mixed effects model analyses. Additionally, a larger sample size should enable sufficient statistical power for nuanced multivariate analyses such as an investigation of the inter-temporal relationships between affect and delay and how that relationship might differ according to trait levels of procrastination and personality. Additional trait procrastination measures need to be included in the subsequent study. There are approximately a dozen procrastination scales in common use. It is possible that some other measures of procrastination may be stronger predictors of behavioural delay than those used in this initial study. Measures of active and passive forms of procrastination were included in the subsequent study.

1.4.3 Conclusion

This initial study provided evidence that hyperbolic delay can be adequately observed by regular (i.e., via ESM) subjective reports of assignment progress, and that inclusion of reflection prompts can aid in the reduction of delay. Additionally, results raised questions regarding the ability of two procrastination scales (the AIP and GPS) to predict behavioural delay and procrastination equation of TMT to predict the curvature of delay. The complex data structure produced by this study design and requisite sophisticated analyses were under-powered with the current sample size. A larger replication and extension is presented in Chapter 2.

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Chapter 2: Predicting Procrastination with Active and Passive Procrastination Scales

2.0 Prelude

Chapter 1 summarised findings from Study 1 that provided evidence that behavioural delay associated with procrastination can be quantified through regular progress reporting. It also showed that measures of trait arousal and avoidant procrastination did not significantly predict differences in delay; however, the small sample size and low power meant that firm conclusions could not be drawn. This chapter reports findings from Study 2, which applied a similar methodology with a substantially larger sample in both Phase 1 (baseline survey, $N = 395$) and Phase 2 (ESM surveys; $N = 80$). In order to ensure a larger sample of participants, students enrolled in a first-year undergraduate psychology course completed a laboratory exercise on procrastination that involved completing the baseline survey, which they consented to share for the purpose of this study. Students were later invited to participate in the ESM component (Phase 2) of this study, which was able to be linked to their baseline survey results.

The same multilevel mixed effects modelling as described in Study 1 was used to analyse the intensive longitudinal within-person data to confirm the predicted hyperbolic trajectory. The larger Study 2 sample size was sufficient to meaningfully compare assignment progress trajectories by between-person (e.g., trait procrastination) variables. This study examined differences in the prediction of delay by measures of two different types of procrastination; namely, active and passive procrastination. Similar to arousal procrastination, active procrastination has been described as an adaptive form of procrastination (Choi & Moran, 2009; Habelrih & Hicks, 2015), a claim that has been rebutted from definitional and construct perspectives since its introduction in 2005 (Chowdhury & Pychyl, 2018; Corkin et al., 2011; Hensley, 2014). Results showed that active procrastination is not associated with behavioural delay and consequently challenge the most fundamental requirements for consideration as a valid measure of procrastination.

As in Study 1, participants in the ESM phase were randomly allocated either to a control or an intervention condition, with those in the intervention condition receiving the same prompts as Study 1 that aimed to experimentally reduce delay associated with procrastination. However, unlike Study 1, the intervention condition was not associated with reduced behavioural delay. Non-significant intervention findings in Study 2 are discussed in Chapter 3.

Chapter 2 has been published in the journal, *Personality and Individual Differences*, and has been provided in its published form. Heading, Table, and Figure numberings have been modified from the re-submitted publication in order to be consistent with the numberings in this thesis.

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The co-authors of this manuscript are my thesis supervisors, Graham Bradley and Michelle Hood. My (Jason Wessel) contribution to the manuscript involved: initial concept and research design, data collection and analysis, and preparation of the manuscript. Note, the Heading, Table and Figure numberings have been modified from the original publication to be consistent with the numberings in this thesis.

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Abstract

Time is the one resource we cannot recoup. Nevertheless, as many as 20% of people problematically procrastinate. Controversy exists as to the existence of two types of procrastination; the traditional maladaptive type where behavior is delayed unintentionally, despite known risks of disadvantage to performance and/or personal comfort (passive procrastination), and an adaptive type where behavior is intentionally delayed as a means of enhancing motivation, while not disadvantageous to valued outcomes (active procrastination). Few studies to date, however, have longitudinally observed delay in different types of procrastinators. We tracked progress on an undergraduate assignment over two weeks to determine the ability of the two theorized procrastination types to predict behavioral delay. We found scores on passive procrastination predicted markedly different assignment completion trajectories, with higher scorers delaying assignment completion. However, active procrastination did not predict delay. This study demonstrates a novel and robust method for measuring behavioral delay, adds to evidence that active procrastination does not contribute to behavioral delay, and thereby raises doubts as to the construct validity and/or measurement of active procrastination.

2.1 Introduction

Traditionally, procrastination has been defined as the act of delaying a behavior to the point of experiencing subjective discomfort (e.g., Solomon & Rothblum, 1984; Steel, 2010). Procrastination relates to delays that are unjustified, ones that cannot be defended on grounds of more urgent or important commitments. As many as 20% of adults self-identify as having problems with procrastination (Harriott & Ferrari, 1996). Of concern, procrastination has been linked to lower wellbeing (Habelrih & Hicks, 2015), depression (Fernie, Bharucha, Nikcevic, Marino & Spada, 2017), drug and alcohol use and poor health outcomes (Sirois, 2015), lower salaries, shorter duration of employment, and greater likelihood of being unemployed or under employed (Nguyen, Steel, & Ferrari, 2013)

In contrast to the widely investigated links between procrastination and these disadvantages, Chu and Choi (2005) proposed a second procrastination type, *active procrastination*. The active procrastinator intentionally delays, seeking the pressure imposed by a proximal deadline to increase motivation without diminishing performance. Chu and Choi contrasted this to the traditional *passive procrastination*, where procrastinators unintentionally delay despite recognizing the need to start their task earlier. Research findings have not been consistent in relation to the effects of the two types of procrastination on behavioral delay (e.g., Chowdhury & Pychyl, 2018; Habelrih & Hicks, 2015; Hensley, 2014; Kim, Fernandez, & Terrier, 2017). A major limitation of most past research into procrastination of either type is a failure to assess behavioral delay over time and in situ (Habelrih & Hicks, 2015; Howell, Watson, Powell, & Buro, 2006; Steel, 2007; Van Eerde, 2003).

This study used a novel experience sampling method to examine ways in which behavioral delay varies with each of the two procrastination types. In addition to its contribution to procrastination research methodology, the study makes a substantive contribution to understanding the nature of procrastination.

2.1.1 Procrastination Types and Behavioral Manifestations

Choi and Moran (2009) defined the active procrastinator as somebody who makes a decision to delay, preferring to work under the pressure of a proximal deadline. Contrary to the correlates of passive procrastination, Choi and Moran found active procrastination to be positively correlated with a sense of control over use of time, emotional stability, self-reported performance, and life satisfaction. Subsequent research has supported the positive side of delay, with self-reported scores on active procrastination positively associated, and passive procrastination negatively associated, with psychological well-being, autonomy, environmental mastery, personal growth, positive relations, and purpose in life (Habelrih & Hicks, 2015).

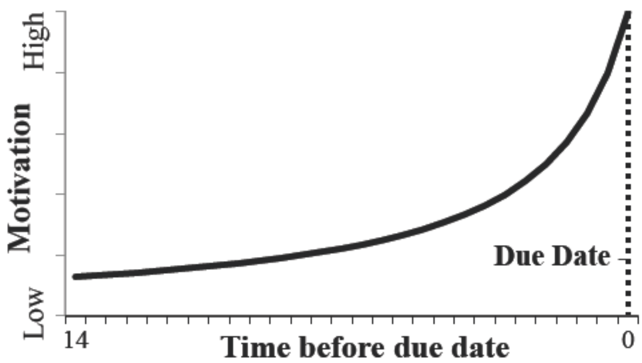
Active procrastination has been criticized on definitional grounds, arguing that it disregards the crucial element of disadvantage that is integral to procrastination (e.g., Corkin, Yu, & Lindt, 2011; Steel, 2010). Moreover, studies (e.g., Chowdhury & Pychyl, 2018; Hensley, 2014) have challenged the ways in which active procrastination is measured. For example, Hensley (2014) found that the Active Procrastination (AP) scale had a 3-factor structure, only one of which correlated with behavioral delay, and this factor was strongly and positively correlated with passive procrastination. As evidence for the construct of active procrastination comes solely from the AP scale, criticism of the dimensionality of the scale is tantamount to criticism of the construct. Thus, doubts exist regarding both the independence of active procrastination and its relationship to behavior delay.

2.1.2 *The Hyperbolic Discounting Hypothesis*

Steel and König (2006) have argued procrastination is an example of hyperbolic discounting, whereby motivation reduces in a hyperbolic curve as a function of its distance from a due date (see Figure 2.1 for an example). In essence, within-person motivation is hypothesized to increase in an accelerated fashion closer to a deadline. In complex tasks that require multiple concerted efforts, increases in motivation as a deadline approaches are likely to mean that a high proportion of task progress occurs near the deadline. Compared to non-procrastinators, procrastinators would display an even greater delay and a steeper increase in behavior proximal to a deadline (Steel & König, 2006).

Figure 2.1

Hyperbolic Curve Depicting Motivation to Complete an Assignment, where Motivation Increases as a Deadline Approaches



As delay is described by the accelerating rate of behavior change over time by virtue of a later start, it is appropriate to observe this dynamic temporal delay when operationalizing procrastination. However, few longitudinal behavioral observation studies have investigated procrastination. No study to date has investigated, let alone supported, the hyperbolic discounting hypothesis in active procrastination. And even among passive procrastinators, there is little evidence of the theoretical hyperbolic growth of motivation and behavior (e.g., (Steel, 2007; Van Eerde, 2003).

Three studies of hyperbolic discounting in (passive) procrastinators stand out. The first, by Dewitte and Schouwenburg (2002), measured student study time leading to a final exam. Contrary to the expectation of behavior being delayed before a steep increase of activity, high procrastinators both planned and studied for an exam more over 11 weeks than did low procrastinators. Moreover, low procrastinators demonstrated a steeper growth curve in study hours proximal to the exam date. Second, Moon and Illingworth (2005) found test taking delays occurred on a hyperbolic curve; however, no difference in hyperbolic curve trajectory was identified between high and low procrastinators. Finally, Howell et al. (2006) demonstrated a steeper hyperbolic curve in high procrastinators by analyzing submission date of assignments, with 94% of variance in submission time explained by a hyperbolic curve in high procrastinators, and only 69% in low procrastinators. Thus, only the first of these studies utilized a longitudinal design, and only the third found evidence of higher hyperbolic discounting in procrastinators. Together, these studies provide limited evidence regarding hyperbolic discounting in procrastinators, and cast doubt over whether procrastination scales purporting to predict behavioral delay accurately do so.

2.1.3 Overcoming Limitations of Past Research

In sum, there is controversy surrounding whether active procrastination is related to delay in the same way as is expected for maladaptive or passive procrastination (Hensley, 2014). Moreover, few studies have observed hyperbolic within-person temporal change in motivation or behavior, few have shown this pattern of change to be particularly evident among procrastinators, and no study has observed whether active and passive procrastinators display similar patterns of hyperbolic discounting. Adding to these research limitations, there is a dearth of longitudinal observational studies, likely owing to procrastination's inherently complex, dynamic, and multifaceted nature (Pychyl & Sirois, 2016; Steel, 2007).

One approach to measuring dynamic phenomena such as procrastination is through the use of experience sampling methodology (ESM; e.g., Larson & Csikszentmihalyi, 2014). This procedure captures individual experiences in the moment through multiple and frequent surveys (Larson & Csikszentmihalyi, 2014). The approach has been recently aided by developments in personal digital technology to monitor within-person temporal changes. ESM is not new to procrastination research, (e.g., Pychyl, Morin, & Salmon, 2000; Reinecke & Hofmann, 2016; Smith, Sherry, Saklofske, & Mushqaush, 2017), although previous studies have focused on relationships with correlates of procrastination such as negative affect, rather than behavior delay itself.

2.1.4 The Current Study

This study had three major objectives. First, we measured behavioral delay through ESM, testing for a general quadratic (hyperbolic) trend in productivity in the lead-up to the final permissible submission date for an undergraduate assignment. Second, we determined whether scores on active procrastination and passive procrastination scales predict behavioral delay in the hypothesized hyperbolic form. Third, we assessed whether each type of procrastination is correlated with indices of performance quality (specifically, assignment marks).

Hypothesis 1. Participants, in general, will display a hyperbolic curve in productivity as a deadline approaches.

Hypothesis 2. Higher scores on (a) active procrastination and (b) passive procrastination will be associated with behavioral delay that takes the form of a steeper quadratic growth curve than that seen in the sample as a whole.

To test the two hypotheses, we assessed the two types of procrastination in a sample of university students, and then followed these students' progress and performance on a written assignment for a period of 14 days. We also explored relationships between the two procrastination types and assignment submission dates and marks, but, given limited empirical evidence, we did not hypothesize either procrastination type to better predict these outcomes. The study involved three phases: (1) administration of baseline measures, (2) experience sampling of progressive assignment completion, and (3) collection of data pertaining to assignment submission and marks.

2.2 Method

2.2.1 Participants and Procedure

Phase 1 participants were students enrolled in a first-year psychology course at a public Australian university who attended class in the week of data collection (N = 395). These students completed the baseline questionnaire, and 384 (97%) of them provided consent to be contacted for a follow up procrastination study. Of these, 102 students registered for Phase 2. In this phase, an SMS message containing a link to the questionnaire was sent to participants' cell phones twice daily (morning and evening) for two weeks leading to the submission of the mid-term written assignment (total = 28 messages). Of the 80 phase 2 participants who provided usable data, 76% were female, and 24% were male, with ages ranging from 17.69 to 65.85 (M = 24.55, SD = 11.17).

In phase 3, at the end of the semester, assignment submission dates, and marks awarded, were collected for the 80 phase 2 participants, and for all other students still enrolled in the course (n = 244; total n = 324). Collecting these details enabled identification of any effect on assignment completion associated with participation in the ESM phase of the study.

2.2.2 Materials

Phase 1. Participants completed two procrastination scales. First, the 16-item Active Procrastination Scale (APS: Choi & Moran, 2009) assesses active procrastination. Items relate to working effectively under pressure and include "I intentionally put off work to maximize my motivation". Choi and Morgan reported its Cronbach reliability coefficient to be .80. Second, the Passive Procrastination Scale (PPS: Chu & Choi, 2005, see Appendix B) is a 6-item measure of maladaptive procrastination with an internal reliability of .82. Items include "I tend to leave things until the last minute." Responses to both scales range from 1 = *not at all true* to 7 = *very true*. Following reversal of negatively-worded items, responses are summed, with higher scores indicating higher levels of the respective procrastination type.

Phase 1 participants also estimated the percentage of their assignment they predicted to have completed at each of nine times (14, 10, 7, 5, 4, 3, 2, and 1 day prior to the due date, and on the due date). A variable, labelled predicted delay, was computed by averaging these responses and subtracting this mean from 100, such that higher scores indicated later expected progress and, therefore, higher predicted delay. Demographic details included sex, age, grade point average, hours of paid work, number of courses taken, and carer responsibilities.

Phase 2. Twice daily for 14 days, participants completed a questionnaire that included the question "As of right now, what proportion of your [assignment] have you completed (0% - 100%)?" Four different prompts were included in a random set of participants' messages to assess whether these altered patterns of responding. The presence of these prompts was uncorrelated with all variables and was not considered further.

Phase 3. Assignment submission date (including time of day) and percentage mark awarded were collected from university records for all phase 1 participants still enrolled in the course.

2.3 Results

The major dependent variable, average modeled delay, was formed by averaging the modeled values derived from each participant's 28 responses to the phase 2 question regarding the percentage of the assignment currently completed, and subtracting the value from 100. Like predicted delay, higher numbers indicate later assignment progress and higher behavioral delay. Missing data were handled in an unconditional multilevel mixed model (described below) by Restricted Maximum Likelihood (REML; Heck et al., 2010), which modeled assignment completion trajectory. As modeled trajectory data were used to derive a within-person average for correlational purposes, the average modeled delay variable contained no missing data. Table 2.1 reports descriptive statistics and correlations for phase 2 participants. Both active procrastination (α = .80) and passive procrastination (α = .86) displayed internal consistency. Passive procrastination was positively correlated with both predicted delay and modeled delay, whereas active procrastination was correlated with neither of these indices. Neither procrastination variable was correlated with either assignment submission date or mark awarded. Among phase 2 participants, proportion of ESM non-responses was uncorrelated with all key variables.

Table 2.1

Descriptive Statistics and Correlations[a] for Phase 2 Participants (N = 80)

		Mean	SD	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1.	Gender	-	-												
2.	Age (years)	24.55	11.00	.09											
3.	Grade Point Average	5.21	0.98	.03	.10										
4.	Study Load (no. of courses)	3.69	0.65	-.04	**-.62**	.19									
5.	Paid Work (hours per week)	2.40	1.34	.08	.12	-.18	-.15								
6.	Dependents	-	-	-.01	**.49**	**.27**	**-.23**	.10							
7.	Predicted delay	22.60	16.59	-.07	-.11	.05	-.03	.01	-.16						
8.	Active procrastination (APS)	66.80	11.07	**-.28**	.03	.14	.14	-.03	.08	.07					
9.	Passive procrastination (PPS)	22.51	7.75	.10	**-.25**	-.19	.11	.01	-.11	**.57**	**-.27**				
10.	Average modeled delay	52.14	24.26	.07	-.20	-.12	.15	-.04	-.11	**.40**	.04	**.60**			
11.	Prediction-Action Gap	29.55	23.34	.13	-.13	-.16	.17	-.03	.00	**-.30**	-.01	.22	**.76**		
12.	Submission date	-0.93	2.45	-.12	-.18	.00	.12	.02	-.17	.13	.05	.09	**.26**	.18	
13.	Assignment mark (%)	66.25	14.21	-.02	.20	**.47**	-.12	-.17	**.24**	-.04	-.08	-.12	-.19	-.17	**-.41**

Note. Gender is coded as 1 = Male, 2 = Female. Dependents is coded as 0 = no dependents, 1 > 0 dependents. Higher Average modeled delay indicates higher behavioral delay. Prediction-Action Gap was computed by subtracting Predicted delay from Average modeled delay. Higher numbers indicate lower predicted delay than actual completion. Submission date was coded with 0 as the due time, lower numbers indicated earlier submission time, with 1 equating to 1 day.

[a] Correlations > .23 significant at $p < .05$ and highlighted in bold; Correlations between .29 and .35 significant at $p < .01$; Correlations > .36 significant at $p < .001$.

To determine whether progress towards assignment completion over the 14 days followed the hypothesized quadratic form (H1), completion trajectories were analyzed using a single-level unconditional linear and growth curve mixed model in a multilevel framework (Heck et al., 2010; Muthén & Muthén, 2017). The unconditional model examined the rate of progress on the assignment (as indicated by reports of the percentage completed at each of the 28 time points). The model included at Level 1 two time variables: Time (the linear effect) and Time^2 (the quadratic or hyperbolic effect). Coefficients represented units of percentage increase in assignment completion either at the start of the two weeks (intercept), additional change over 1 day (slope), or additional change over 1 day^2 (quadratic). Thus, the general form of the unconditional model was as follows:

$$Y_{ti} \text{ (Percentage completed)} = \Pi_{0i} + \Pi_{1i} (\text{Time}_{ti}) + \Pi_{2i} (\text{Time}^2_{ti}) + \varepsilon_{ti},$$

$$\Pi_{0i} = + \beta_{00} + \gamma_{0i},$$

$$\Pi_{1i} = + \beta_{10} + \gamma_{1i},$$

$$\Pi_{2i} = + \beta_{20} + \gamma_{2i},$$

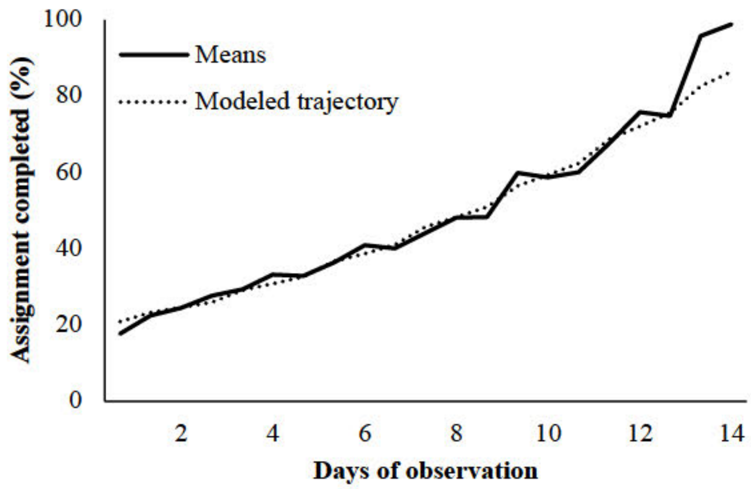
where Π_{0i} is Person i's mean completion percentage at Time 1, Π_{1i} is Person i's linear growth rate, and Π_{2i} is Person i's quadratic curvilinear growth rate (or acceleration in assignment percentage completed). Mean completion percentage, signified by β_{00}, indicates the average percentage of assignment completed at Time 1 (2 weeks prior to the due date), while mean growth (linear) and the acceleration (quadratic) rates are signified by β_{10} and β_{20}, respectively.

In support of H1, the unconditional model trajectory suggests strong linear growth ($\beta_{10} = 2.15$, $p = .02$) from a starting value of 21.16% assignment completed ($\beta_{00;}$ at Time 1, 14 days prior to the assignment due date) and a final value of 87% completed at Time 28 (on the due date), with significant positive quadratic growth

(β_{20} = .18, p = .02). Participant means and modeled completion trajectory are depicted in Figure 2.2.

Figure 2.2

Means and Modeled Assignment Completion Trajectory of Phase 2 Participants



Wald Z tests identified significant between-person differences in linear growth (Wald Z = 5.92, p < .001) and quadratic growth (Wald Z = 5.83, p < .001), suggesting extant variance in growth trajectories not explained by the unconditional model (Heck, 2010).

To assess the degree to which active procrastination and passive procrastination explained between-person variance in assignment completion trajectory over the two-week period, separate growth curve mixed models included either active or passive procrastination at Level 2. Thus, the general form of models 2 and 3 was as follows:

$$Y_{ti}\text{ (Percentage completed)} = \Pi_{0i} + \Pi_{1i}\text{ (Time}_{ti}) + \Pi_{2i}\text{ (Time}^2{}_{ti}) + \varepsilon_{ti},$$

$$\Pi_{0i} = + \beta_{00} + \beta_{01}\text{ (Covariate)} + \gamma_{0i},$$

$$\Pi_{1i} = + \beta_{10} + \beta_{11}\text{ (Covariate)} + \gamma_{1i},$$

$$\Pi_{2i} = + \beta_{20} + \beta_{21}\text{ (Covariate)} + \gamma_{2i},$$

where mean completion percentage, signified by β_{00}, indicates the average percentage of assignment completed at Time 1 (14 days prior to the due date), with other variables equal to zero (grand mean centered). The coefficient β_{01} reflect differences in mean completion percentage as a function of the covariate under analysis. Mean growth (linear) and the acceleration (quadratic) rates are signified by β_{10} and β_{20}, respectively. Other coefficients associated with linear growth rate (Π_{1i}) and acceleration (Π_{2i}) are interpreted as for the intercept (Π_{0i}); however, these coefficients index the effect of the covariate (e.g., active or passive procrastination) on linear and quadratic growth.

Models 2 and 3 provide information about changes in completion rates across all 28 study observations for the sample mean covariate predictor as well as for participants scoring one standard deviation above the mean (the time x covariate interaction coefficient). Including the covariate interaction coefficients allowed examination of whether the measures of each type of procrastination predicted behavioral delay as indicated by a significant relationship with quadratic (Π_{2i}) growth. Model fit (and parsimony) were assessed by the Akaike Information Criteria (AIC), where smaller values indicate a closer fit between the model and data.

Table 2.2

Multilevel Mixture Model Fit (AIC) and Growth Curve Estimates (N = 80)

Covariate model	AIC	Δ	β_{00}	β_{10}	β_{20}	β_{11}	β_{21}
1. Unconditional	14,495.65	-	21.16^{***}	2.15^{*}	$.20^{**}$	-	-
2. APS	14,496.46	0.81	21.17^{***}	2.15^{*}	$.20^{**}$	-.16	.01
3. PPS	14,457.78	-37.87	21.15^{***}	2.15^{**}	$.20^{**}$	-3.67^{***}	$.25^{***}$

Note. AIC = Akaike Information Criteria; Δ denotes AIC change from the baseline unconditional model; PPS = passive procrastination; APS = active procrastination; β_{00} = intercept estimate; β_{10} = slope estimate; β_{20} = quadratic estimate; β_{11} = covariate by slope interaction estimate; β_{21} = covariate by quadratic interaction estimate.

* $p < .05$. ** $p < .01$. *** $p < .001$.

Model 2 revealed no significant interactions between active procrastination (score on APS) and either linear ($\beta_{11}^{APS} = -.16$, $p = .85$) or quadratic ($\beta_{21}^{APS} = .01$, $p = .87$) growth curves, thereby failing to confirm H2a. A higher score on active procrastination was not related to greater delay in assignment completion trajectory. Furthermore, inclusion of APS as a covariate made no substantive improvement to model fit (Δ = 0.81). The absence of a time x APS interaction is graphically illustrated in Figure 2.3(a), where participant completion trajectory by mean APS percentile shows minimal visible difference.

In contrast to results of model 2, the negative linear coefficient in model 3 ($\beta_{11}^{PPS} = -3.67$, $p < .001$) demonstrates that students who scored one standard deviation higher on passive procrastination progressed their assignment 3.67% less each day over the 14-day observation period than did those with average PPS scores, accumulating to 22.82% less progress by the seventh day. This generally flatter linear trend in procrastinators is compensated for by the positive quadratic coefficient (β_{21}^{PPS}

= .25, $p < .001$), which compounds exponentially closer to the due date. Thus, as hypothesized (H2b), the trajectory culminated in the hyperbolic, or quadratic, curve. This is exemplified in Figure 2.3(b), where it can be seen particularly in the group of students scoring in the fourth or highest quartile of PPS.

Figure 2.3

Comparison of Average Modeled Completion Trajectories in Participants Scoring in Each Quartile of the Distribution of Active Procrastination (Panel 3a) and Passive Procrastination (Panel 3b)

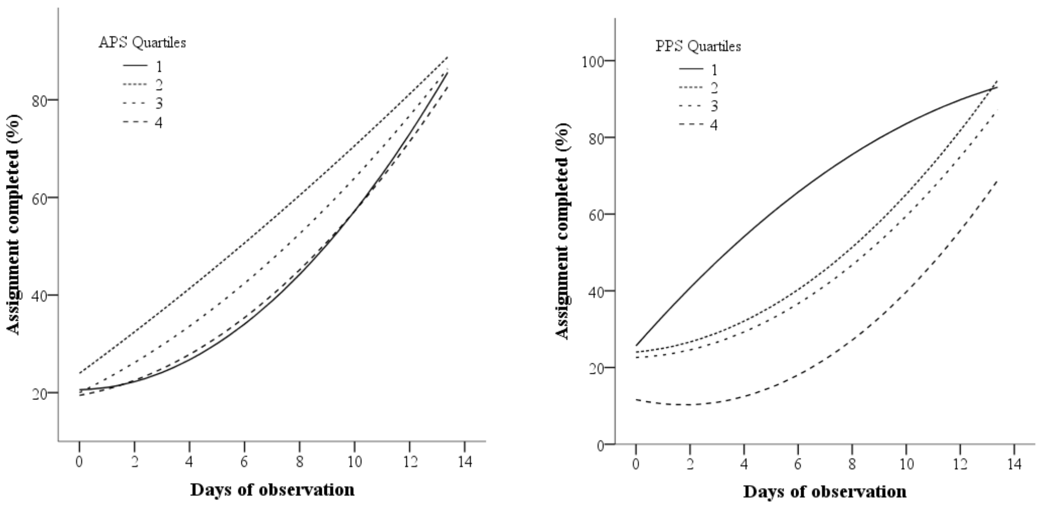


Figure 2.3(a) – Active procrastination Figure 2.3(b) – Passive procrastination

Models 1 through 3 were run controlling for demographic variables expected to restrict participant time for work on the assignment, namely, hours of paid work per week, study load, and dependent responsibilities. Introducing these control variables did not substantively change β coefficients or their statistical significance in any model.

Finally, there was no significant difference in submission date (t = 0.93(322), p = .36, phase 1 M = -1.15, SD = 1.51, phase 2 M = -0.93, SD = 2.45) or assignment mark (t = 0.57(322), p = .57, phase 1 M = 65.14, SD = 15.59, phase 2 M = 66.25, SD

= 14.22) between students who did and did not participate in phase 2, the ESM component of the research.

2.4 Discussion

Maladaptive procrastination affects as much as 20% of the population (Harriott & Ferrari, 1996; Steel, 2007; Van Eerde, 2003). Recently, scholars have proposed a second type of procrastination whereby individuals may intentionally delay with no adverse psychological or performance consequences (Choi & Moran, 2009; Chu & Choi, 2005). These two types have been dubbed passive and active procrastination, respectively. Research evidence is equivocal as to the role of adaptive elements of active procrastination in producing behavioral delay (Hensley, 2014).

This study makes two major contributions to the procrastination literature. First, it demonstrates a novel longitudinal method for measuring behavioral delay in situ. Findings using this method support a hyperbolic increase in productivity, whereby students completed a disproportionately higher amount of their assignment closer to the due date. By modeling the trajectory that students who are high in procrastination take in completing a task, we have identified a metric with which to cross-validate procrastination scales intended to predict delay. Second, we demonstrate that higher passive procrastination, but not active procrastination, is related to greater delay in assignment progress. To our knowledge, this is the first longitudinal study to demonstrate hyperbolic delay in passive procrastinators, and the first to show contrasting productivity curves between high and low passive procrastinators. It is also the first to include longitudinal behavioral observations of delay in active procrastinators.

A major finding was that active procrastination was not predictive of behavior delay. Arguably, this can be partly attributed to the active procrastination scale being not well established, notwithstanding some evidence of the scale's concurrent validity in the form of positive relationships with perceived control of time, life satisfaction, and self-reported performance (Choi & Moran, 2009; Habelrih & Hicks, 2015; Kim et al., 2017). By not supporting the hypothesis relevant to active procrastination, the study casts doubt on the idea that there is a form of behavioral delay that is genuinely adaptive. This has important implications for those working to reduce procrastination. For example, students may need to be counseled that their claims as to the adaptive nature of procrastination may actually be a self-deceptive strategy to rationalize harmful delay.

2.4.1 Strengths, Limitations, and Future Directions

Strengths of this study include its use of measures of both active and passive procrastination, its field setting, its collection of data over multiple waves (and through two sources), and its application of growth curve modeling techniques. The ESM approach taken provides a method for future use in behaviorally validating measures of procrastination, and in assessing the efficacy of anti-procrastination interventions.

Passive procrastination was strongly correlated with hyperbolic discounting, yet it was not related to delayed submission. This suggests that assignment submission date as a singular measure of behavioral delay might over-simplify the relationship between self-reported procrastination and hyperbolic discounting. There are also limitations in using self-reports of task completion. Future research might investigate other predictors of delay, such as task importance and conscientiousness, or study procrastination and behavioral delay using more objective measures of task performance. For example, in information technology settings, progress on programming assignments could be measured in real-time by the number of lines of functional code written.

2.4.2 Conclusion

Few studies have observed the maladaptive delay associated with traditional procrastination, or the purported adaptive delay associated with active procrastination. Through observing progress on an undergraduate assignment over a two-week period, we have shown that traditional passive procrastination predicts behavioral delay, whereas active procrastination does not. We have also introduced a novel method for measuring procrastination longitudinally that has applications beyond academic settings.

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Chapter 3: Reducing Procrastination: A Low-Intensity, High-Frequency Approach

3.0 Prelude

As detailed in Chapter 2, findings from Study 2 confirmed ESM followed by multilevel mixed effects modelling as a viable technique to measure behavioural delay indicative of procrastination. The association of delay trajectories with procrastination was primarily supported by comparing individual modelled trajectories based on trait levels of procrastination. Study 2 provided evidence that the more traditional passive, but not the more contentious active, trait procrastination is meaningfully associated with behavioural delay. This study presented an example of the differing ability of trait procrastination measures to predict behavioural delay, confirming the validity of the more traditional conceptualisation of procrastination, and indicated that intensive longitudinal observation of task progress is a robust method for quantifying behavioural delay for validation of trait scales. The same measurement approach is likely to apply equally well to the assessment of intervention efficacy.

While the published paper presented in Chapter 2 focused on the delay trajectory and trait measures of procrastination, successfully replicating and extending findings from Study 1, the significant differences between experimental conditions found in Study 1 were not replicated in the larger Study 2 sample. Study 3 particularly focused on methodological refinements in the intervention component of the methodology. Chapter 3 presents this further replication and extension of the study protocol, based on a thorough consideration of what might have produced the different results between Studies 1 and 2 for the intervention.

3.0.1 Differences Between Study 1 and Study 2

Both Study 1 and Study 2 involved random allocation of participants into either an intervention or control condition, with those in the intervention condition receiving reflection questions/prompts at the end of each ESM survey that aimed at reducing delay behaviour. As reported in Chapters 1 and 2, although a significant intervention effect was identified in Study 1, no intervention effect was found in Study 2 (see Table 3.1, and Figure 3.1 panels A and B).

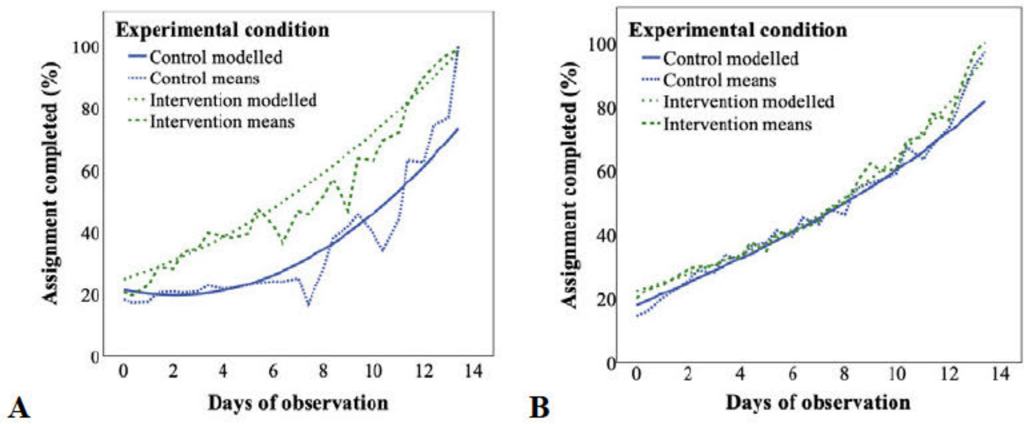
Table 3.1

Average Delay Means, Standard Deviations, and Mean Differences for Those in the Control and Intervention Conditions in Studies 1 (N = 24) and 2 (N = 80)

Study	Control Mean delay (*SD*)	Intervention Mean delay (*SD*)	Cohen's *d*	*p* (1-tailed)
1.	64.5 (27.9)	44.8 (20.2)	0.86	.03
2.	50.4 (25.6)	54.1 (22.9)	-0.15	.75

Figure 3.1

Assignment Completion Trajectories of Participants Allocated Into Intervention and Control Conditions in Study 1 (Panel A) and Study 2 (Panel B)



The substantial difference in intervention effects between the first two studies is worthy of consideration. With more power but similar methodology in Study 2, two potential explanations come to mind. First, the significant intervention effect for mean delay in Study 1, while statistically significant, may have occurred by chance (3%, one-tailed). With such a small sample size in that study (intervention n = 16, control n = 8), individual differences may have had a disproportionate effect on the outcome. Second, the different intervention results may have been influenced by contextual or methodological differences. Study 2, although similar in design to Study 1, including focusing on completing the assignment in the same first-year psychology course, diverged from Study 1 methodologically through association with a laboratory exercise on procrastination in the participating course to obtain a larger sample. Study 1 participants were recruited directly from a research participation pool (a small percentage of course marks require research participation). They were told the aim of the study was to understand their ‘study behaviour’ and that this focused on their behaviour in completing the assignment in the specific first-year course. Thus, the focus on procrastination in Study 1 was covert. By contrast, Study 2 participants completed the baseline survey as part of the laboratory exercise on procrastination in the participating course. Thus, Study 2 participants had been introduced to the concept of procrastination via completing the survey on procrastination and examining and discussing those results in their classes in the participating course. Less than two weeks after that, they were then invited to participate in Study 2, with the invitation citing the ESM phase of the study as a second phase for which the survey completed as part of their laboratory exercise on procrastination would form the Phase 1 baseline data. Following participant recruitment, the study intention referred to being about their ‘study behaviour’, similarly to Study 1.Thus, it is possible that this more overt association between course learning activities on procrastination and the study primed the participants to be wary of procrastination and reduced the effects of the reflection prompts in the intervention condition, increased an underlying observer effect in the control condition, or both. To explore whether the overt linking of Study 2 to procrastination may have been associated with an observer effect, analyses were conducted to investigate the effect that ESM survey response rates and conscientiousness had on delay.

3.0.2 Post-hoc Analyses Comparing Differences Between Study 1 and Study 2

ESM Response Rate as an Indicator of Intervention Efficacy. If participation in the intervention condition was the dominant causal factor in the reduced delay observed among those in the intervention condition in Study 1, then participants who responded to a higher number of ESM surveys in the intervention condition, and, therefore, engaged in a higher number of reflections based on the prompts, would be expected to report a lower level of delay. By contrast, if there were demand characteristics from the overt connection between Study 2 and procrastination, then a smaller or null relationship between ESM response rate and delay would be expected in Study 2. This was not supported by the data, There were no statistically significant relationships between ESM response rate and delay in Study 1 or 2. Correlations between ESM response rate and delay in the control and intervention conditions in both Study 1 (r = -.28, p = .50; r = .23, p = .38, respectively) and Study 2 (r = .11, p = .50; r = -.08, p = .65, respectively) were all nonsignificant.

Conscientiousness as an Indicator of Sensitivity to Demand Characteristics. If the intent of Study 2 as a study of procrastination was overt and salient in the minds of participants, particularly in comparison to Study 1, then it is possible that those participants who were higher in conscientiousness would be more likely to comply with the study's demand characteristics (Nichols & Maner, 2008). That is, more conscientious students would be expected to show less delay in Study 2 compared to the same types of students in Study 1, because Study 2 participants knew what was expected of them. Simple correlations support this, with no statistically significant correlation between conscientiousness and delay in Study 1 (r = -.19, p = .37), and a strong negative correlation in Study 2 (r = -.51, p < .001). The obvious difference in effect sizes between these results in Study 2 compared to Study 1 (26.01% cf. 3.61% of variance in delay explained by conscientiousness) indicates that this was a real difference, and not simply a difference of statistical significance attributable to the stronger power in Study 2.

Prompted by this simple bivariate relationship between conscientiousness and delay, further analysis of between-person differences in conscientiousness and delay on assignment progress was conducted using the multilevel mixed effects modelling method. These analyses revealed that participants high in conscientiousness reported earlier assignment progress, and, therefore, less delay, compared to those low in conscientiousness in Study 2, but not in Study 1 (see Table 3.2). Assignment completion trajectories of those scoring in the lower and higher halves of conscientiousness for each study are presented in Figure 3.1 panels A and B. Figure 3.1 shows a substantially higher assignment progress trajectory for participants in the intervention condition compared to those in the control condition in Study 2 (panel B), but not Study 1 (panel A).

Table 3.2

Multilevel Mixed Effect Model fit (AIC) and Growth Curve Standardized Estimates with Conscientiousness as a Covariate in Studies 1 (N = 24) and 2 (N = 80)

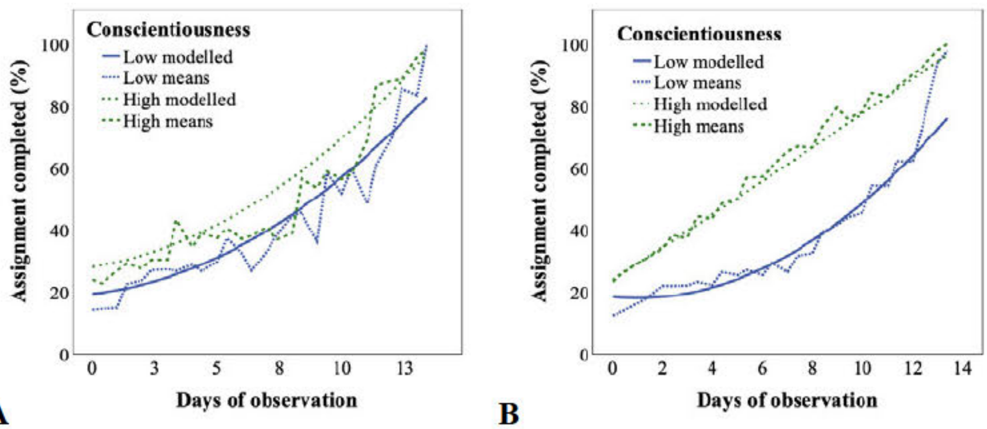
Study	AIC	Δ	t_{00}	t_{10}	t_{20}	t_{11}	t_{21}
1.	4,586.47	-7.03	4.77***	0.75	2.39*	-0.56	0.67
2.	14,465.78	-29.87	9.56***	3.15**	3.36**	5.22***	-4.25***

Note. AIC = Akaike Information Criteria; Δ = AIC change from baseline unconditional model; t_{00} = intercept estimate; t_{10} = slope estimate; t_{20} = quadratic estimate; t_{11} = covariate by slope interaction estimate; t_{21} = covariate by quadratic interaction estimate.

* $p < .05$. ** $p < .01$. *** $p < .001$. All statistical tests were two-tailed.

Figure 3.2

Mean Assignment Progress Trajectories Split by High and Low Levels of Conscientiousness for Studies 1 (Panel A) and 2 (Panel B)



Rationale for Study 3. Considering the strong effect size of the procrastination reduction intervention in Study 1 (Cohen's d = .86), and the results of these analyses comparing the potential effects of response rate and conscientiousness on delay, the failure to demonstrate an intervention effect in Study 2 does not conclusively indicate that the significant intervention effect in Study 1 was due to chance alone. Rather, it seems likely that the "priming" of the procrastination focus explained the diffusion of the effect in Study 2.

Consequently, a further replication of the intervention protocol was warranted. Critical to this was the need to ensure that the focus on procrastination remained covert during recruitment and associated assignment completion in line with the procedure in Study 1. To ensure the conclusions made in Study 2 (Chapter 2) regarding active and passive procrastination were not also influenced by the potential demand characteristics in Study 2, both scales were retained in Study 3. This also ensured that Study 3 was not a simple replication but rather a replication with extension. In line with the findings in Study 2, passive, but not active, procrastination was associated with behavioural delay in Study 3 ($t_{21} = 3.03$ $p = .003$, and $t_{21} = -0.41$, $p = .68$, respectively). This analysis was conducted prior to submission of the paper presented in Chapter 2 for publication.

Chapter 3 presents findings from Study 3. An even larger sample was obtained for the ESM component in this study ($N = 107$), with other elements of the methodology as per Study 1. Participants were randomly assigned to a control or intervention condition, with the latter receiving the randomly selected questions/prompts at the end of each ESM survey. Findings presented in this chapter describe a significant intervention effect, whereby students who received the reflection prompts reported significantly lower levels of delay compared to those who did not.

Chapter 3 has been submitted for publication and is under review. It is included in its adapted form after including minor revisions suggested by anonymous reviewers. Heading, Table, and Figure numberings have been modified from the re-submitted publication in order to be consistent with the numberings in this thesis.

The citation is as follows:

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The co-authors of this manuscript are my thesis supervisors, Graham Bradley and Michelle Hood. My (Jason Wessel) contribution to the manuscript involved: initial concept and research design, data collection and analysis, and preparation of the manuscript.

Statement signed by:

(Signed)__________ [redacted] __________(Date)___17/09/2020___

Jason Wessel (corresponding author)

(Countersigned) ________[redacted]________(Date)___17/09/2020___

Principal supervisor: Graham Bradley

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Associate supervisor: Michelle Hood

Abstract

Studies assessing the efficacy of interventions aimed at reducing procrastination have generally lacked robust longitudinal measurement tools. Recent developments in communication technology and applications of the Experience Sampling Method (ESM) have made observations of such dynamic phenomena possible. We leveraged recent advancements in smartphone technology and ESM to measure delay associated with procrastination, while testing a low-intensity, high-frequency intervention to reducing that delay. First-year university students (N = 107) reported their progress on an assignment twice daily over 14 days prior to the required submission date. Half (n = 51) were randomly allocated to an intervention condition in which they were also asked open-ended questions designed to prompt reflection on 4 domains proposed to reduce procrastination, namely *expectancy*, *value*, *delay sensitivity*, and *metacognition*. Multilevel mixed effect models revealed lower behavioral delay in the intervention condition compared to the control condition. This effect was strongest in those who at baseline scored below the median on trait procrastination. Behavioral delay over the 14-day period was not associated with later assignment submission or lower assignment marks. These findings support a novel method for reducing delay and suggest procrastination can be alleviated in a wide range of contexts using relatively inexpensive and non-intrusive strategies.

3.1 Introduction

To procrastinate is to delay performing an intended task, despite believing delay will be harmful (Corkin et al., 2011; Howell & Watson, 2007; Nguyen et al., 2013; Steel, 2007). The range of tasks, goals, and behaviors that are prone to delay are many, and the personal and organizational impacts of procrastination can be profound. Many strategies have been proposed to reduce the prevalence and impact of procrastination (Kachgal et al., 2001; Steel, 2007). However, a limited number of studies have investigated the efficacy of these strategies (van Eerde & Klingsieck, 2018).

Research into the efficacy of procrastination interventions has been limited for many reasons, including difficulties associated with embedding interventions in ecologically valid contexts, assessing behavioral delay, and gaining the high level of commitment required of participants in intensive interventions (van Eerde & Klingsieck, 2018). We report the findings of a study that used experience sampling and a randomized control design to evaluate a low-intensity, high-frequency, and relatively brief intervention aimed at reducing student procrastination on a written assignment.

3.1.1 Prevalence and Consequences of Procrastination

As many as 20% of US adults identify as having problems with procrastination (Harriott & Ferrari, 1996), and 25% of US adults consider procrastination to be one of their defining traits (Nguyen et al., 2013). These percentages are particularly high in students, with a meta-analysis by Steel (2007) finding 80 to 90% of college students procrastinate, 75% self-identify as procrastinators, and 50% procrastinate consistently and problematically. Indeed, Pychyl et al. (2000) surveyed students 40 times over five days, finding that, on average, they procrastinated over a third of that time.

The impact of procrastination is considerable. Student procrastinators, for example, have been found to experience greater anxiety and receive significantly lower grades on both written assignments and exams compared to non-procrastinators (Tice & Baumeister, 1997). Among workers, procrastination is associated with lower income, shorter employment duration, and a higher likelihood of underemployment (Nguyen et al., 2013), with white-collar workers reporting higher levels of chronic procrastination than blue-collar workers (Gupta et al., 2012; Hammer & Ferrari, 2002). Several studies have also observed group-level procrastination, with the initially slow rate of productivity among business teams increasing as the remaining available work time decreases (Waller et al., 2002). Office workers may spend up to 1.5 hours per work day procrastinating, costing employers an estimated average of USD$8,875 per employee per year (D'Abate & Eddy, 2007). The economic impact of such dilatory behaviors extends beyond the office to a range of personal finance issues as well, with procrastinators less likely to redeem gift certificates (Ferrari, 1993) and as many as 80% of Americans delaying saving so long that an adequate retirement income is unlikely (Byrne et al., 2006). Consequently, the likely economic and social benefits associated with reducing maladaptive dilatory behavior are considerable.

3.1.2 Measuring Procrastination

When people work on a task, rather than distributing their effort equally across the time available, they often begin slowly, and gradually increase their effort as a deadline approaches. Thus, theory (Steel & König, 2006) suggests, and research (Wessel et al., 2019) shows, that progress over time tends to follow an accelerating, or hyperbolic, curve. Notwithstanding this, research has documented individual differences in pacing style, delay behavior, and in the shape of the curve in task performance (Gevers et al., 2015; Wessel et al., 2019). Indeed, the task-focused behavior of individuals who are high in trait procrastination has been shown to display a particularly steep curve over time, indicative of either a considerably delayed start and/or a prolonged initial period of limited activity before effort and output increase (Wessel et al., 2019; see also Svartdal et al., 2020).

Until recently, there was no clearly established method for reliably observing behavioral delay associated with procrastination. To address this deficit, Wessel et al. (2019) introduced the use of Experience Sampling Method (ESM) via brief but frequent (twice daily) mobile phone surveys to measure task progress and map behavioral delay in university students. Results showed that individuals who were high in trait procrastination displayed particularly marked hyperbolic progress curves, whereas the progress of individuals low in trait procrastination tended to be distributed over time in a more linear manner. Consistent with this, the current research tested the proposition that, while progress generally follows a hyperbolic curve, departures from linearity increase with trait procrastination.

3.1.3 Procrastination Interventions

Few studies report attempts to reduce procrastination (Steel & Klingsieck, 2016). Extant research either assesses the effects of a single, targeted personal change intervention such as time-management training or therapeutic treatments such as CBT, or evaluates interventions embedded into naturalistic task environments. The efficacy of personal change interventions has typically been assessed not by way of reductions in actual delay behavior, but by changes in trait procrastination (van Eerde, 2003; van Eerde & Klingsieck, 2018; Rozenthal et al., 2018). The practicality and cost-effectiveness of these interventions are limited by multiple factors, such as the availability and skill of practitioners, barriers to participant access, and time investment required of participants (Rozental et al., 2015; van Eerde & Klingsieck, 2018). Naturalistic task interventions, such as scheduled daily writing tasks and random compliance checking (Boice, 1989), are more scalable, do not need highly trained therapists, and are often able to use more objective measures of task delay to quantify efficacy. However, studies evaluating these interventions are scarce and findings have been inconsistent, with recent examples producing mixed success in reducing procrastination (Ariely & Wertenbroch, 2002; Delaval et al., 2015).

3.1.4 Strategies to Reduce Procrastination

While empirical evidence of effective procrastination interventions, particularly those measured against behavioral delay, is limited, the literature is rife with suggested strategies that could be incorporated into a comprehensive procrastination intervention. Other than interventions that seek to reduce procrastination through an externally-imposed deadline, most strategies can be categorized as targeting one of four elements linked to procrastination. The first three are summarized by Steel and König (2006) in their Temporal Motivation Theory (TMT), namely, expectancy of task success, perceived value of the task or behavior, and sensitivity to delay (see also Steel, 2007). A fourth category, comprising general metacognitive strategies, could be added as research has linked these to lower trait procrastination (Corkin et al., 2011; Howell & Watson, 2007; Steel & Klingsieck, 2016).

Expectancy-value theories of motivation are well known and widely applied in work and other contexts (e.g., Porter & Lawler, 1968; van Eerde & Thierry, 1996; Vroom, 1964). However, we know of no applied approaches targeting expectancy or value in the context of reducing procrastination. Nonetheless, Steel (2007) suggested that procrastination can be tackled by increasing expectations of the likelihood that positive outcomes will result from initiating and/or completing targeted behaviors. One way to do this is to present evidence or examples of other like-individuals who have started the behavior early and successfully completed it on time. This kind of descriptive norm or 'social proof' information has been shown to influence behavior in other contexts (Goldstein et al., 2008). While effects on procrastination have not previously been demonstrated, informing people of the behaviors displayed by similar and successful others may help to build expectancy and, thereby, reduce procrastination.

To increase perceived value of task progress and completion, scholars have recommended visualization techniques like mental contrasting or mental time travel (e.g., Blouin-Hudon & Pychyl, 2017, Steel & Klingsieck, 2016; Taylor & Wilson, 2016). These techniques involve the vivid imagining of future goal attainment and the associated rewards. Participants may be encouraged to savor the feelings associated with task completion, both independently and compared to their current state or to non-attainment (Kappes et al., 2012). Procrastination has been shown to be inversely related to the ability to visualize future scenarios and the implications of current behavior (Rebetez et al., 2016). Thus, providing opportunities for visualization might make outcomes appear more proximate and desirable, and, thereby, reduce procrastination.

Delay sensitivity refers to a higher likelihood of impulse-driven behavior when a deadline is temporally distant (Steel, 2007). To decrease delay sensitivity and promote purposive use of time, a parsimonious approach involves encouraging individuals to break large complex tasks into smaller achievable steps, and, thus, build momentum through earlier achievement of milestones. This has been shown to produce quick gains (Abbasi & Alghamdi, 2015) and has been variously referred to as chunking (Ferrari, 2010), success spiraling, or island hopping (Steel, 2007). We posit that the focus on more immediate 'quick wins' can exploit an innate bias towards acting in one's present interests (O'Donoghue & Rabin, 1999) and reduce fixation on the larger complex task that may otherwise be perceived as overwhelming.

In addition to these three kinds of strategies anticipated by TMT, a fourth broad category, general metacognitive strategies, has been linked to lower trait procrastination (Corkin et al., 2011; Howell & Watson, 2007; Steel & Klingsieck, 2016). Metacognitive strategies involve reflection on the thinking (e.g., planning, decision-making) behind one's task approach or time use. One possible way to enhance this is to prompt thoughts as to specific actions that could be, but are not currently, done to facilitate on-time task completion. Promoting this type of thinking might enhance awareness not only of task progress, but also of the most efficacious way forward. If procrastinating, metacognitive reflection may lead to self-correcting behaviors (Rozental et al., 2018; van Eerde, 2000).

These strategies are often proposed to reduce procrastination; however, none is likely to be effective in all circumstances. Rather, their efficacy may vary with both task and individual factors (Claessens et al., 2010). For example, individuals who expect success relating to one task may not expect success in another, and those who place little value on the pursuit of one task may highly value another. Similarly, individual and task-related differences will exist for delay sensitivity and the depth of metacognitive reflection on delay. Leveraging a spectrum of strategies has two main advantages. First, it increases the likelihood that one of the strategies will be efficacious for the particular task and with each of the individuals requiring a reduction in procrastination. Second, it has the benefit of reducing monotony during an intervention, particularly one that is delivered over a prolonged period of time. For these reasons, naturalistic task interventions are likely to benefit from an approach incorporating all the above strategies.

3.1.5 The Current Study

To our knowledge, no prior attempt has been made to combine these four types of strategies into a single procrastination reduction intervention. Moreover, no known study has used an *in situ* measure of behavioral delay to evaluate the procrastination intervention against delay curves. Following Wessel et al. (2019), we used ESM delivered by smartphone twice daily to repeatedly measure students' progress toward goal attainment, namely, on-time submission of a course assignment. In addition to requesting goal progress reports, we delivered intervention strategy messages to reduce procrastination based on the four approaches described above. We used an equal mix of the four strategies, presented in a random order, to both maintain participant engagement and hedge against individual sensitivity to the four strategies. Given evidence as to the potential benefits of the strategies when used independently, we expected that using all four in combination would be effective in reducing procrastination. In addition, we examined whether reducing behavioral delay leading up to assignment submission was associated with earlier submission of, and/or higher grades for, the assignment.

Participants recorded their progress on an assignment twice daily over a 2-week period leading up to the submission deadline. Half were randomly assigned to receive the intervention messages; the other half functioned as a control group who did not receive these messages. We anticipated that, compared to the control group, the intervention group would display less behavioral delay.

Three hypotheses were tested:

Hypothesis 1. Participants' task progress over time as the submission date approaches is best modeled by a hyperbolic function.

Hypothesis 2. Trait procrastination will predict behavioral delay.

Hypothesis 3. An intervention comprising a series of brief, twice daily prompts targeting task expectancy, value, delay sensitivity, and general metacognitive strategies will reduce behavioral delay.

3.2 Method

3.2.1 Participants and Procedure

First-year psychology students at a public Australian university participated in exchange for course credit. They first completed a baseline questionnaire and provided their (cell) mobile phone number to receive links to brief but frequent Short Message Service (SMS) texts. SMSs were sent twice daily (morning and evening) for the two weeks leading up to the submission deadline of a written assignment, which was worth 30% of the students' final grade (total = 28 messages). Each message contained a brief questionnaire that required a SMS reply to indicate the extent of progress on the assignment. Of the initial 148 respondents (from 463 eligible students), 8 were granted extensions, 3 never submitted their assignment, and 30 responded to fewer than 30% of surveys, so were excluded. A Mann-Whitney test indicated that trait procrastination was higher for participants in receipt of an extension (*Mdn* = 33) than for the retained sample (*Mdn* = 24), $U = 248$, $p = .047$. No other differences between groups (e.g., in Grade Point Average, GPA) were identified. Of the remaining 107 participants (aged between 17.7 and 55.9 years; $M = 23.54$, $SD = 8.42$), 69% were female. They responded to an average of 81.24% ($SD =$

19.4%) of ESM surveys. Participants were randomly assigned to the intervention (*n* = 52) or control (*n* = 55) condition.

3.2.2 Materials

Baseline Survey. Trait procrastination was measured through the 6-item Passive Procrastination Scale (PPS; Chu & Choi, 2005), which measures maladaptive procrastination on a response scale from 1 = *not at all true* to 7 = *very true*. Chu and Choi (2005) reported coefficient alpha internal reliability as .82 and alpha from the current sample was .88. Items include "I tend to leave things until the last minute." Following reversal of the single negatively-keyed item, responses were summed, with higher scores indicating higher trait procrastination. In support of scale validity, past research (e.g., Wessel et al., 2019) has shown that scores on the PPS predicted behavioral delay as expected. Participants provided demographic details including gender, age, GPA, hours of paid work, number of courses taken, and carer responsibilities.

ESM. Twice daily for 14 days, all participants received via their smartphone a question "As of right now, what proportion of your assignment have you completed (0% - 100%)?" Data were collected as to the number of these ESM messages answered by each participant.

Intervention Condition. Intervention participants received one of four open-ended prompts or questions at the end of each ESM survey. Each prompt was designed to elicit reflection on one of the four strategies to reduce procrastination. The prompt participants received varied randomly between consecutive ESM surveys to minimize participant boredom and consequent inattentiveness. The four prompts were:

1. Expectancy: “Our analyses suggest that students who do best in this course start early and submit their Lab Report the day before it’s due. To demonstrate you have read the above statement, in the following box please repeat what students who perform the best do:”,
2. Value: “I want you to imagine yourself the day before this assignment is due, and you haven’t started working on it. How do you feel?”,
3. Delay sensitivity: “Research has found breaking larger tasks (like completing an assignment) into smaller tasks (like brainstorming 3 dot-points) can help with motivation. What is your next small step?”, and
4. General metacognition: “If you could do one thing to ensure you finish the Lab Report on time, what would it be?”

All intervention condition participants received each prompt on approximately seven occasions (28 SMS messages / 4 different prompts = 7 times per prompt).

Assignment performance. At the end of the semester, assignment submission date (including time of day) and assignment mark were collected from university records for the 107 participants as well as for other students who were enrolled in the course but did not participate in this study (non-participants; $n = 315$). Collecting these details from non-participants enabled identification of any effect on assignment completion associated with participation in the study. There were no statistically significant differences in submission date or assignment mark between study participants and the remainder of the course cohort.

3.3 Results

The major dependent variable, average modeled delay, was formed by averaging the reported percentage assignment completed values for each participant’s responses over the 28 ESM observations and subtracting the value from 100. Higher numbers indicate later assignment progress and higher behavioral delay. Missing data were handled in an unconditional multilevel mixed model (described below) by Restricted Maximum Likelihood (REML; Heck et al., 2010). As behavioral trajectory data were used to derive a within-person average for correlational purposes, average modeled delay contained no missing data.

Table 3.3 reports descriptive statistics and correlations. Trait procrastination was positively correlated with average modeled delay. Both trait procrastination and average modeled delay were correlated with assignment submission date but not assignment mark. Proportion of ESM non-responses was correlated with study load, but correlations with key variables were non-significant or trivial. There was no association between intervention condition and trait procrastination, indicating that random assignment was effective.

Table 3.3

Descriptive Statistics and Correlations[a] (N =107)

		Mean	***SD***	**1.**	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	**8.**	**9.**	**10.**	**11.**
1.	Gender	-	-											
2.	Age (years)	23.54	8.42	-.07										
3.	Grade Point Average	4.91	1.71	-.13	**-.27**									
4.	Study Load (no. of courses)	3.66	0.60	.03	**-.45**	.12								
5.	Paid Work (hours per week)	2.50	0.81	-.09	**.23**	-.03	.08							
6.	Dependents	.18	0.38	.15	**.28**	**-.20**	**-.23**	.05						
7.	Trait procrastination	23.18	6.70	**-.23**	**-.21**	.03	.17	-.08	-.12					
8.	Intervention condition	0.49	0.50	-.12	.06	.19	-.11	.12	-.01	-.03				
9.	Average modeled delay	45.52	27.63	-.06	-.14	.13	.14	-.04	-.10	**.51**	**-.**14			
10.	ESM response rate	22.75	5.42	.03	**.20**	.19	**-.21**	**.21**	.10	-.12	.08	-.02		
11.	Submission date	-0.80	1.40	-.09	-.19	-.03	.08	-.06	-.10	**.43**	.12	**.39**	-.13	
12.	Assignment mark (%)	73.46	13.87	**-.25**	-.10	**.27**	.09	-.05	-.17	-.03	-.05	.02	.11	.05

Note. Gender is coded as 0 = *Male*, 1 = *Female*. Dependents is coded as 0 = *no dependents*, 1 = > *0 dependents*. Submission date was coded as the proportion of a day around the due time that the assignment was submitted, with 0 as the due time, and 1 equating to one day post deadline (lower numbers indicate an earlier submission time). Intervention condition is coded as 0 = *Control*, 1 = *Intervention*.

[a] Correlations > .189 significant at $p < .05$ (two-tailed); correlations between .25 and .28 significant at $p < .01$; correlations > .28 significant at $p < .001$. Significant correlations are highlighted in bold. (Correlations entered as .19, but not highlighted in bold, were rounded up from a value between .185 and .188).

Testing of H1 required assessment of linear and quadratic progress towards assignment completion over the 14 days of observation. To achieve this, completion trajectories were identified through single-level unconditional and multi-level covariate linear and growth curve mixed models. The unconditional model (model 1) tested the rate of progress on the assignment (as indicated by reports of the percentage completed at each of the 28 time points). The model included two time variables: Time (the linear effect) and $Time^2$ (the quadratic or hyperbolic effect). Put simply, we expected a significant quadratic effect, or departure from linearity. Coefficients represented units of percentage increase in assignment completion either at the start of the two weeks (intercept), additional change over 1 day (slope), or additional change over 1 day^2 (quadratic; see online supplemental materials for more details). Model results for Hypotheses 1 to 3 are displayed in Table 3.4.

Table 3.4

Multilevel Mixture Model Fit (AIC) and Growth Curve Standardized Estimates (N = 107)

Covariate model		AIC	Δ	t_{00}	t_{10}	t_{20}	t_{11}	t_{21}
1.	Unconditional	19,173.19	-	9.18^{***}	4.00^{***}	3.50^{**}	-	-
2.	Procrastination (PPS)	19,143.09	-30.10	9.64^{***}	4.07^{***}	3.75^{***}	-3.37^{**}	3.03^{**}
3.	Intervention	19,159.06	-14.13	8.93^{***}	4.35^{***}	3.47^{**}	3.05^{**}	-2.51^{*}

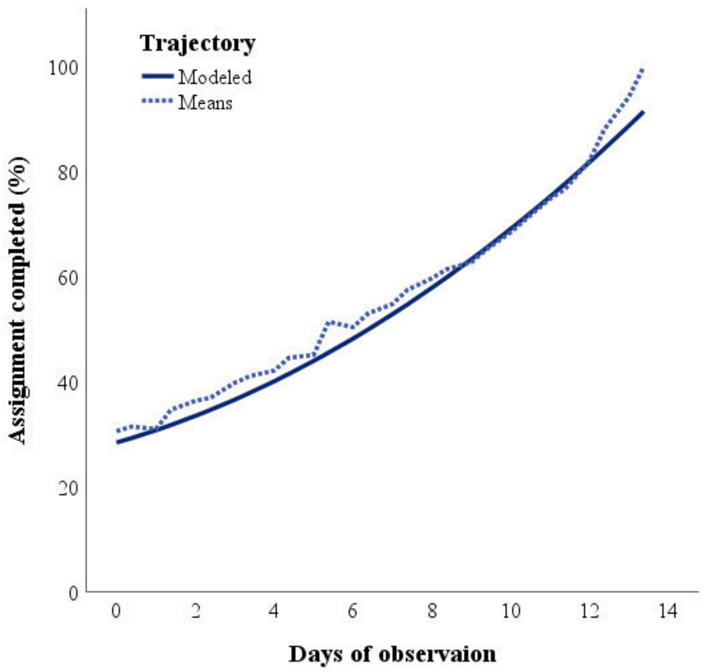
Note. I = Intervention; Δ denotes AIC change from the baseline unconditional model; t_{00} = standardized intercept estimate; t_{10} = standardized slope estimate; t_{20} = standardized quadratic estimate; t_{11} = standardized covariate by slope interaction estimate; t_{21} = standardized covariate by quadratic interaction estimate. Unstandardized coefficients are provided in Supplemental material.

* $p < .05$. ** $p < .01$. *** $p < .001$. All statistical tests were two-tailed.

The unconditional model trajectory supported clear linear growth ($t_{10} = 4.00$, $p < .001$) from a starting value of 27.74% assignment completed (β_{00}; at Time 1, 14 days prior to the assignment due date), and, in support of H1, significant positive quadratic growth ($t_{20} = 3.50$, $p < .01$). Participant mean completion percentage and modelled completion trajectory are depicted in Figure 3.3.

Figure 3.3

Percentage of Assignment Completed Means and Modeled Assignment Completion Trajectory Over 14 Days Prior to Due Date (Day 14)

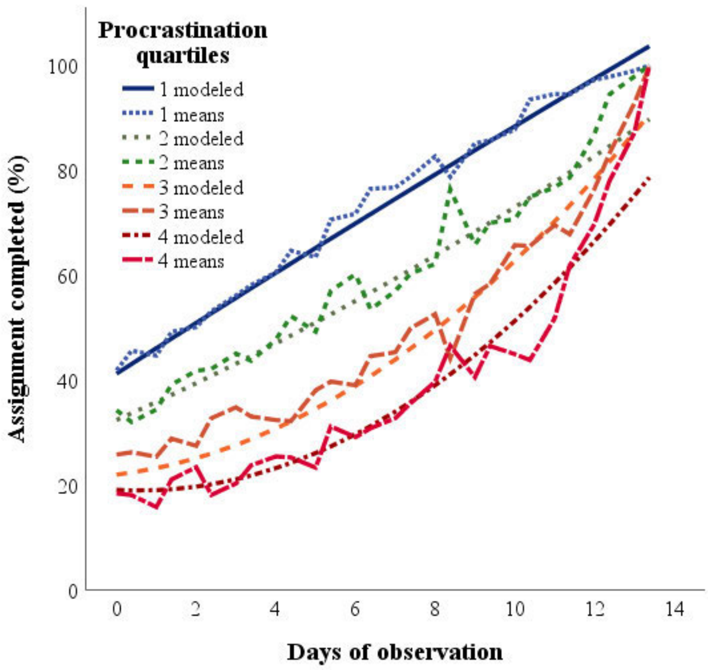


Wald Z tests were used to identify significant between-person differences in linear (Wald $Z = 6.49$, $p < .001$) and quadratic growth (Wald $Z = 6.50$, $p < .001$). Results indicate variance in growth trajectories was not satisfactorily explained by the unconditional model. To assess the degree to which trait procrastination (H2) and the intervention (H3) explained between-person variance in assignment completion trajectory over the two-week period, separate growth curve mixed models were run including either trait procrastination (model 2) or intervention condition (model 3) as covariates at Level 2 (Heck et al., 2010). Model fit and parsimony were assessed by the Akaike Information Criteria (AIC), where smaller values indicate a closer and/or more parsimonious fit between the model and data. Results are summarized in Table 3.4.

Model 2 tests revealed a significant interaction between trait procrastination and both linear ($t_{11}^{PPS} = -3.37$, $p < .01$) and quadratic ($t_{21}^{PPS} = 3.03$, $p < .01$) growth curves, supporting H2 and the veracity of the PPS as a strong predictor of behavioral delay, and, conversely, behavioral delay providing a robust indication of trait procrastination. Furthermore, inclusion of trait procrastination as a covariate improved model fit (ΔAIC = -30.10). The interaction between time and trait procrastination is illustrated in Figure 3.4, where participant modeled and actual completion trajectories by PPS quartiles show clear increases in delay with higher trait procrastination.

Figure 3.4

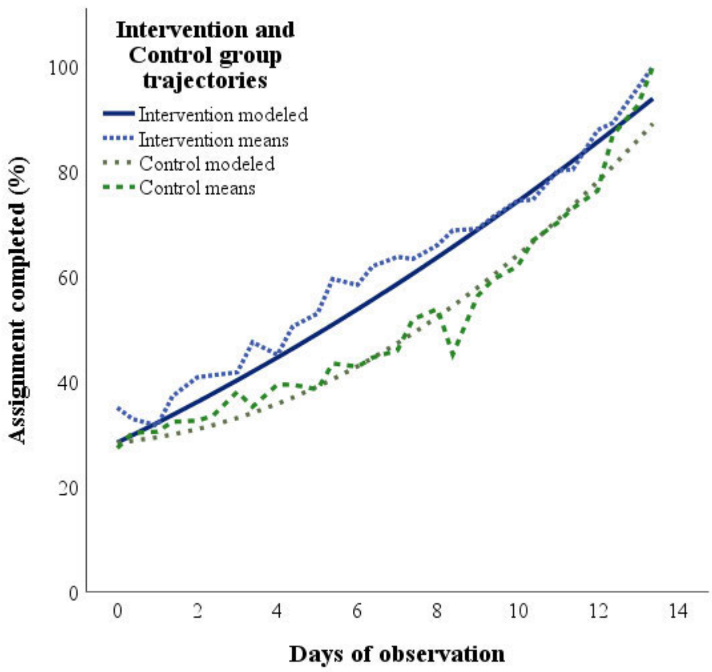
Means and Modeled Assignment Completion Trajectories of Participants by PPS Puartile



Inclusion of intervention condition as a covariate in model 3 resulted in significant linear ($t_{11}^{\text{Intervention}} = 3.05$, $p < .01$) and quadratic ($t_{21}^{\text{Intervention}} = -2.51$, $p = .01$) trajectories. However, in contrast to trait procrastination with negative linear and positive quadratic growth, students allocated to the intervention condition displayed positive linear and negative quadratic trajectories. In support of H3, this indicates a trajectory of significantly less behavioral delay (i.e., earlier assignment progress) among participants in the intervention condition compared to the control condition. Alternatively stated, the average modelled delay reported by those in the intervention condition ($M = 41.4$, $SD = 26.6$) was lower than that in the control condition ($M = 49.1$, $SD = 26.8$; Cohen's $d = .29$). The significant intervention effect is depicted in Figure 3.5.

Figure 3.5

Means and Modelled Trajectories for Participants in Intervention and Control Conditions



Given this evidence as to the effectiveness of the intervention, on a post hoc basis participants were split into either high or low trait procrastination groups based on the median score, and multilevel mixed models were run on each group with participation in the intervention as a covariate. Results showed that, consistent with the trends evident in the whole sample, participants with below median procrastination scores displayed significant positive linear (t_{11} = 2.70, p < .05) and negative quadratic (t_{21} = -2.75, p < .01) growth (see Figure 3.6a). That is, those lowest in trait procrastination reported significantly less delay if in the intervention condition (M = 26.9, SD = 16.2), compared to those in the control condition (M = 37.8, SD = 25.3; Cohen's d = .51). However, there were no significant differences between experimental and control conditions in linear (t_{11} = 1.15, p > .05) or quadratic (t_{11} = -0.41, p > .05) assignment completion trajectories among participants scoring in the higher 50% of trait procrastination (see Figure 3.6b; Intervention M = 52.9, SD = 27.6; Control M = 59.1, SD = 24.1; Cohen's d = .24).

Figure 3.6a

Means and Modelled Trajectories for Participants Scoring Below the PPS Median in Intervention and Control Conditions (n = 48)

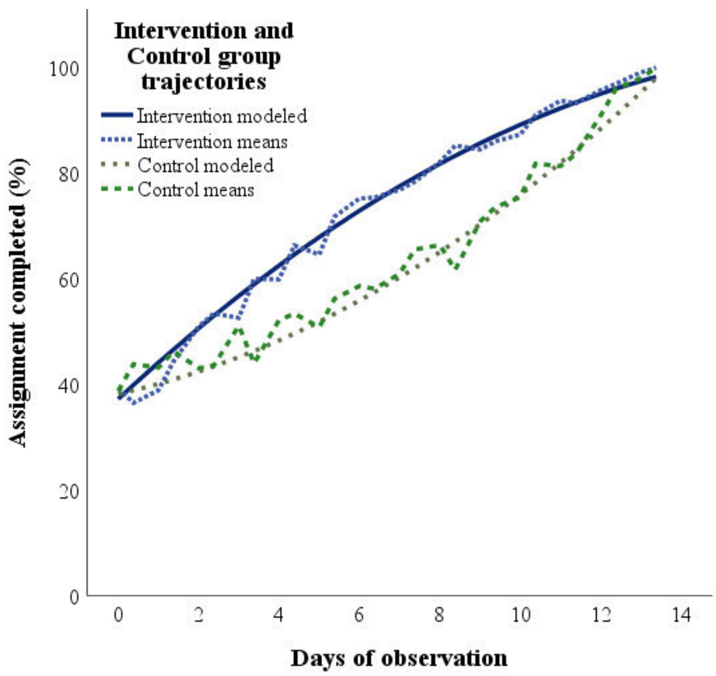
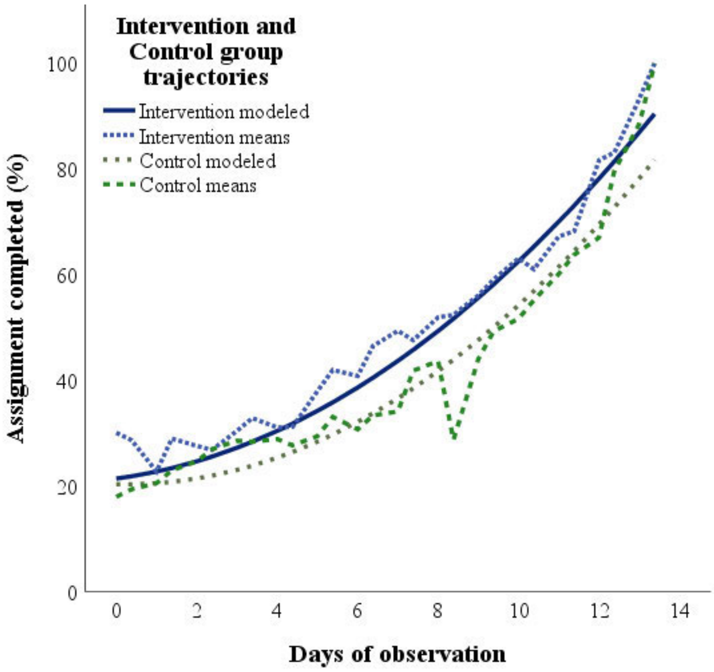


Figure 3.6b

Means and Modelled Trajectories for Participants Scoring Above the PPS Median in Intervention and Control Conditions (n = 59)



The intervention model (model 3) was replicated in Mplus (Muthén & Muthén, 1998-2011) for post hoc power analyses using Monte Carlo simulation (Bolger & Laurenceau, 2013). Factoring in 18.76% missing data, our study was slightly under-powered to identify significant changes to the linear and quadratic trajectories in the intervention condition (power = .75 and .72, respectively, where .80 is the ideal). A further simulation using a sample of 130 identified sufficient power of .83 for the intervention effect on increased slope, and .81 for the intervention effect on reduced quadratic trajectory.

Introducing age, gender, GPA, hours of paid work per week, study load, and carer responsibilities as demographic control variables did not substantively change *t* coefficients or their statistical significance in any model.

Finally, there were no significant differences in submission date ($t_{90.71}$= -1.28, p = 0.21, Control M = -0.97, SD = 1.68, Intervention M = -0.63, SD = 1.04) or assignment mark (t_{105} = 0.46, p = .65, Control M = 22.22, SD = 3.61, Intervention M = 21.85, SD = 4.70) between students in the control and intervention conditions. Similarly, there were no significant differences in assignment submission date or mark between the two groups when analyses were restricted to just the high, or just the low, procrastination participants.

3.4 Discussion

Despite problematic procrastination affecting as much as 20% of the general population (Harriott & Ferrari, 1996) and 50% of students (Steel, 2007), there are relatively few robust and empirically supported intervention strategies to reduce it (Steel, 2007). This study introduces a novel approach to reducing procrastination that involved leveraging the accessibility of smartphones to deliver brief but frequent prompts. The intervention used a combination of regular progress reporting and targeted open-ended questions designed to prompt reflection on task expectancy and value, to mitigate sensitivity to delay, and to promote relevant metacognition. Results indicate that the operationalization of these constructs was successful in reducing behavioral delay in an undergraduate university sample with respect to progress in completing an assignment.

Our findings supported the first two hypotheses. As expected, student progress on the assignment followed a hyperbolic delay curve (H1), and students who scored higher in trait procrastination demonstrated a more pronounced delay curve than those who scored lower (H2). These findings add credence to the method employed to measure delay associated with procrastination, replicate findings from Wessel et al. (2019) regarding delay trajectories over time, and support the Passive Procrastination Scale as a valid measure of trait procrastination in this sample.

Our major hypothesis (H3) was also supported. In both conditions, progress was made salient by the requirement for regular progress reporting, yet reduced delay was evident in participants randomly allocated to the intervention condition. Thus, the intervention effect can be confidently attributed to receipt of the prompts to reflect in the four targeted domains, rather than to general reflection on or awareness of task progress.

Unexpectedly, we found that this intervention effect was qualified by level of trait procrastination. The intervention significantly reduced delay in participants scoring in the lower 50% on trait procrastination, but not the higher 50%. It is possible that change in those with higher levels of trait-based procrastination requires a stronger or longer-term intervention across a range of contexts (Roberts et al., 2017). Reduced behavioral delay from the intervention among those scoring lower on procrastination may indicate change in what is to them an occasional and discretionary behavior, while behavioral delay may reflect a more deeply entrenched, and, thus, less malleable, habit in individuals higher in trait procrastination. It is also possible that, for high procrastinators in the control condition, the requirement to frequently report progress had a motivating effect large enough to crowd out any intervention effect.

Though the introduction of regular reflection prompts generally reduced behavioral delay, and behavioral delay was correlated with submission date, there was no observed effect of intervention condition on either submission date or assignment mark. These findings do not invalidate the effectiveness of the intervention, but they do warrant explanation. Regarding submission date, this may not be identical to completion date: given the high-weighting of the assignment (worth 30% of participant grades), students who completed the assignment early may have intentionally delayed submission to allow final revision 'just in case' (Gregory & Morón-García, 2009). Although we have no data directly pertaining to this point, the observed task progress curves suggest there may have been more early completion-delayed submission students in the intervention than in the control condition. In addition, many students who submitted on time may not have felt they had completed the assignment to the best of their ability and would have ideally taken more time to feel the piece of work was fully complete. Moreover, we removed a large portion of variability around submission date by excluding participants who were granted extensions. Though removal of these cases was necessary to maintain a standardized timeline for statistical modeling, higher trait procrastination among those receiving an extension (see section 2.1) suggests behavioral delay may have been an underlying factor.

The absence of an intervention effect on assignment mark invites questioning of the value of reducing behavioral delay. Nevertheless, performance as measured by grades is only one known consequence of problematic procrastination. Reductions in behavioral delay may free up time for incidental learning and performance of other tasks, may reduce other adverse consequences such as experiences of negative affect, and may limit spill-over to other life domains while procrastinating (Pychyl et al., 2000).

3.4.1 Strengths and Limitations

This study is particularly robust in its measurement of procrastination as both a trait and behavior by longitudinally quantifying delay. Moreover, the significant effect of the intervention and use of a randomized control design was robust to controlling for a variety of variables such as engagement (i.e., ESM reply rate) and demographic variables (including competing demands on students' time from work, other courses, and caring responsibilities). A major strength of this intervention pertains to the reflection prompts that were used: they were brief, frequent, but not onerous. This low-intensity approach may have led to a high participant retention rate relative to past ESM interventions (Modecki & Mazza, 2017). The prompts were also quite generic, and can, thus, be adapted to a wide range of tasks and applied contexts inside and outside of education. Finally, the intervention is highly scalable, and, compared to more intensive and personalized treatments, has the potential to be delivered in cost-effective ways that meet the demands of a problem as prevalent as procrastination.

We relied on subjective reports of progress, which introduces the potential for social desirability confounds and measurement error. This may be overcome by studying progress on objectively quantifiable assignments such as with students working on an online project where the amount of work can be accurately tracked over time. In many programming projects, for example, the number functioning features or completed events can be automatically recognized (Kazerouni et al., 2017). Modern learning management systems and educational technology tools with the capacity for tracking not just task completion, but incremental progress, may also enable a more objective measurement of progress.

As control participants reported their assignment progress as frequently as those in the intervention condition, it is possible that progress reporting alone increased all participants' motivation, and, therefore, would not have accurately reflected their completion trajectory had they not participated in the study. This is both a research limitation and a strength: by ensuring that progress reporting was both frequent and consistent across conditions, we potentially under-estimated the true effect size of the intervention, but were able to attribute the intervention effect unambiguously to the reflection prompts.

Finally, expectancy, value, and delay sensitivity as articulated by Steel and König (2006) have received limited research attention or support in the procrastination literature beyond this targeted intervention. We acknowledge that our use of reflection prompts that targeted only these domains, plus metacognition, overlooked other possible barriers to timely task completion.

3.4.2 Recommendations for Future Research

The prompts and questions in the present study were designed to promote reflection on behaviors associated with academic assignment writing. Future research may explore whether this low-intensity, high-frequency, reflective approach can be effectively applied to a range of different activities on which people are prone to procrastinate. For example, progress toward professional development goals may be more consistent if workers are regularly prompted to visualize future benefits of achieving those goals, health-related behavior change such as smoking cessation, weight loss, or other advice following a medical appointment may be more consistent if patients are regularly prompted to define their next small and achievable actions, and regular contributions to their retirement account may be more likely if workers are regularly exposed to and compelled to describe the early behaviors of those who are financially comfortable upon retirement. Research seeking to clarify the effect that regular progress reporting has on behavioral delay may seek to experimentally manipulate ESM survey frequency without the use of reflection prompts to further understand the "dose effect" required to change delay. Future research may use the different prompts separately to isolate their independent/unique effects and may conduct post-intervention trait measurements of procrastination to detect possible trait-level change.

Future research should seek to enhance the effectiveness of the current intervention, particularly when applied to individuals who are high in trait procrastination. This could involve use of reflection prompts targeting other known covariates of procrastination such as perfectionism. Other strategies could be borrowed from therapies such as CBT, where participants may be asked to challenge common dysfunctional thoughts around procrastination, identify environmental cues to action, or nominate their problem behaviors and propose solutions. As procrastination is a cross-cultural phenomenon (Ferrari et al., 2007), we invite researchers from non-English speaking countries to replicate these findings, and, when doing so, recommend a minimum sample of 130 participants to insure a sufficiently powered study.

3.4.3 Conclusion

Studies demonstrating effective reduction in procrastination are scarce. By combining regular progress reporting with open questions to prompt reflection, this study provides evidence for a novel method of reducing behavioral delay. Put simply, compared to those in the control condition, intervention condition participants displayed less delay (i.e., earlier assignment progress). The approach is likely to suit replication in a variety of non-academic domains where individuals frequently delay taking action (e.g., saving for retirement, or engaging in healthier behaviors).

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3.5 Supplemental Materials

3.5.1 Detailed Model Description

The unconditional model examined the rate of progress on the assignment (as indicated by reports of the percentage completed at each of the 28 time points). The model included two time variables: Time (the linear effect) and Time^2 (the quadratic or hyperbolic effect). Coefficients represented units of percentage increase in assignment completion either at the start of the two weeks (intercept), additional change over 1 day (slope), or additional change over 1 day^2 (quadratic). Thus, the general form of the unconditional model was as follows:

$$Y_{ti} \text{ (Percentage completed)} = \Pi_{0i} + \Pi_{1i} (\text{Time}_{ti}) + \Pi_{2i} (\text{Time}^2_{ti}) + \varepsilon_{ti},$$

$$\Pi_{0i} = + \beta_{00} + \gamma_{0i},$$

$$\Pi_{1i} = + \beta_{10} + \gamma_{1i},$$

$$\Pi_{2i} = + \beta_{20} + \gamma_{2i},$$

where Π_{0i} is Person i's mean completion percentage at Time 1, Π_{1i} is Person i's linear growth rate, and Π_{2i} is Person i's quadratic curvilinear growth rate (or acceleration in assignment percentage completed). Mean completion percentage, signified by β_{00}, indicates the average percentage of assignment completed at Time 1 (2 weeks prior to the due date), while mean growth (linear) and the acceleration (quadratic) rates are signified by β_{10} and β_{20}, respectively.

Thus, the general form of models 2 and 3 were as follows:

$$Y_{ti} \text{ (Percentage completed)} = \Pi_{0i} + \Pi_{1i} (\text{Time}_{ti}) + \Pi_{2i} (\text{Time}^2_{ti}) + \varepsilon_{ti},$$

$$\Pi_{0i} = + \beta_{00} + \beta_{01} (\text{Covariate}) + \gamma_{0i},$$

$$\Pi_{1i} = + \beta_{10} + \beta_{11} (\text{Covariate}) + \gamma_{1i},$$

$$\Pi_{2i} = + \beta_{20} + \beta_{21} (\text{Covariate}) + \gamma_{2i},$$

where mean completion percentage, signified by β_{00}, indicates the average percentage of assignment completed at Time 1 (14 days prior to the due date), with other variables equal to zero (grand mean centered). The coefficient β_{01} reflect differences in mean completion percentage as a function of the covariate under analysis. Mean growth (linear) and the acceleration (quadratic) rates are signified by β_{10} and β_{20}, respectively. Other coefficients associated with linear growth rate (Π_{1i}) and acceleration (Π_{2i}) are interpreted as for the intercept (Π_{0i}); however, these coefficients index the effect of the covariate (e.g., trait procrastination, or intervention condition) on linear and quadratic growth. In Table 3.4 of the paper, standardized coefficients are reported for interpretability. Thus, instances of β in the above description can be interpreted interchangeably with instances of *t* reported in the paper.

3.5.2 Table of Multilevel Models (Table 3.4) Presented with Unstandardized (β) Estimates

Table 3.4 (unstandardized)

Multilevel Mixed Effect Model Fit (AIC) and Growth Curve Unstandardized Estimates (N = 107)

	Covariate model	AIC	Δ	β_{00}	β_{10}	β_{20}	β_{11}	β_{21}
1.	Unconditional	19,173.19	-	27.74***	2.44***	.17**	-	-
2.	Procrastination (PPS)	19,143.09	-30.10	27.62***	2.37***	.17***	-1.98**	.14**
3.	Intervention	19,159.06	-14.13	27.40***	2.54***	.16**	1.78**	-.12*

Note. I = Intervention; Δ denotes AIC change from the baseline unconditional model; β_{00} = intercept estimate; β_{10} = slope estimate; β_{20} = quadratic estimate; β_{11} = covariate by slope interaction estimate; β_{21} = covariate by quadratic interaction estimate.

* $p < .05$. ** $p < .01$. *** $p < .001$. All statistical tests were two-tailed.

3.5.3 Supplemental Confirmatory Findings from Study 3

Although there was no evidence that exposure to the reflection prompts through higher ESM response rate in the intervention condition was related to lower delay in Studies 1 or 2, response rate was related to lower delay in Study 3. No statistically significant relationship was identified between ESM response rate and delay in the Study 3 control condition (r = -.07, p = .60); however, there was a moderate negative correlation in the intervention condition (r = -.31, p = .03). Although this differs to the results for Studies 1 and 2 where there were no significant relationships between the proportion of intervention exposure (i.e., ESM response rate) and reduced delay, the significant relationship identified specifically in the intervention condition in Study 3 adds weight to the conclusion that the lower rates of delay were due to the intervention prompts.

In addition, while there was a significant, albeit weak, negative correlation between conscientiousness and delay in Study 3 (r = -.21, p = .03), conscientiousness was not associated with differing levels of delay intercept (i.e., percentage of assignment completed 2 weeks prior to the due date) or either linear or quadratic change in delay over time (t_{01} = 1.47, p = .15; t_{01} = 1.10, p = .27; and t_{21} = -1.02, p = .31, respectively). This is in contrast to the significant quadratic relationship between conscientiousness and delay in Study 2, indicating those higher in conscientiousness may have procrastinated less while they knew they were participating in a study on procrastination. This provides further supporting evidence for the speculation that demand characteristics in Study 2 might have influenced the efficacy of the ESM procrastination intervention.

Chapter 4: Participant Experiences of ESM and the Intervention

4.1 Introduction

This chapter discusses emergent themes from eight ($N = 8$) semi-structured interviews conducted with participants of Studies 1 and 3. In contrast to the other empirical studies reported in this thesis, a qualitative approach was taken in this interview-based study. Central to such an approach are several defining characteristics: the collection of verbal, rather than numeric, data; a preference for fewer rather than more interviews, with each interview involving greater depth; the use of proportionately more open- than closed-ended questions; data collection that is flexible rather than entirely predetermined; data analysis that is at least partly inductive, rather than exclusively deductive. Critically, the approach identifies the researcher as a key instrument of data collection, and thus encourages *reflexivity*, that is, the process of the researcher acknowledging his/her (personal) reasons for, and biases in, carrying out the research, and reflecting upon his/her experience of the research (Creswell & Poth, 2016).

The intent of these interviews was to retrieve first-hand experiences from participants of the ESM phase of these studies, as well as elements specific to those in the intervention condition (i.e., those who received reflection prompts). Of interest were positive and negative participant experiences with the ESM study protocol, whether there was any evidence of the influence of an observer effect or demand characteristics of the experiment, perceived accuracy of regularly estimating assignment progress over the two weeks, and reported salience of the experimental reflection prompt questions seeking to target expectancy, value, delay sensitivity, or metacognition. Interview questions were also directed to gain a deeper understanding of the effect that the ESM survey (and related reflection prompt) timings and frequency had on the experience of motivation.

Just as there is potential for an observer effect during the ESM phase of all three studies, there is also potential for an observer effect in conducting interviews. In acknowledgement of that likelihood, I take a *reflexive* approach, and offer the following personal context to the reader so analyses can be interpreted in the context of my personal attributes which may have influenced interviews.

4.1.1 Reflexivity Statement

I largely consider myself a quantitative experimental researcher and empiricist. Though I have had some experience conducting qualitative analyses on pre-existing data-sets, the current interviews were my first as part of a specific qualitative or mixed-method research study. Nevertheless, at the time of conducting these interviews I had a significant number of years in retail (7 years), counselling (3 years), and career coaching (1 year). As such, I value the nuance of personal accounts, and have learned many times over that holding assumptions about the reasoning and experiences of others, even with supporting quantitative data, are seldom accurate. At the same time, I also believe individuals are not always reliable narrators of their own stories. This belief is largely influenced by decades of research on eye-witness testimony (e.g., Loftus & Zanni, 1975). The combination of my professional and educational experience has equipped me with skills, and left me with firm opinions, on how to build rapport and elicit truth in experiential accounts, the value in doing so while trying to minimise influence, and the importance of taking accounts on face value, but not as concrete fact. Broadly, my approach prioritises the importance of building an informal air and comfort; leading with broad open questions; and using active listening techniques to prompt elaboration, encourage interviewees to open up in a supportive non-judgemental environment, and project an air of curiosity and unconditional positive regard for the other person and the unfiltered truth.

Also central to my qualitative approach is a degree of *flexibility* in how interviews are conducted. That is, questions may be re-ordered and re-worded, level of language may be adjusted, and probes may be included or excluded. As Berg (2004, p. 81) states: in semi-structured interviews, "interviewers are allowed freedom to digress … [they] are permitted (in fact, expected) to probe far beyond the answers to their prepared standardized questions." Babbie (2007, p. 305) make a similar point, quoting Rubin and Rubin (1995): "Qualitative interviewing design is flexible, iterative, and continuous, rather than prepared in advance and locked in stone. …. The continuous nature of qualitative interviewing means that the questioning is redesigned throughout the project." My preference for this qualitative approach may jeopardise consistency. However, as my aim for these interviews was to explore and understand experiences that I had and had not considered or anticipated, I feel flexibility to organic minimally-prompted conversation was suitable.

4.1.2 Review of Past Research

To my knowledge, no study of procrastination has used experience sampling as a medium for intentionally reducing procrastination, and, thus, there are no known qualitative experiential accounts of participation in any such study. Perhaps the closest to this is Rozental et al. (2015a) who sought feedback by distributing open-ended questions relating to participant experience following an internet-based cognitive behaviour therapy (ICBT) intervention to reduce procrastination. Questions included "How pleased are you with the pace of the treatment (the intensity and distribution of the modules in relation to the length of the treatment)?", "How valuable do you believe that this treatment has been for you?", and "Has the treatment helped you find a better way of managing your problems?”. Their treatment consisted of 10 modules over as many weeks. Modules on average contained 17 pages of text and graphics and three exercises for participants to complete throughout the week, with participants self-reporting spending an average of 2.52 hours on each module. Qualitative responses were thematically analysed, with parent themes of ‘positive aspects’, ‘negative aspects’, and ‘the treatment circumstances’, and child themes including ‘increased self-efficacy’, ‘burden’, and wish for ‘individual tailoring’, respectively.

Rozental et al. (2015a), and the studies conducted as part of the current research program, are similar in their internet-based virtual delivery and repeated nature, but are dissimilar in their volume of content, frequency, and specificity towards a shared goal, such as the completion of an assignment. Nevertheless, some differences are of note. For example, while some of Rozental et al.’s ICBT participants reported increased self-efficacy and momentum on day-to-day tasks, many reported finding the high volume of content, and the time commitment required to engage in it, as de-motivating. This led to delays in engaging with the treatment, which in some cases led to increased guilt and the perception that their procrastination could not be helped, creating a self-fulfilling prophesy, with one participant commenting “…a treatment for procrastination is bound to result in procrastination” (p.318). Thus, Rozental et al. (2015a) were able to obtain qualitative feedback that pinpointed some potential shortcomings of their intervention, with this feedback helping to inform the design of the intervention reported in this thesis.

In comparison to Rozental et al.’s study, in the current research, the frequency of ‘modules’, or surveys, was much higher, with 28 surveys over two weeks, compared to 10 modules over 10 weeks, and each survey took little time to complete.

In Study 3 presented in chapter 3, for example, the median ESM survey completion time was 38 seconds (Control = 28 seconds, Intervention = 50 seconds) – much shorter than the 2.52 hours reported by ICBT participants (Rozental et al., 2015b). In an intervention study designed to reduce procrastination, minimising the effort to participate is likely to be of particular importance. In addition to examining other factors relevant to the current novel study design, the interviews discussed in this chapter provide an insight into whether the current sample of ESM participants reported the same levels of demotivation and potential disengagement from the program as were reported by the ICBT participants in Rozental et al. (2015a).

4.1.3 The Current Study

One of the challenges of utilising progress reporting to measure behavioural delay is uncertainty whether procrastinators have a bias to over- or under-appreciating the size of the task ahead of them. Two notable studies have considered the presence of a planning fallacy (see Buehler et al., 1994) in procrastinators. Investigating student estimations of the time it would take to read three short paragraphs, McCown et al. (1987) found those highest in trait procrastination underestimated the time it would take them to read the text compared to those lowest in procrastination. However, in relation to a more complex study exercise arguably closer aligned to the study task discussed herein, that is, estimation of study plans for the eight days prior to two exams, Pychyl et al. (2000) found no evidence of a difference between these groups in the size of this bias. Both of these examples pertain to duration spent studying, which as discussed in the introductory chapter, is an imperfect proxy of task progress (e.g., Dewitte & Schouwenburg, 2002). Consequently, though individuals may vary in the accuracy of their estimates of percentage of task complete, there is no compelling evidence that biases in reporting, optimistic or pessimistic, differ based on trait levels of procrastination.

A thematic analysis approach was used to analyse the current interviews (Braun & Clarke, 2006). The intent was not to form new theories (e.g., through use of grounded theory), but to build an understanding of study participant experiences during the ESM phase of the study, with particular focus on elements researchers may be able to alter to improve the participant experience and ideally increase the efficacy of the intervention approach described in Chapters 1 and 3. Interview questions were open and broad, with interviewees able to speak to and explore their experiences at length and direct the interview to components of the study which most resonated with them. As the interviewer, I was focused particularly on not posing leading questions which could signal to the participant the answer I was looking for. Indeed, I was not looking for any particular answers, other than to understand how the experience of participating in the ESM phase was for them. An over-arching objective of these interviews was to explore whether the elements of the study designed to reduce procrastination were received and experienced in the ways anticipated in the design of the studies.

4.2 Method

The semi-structured interviews were conducted following participation in baseline surveys, 2-week intensive longitudinal observational ESM surveys, and submission of a target undergraduate psychology lab report worth 30% of students' grade. To recruit participants from Study 1, an additional question was included at the end of the baseline survey, inviting participants to record their email address if they were interested in participating in a follow-up study for additional course credit. To recruit for interviews following Study 3, an additional study participation opportunity for course credit was advertised on the university study participation portal for first-year psychology students. In both cases (Studies 1 and 3), ethical approval for interviews was obtained from the Griffith University Human Research Ethics Committee.

Interviews were conducted between 10 and 21 days following assignment submission. They were conducted both face-to-face or over the phone with participants from each of the control and intervention conditions. Interviews were scheduled for half an hour but allowed to extend beyond that time as required. They ranged from 19:58 to 47:21 minutes, with an average duration of 32:33 minutes.

Interviews focused on (a) general positive and negative experiences of participating in the ESM phase of the study, (b) the possibility of an observer effect on motivation in the control condition, (c) the effect of the frequency of ESM surveys and duration of observational period, and (d) querying the motivational effect of various questions in the surveys, including specific intervention questions. The interview schedule included topics such as: general positive or negative experiences with completion of regular surveys, elements of the surveys that influenced behaviour or feelings of motivation towards completing the lab report, and suitability of the frequency of surveys. Interviews were conversational and non-linear. The below questions were used by the interviewer to facilitate discussion and were not posed verbatim in all interviews:

1) What did you think of the study?
2) How did you find completing the regular surveys? (if needed, prompt about how time-consuming they were, whether they found it bothersome, were unable to complete and the reasons, think more or less would be better, or thought it helpful with their study behaviour)

3) What did you learn about yourself and/or your work style while participating in the study?
4) What did you think of the open questions at the end of each survey?

4.2.1 Participants

All 24 participants who completed the ESM component of Study 1 volunteered to be invited to the interview component. Five scheduled an interview time, and all five were interviewed. Forty-nine participants from the ESM phase of Study 3 registered interest to participate in an interview. Of those, 13 scheduled a time; however, 8 were ineligible to participate as they had not completed greater than 70% of the ESM surveys. Interviews were conducted with the five remaining participants, but recordings from the first two interviews with Study 3 participants failed to save on the recording device. While all 10 interviews influenced the broad understanding of research themes, only the eight interviews with saved recordings were transcribed and formally analysed. As the aim behind conducting interviews was to better understand experiences of all participants, interviews were obtained from participants in both intervention (n = 4) and control conditions (n = 4).

All interviews were conducted in the final few weeks of trimester, close to the cut-off for student research participation where the majority of students had already completed required participation. Consequently, response rates for interview participation were low, with a majority of interviewees (62.5%), indicating they had already obtained their maximum amount of course credit, and resultantly having no extrinsic motivation for volunteering to participate in the interview.

Interviewees responded to an average of 93% (26/28) of ESM surveys. This was generally higher than other ESM participants (Study 1 M = 86%, Study 3 M =

81.1%). Summary interviewee demographics and details relevant to their procrastination and study behaviour are included in Table 4.1.

The interview sample was broadly representative of participants in the ESM phase of Studies 1 and 3. Interviewees were aged between 17.5 and 55.9 years at the time of interview. One quarter were male, which is generally representative of the gender balance across both studies (19% male). Half of the interviewees were enrolled in four courses, compared to 64% across both studies. Twenty-five percent of interviewees had caring responsibilities for a dependent, compared to 17% across both studies. GPA data were only available for interviewees in Study 3, who had an average GPA of 4.8, compared to an average of 5.2 for all participants in the ESM phase of Study 3.

To aid interpretation throughout, interviewee IDs are constructed with their number (e.g. ‘1’), study (i.e., ‘1’ for Study 1, or ‘3’ for Study 3), experimental condition (i.e., ‘I’ for intervention, or ‘C’ for control), gender (i.e., ‘F’ for female, and ‘M’ for male), and score on the Adult Inventory of Procrastination (McCown & Johnson, 1989; AIP; e.g., ‘39’), separated by decimals. To illustrate, interviewee ID 3.1.C.M.32 refers to interviewee number 3, who participated in Study 1, was in the Control condition, is male, and had an AIP score of 32.

Table 4.1

Interviewee Profile Summaries, Including ID, Age, Gender, Trait Procrastination Scores, Experimental Condition, and Course Credit Requirements

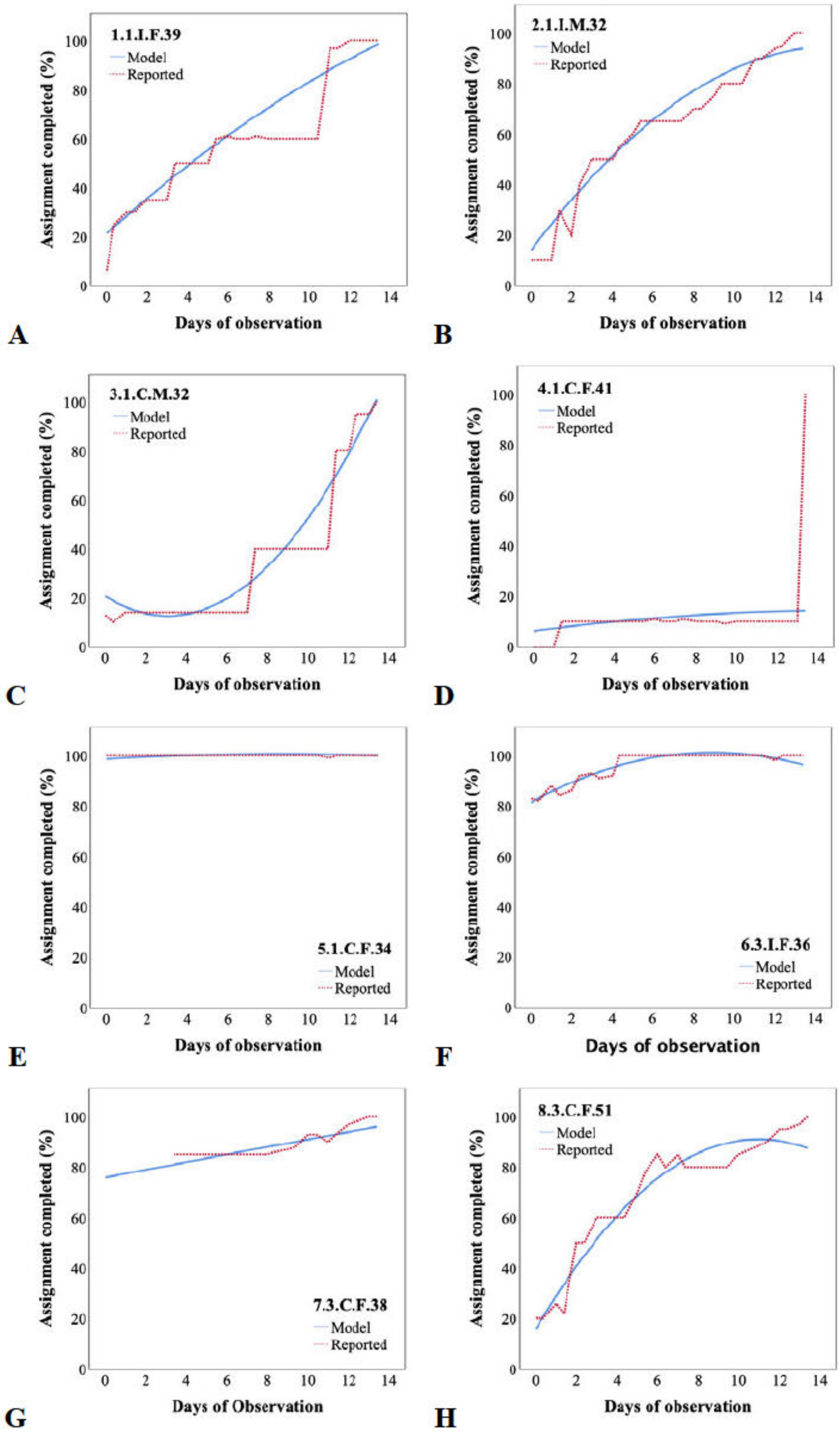
Interviewee	Study	Interviewee ID	Gender	Age	Trait procrastination	Experimental condition	Assignment Submission date	Assignment mark
1	1	1.1.I.F.39	F	39.9	39	Intervention	-0.82	87%
2	1	2.1.I.M.32	M	18.3	32	Intervention	-0.05	64%
3	1	3.1.C.M.32	M	18.7	32	Control	-0.08	49%
4	1	4.1.C.F.41	F	17.5	41	Control	-0.04	79%
5	1	5.1.C.F.34	F	-	34	Control	-0.20	85%
6	3	6.3.I.F.36	F	55.9	36 (11)	Intervention	-1.31	15%
7	3	7.3.C.F.38	F	28.4	38 (7)	Intervention	-0.80	80%
8	3	8.3.C.F.51	F	43.6	51 (30)	Control	0.10	57%

Note. Interviewee scores on the Adult Inventory of Procrastination (AIP) are reported as it is the only trait procrastination measured across studies 1 and 3. Passive Procrastination Scale (PPS) scores are provided in brackets where available. Submission date was coded with 0 as the due time, lower numbers indicated earlier submission time, with 1 equating to 1 day.

Trait procrastination scores among interviewees (M = 37.88, SD = 6.22) were generally representative of trait procrastination scores among all ESM participants (M = 37.25, SD = 7.26), and included examples of substantial delay in assignment progress until the submission date (Figure 4.1, panel D) and completion prior to *commencement* of the ESM study period (Figure 4.1, panel E). Trajectories represent a wide spectrum of reported assignment progress over the two-week period of observation, indicating that the sample included perspectives from those who postponed the majority of their assignment until the last day (4.1.C.F.41), those who completed two weeks earlier (5.1.C.F.34), and a range of experiences between.

Figure 4.1

Matrix of Graphs Displaying Quadratic Modelled Assignment Progress Trajectories (and Reported Responses) for the Eight Interviewees (Panels A-H)



4.2.2 Analysis

Interviews were digitally recorded, transcribed, and imported into NVivo 12 for organisation and coding. A combination of inductive and deductive thematic analysis was used to identify themes shared across the data. Initially, all interview transcripts were read and free- or open-coded. This first stage of free-coding involved chunking of interview data based into broad categories (examples include experience of intervention open-questions, effect of regular progress reporting, and frequency of ESM surveys). These concepts reflected key questions and themes underpinning the research. Data allocated to these categories were then divided into subcategories or dimensional properties of a particular concept (i.e., key concepts were then divided into sub-concepts), sometimes referred to as axial coding (Strauss & Corbin, 1990). Once concepts and sub-concepts were identified, all transcripts were re-read and additional coding was completed focusing on the identified concepts. For example, one key concept identified in the data was ‘Intervention prompt efficacy’, which was then divided into sub-concepts comprising ‘Expectancy’, and ‘Value’, and so on. The concepts and sub-concepts, hereafter referred to as Parent and Child themes, were then revised and refined by examining the coded extracts within each concept, and referring back to the interview transcripts as required. This follows recognised best practice in thematic analysis, as outlined by Braun and Clarke (2006).

All coding was completed by the PhD candidate and inter-coder reliability was not tested. This is a possible limitation of the analyses; however, only common recurrent themes are reported. For this analysis, the focus was on six main themes: ESM experience; Progress report accuracy; Intervention prompt efficacy; Other factors affecting assignment progress; ESM survey frequency and timing; and

Extraneous circumstances. A full summary of Parent and Child themes is presented in Table 4.2.

Table 4.2

Parent and Child Themes, Including the Number of Interviews Each Theme was Recorded in, and Total Frequency of Theme Occurrence

Parent theme ***Child theme***	**No. of Interviews**	**Total Frequency**
ESM experience	7	27
Course credit not needed	5	7
Progress report accuracy	3	4
Intervention prompt efficacy	8	30
Expectancy	4	8
Value	4	4
Delay sensitivity	5	6
Metacognition	2	2
Prompt variety	1	2
Delayed intervention effect	4	11
Resolve to overcome procrastination and change behaviour	4	14
Other factors affecting assignment progress	8	37
Control condition observer effect	7	18
Progress and planned progress reporting	5	11
Control condition influence from peers in intervention condition	1	2
ESM frequency and timing	8	22
Extraneous circumstances	2	6

4.3 Results

4.3.1 ESM Experience

The majority of interviewees had positive comments about the general ESM experience. For example: "I really liked them […] I found the survey questions pretty simple" (4.1.C.F.41) and "it was like convenient as well 'cos it took literally 30 seconds, and yeah, we did it, and it was on my phone, which I always have on me […] I thought it was really well done. So good job with that!" (5.1.C.F.34). Others specifically referred to study participation being helpful in completing the assignment (6 of 8 interviews): For example; "They (the surveys), uh, helped me organise myself a little bit better. You know, to see if I wasn't where I wanted to be, then I could catch up or something like that and plan my time better. So I thought they were actually pretty useful" (2.1.I.M.32) and "They actually probably helped me stay on time with actually doing the, uh, assessment. I found. I found that just having that daily and 12 hour reminder to just do that work every day it was a useful thing to have" (3.1.C.M.32).

The only clear contrast to the largely positive experiences reported were from a small number of participants who reported either boredom (2 comments) or annoyance with the high level of repetition (1 comment). In the case of annoyance, one interviewee described that the messaging nonetheless had positive attributes influencing motivation: "Sort of like annoying, but the annoyance that is like motivational sort of thing. Rather than just being annoying where it becomes a burden. Annoying to the point where 'OK, I'll just have to get this done really quickly'" (3.1.C.M.32). Taken together, these reports suggest most participants found participation in the study to be easy and helpful, albeit occasionally repetitive.

4.3.1.1 Course Credit Not Needed. Potentially indicative of positive affect towards study participation, five of the eight interviewees reported not needing the additional course credit offered for participation in the interview phase of the study. Most, but not all, elaborated on why they volunteered to participate in an interview without needing the course credit. Of those that did, explanations did not share much common ground.

Only one person specifically referred to their positive experience of the ESM study, and expressed they wanted to use the interview as an opportunity to provide that feedback: "I really did enjoy it. You know, one of the things is why I wanted to follow up with it is that I did… I did find it useful. And I have taken things away from it, so I guess that's what I wanted to sort of let you know." (1.1.I.F.39). Another interviewee's reasoning related to not wanting to let the researcher down: "I know it's your research, so I wasn't going to let you down!" (5.1.C.F.34). Another suggested she wanted to be helpful, and light-heartedly commented about using the interview as a form of procrastination: "[…] 'cause I thought I was being helpful […] I got the email, and I'm like, 'Oh, do I really want to spend half an hour', and I was like, 'you know what, I don't want to study. I'll procrastinate and I'll do that instead' *laughs*." (7.3.C.F.38)

4.3.2 Progress Report Accuracy

Another concern about the research design was the subjective and somewhat speculative nature of progress reporting. That is, the nature of the assignment relating to the study, a psychology lab report, is relatively large and complex, and I expected this would be the first time completing one for many students. Consequently, I did not expect the self-reporting assignment progress to be particularly accurate, but at the same time, I did not have any evidence to suspect pervasive optimistic or pessimistic biases. Progress reporting accuracy was discussed in three interviews. While one interviewee felt they were "pretty accurate", using the example of reporting being 99% complete when they were working on the report's references section (6.3.I.F.36), another reported learning through the process of regular progress reporting that they tended to under-estimate how much they had completed:

> "… I tend to under, um, when I said I was 40% complete, I was probably 60% completed. I tend to under- can't think of what the word is, but not, not over-estimate, I under-estimated how much I had completed." (1.1.I.F.39).

The third interviewee describing reporting accuracy stated she found the frequent surveys could become boring, but after being asked whether the tedium of reporting might have affected the quality of her responses, she responded that "I still thought about it. I still answered it honestly" (4.1.C.F.41).

4.3.3 Intervention Prompt Efficacy

Another major objective of these interviews was to explore participant experiences of the individual reflection prompts presented as part of the intervention (i.e., those targeting expectance, value, delay sensitivity, and metacognition). The focus for these questions was on the intervention participants who were not reminded of the specific prompts in a structured order, however, where possible, the intervention condition was described to control participants, who were then asked their thoughts on the intervention questions, and what they thought might have been different if they had received them. Interviewees who were in the control condition were only told about the intervention condition and read the prompts after all other questions had been covered (e.g., general experiences with the ESM phase, effect on their motivation, survey frequency).

4.3.3.1 Expectancy. The reflection prompt relating to expectancy was: "*Our analyses suggest that students who do best in this course start early and submit their Lab Report the day before it's due. To demonstrate you have read the above statement, in the following box please repeat what students who perform the best do:*"

Only one of the intervention condition participants described, in detail, her experience of the expectancy prompt. This was the same interviewee who reported that, instead of for course credit, participating in the interview was a way to provide feedback on how helpful she found the study. From the conversation, it was evident that this prompt was particularly influential in her positive experience of the study. Indeed, she reported, finishing and submitting her assignment a day early is new standard she has adopted for herself:

> "I kind of have, you know, got it stuck into my head to get my assessment in a day before […] and I felt that that has now, in subsequent assessment pieces that I've handed in now has been to make sure that I get it in the day before. So, I mean, obviously the flexibility is there, you know, if I need to re-visit it, you know before the dead.. that.. kind of benchmark that sort of has made it… […] that did resonate" (1.1.I.F.39)

Two participants in the control condition gave their impressions of how they might have responded if they had been allocated to the intervention condition. One control participant thought that the prompt might have adversely reduced his stress, which otherwise would have motivated them:

> "[I] think having that sort of like, extra confidence that like 'oh, you've finished it early, don't worry, you'll do better because you've handed it in early', I think that would have been ah, a negative thing. Because I would

> have taken the, ah, taken any of the stress that you would have had away and been like ‘ah, nah, it’s fine. It’s fine. I’ll get it done’.” (3.1.C.M.32)

The other control participant described a response to the expectancy prompt more in line with what I imagined might occur when designing it. Namely, that they would internalise it as social proof that something relatively achievable has a track-record of success in people like them:

> “If you’d asked me what do students do in general to do better, I probably would have thought about it and then feel like I think that’s what students do, and then in the back of my mind be like maybe you could do that as well.” (4.1.C.F.41)

4.3.3.2 Value. The reflection prompt relating to value was: “I want you to imagine yourself the day before this assignment is due, and you haven’t started working on it. How do you feel?”

Two participants in the intervention condition described their experiences with the value prompt, with only one of the two describing the prompt as helpful:

> “That one resonated as well, because obviously… and just the way it was phrased, uh, that, because obviously you didn’t want to feel that sort of stress. I think that tied in well with, you know the assessment the day before as well um, that, that, kind of, you know, messaging. It did kind of keep you motivated to get your assessment done earlier.” (1.1.I.F.39)

The other participant reported that the value prompt was not particularly helpful. This participant thought that it might have been more effective for somebody that had not completed as much of the assignment as them, and suggested reversing the wording to a more positive frame may have been more efficacious for her.

> "Could it actually be framed in a more, like, positive side? Like, 'Imagine it's the day before your assessment and you've finished. How do you feel?' […] I guess that would have made me think about how relieved I would have been, as opposed to 'oh fuck, I've not done anything'." (7.3.C.F.38)

Regarding the negative wording of the value prompt, one participant from the control condition when asked to imagine being asked the question as part of the ESM surveys suggested he would find it "very, very stressful. Like just thinking about […] not having enough time to finish, immediately with a complicated paper, would just be yeah, no, no that would be stressful." (3.1.C.M.32). Another suggested she would "feel motivated but stressed" (4.1.C.F.41). A third participant from the control condition described how her feelings towards the question might change over the two weeks of the ESM study:

> "If it was 2 weeks before, it probably wouldn't have bothered me so much […] because hopefully I would have allowed some time to get it done, but, the night before, although I still would have felt physically sick, I think. I don't like having that much to do, and I seem to leave myself with work like that." (8.3.C.F.51)

In all, this prompt seems to have the potential to yield strong emotional reactions from visualisation of delay.

4.3.3.3 Delay Sensitivity. The reflection prompt relating to delay sensitivity was: "*Research has found breaking larger tasks (like completing an assignment) into smaller tasks (like brainstorming 3 dot-points) can help with motivation. What is your next small step?*"

One participant in the intervention condition reflected on how the delay sensitivity prompt helped to reduce her anxiety around participating in the study, particularly as the focus was laid on the next small step, and not the big picture.

> "At first I thought, oh, this is going to cause me um, you know, to be anxious over oh, I haven't done this. You know, this kind of reminder that you know where you are up to it. Um, but, then[…] because you kind of had that goal thing around […] just doing it block by block, I felt that you know, I wasn't worried about it like that because I was just looking at it as small steps to actually finishing it, not a reminder or 'look, you haven't done it', you know. Or you haven't met that goal, on the day that you said you were going to meet it […] I just knew, ok, that's the next one I'm going to, I'm going to work towards." (1.1.I.F.39)

After the delay sensitivity prompt was described to them, all interviewees from the control group described how this prompt would likely lead to greater productivity. One interviewee described the internal process they would likely go through if she had been in the intervention condition and received this prompt:

> "I probably would have actually stopped and thought about my assignment, and looked at the question and think, like 'OK', think it seriously, like what are you going to do, and then like once I've written that down, it would sort of be in the back of my mind because I took that time to think about it. So that when I'd go home and work on the assignment, that would be at the back of my mind. Where it would be 'OK, you said this, so maybe you could actually attempt to do that'." (4.1.C.F.41)

The above is closely aligned to the general reflective process participants were expected to go through, with repetition over time expected to increase the probability of the reflection leading to action. This sentiment is echoed by 3.1.C.M.32, who referred to this prompt as "… a good way to start thinking about the assignment", and 8.3.C.F.51, who said she likes that it "sparks people thinking as well, not just remembering that the assignment's coming, but thinking about, you know, what they have to do next. You know, that sort of puts it in their memory more. Cements it a little bit when they actually have to think of an answer".

However, the intent behind the delay sensitivity reflection prompt was specifically to reduce the impact of individual differences in delay sensitivity by compelling recipients to set smaller and more achievable mile-stones. A more specific insight into whether this prompt would be effective in addressing delay sensitivity was suggested by the consideration of another control participant. This interviewee explained the question may prompt her to earlier action than if she was not thinking about either the task as a whole, or overly focused on the due date as a motivating critical event.

> "It's gonna be hard, but you've just got to do it. And if like you break it down, it will be fine. Like do a little bit at a time, or something like that. It's just like, I don't know, when it's hard, I'm like 'oh, like I really couldn't be bothered to do that right now', so you know I guess it feels like break it down, or like break it down for myself, and like actually like do it. Like at the start, or try and set little goals to do each time then I guess it would be better than like leaving the whole thing. Or like doing the parts that I can do, instead of like leaving everything." (5.1.C.F.34)

Though limited insight was obtained from those who were in the intervention condition and received these reflection prompts in vivo, feedback from the five interviewees who commented on the efficacy of this prompt suggests it may have been particularly useful in clarifying achievable steps and converting them into action.

4.3.3.4 Metacognition. The reflection prompt relating to metacognition was: "*If you could do one thing to ensure you finish the Lab Report on time, what would it be?*"

Two interviewees in the intervention condition commented on the metacognition reflection prompt, neither of which particularly resonated with the question. One interviewee described generally not connecting with the question in a meaningful way: "I didn't really identify with that, I mean it was, yeah..." (1.1.I.F.39). The other interviewee suggested that the question may not have been useful to them as they had mostly completed the assignment earlier: "I didn't really know how to answer that because I only had one portion of my thing to go" (7.3.C.F.38). No interviewees from the control condition commented on the metacognition reflection prompt.

4.3.3.5 Prompt variety. An intervention delivering all four prompts at random removes the ability to analyse, quantitatively, the efficacy of each prompt individually. However, as was described in chapters 1 and 3, the aim was to first test for a successful intervention, before later studies could seek to assess the unique contribution of each of expectancy, value, delay sensitivity, and metacognition. Moreover, an intervention study with only one reflection prompt question would lack variety, may result in reduced participant attention over time, and consequently demonstrate reduced efficacy unrelated to the relevance of the prompt construct (e.g., expectancy) being tested.

On this, one participant commented on the variety of the four prompt types, suggesting that the changing prompts kept the experience fresh, while also ensuring if one prompt-type did not particularly resonate, it would soon be replaced by one that did: “it kind of did help that is changes up, […] when the one that came up that I did identify with; “students who do it the day before…”, kind of go ‘alright, how many days out are we? Where am I up to?’ […] it helped with that process to sort of make it fresh each time when that came up” (1.1.I.F.39).

Another participant suggested that even four prompts, with each delivered seven times, may have been too repetitive, and more prompt variations may have helped reduce boredom:

> “It would have been good to have, like, probably at least 5 different questions. Because they did cycle through pretty quickly and I got pretty, like, over writing the same thing for that last one” (7.3.C.F.38)

This recommendation of at least five different prompts suggests that the use of four prompts may have been close to the minimum number necessary to reduce tedium in an unknown number of participants.

4.3.3.6 Delayed Intervention Effect. Two of the four interviewees in the intervention condition described an increase in salience of the reflection prompt questions as the ESM period progressed. In both cases, interviewees described an initial complacency towards the prompts (e.g., “To start with, I got really lazy” – 1.1.I.F.39). Instead of being an artefact of distance to the deadline (i.e., perhaps prompts were most salient when the deadline was near), one interviewee clarified: “the first week [I] might not have paid attention as much, and the second week I started to, uh, if I only got one week (only prompts in the second week) I would have probably just done the same as I did in the first week” (2.1.I.M.32)

In an interview with a participant who was in the control condition (8.3.C.F.51), I asked how she might feel completing the reflection prompts over the two weeks. This participant used the Value question in her response, stating she would have found it more salient in the second week (closer to the due date), as in the first week, she would have likely still been expecting to complete the assignment on time.

4.3.3.7 Resolve to Overcome Procrastination and Change Behaviour. Initially, it was unknown whether a relatively short-term, naturalistic task intervention could have effects on participants' propensity to procrastinate that would endure beyond the duration of the intervention. However, four of the eight interviewees (2 intervention, 2 control) mentioned either learning something about themselves they did not previously know, or feeling as though they would procrastinate less in the future following participating in the study. Participants credited different elements of the study for influencing their likelihood of reduced procrastination in the future.

Two participants in the intervention condition reported reaching a new found realisation, or adopting new behaviours, due to participation in the ESM phase. One interviewee specifically noted how regularly reporting the percentage of their assignment they had completed was influential in their realisation that they could have started planning further in advance (2.1.I.M.32). The second participant directly credited the intervention reflection prompt designed to address expectancy for changing the way she would set goals to complete assignments in the future:

> "in subsequent assessment pieces that I've handed in now has been to make sure that I get it in the day before. So, I mean, obviously the flexibility is there, you know, if I need to revisit it…" (1.1.I.F.39).

Two participants in the control condition described coming to realisations about their own procrastination behaviour during the study. One of these indicated that participating in the study acted as a reminder that he needs to prioritise addressing his chronic procrastination, and spoke of his expectation that continued procrastination will hold him back in future:

> "Eventually it will just become a burden on myself if I keep pushing things back, and eventually I'll just have something that's very large and I'll misinterpret how big the final result is meant to be and I'll have to rush it all in a very small amount of time, so figuring out how to stop procrastinating is one of the main things that I have to work on […] definitely been something that I've been thinking about for a while" (3.1.C.M.32).

Taking this kind of realisation a step further, another interviewee who was in the control condition, described that she felt she had learned to manage her time better during the study. She described realising she would like to put more effort into her university work:

> "I sort of think it taught me to… like I want to put more effort into my uni studies and try and get more done earlier so at the end I wasn't sort of leaving it to the last minute and rushing around getting the last of it done" (8.3.C.F.51).

When prompted about whether she thought her habits would be different the following year, she responded with "definitely", and that she was "starting to put things into place now so that I can, you know, organise my time a bit better […] and get it in well before the due date, even. Just give myself that time" (8.3.C.F.51).

4.3.4 Other Factors Affecting Assignment Progress

4.3.4.1 Control Condition Observer Effect. In the early stages of research design, my supervisors and I anticipated sending 2 SMSs per day could itself influence study behaviour. One of the primary reasons for conducting follow-up interviews was to gain first-hand participant perspectives on how receiving regular

SMSs and associated questions may have affected motivation to study. The difference between receiving reminders via SMS and the need for participants to open the message, and answer a small number of questions about their study behaviour was explored in one interview, with the interviewee reporting:

> "I think there is definitely a difference, because with a text message, I'd read it and just be like 'OK', and just forget about it like 30 seconds later. Whereas with a survey, I actually have to go in to the text message, open the link up, do the survey, read the questions, think about the answers, and close the phone. And by the time I've like turned my phone off, it's in my mind. Like I'd remembered it. So I feel like it has more of an impact to actually be interactive with the text message." (4.1.C.F.41)

All interviewees in the control condition reported that their participation in the study motivated them to complete the assignment earlier. One interviewee high in trait procrastination who completed the assignment early stated that without the regular surveys, she "… probably would have left it 'til the night before" (8.3.C.F.51). All other interviewees, not just those in the control condition (n = 7), provided more specific feedback on the effect of progress reporting, and the effect of having to state how much they planned to have completed by the same time the following day, had on their motivation.

4.3.4.2 Progress and Planned Progress Reporting. When talking about the effect progress reporting had on productivity, all but one interviewee (87.5%) also described how expressing intent to complete a certain amount of their assignment by the following day related to their productivity. In all cases, progress reporting and expression of intent were seen as positively motivating. Expression of intent here relates to participants indicating the percentage of their assignment they planned to have completed by the same time the following day. This expression of intent may be related to the commitment and consistency effects described by Cialdini (1993), where a stated intent to perform an action increases an internal pressure to be consistent with that statement, and consequently the likelihood of follow-through.

Participants allocated into both intervention or control groups described motivating effects of answering questions on progress and intent. Consequently, responses from participants from both conditions are included here, with their condition provided to aid interpretation. One interviewee summed up the general sentiment reported by all interviewees:

> "I think it was all pretty useful just in general having that reminder like just being like this is what you need to do today. How much do you want to do today? How much do you think you'll complete today, just all of that was really quite useful" (3.1.C.M.32).

Another participant suggested there might be an intraday effect of asking people to report how much they intend to complete, where expressing intention in the morning survey may have influenced motivation to report progress to the intended percentage complete by the evening survey;

> "[Interviewer: So are you saying that when you are completing in the afternoon, you're thinking about what you answered in the morning. But when you answered it the day after, you weren't necessarily thinking about how you answered it the day before?] The day before. Exactly right." (1.1.I.F.39)

This effect of expressing intent for the day, and reflecting on it at the end of the day was echoed by another interviewee, who further explained that, although she had considered setting daily goals before, the experience of setting goals within the ESM study was effective at holding her to account:

> "I have thought about it before, but usually it's just kind of, I set kind of targets of things that I need to do that day, and usually if I don't do it, I'm just like 'no, it's fine, it doesn't matter'. Whereas this made me more aware of it, so it's like, you know, I should do this. So I have thought about it before, but, this made me think about it a lot more, and held me more accountable to it I guess […] Doing it made me think about 'oh, I said I was going to do, like, this much of it today', […] but I didn't really get around to it as much, so that in itself was a reminder". (5.1.C.F.34)

At no point during the study were participants reminded of what they had previously stated they intended to do, and no part of the control condition was engineered to create a feeling of accountability beyond merely asking participants to record their intentions. Participants may or may not have assumed those intentions might later be read by the researcher. One participant spoke of the effect this had on motivation despite not being externally held to account:

> "If I say I'm going to do something, I have to do it. So, if I put in there that on the date, I'm going to have this done, I, one for my own instinct, didn't want to lie to myself, and also knowing that some other instructor person, i.e., you, is going to look at my results and go 'hah, they lied', then I feel obligated to put more effort into it." (7.3.C.F.38)

I followed up on this directly by asking whether, if the question on intended percentage completed by the same time tomorrow was not included, it would that have changed anything. The interviewee responded that to her mind, it likely would have:

> "Um, probably, because I wouldn't have been accountable on a daily basis. So, yeah, I think it probably would have […] I feel like if you remove the

> accountability thing it makes people more likely to do less work, because they're not, yeah, held accountable. [Interviewer: Even though I don't hold you accountable?] Yeah, I know, but they've got their own conscience to deal with, so, I don't know" (7.3.C.F.38)

This particular interviewee was in the intervention condition. On being asked if she felt if she was sent only the reflection prompts (i.e., in the control condition), would she have completed the assignment at a different rate to what she did. Her response was that she thought not: "I believe it would have been the same rate. 'Cause, yeah, I feel like I most benefit holding myself accountable." (7.3.C.F.38)

The one interviewee who reflected on progress reporting without also describing the effect of the intent question was in the intervention condition. This interviewee stated she most looked forward to answering the question about how much of her assignment she had completed:

> "I think when I actually did the assignment, or I was actually getting close to completing the assignment and I could just push that little button along to 100%, or near 100%, it was really good. I felt really good about myself that I had done that much." (6.3.I.F.36)

4.3.4.3 Control Condition Influence from Peers in Intervention Condition. During one interview with a participant in the control condition, it occurred to me that if participants studying together had spoken about their participation during the ESM phase, and learned that the SMS surveys were slightly different (i.e., there were intervention and control conditions), then that may have highlighted the intention of the study and promoted a demand or Hawthorne effect, where participants in the intervention condition could deduce what the study was aiming to achieve. Towards the end of this one interview, I disclosed the details of the intervention condition and brought up the above possibility. The interviewee responded that "we didn't even realise that other people had different ones. We just were like 'oh, you're doing that one', they were like 'yeah, I get the messages', and then we were like 'so quick, because it's over in like 30 seconds' " (5.1.C.F.34).

4.3.5 ESM Survey Frequency and Timing

The ESM surveys and reflection prompts scheduled at 10 am and 7 pm were selected with the intention of covering both morningness and eveningness preferences described by Ferrari et al. (1997) and Hess et al. (2000), as well as to cover a variety of study and work schedule commitments I suspected students would likely be juggling. Otherwise, the decision for two surveys per day and their scheduled times, or even that times would be scheduled and not random as is not uncommon in ESM studies (e.g., Pychyl et al., 2000a), was largely speculative with little empirical justification. Moreover, the decision to observe study behaviour over two weeks prior to the due date was largely pragmatic, with no known theoretical frameworks to inform ideal observation periods. The aim of discussing survey timing and frequency with participants was to explore whether the frequency and timing should be adjusted to better suit participant needs, or maximise the effect of the intervention.

All participants were asked about the frequency of prompts, and their experiences responding to two surveys per day, over the course of two weeks. Interviewees were generally in favour of twice daily surveys for the duration of the study. Participants did not describe a preference for morning or evening assignment writing, however, one participant described the (unforeseen on our part) benefit of bracketing their day with surveys. Specifically, the expressing of an intention in the morning equated to them setting a goal for the day which they could reflect on in the evening survey.

> “(twice) I think was good because it made you think about what you had done that day and whether or not you had done everything you said you were going to do, or that you didn’t do it” (5.1.C.F.34)

Two participants suggested that as few as one survey every two days may have sufficed for them.

Only one of the eight interviewees suggested more frequent surveys would have helped her start earlier:

> “for me personally if there were reminders like 3 or 4 times a day every day for like a month, maybe I probably would have started it a month earlier” (4.1.C.F.41).

When asked to elaborate on the ideal starting point of the ESM observational period, 4.1.C.F.41 suggested commencement as soon as the assignment details were made available may have been more effective at reducing delay.

> “I think if it came out like the day that the lab report also came out, with like the criteria sheet and everything, it would be the constant reminder of ‘hey, do this assignment now’. And for someone like me, who leaves everything to the last minute, it probably would have been better to have come out at the start, ‘cos then it would have reminded me like ‘hey, do the assignment now rather than later’.” (4.1.C.F.41)

When asked about whether the study protocol would be improved by sending an SMS at random times, one participant responded that random timing would not be effective for her, and she would be more likely to have forgotten about the survey if it was not convenient for her to take at the time.

> “I don’t know that would have been as effective for me. Cause if it had come, you know, while I was at work or something like that, I would have probably

> just brushed it off and not thought about it […] having one in the morning and one at night time was good for me" (8.3.C.F.51).

4.3.6 Extraneous Circumstances

Procrastination is invariably complicated. Associating delay with procrastination on a single task is likely to be nearly impossible, particularly in the context of competing obligations and priorities. Two interviewees recounted very different contextual circumstances that had the potential to affect their participation in the study and related assignment progress. In the first case, an interviewee (4.1.C.F.41) described prioritising a law report due on the same day as the assignment (a psychology lab report) on which this study was focused.

> "I think it's because when I first got the assignment, it's a lab report, and I've done so many lab reports in high school, that I kind of thought 'yeah, it'll be a piece of cake'. It'll be like a quick couple of hours one day and I'll be done. I think what I didn't realise was it was also due at the same work as my Interpersonal Skills assignment and my Law assignment. Which probably had more work than the other two psych assignments. So, I think at the beginning I was like, 'yeah I'll get it done easy.' And then, the closer it got to dates, the more, I think because I had done a lab report before I sort of put it to the side and I was like OK I've done that before I don't need to stress about it. I haven't done this law assignment before. I should probably focus more on that. Which is what I did. So I got that done, with like a week before the due date. But then the lab report was such a last minute, so yep."

Her rationale is somewhat counterintuitive to expectancy and the thesis of Temporal Motivation Theory (TMT; Steel & König, 2006). That is, with a clear expectation of the ease with which she could complete the lab report, TMT would predict reduced delay on the lab report. However, despite a relatively high level of trait procrastination, 4.1.C.F.41 appears to have taken an adaptive approach, where she prioritised the concurrent task in which she had low expectancy (the law report), and consequently delayed completing the task she had high expectancy in.

In a very different example, one participant (6.3.I.F.36), reported experiencing domestic and family violence during the ESM study period, and needing to immediately prioritise filing legal papers against her spouse. 6.3.I.F.36, however, continued to regularly complete the surveys (100% response rate), and stated that she found participating easy and that she really enjoyed it. 6.3.I.F.36 reported a particularly high progress trajectory and submitted 1.3 days early. However, she was awarded a mark of only 4.5 out of 30, or 15%, a non-passing grade.

In any case, these two examples demonstrate the extent to which individual levels of delay, be they related to procrastination or not, are likely to vary between individuals based on unobserved variables.

4.4 Discussion

This chapter provides an exploration of experiences completing an intensive longitudinal intervention aimed at reducing procrastination across both control (progress reporting only), and intervention (progress reporting, plus reflection prompts) conditions. The purpose of the current chapter was to examine the degree to which participation in the ESM phase was a positive or negative experience, the likelihood of an observer effect resulting from frequent surveying of task progress, the efficacy of intervention prompts in promoting earlier action, and general dynamic variables of the study design, such as survey frequency and timing. Analysis of interview data suggests that the low-intensity, high-frequency surveys relating to study behaviour can be a positive experience for students, by both increasing awareness of delay and encouraging the adoption of strategies to mitigate future delay. Interviewees identified three aspects of the study as being influential in their resolve to reduce procrastination: general study participation, progress reporting, and two (of the four) specific reflection prompts from the intervention condition.

4.4.1 Summary of Themes

ESM Experience and Course Credit Not Needed. The majority of interviewees reported positive experiences with the ESM phase of the study, with comments referring to the simplicity of the surveys, how quickly and easily they could be completed, and how the surveys helped interviewees stay on track with their assignment. The only negative comments pertained to boredom and slight annoyance through high frequency survey repetition. However, the interviewee who described finding the frequent surveys annoying also described these surveys as useful, and the annoyance as a motivating factor to complete their assignment earlier. Moreover, 62.5% of interviewees reported not needing the course credit offered for volunteering to interview, with one of these explaining that she wanted to use the interview to express thanks for how useful she found the ESM phase of the study. The overall positive comments suggest that low-intensity surveys (sub 60 seconds to complete) sent at a relatively high-frequency to student mobile phones are not necessarily perceived as a burden on student time, and in addition to reducing delayed task progress, may also increase student engagement.

Progress Report Accuracy. One interviewee described her progress reporting as fairly accurate in retrospect, with another stating that the tedium of regular reporting did not translate to her being any less careful or honest with her reporting accuracy. Only one interviewee suggested she was likely to have under-estimated how much of her assignment had been completed during reporting. This particular interviewee was marginally higher than average on trait procrastination (Study 1 cohort *z* score = 0.50). Though there is limited research on perception of task size and complexity (e.g., planning fallacy) in trait procrastinators, an under-estimation of percentage complete is contrary to what previous research on the planning fallacy among procrastinators might suggest (Pychyl et al., 2000b). These three accounts cannot be considered a comprehensive assessment of reporting accuracy, but at the least, give nothing to suggest that subjective progress reporting invalidates the interpretation of results.

Intervention Prompt Efficacy. Both intervention and control participants were asked about their thoughts on the efficacy of the reflection prompt questions used in the intervention condition. Comments were mixed. Expectancy and delay sensitivity prompts received generally favourable comments, the value prompt received both favourable and unfavourable comments, and no strong opinions were expressed regarding the metacognition prompt. In an effort to minimise the conscious post-hoc appraisal of prompts, interviewees from the intervention condition were first asked to reflect on the open questions they received in general terms, without the interviewer reading back the questions or referring to them as explicitly designed to increase motivation. Nevertheless, it is unclear whether these post hoc conscious appraisals, elicited as they were via interviewer questioning, can be interpreted as evidence as to the true efficacy of the prompts.

The expectancy prompt appeared to strongly resonate with one interviewee, who reported that as a result of that question, her goal for all assessment pieces is to complete the assignment a day early. The potential strength of this effect, even if only felt by a minority of participants, indicates that this component of the intervention should be retained in future multi-pronged programs. However, as strong positive sentiments were not reported by a majority of interviewees, a social proof approach to increasing expectancy should not be used as the solitary, or even major, aspect of a more narrowly defined program. Interviewees in the control condition hypothetically posited that students who perform best start the task sooner and submit a day early could either make higher achieving more attainable by role modelling, or reduce concern for quality by shifting priority to early completion. This latter potentiality should be considered in future research, but with no accounts of such an interpretation from those who received the prompt, may indicate a difference between post hoc and *in vivo* appraisal.

The value prompt appeared to succeed in rousing a visceral connection to reducing delay on the assignment. However, interviewee reports were mixed as to whether the negative framing of the prompt was helpful or not. To imagine not having started the day before the assignment was due might have inadvertently increased stress and an avoidant response which may have been circumvented by prompting recipients to imagine their feelings if it were the day before the assignment was due, and they had completed it in full. At the very least, a future ESM intervention with reflection prompts may retain the negatively framed question, while also adding a positively framed visualisation prompt. The contrasting visualisations of both positive and negative future states may add further dimensionality to mental contrasting targeted by the value prompt (Kappes et al., 2012; Steel & Klingsieck, 2016), as well as further variety to the limited range of prompts used in these studies.

Interviewees gave highly favourable comments regarding the delay sensitivity reflection prompt. In contrast to the value prompt, one interviewee described how asking them to describe their next small step helped to reduce anxiety and increase instrumentality. This sentiment was generally echoed by interviewees who were in the control condition after having the prompt described to them. Goal setting is one of the most effective strategies to reduce procrastination (Abbasi & Alghamdi, 2015). The positive impressions of this prompt indicate that goal setting is likely to have been effectively and pragmatically operationalised here by the delay sensitivity prompt, and should be retained in future interventions with minimal adjustment.

The metacognition reflection prompt did not receive strong responses, and may have been ineffectual in triggering broader reflection of personal procrastination patterns or triggers. Five possible explanations for this are: (1), metacognition is not an efficacious practice in reducing procrastination in the short-term, (2) the wording of the prompt failed to trigger adequate metacognitive reflection, (3) ESM is an ineffective medium for prompting this type of reflection, (4) the prompt did have some effect, but not among those interviewed, and (5) participants were not cognisant of the true effectiveness of the prompt through post hoc appraisal. To examine which of these explanations carry most weight, future research could trial variations of the metacognition prompt, with additional follow-up interviews addressing the efficacy of various metacognition prompts, as well as the merits of metacognition more generally as a suitable approach to reducing procrastination *in vivo*. Future research could also compare the efficacy of two interventions, one with, and one without, this prompt.

Prompt Variety. No part of the study attempted to measure individual differences in task expectancy, value, delay sensitivity, or metacognition. Even if these constructs could be perfectly measured, it can be reasonably expected individuals would score on a spectrum of each element. Furthermore, tailoring exposure to each reflection prompt relative to individual 'need' would likely increase the logistical load of delivering the intervention, diminishing the value proposition of a largely scalable intervention. Thus, cycling through prompts at random for all participants was intended as a pragmatic approach. A possible secondary benefit of cycling through all reflection prompts was that it helped retain prompt variety in what might otherwise be a highly repetitive series of surveys. The benefits of prompt variety were commented on by two interviewees. One participant stated that receiving a prompt which did not resonate with them kept the prompt that did resonate feeling fresh. This suggests cycling through prompts with the potential to be both effectual and ineffectual to different participants may be more beneficial in reducing procrastination than the use of effectual prompts alone. Moreover, for participants looking forward to a particular prompt, the randomness in prompt presentation may result in an operant conditioning-like variable interval variable ratio schedule of reinforcement, increasing engagement (Miltenberger, 2001).

Delayed Intervention Effect. Three of the eight participants described experiences in line with a delay in the intervention effect. That is, these participants indicated greater engagement with the ESM surveys and reflection prompt in the later stages of the ESM period. While this may be related to increased task motivation as theorised by Steel and König (2006), it may also be an artefact of the repeated and persistent exposure to reflection prompts. Bornstein's (1989) meta-analysis of the Mere Exposure Effect indicates mere repeated exposure to reflection prompts is likely to increase cognitive processing speeds, aid in embedding prompt responses in long-term memory, and increase positive affect regarding ESM survey completion. The Mere Exposure Effect has been shown as both robust and reliable, with a mean effect size of .26 and a maximum effect occurring within 10-20 presentations (Bornstein, 1989). The maximum presentation effect of mere exposure theoretically supports a case for fewer unique prompts delivered repeatedly over time, and may explain why participation in the intervention condition was associated with reduced behavioural delay and participant reports of a lag in study engagement.

Resolve to Overcome Procrastination and Change Behaviour. Four of the eight interviewees mentioned either learning something about themselves they did not previously know, or feeling as though they would procrastinate less in the future following participating in the study. Participants credited frequent progress and intent reporting, reflection prompts, and greater general awareness of their study behaviour gained during participation for influencing their likelihood for reduced procrastination in the future. It is unclear whether these efficacious elements may be enhanced in future studies. Instead, given the possibility that these elements may have effects that endure beyond the ESM period, future researchers may seek to conduct further follow-up assessments to identify changes in trait level procrastination (e.g., 3, 6, or 12 months post ESM participation).

Other Factors Affecting Assignment Progress Trajectories. High-frequency surveys related to task progress were anticipated to promote student engagement with the task, resulting in an observer effect where students in receipt of the surveys perform differently than those who did not receive them. It was considered that an observer effect would likely promote earlier assignment progress, with the potential to also affect assignment submission times and grades. Although the aim of the intervention was to use reflection prompts to reduce behavioural delay associated with procrastination, the potential for an observer effect was of particular interest in the control condition. Ideally, true unobserved assignment progress trajectories could be measured to contrast with participants in the intervention condition. However, without objective unobtrusive measurement of assignment progress (e.g., lines of code in a computer programming assignment), regular self-reports of assignment progress are necessary.

The possibility of an observer effect, or rather, the effect of regular assignment progress reporting questions required to measure assignment progress trajectories, was discussed with all but one interviewee. All seven considered the regular progress reporting to positively influence their awareness of and motivation to complete the assignment. More specifically, these participants cited the combination of progress reporting and reporting of the percentage of their assignments they intended to have completed on the following day as increasing their sense of accountability, and at least in one case, this sense of accountability may have had more of an effect on earlier assignment progress than the reflection prompts of the intervention condition. In light of the findings reported in chapters 1 and 3, anecdotal evidence suggests that the high frequency of progress and intent reporting in the control condition decreased otherwise unobserved latent delay. This is likely to have reduced the relative effect size of the intervention. In order to understand the true effect of observation in the control condition, and the reflection prompts in the intervention condition, future researchers may seek to reduce the frequency of ESM surveys in the control condition, and thereby potentially measure a closer approximation of latent delay.

ESM Frequency and Timing. Interviewee comments suggested that the frequency and timing of surveys were likely appropriate for the context, even if a little tedious. The decision to use two measurements per day stemmed from evidence for morning and evening preferences in procrastinators (Ferrari et al., 1997; Hess et al., 2000), however, it may have had the unforeseen benefit of bracketing the day with progress reports, increasing the salience of the commitment/consistency effect (Cialdini, 1993). It may also be that starting the ESM phase of the study as soon as the assignment was set, instead of two weeks prior to the due date, could have made a larger difference to assignment progress trajectories. However, with a theoretically discounted value of the assignment longer than two weeks before the due date (Steel & König, 2006), it is unknown how much of a difference this might have made. Decisions around frequency and timing are likely to differ substantially based on the size and complexity of a goal, and the duration individuals have available to complete it. Interviews suggest the frequency and timing of ESM surveys deployed in this study are likely to have been as effective as could reasonably be expected for a task (i.e., assignment) of moderate size and complexity.

Extraneous Circumstances. Finally, two participants described extraneous circumstances that are likely to have affected their rate of assignment progress. One of these reported experiencing domestic violence during the study period but not feeling progress on her assignment was affected; while another described having high expectancy in her ability to complete the target assignment of this study, but prioritising an assignment in another course she was less certain of. The seemingly polar variety in these examples illustrates one of the many complexities of attempting to observe procrastination in the field. It is easy to imagine the inverse of these examples. For example, a participant experiencing domestic violence could be reasonably expected to delay an assignment, and request an extension if complete is at all, while another who does not face such challenges and has clear expectations on how to complete the assignment could be expected to complete it sooner, delaying the tasks they have less certainty about completing. In seeking to measure and predict procrastination, it seems inevitable there will be many unmeasured and unmeasurable pressures on one's time and priorities. If nothing else, these examples speak to the complexity of procrastination as a study area, and reinforce the need for interventions to be as low in intensity as possible, even if high-frequency.

4.4.1 Broader Implications

In retrospect, it is clear that conducting interviews following Study 2 would have greatly improved the interpretation of a non-significant intervention effect and improved understanding of participant experiences across all three studies. However, this oversight is only apparent in contrast to the great benefit of the interviews conducted following Studies 1 and 3. Interviewees did provide valuable insight on a range of elements relating to the ESM surveys and reflection prompts which otherwise would not have been possible to glean. For example, the possibility of a delay in reflection prompt efficacy was not considered prior to conducting interviews. These insights greatly enhance the interpretation of the intervention discussed particularly in the previous chapter.

Anecdotally, the use of brief but frequent ESM surveys for progress reporting and delivering a range of targeted reflection prompts is generally engaging, and effective at reducing procrastination. That said, there were mixed subjective experiences of the reflection prompts and whether they influenced reduction in behavioural delay. While assignment progress trajectories, as explored in chapter 3, indicate exposure to reflection prompts reduces delay, there are likely to be individual differences in how prompts are received. It is also possible that brief but repeated exposure to reflection prompts subtly shifts behaviour without participants directly attributing the shift to regular reflection.

4.4.2 Limitations

The primary limitation of the findings reported in this chapter is that they come from so few (eight) interviews. Interviews were initially intended to be supplementary to the main study design comprised of the baseline survey and ESM phases. However, after conducting extensive analyses of the ESM data, it became clearer that a deeper exploration and in-depth presentation of themes would be of value. Moreover, no interviews were held with Study 2 participants. Study 2 interviews would have been particularly valuable in light of the non-significant intervention effect and potential Hawthorne effect / demand characteristics. Unfortunately, as Study 2 was intended as a larger scale replication of Study 1, and the implications of what at the time were considered to be minor methodological differences were yet unknown, the need for follow-up interviews was not fully anticipated.

In retrospect, questions on reflection prompts could have been asked more consistently. All intervention participants equally discussing their thoughts on the efficacy and relevance of each reflection prompt would have added a valuable range of perspectives. While an exploratory approach led to themes being discussed which may not have otherwise been imagined, feedback on some of the general topics (e.g., what participants found to be most useful for increasing study motivation) could have been collected by follow-up surveys. This would have allowed more participants to respond, with more standardised response types for ease of both quantitative and qualitative analysis and reporting.

Moreover, interviews and analyses were conducted by a single interviewer, leaving potential for individual biases in qualitative data interpretation to skew conclusions. Interviews are generally vulnerable to socially desirable responding (Edwards, 1957), however, as the interviewer was also the chief investigator, participants may have been additionally inclined to answer in a socially desirable way during the interviews. That being said, participants appeared to speak freely about elements of the study they did not like, or did not find useful. On balance, it is unclear how much of an effect socially desirable responding had on interview content. Related to this, all interviewees reported largely positive views about the study. It is possible that there was a self-selection bias, as evidenced by numerous respondents not needing the course credit, and/or interviewees being biased to speak positively as the chief investigator was also the interviewer. The lack of participant anonymity was also a potential biasing factor. Efforts were made early in each interview to mitigate this possibility through building rapport, and appealing for critical feedback to the study design.

4.4.4 Conclusion

There are a many complex mechanisms seemingly at play in the ESM component of the studies described in this thesis. Interviewee feedback suggests that the use of expectancy, value, delay sensitivity, and metacognition reflection prompts differ in utility. Differences are likely to relate to individuals' receptivity to each prompt, as well as the relevance of the construct underlying the prompt to an individual's behavioural delay. Moreover, frequent progress reporting and stating of intended progress undoubtedly influenced assignment progress trajectories. ESM survey frequency, timing, and reflection prompt variety are all likely to have influenced assignment progress trajectories to some extent. Participation in Studies 1 and 3 appears to have influenced both short- and long-term reflection on and change in behaviour for some participants. These effects appear to have combined to make for a generally engaging experience for those interviewed, however, there was an obvious self-selection bias, so reports of positive experiences should be interpreted with caution. Nonetheless, the anecdotal participant reports presented in this chapter suggest a program of brief but regular surveys of assignment progress and prompts for reflection can be both engaging and efficacious in reducing procrastination.

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Chapter 5: Procrastination and Delay Over Time: State Affect as a Mediator and Emotional Stability as a Moderator

5.0 Prelude

Chapters 1 to 4 focused on behavioural delay as the primary dependent variable. Utilising data collected during Study 3, Chapter 5 more fully explores state affect related to overall delay and assignment progress in the moment over the two weeks prior to its submission date. This chapter leverages the high density of longitudinal data on both assignment progress and affect, as well as trait measures collected at baseline, to test several hypotheses that are as yet unexplored in the procrastination literature. Particularly, the aim was to explore the extent to which trait procrastination, emotional stability, and behavioural delay predict levels and change in affect in the two weeks leading up to submitting an assignment.

Chapter 5 has been prepared as a stand-alone chapter requiring minimal adjustment (e.g., modification of Header, Table, and Figure numbering, and removal of references to previous chapters) for submission to a peer-reviewed journal incorporating thesis examiner comments.

The co-authors of this chapter are my thesis supervisors, Graham Bradley and Michelle Hood. My (Jason Wessel) contribution to the chapter manuscript involved: initial concept and research design, data collection and analysis, and preparation of the manuscript.

Statement signed by:

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Abstract

Procrastination is defined not just by delay, but by an awareness of that delay being harmful. The harm may include not only reduced performance, but also affective states such as stress, anxiety, guilt, and shame. Few studies have measured simultaneous changes over time in procrastination-related affect and state changes in procrastination behaviour. We used an experience sampling method to test the relationship between trait procrastination and behavioural delay over a 2-week period leading to submission of an undergraduate mid-term assignment (N = 107). We also assessed the roles of state affect as a mediator of the procrastination-delay relationship, and emotional stability as a moderator of the procrastination-affect relationship. Affect partially accounted for the relationship between trait procrastination and delay, but only among students who reported moderate and low levels of emotional stability. Students who reported more progress on their assignment at one measurement time displayed greater positive affect at the next measurement time, but, as positive affect increased, subsequent assignment progress declined. To the extent that task progress leads to feelings of comfort, and these feelings are associated with a slowing of subsequent progress, we recommend caution in designing procrastination interventions that encourage the promotion of positive affect.

5.1 Introduction

Procrastination refers to the tendency to voluntarily avoid or delay performing behaviours despite such delays being difficult to defend on rational grounds (Wessel et al., 2019). When procrastinating, behaviour over time tends to follow a hyperbolic curve, starting slowly and accelerating as time passes and a relevant deadline approaches (Steel & König, 2006; Wessel et al., 2019). As many as 20% of adults self-identify as having problems with procrastination (Harriott & Ferrari, 1996). Rates of procrastination are particularly high among students (Steel, 2007; Tice & Baumeister, 1997). Of concern, procrastination has been linked to lower wellbeing (Habelrih & Hicks, 2015), depression (Fernie et al., 2017), drug and alcohol use and poor health outcomes (Sirois, 2015), lower salaries, shorter duration of employment, and greater likelihood of being unemployed or under employed (Nguyen et al., 2013).

Procrastination varies between and within people. At a trait level, stable differences exist in the frequency and duration with which individuals put off doing things (Steel, 2007). Given that procrastinators do not always delay performing needed behaviours, and non-procrastinators sometimes do so, we investigated the nature of procrastination and mechanisms through which trait procrastination does, or does not, lead to actual delays in behaviour.

The harm associated with procrastination is commonly conceptualised not just in terms of reduced task performance (Steel 2007), but also as negative affective states such as guilt and shame. In academic contexts, procrastinators are more likely to report test anxiety, including anxiety-related physical symptoms (Rothblum et al., 1986). Similar, possibly reciprocal associations may exist ‘in the moment’ or at a state level; that is, the more one delays, the worse one starts to feel, and the worse one feels, the more one delays. Trait or chronic procrastination has a well-established link with higher rates of neuroticism or low emotional stability (Johnson & Bloom, 1995; Schouwenburg & Lay, 1995; Steel, 2007), and both procrastination and emotional stability have been associated with higher levels of generalised depression, anxiety, and stress (Balkis, 2016; Sirois 2014 cited in Balkis, 2016; Stead et al., 2010; van Eerde, 2003).Together these findings suggest that traits associated with negative affective states, as well as those affective states, may play crucial roles in the relationship between trait procrastination and in situ delay behaviour.

The current study investigated the associations between trait-level procrastination and emotional stability and state-level delay/progress and affect. In the sections that follow, we review past research pertaining to these variables and their associations, and we draw attention to the limitations of past research, deficiencies in current knowledge, and likely complexities in the relationships under investigation. We then describe ways in which the current research sought to fill existing knowledge gaps and inconsistencies using observational and analytic methods that improve on those most commonly adopted in the past. Together, the evidence obtained from this more rigorous approach contributes to a better understanding of questions relating to if, when, and how trait procrastination, and trait and state affective variables, lead to delays in task-related behaviour.

5.1.1 Trait Procrastination and Measurement of Affect Over Time

Although procrastination has been firmly associated with experiences of negative affect (Pychyl et al., 2000; van Eerde, 2003), we identified only three studies of procrastination that measured changes in state affect over time specifically related to a critical event such as the lead up to an exam or submission of an assignment. The earliest of these studies measured affect in weekly surveys over three weeks prior to a mid-term exam period (Rothblum et al., 1986). Perhaps counterintuitively, as the exam deadline approached, both high and low trait procrastinators were shown to perceive the exam to be less difficult, less important, and less anxiety provoking. Moreover, higher trait procrastination was not associated with increased behavioural delay in completing a self-paced quiz as the exam approached. Lay and colleagues (1989) assessed state anxiety seven days and one day before an exam period, then five days post a final exam. They found that students who were high in trait procrastination felt less challenged by the coming examination period seven days beforehand. State anxiety was highest in all participants one day prior to the first exam, with no differences in anxiety based on trait procrastination. Finally, using six assessments of psychological states spread over a semester prior to a final exam, Steel et al. (2001) found self-reported procrastination correlated with high state anxiety across the semester, with no change in anxiety among procrastinators closer to the final exam. Moreover, the authors found no link between state affect and behavioural delay in completing multiple self-paced quizzes.

This limited research provides mixed evidence on the relationship between trait procrastination and changes in state affect prior to a critical event. Among high trait procrastinators, one study showed increasing levels of positive affect over a 3-week period (Rothblum et al., 1986), another showed a reduced sense of challenge over a 7-day period (Lay et al., 1989), and a third found no change in anxiety over the duration of a semester (Steel et al., 2001). Additionally, these studies suggested that trait procrastination is not highly predictive of behavioural delay; however, as shown in Chapters 2 and 3, certain trait measures of procrastination do firmly predict delayed task progress. These previous null findings may, however, be due to measurement limitations of either behavioural delay and/or state affect. Though Rothblum et al. (1986) and Lay et al. (1989) collected state affect data relative to a critical event such as an examination period, behavioural delay was not measured relative to that same event. Steel et al. (2001), on the other hand, did not anchor state affect to the multiple self-paced assessments used to quantify behavioural delay. Behavioural delay in all these studies was operationalised as the execution of discrete behaviours (e.g., delayed submission of self-paced assessments). As has been discussed by Gregory and Morón-García (2009) and Wessel et al. (2020), delayed submission times are likely to be poor proxies for behavioural procrastination, with other situation-based explanations for postponements in assignment submission, for example, where students aim to maximize time available after completing an assessment piece for proof reading prior to submission.

5.1.2 Simultaneous Measurement of Delay and Affect Over Time

The three studies reviewed above measured affect over time: however, they did not simultaneously measure both state affect and delay anchored to a critical event. Indeed, we found only two studies, both using an Experience Sampling Method (ESM), that reported simultaneous experiences of affective state and procrastination or task delay, over time, relative to a critical event or deadline.

In the first study, Pychyl et al. (2000) sampled the experiences of general positive and negative affect (e.g., ‘happy’ or ‘sad’ feelings), guilt, motivation, and trait procrastination of 45 participants at 8 randomly selected times per day over 5 days in the lead up to an exam, paper, or major project being due. Participants also recorded whether they were procrastinating at the time of the experience sampling (i.e., an indicator of subjective behavioural delay). They found no relationship between affect and trait procrastination, but behavioural delay correlated positively with feelings of guilt (r = .42). Unfortunately, the authors did not describe how the relationship between affect and behavioural delay changed over the course of the study proximal to the critical event, did not include a more objective measure of behavioural delay (e.g., task progress), and, as others before them, measured affect generally, not specific to the focal task. Consequently, while they included many of the criteria we argue are necessary for the investigation of affect and procrastination over time, methodological constraints limit what we can learn about the interaction between these variables.

In the second study, Krause and Freund (2014) examined both self-reported procrastination (i.e., repeated measures of how frequently in the last few days the participant had delayed a task) and discrepancy between planned and actual study duration over nine weeks (measured twice weekly) prior to an exam. Discrepancy between planned and actual study duration was taken as a behavioural measure of procrastination (i.e., behavioural delay). They found that higher self-reported procrastination, but not behavioural delay, predicted lower state affective wellbeing. Behavioural delay fluctuated considerably over time, while self-reported procrastination decreased only slightly over the nine weeks in a roughly linear trajectory. Consistent with other studies, the authors measured affect generally, not specific to the pending exam. Moreover, there are doubts as to the validity of time spent studying as a measure of procrastination; previous longitudinal procrastination research operationalising behavioural delay as time spent studying has found students who are high in trait procrastination can report studying for more hours than those who are low in trait procrastination (DeWitte & Schouwenburg, 2002). The disconnect between reporting more study time and self-reported procrastination may explain why neither behavioural delay nor self-reported procrastination approached the hyperbolic delay associated with behavioural procrastination that is predicted by theory (Steel & König, 2006) and has been demonstrated in recent research (Wessel et al., 2019). Consequently, it is unlikely the authors operationalised either state affect or behavioural delay in ways that enabled the assessment of relations with trait level procrastination over time.

In all five studies reviewed, state affect was measured generally, rather than in direct response to a critical task such as a pending exam or progress on a paper, or critical event such as a deadline. Additionally, several of the reviewed studies did not simultaneously measure affect and task delay. There are numerous reasons one might be feeling a certain way at any given time, and without orienting the measure of affect to the task of interest, the researcher is unlikely to fully capture feelings associated with task-related behavioural procrastination. As such, it is unclear what happens with affect over time as a critical event approaches, and whether this varies with differing levels of trait procrastination, task progress/delay, or emotional stability. To clarify these issues, we measured affect relating specifically to a critical task at frequent intervals, while simultaneously measuring delay on that same task. Such an approach is likely to be more sensitive to individual differences in affect relating to trait procrastination, differences in delay relating to procrastination, and emotional stability.

Hypothesis 1. Trait procrastination (a) is positively associated with observed behavioural delay, and negatively associated with (b) emotional stability and (c) state positive affect relating to assignment progress

Hypothesis 2. State positive affect relating to assignment progress (a) improves as a deadline approaches, and, after controlling for delay, this state positive affect is (b) negatively associated with trait procrastination, and (c) positively associated with emotional stability.

5.1.3 Trait Procrastination, Emotional Stability, State Affect, and Behavioural Delay

While there is a clear link between heightened levels of trait procrastination and behavioural delay (Wessel et al., 2019), trait procrastination alone does not explain all subsequent delay. However, the situational factors that inevitably influence behavioural delay (e.g., family emergencies, competing life priorities) may be too many, varied, and nuanced to pragmatically measure (Haghbin, 2015). There may be more stable person-level variables that can help to explain the relationship between procrastination and delay. Sirois and Giguère (2018) explored whether general (i.e., not task progress specific) state affect (measured once) mediated the relationship between procrastination and delay over a 48-hour period. They found that if those high in trait procrastination reported lower levels of positive general affect, they also tended to report higher levels of delay. Moreover, they found that, after including positive general affect as the mediator, the direct effect disappeared, indicating that the role affect plays in the relationship between trait procrastination and delay is a substantial one. This begs the question, if a single indicator of general state affect fully explains the trait procrastination-delay behaviour relationship over 48 hours, to what extent do repeated measures of affect explain task delay, and to what extent does a more stable trait variable explain that relationship?

Trait emotional stability and state affect are closely associated conceptually and operationally (Tamir & Robinson, 2004; Wilson & Gullone, 1999). Indeed, both can be measured using self-report items pertaining to anxiety, worry, and calmness. In addition to the direct effects of trait emotional stability on current affective state (Gunthert et al., 1999), emotional stability can play a role in moderating the effects of external and internal factors on state affect. Trait procrastination may be one internal factor whose adverse effects emotional stability can buffer (McCown et al., 1987). Individuals with high emotional stability tend to display a range of characteristics of resilience, including positive cognitive appraisal processes, problem-focused coping strategies, and social support availability, each of which may contribute to its moderating role. For example, research (e.g., Gunthert et al., 1999; Costa & McCrae, 1990; Gallagher, 1990; Terry, 1994) shows that emotional stability is positively correlated with high levels of self-efficacy beliefs, friendship support, and active problem-solving tendencies, and negatively correlated with use of denial, avoidance, and self-blaming coping strategies. Compared to their low emotional stability peers, procrastinators who are high in emotional stability should be able to maintain a (relatively) positive affective state by drawing on one or more of these coping resources.

In sum, while state affect may mediate the relationship between trait procrastination and delay, it is feasible that this effect is moderated by trait levels of emotional stability. In order to test this possibility, the following hypotheses were posed:

Hypothesis 3. State positive affect mediates the relationship between trait procrastination and behavioural delay.

Hypothesis 4. Emotional stability weakens the negative relationship between trait procrastination and positive state affect.

5.1.4 Intertemporal Relationship Between Affect and Delay

Though there is clear evidence of a link between procrastination and negative affect (Krause & Freund, 2014; van Eerde, 2003), the existing studies do not clarify the temporal nature of that link. On the one hand, consistent with the view that affective states are an antecedent to behavioural delay, some researchers have conceived of procrastination as a mechanism of emotion-focused coping, such as failing to perform a needed behaviour or task, that is employed following a stressful event (Lay et al., 1989; van Eerde, 2003). On the other hand, behavioural delay may adversely influence self- and social esteem, and, thereby, give rise to negative affect. Thus, when one is depressed, anxious, or stressed, one tends to procrastinate, and the reduced productivity associated with procrastination may, in turn, further elevate feelings of depression, anxiety, and stress. van Eerde (2003) noted “there is no indication from previous studies whether to consider them [affective states] as antecedents or consequences” (p.1,404).

However, this uncertainty regarding the temporal order of affective states and delay was recently addressed by Pollack and Herres (2020). These authors conducted daily surveys over two weeks, surveying participants on general positive and negative affect (i.e., not related to a specific task) and procrastination-related behaviours over the past day (e.g., “I generally delayed before starting on work I have to do”). Cross-lagged panel analysis showed that higher reported levels of negative affect on one day were related to higher rates of self-reported procrastination behaviours on a subsequent day. However, procrastination behaviours on one day were not related to differences in positive or negative affect on the following day. This study shared the limitations identified in other previous studies. That is, the authors did not anchor either affect or delay to a specific critical task, and as such, it is unclear if delay on a specific task influences affect towards progress on that task, or vice versa. Additionally, they used a simple form of a cross-lagged model that did not control for unit effects, auto-regression, moving averages, and indirect effects over time (see Hamaker et al., 2015; Zyphur et al., 2019a; Zyphur et al., 2019b; for descriptions of these terms Zyphur et al., 2019a).

In sum, extant research does not adequately answer the question of whether delay on an intended task leads to reduction in positive affect, lower affect leads to behavioural delay, or there a bi-directional relationship?

Hypothesis 5. State affect both (a) precedes and (b) follows behavioural delay over time.

5.1.5 The Current Study

We aimed to overcome limitations of previous investigations of affect and procrastination over time by (a) frequently measuring state affect over time relative to a complex task with a hard deadline, (b) exploring the role that two trait variables, propensity to procrastinate and emotional stability, play in the relationship between behavioural delay and affect, and (c) explore the intertemporal (or time-lagged) relationship between affect and delay. We addressed these aims using ESM in the context of a student sample completing an undergraduate assignment.

5.2 Method

5.2.1 Participants and Procedure

First-year students enrolled in a psychology subject at a public Australian university volunteered to participate for course credit. They first completed a baseline questionnaire and provided their (cell) mobile phone number to receive links to brief but frequent Short Message Service (SMS) texts. SMSs were sent twice daily (morning and evening) for the two weeks (total = 28 messages) leading up to the submission deadline of a written assignment (a laboratory report) that was worth 30% of the students' final grade. Each message contained a link to a brief questionnaire that included questions on assignment progress and affect regarding progress. Of the initial 148 students, 11 were either granted extensions or never submitted their assignment and 30 responded to fewer than 30% of measures so were excluded. A

Mann-Whitney *U*-test indicated that trait procrastination was greater for students in receipt of an extension (*Mdn* = 33) than for the retained sample (*Mdn* = 24), $U = 248$, $p = .047$. No other demographic or academic differences between groups were identified. Of the remaining 107 participants (aged 17.66-55.91 years; $M = 23.54$, $SD = 8.42$), 69% were female.

5.2.2 Materials

Baseline survey. Trait procrastination was measured through the 6-item Passive Procrastination Scale (PPS: Chu & Choi, 2005), which measures maladaptive procrastination on a response scale from 1 = *not at all true* to 7 = *very true*. Chu and Choi (2005) reported coefficient alpha internal reliability as .82 and alpha from the current sample was .88. Items include "I tend to leave things until the last minute." Following reversal of the single negatively-keyed item, responses were summed, with higher scores indicating higher trait procrastination. In support of scale validity, past research (e.g., Wessel et al., 2019) has shown that scores on the PPS predicted behavioural delay as expected.

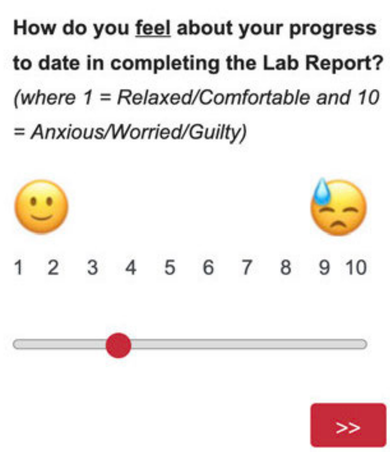
Emotional Stability was measured through the 8-item Neuroticism subscale of the NEO-PI-R scale (Costa & McCrae, 1992; 1994). Items are preceded by "I tend to see myself as somebody who…" and include "is emotionally stable, not easily upset" and "is relaxed, handles stress well". The reported internal reliabilities of NEO-PI-R are above .80, and test retest reliabilities are above .75 (Costa & McCrae, 1992). Coefficient alpha from the current sample was .80.

Participants also provided demographic details including gender, age, grade point average (GPA), and other responsibilities (i.e., hours of paid work, number of courses taken, and carer responsibilities).

ESM. Twice daily for 14 days (10am and 7pm), all participants received via their smartphone the following question to track assignment progress "As of right now, what proportion of your assignment have you completed (0% - 100%)?". Responses to this question over time were used to model completion trajectory, with differences in modelled average completion (area over the curve) used as a proxy for behavioural delay. State affect was assessed through the following question: "How do you feel about your progress to date in completing the Lab Report? (where 1 = *Anxious/Worried/Guilty* and 10 = *Relaxed/Comfortable)*". Emojis depicting affective states were used at both ends of the scale (see Figure 5.1). Scores were reversed and centred, with positive scores relating to positive affect regarding assignment progress (i.e., relaxed/comfortable), zero indicating the mid-point, and negative scores relating to negative affect.

Figure 5.1

Screenshot of Affect Question in ESM Survey Depicting Sliding Scale Between Positive and Negative Affective States Relating to Assignment Progress



Participants were randomly allocated into either an intervention or a control condition. The intervention involved additional prompts in each SMS message (for details, see Wessel et al., 2020). As no significant differences in any variable of interest in the current study were identified between experimental conditions, data from all 107 students were collapsed for inclusion in the current analyses.

Assignment performance. At the end of the semester, assignment submission date (including time of day) and assignment mark were collected from university records for the 107 participants and for the 315 other non-participating students enrolled in the course. Collecting these details from non-participants enabled identification of any effect on assignment completion associated with participation in the study. There were no statistically significant differences in submission date or assignment mark between study participants and the remainder of the course cohort.

5.3 Results

5.3.1 Means, Standard Deviations, and Correlations

Affect was formed by averaging the reported affect for each participant's responses over the 28 ESM observations. Affect was reported on a sliding scale from negative to positive, with higher (positive) numbers indicating positive affect and lower (negative) numbers indicating negative affect, with zero indicating neutral affect. Average progress was the average of the participants' percentage of assignment completed over the 28 ESM observations. Delay was then computed by subtracting the average percentage of assignment progress value from 100, such that higher scores indicated greater delay. Thus, the terms progress and delay are used interchangeably based on context, with 'progress' preferred when referring to daily participant behaviour, and delay preferred when referring to average assignment progress (or lack thereof) over two weeks. This method has been used previously for reducing behavioural delay to a single between-person measure by Wessel et al. (2019; 2020). Missing data were handled in an unconditional multilevel mixed model (described below) by Restricted Maximum Likelihood (REML; Heck et al., 2010). As both average affect and average delay were derived from within person trajectories in multi-level models (see Wessel et al., 2019 for more detail), neither variable contained missing data.

Table 5.1 reports descriptive statistics and correlations. Trait procrastination was moderately correlated with both delay (H1a) and state affect (H1c), but not with emotional stability (H1b). Those who delayed completing their assignment were also substantially more likely to experience negative affective states. There was a weak positive correlation between trait emotional stability and state affect.

Table 5.1

Descriptive Statistics and Correlations of Composite Variables Over the Two Weeks of Observation (N = 107)

	Covariate	*Mean*	*SD*	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1.	Gender	—	—	—											
2.	Age	23.54	8.42	-.07	—										
3.	GPA	4.91	1.71	-.13	-.27**	—									
4.	Study load (no. of courses)	3.66	0.60	.03	-.45***	.12	—								
5.	Paid work	2.50	0.81	-.09	.23*	-.03	.08	—							
6.	Dependents	0.18	0.38	.15	.28**	-.20*	-.23*	.05	—						
7.	Trait Procrastination	23.18	6.70	-.23*	-.21*	.03	.17	-.08	-.12	—					
8.	Emotional Stability	23.65	5.59	-.27**	.03	-.02	.02	-.05	.11	-.11	—				
9.	Experimental Condition	0.49	0.50	-.12	.06	.19	-.11	.12	-.01	-.03	.02	—			
10.	Delay	45.52	27.63	-.06	-.14	.13	.14	-.04	-.10	.51***	.12	-.14	—		
11.	Affect (positive)	0.62	2.18	-.24*	.08	.06	-.07	.07	.02	-.38***	.20*	.08	-.56***	—	
12.	Submission Date	-0.80	1.41	-.09	-.19*	-.03	.08	-.06	-.10	.43***	.02	.12	.39***	-.29**	—
13.	Assignment mark (%)	73.46	13.87	-.25*	-.10	.27**	.09	-.05	-.17	-.03	.05	-.05	.02	.07	.05

Note. Gender is coded as 0 = *Male*, 1 = *Female*. Paid work is coded as 1 = *<5 hours per week*, 2 = *5-10 hours*, 3 = *10-15 hours*, 4 = *15-20 hours*, and 5 = *>25 hours*. Dependents is coded as 0 = *no dependents*, 1 = *dependents*. Experimental Condition is coded as 0 = *control condition*, 1 = *intervention condition*.

* $p < .05$. ** $p < .01$. *** $p < .001$. All statistical tests were two-tailed.

5.3.2 Multi Level Mixed Effect Models

To investigate change in positive affect pertaining to the task over the 14 days of observation, linear and quadratic trajectories were identified through single-level unconditional and multi-level covariate linear and growth curve mixed effect models. The unconditional model (model 1.1) tested changes in affect only. The model included two time variables: Time (the linear effect) and Time^2 (the quadratic or hyperbolic effect). Coefficients represented level of affect either at the start of the 14 days (intercept), additional change per day (slope), or additional change over one day^2 (quadratic). The full statistical method is presented in Wessel et al. (2019). Model fit and parsimony were assessed by the Akaike Information Criteria (AIC), where smaller values indicate a closer fit between the model and data. Results of the models are displayed in Table 5.2.

The unconditional model trajectory did not identify significant linear growth (t_{10} = 0.13, p = .90) from a starting affect value of -0.27 (t_{00} = -1.08, p = .28; at Time 1, 14 days prior to the assignment due date). There was, however, significant positive quadratic increase in positive affect as participants approached the assignment submission due date (H2a; t_{20} = 3.89, p < .001). Participant means and modelled affect trajectory are depicted in Figure 5.2.

Figure 5.2

Modelled Affect Trajectory and Means

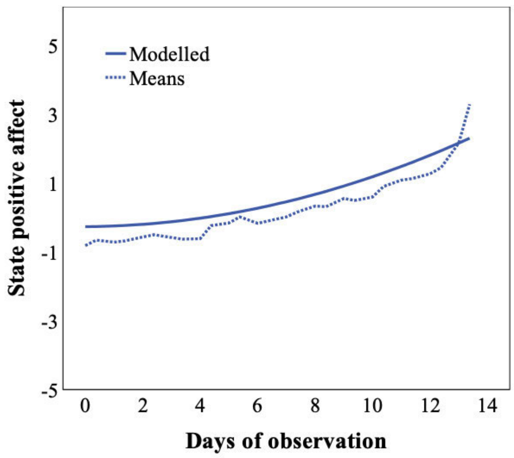


Table 5.2

Multilevel Mixed Effect Model Fit (AIC) and Growth Curve Standardized Estimates on Affect (Models 1.1 – 1.4.3, N = 107)

	Covariate model	AIC	Δ	t_{00}	t_{10}	t_{20}	t_{01}	t_{11}	t_{21}
1.1	Unconditional	8,843.12	-	-1.08	0.13	3.89***	-	-	-
1.2	Procrastination	8,850.95	7.83	-1.14	0.12	3.85***	-2.53*	-0.08	-0.81
1.3	Emotional Stability	8,855.50	12.38	-1.08	0.12	3.87***	1.37	0.48	-0.23
1.4.1	Delay	8,163.82	-679.30	-0.79	0.37	4.23***	-8.87***	-0.13	-2.04*
1.4.2	+Procrastination	8,161.67	-681.45	-0.85	0.56	4.17***	-1.62	3.20**	-3.52**
1.4.3	+Emotional Stability	8,173.11	-670.01	-0.79	0.36	4.28***	2.21*	0.63	-0.70

Note. AIC = Akaike Information Criteria; Δ denotes AIC change from the baseline unconditional model; t_{00} = standardised intercept estimate; t_{10} = standardised slope estimate; t_{20} = standardised quadratic estimate; t_{11} = standardised covariate by slope interaction estimate; t_{21} = standardised covariate by quadratic interaction estimate.

* $p < .05$. ** $p < .01$. *** $p < .001$. All statistical tests were two-tailed.

Wald *Z* tests were used to identify significant between-person differences in intercept (Wald $Z = 6.93$, $p < .001$), linear (Wald $Z = 5.57$, $p < .001$), and quadratic growth (Wald $Z = 5.31$, $p < .001$). Results indicated that the variance in the growth trajectories was not fully explained by the unconditional model. To assess the degree to which trait procrastination and emotional stability explained this between-person variance in affect over the 2-week period, separate growth curve mixed models included either trait procrastination (model 1.2) or emotional stability (model 1.3) as covariates at Level 2 (Heck et al., 2010).

As summarised in Table 5.2, Models 1.2 and 1.3 revealed no significant moderating effects of trait procrastination or emotional stability across time. Of all singular covariate intercepts tested, trait procrastination predicted variance at time 1 only, 14 days prior to submission ($t_{10} = -2.53$, $p = .01$), with neither trait procrastination nor emotional stability predicting significantly different linear or quadratic change in affect. Graphs plotting affect by those highest and lowest in trait procrastination and emotional stability, are presented in Figures 5.3 and 5.4, respectively.

Figure 5.3

Modelled Affect Trajectory and Means for Participants Scoring in the Highest and Lowest Quartiles on Trait Procrastination

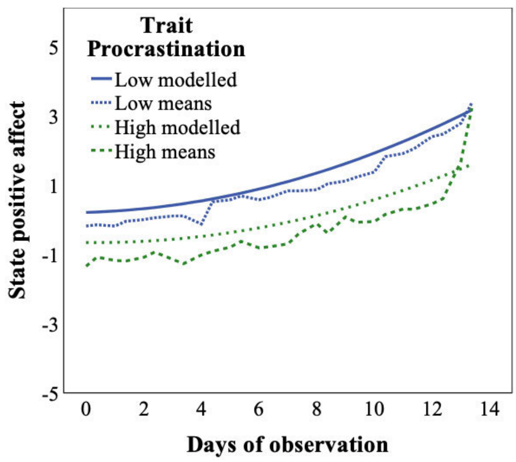
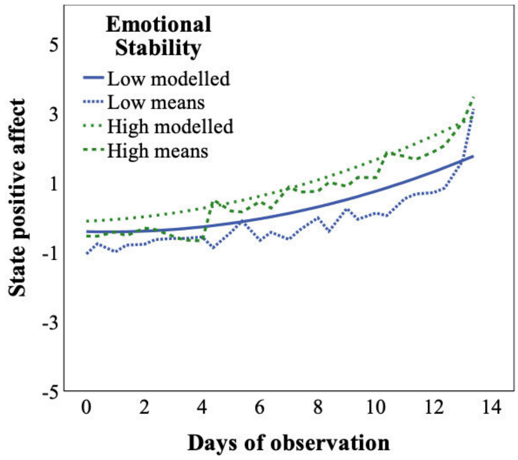


Figure 5.4

Modelled Affect Trajectory and Means for Participants Scoring in the Highest and Lowest Quartiles on Emotional Stability



Introducing age, gender, GPA, hours of paid work per week, study load, and carer responsibilities as demographic control variables did not substantively change *t* coefficients or their statistical significance in either covariate model (models 1.2 and 1.3).

To test the effect of the trait variables, (H2b) procrastination and (H2c) emotional stability, on state affect while controlling for assignment delay, an additional set of models (1.4.1 – 1.4.3) were run. Controlling for delay substantially improved model fit (AIC = 8,163.82; model 1.1 Δ = -679.30). After controlling for delay, participants scoring one standard deviation above the mean in emotional stability ($t = -2.43$, $p = .02$), but not trait procrastination ($t = -0.23$, $p = .82$), demonstrated variance in affect intercept. Emotional stability did not predict linear or quadratic change in affect after controlling for delay, whereas, those higher in trait procrastinating recorded higher linear growth and lower quadratic growth in affect. See Table 5.2.

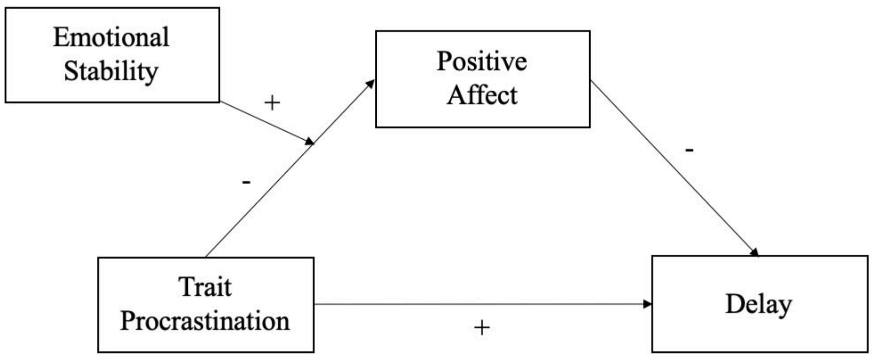
In summary, a large proportion, but not all, of the variance, in state affect towards progress on an assignment can be explained by the progress made on that assignment. After controlling for fluctuations in state affect due to delay, emotional stability moderated the base-level (i.e., intercept) of state affect, and trait level procrastination predicted linear and quadratic change in affect as the deadline approached.

5.3.3 Moderated Mediation

To further explore the structural relationship between procrastination, emotional stability, affect, and delay, we tested whether affect mediates the relationship between procrastination and delay (H3), and whether emotional stability moderates the relationship between procrastination and affect (H4). The full hypothesised moderated mediation model can be seen in Figure 5.5.

Figure 5.5

Proposed Moderated Mediation Model



First, we assessed the mediating role of average state positive affect on the relationship between trait procrastination and average delay. To do this, we evaluated the direct effect of procrastination on delay before estimating the direct plus indirect effects of procrastination on delay (Model 2.1: procrastination → delay). We used Jamovi (Jamovi project, 2018) to generate standard errors and 95% bias-corrected confidence intervals (CIs). With this approach, an indirect effect is confirmed if the CI of the indirect effect does not include zero (Preacher & Hayes, 2008).

There was a significant direct effect of procrastination on delay (Model 2.1; β = .51, $p < .001$), with procrastination alone explaining 26% of the variance in average modelled delay. In the mediation model (see Table 5.3), the direct effect from procrastination to delay was statistically significant (Model 2.2: β = .35, $p < .001$), as was the indirect path via affect (β = .16, $p < .001$). The joint presence of significant direct and indirect paths suggests that affect partially accounts for the relationship between procrastination and delay (H3).

Table 5.3

Model 2.2. *Direct, Indirect, and Total Effects of Procrastination on Delay, via Affect*

				95% Confidence Interval				
Effect	**Path**	**Estimate**	**SE**	**Lower**	**Upper**	**β**	**p**	**% Effect**
Direct	c	1.430	0.328	0.79	2.07	.35	< .001	68.1
Indirect	a × b	0.669	0.201	0.27	1.06	.16	< .001	31.9
Total	c + a × b	2.098	0.343	1.43	2.77	.51	< .001	100.0

We used bootstrapping (5,000 samples) to determine bias corrected confidence intervals (Hayes, 2017) to test the full moderated mediation model (Model 2.3). We first tested the moderating role of emotional stability on the direct relationship between trait procrastination and state affect.

The interaction term (Procrastination * Emotional Stability) was significantly and positively associated with affect (H4, $B = .013$, $p < .01$). Simple slope tests (Aiken & West, 1991) showed that when emotional stability was high (+1 *SD*), there was no relationship between procrastination and affect ($B = -.04$, $p = .29$). However, when participants reported either average or low (-1 *SD*) levels of emotional stability, higher trait procrastination was related to lower positive affect (B = -.11 and B = -.18, respectively, $p < .001$).

Results were confirmed by conducting the same analyses using PROCESS, (Hayes, 2017) to reveal an index of moderated mediation -.07 of X (95% CI = [-0.13, -0.02]). Thus, the indirect relationship between trait procrastination and behavioural delay via positive affect was moderated by emotional stability, with affect mediating the relationship between procrastination and delay among those low and average, but not high, in emotional stability. The full moderated mediation model, including standardised coefficients, is reported in Table 5.4, with paths a, b, c, and c' depicted in Figure 5.6. As shown, there was a significant mediating effect of state positive affect on the relationship between trait procrastination and delay for participants scoring -1 standard deviation and mean levels of emotional stability (β = .27, p < .001, mean ES β = .17, p < .001, respectively), but not for those scoring +1 standard deviation in emotional stability (β = .06, p = .29).

Table 5.4

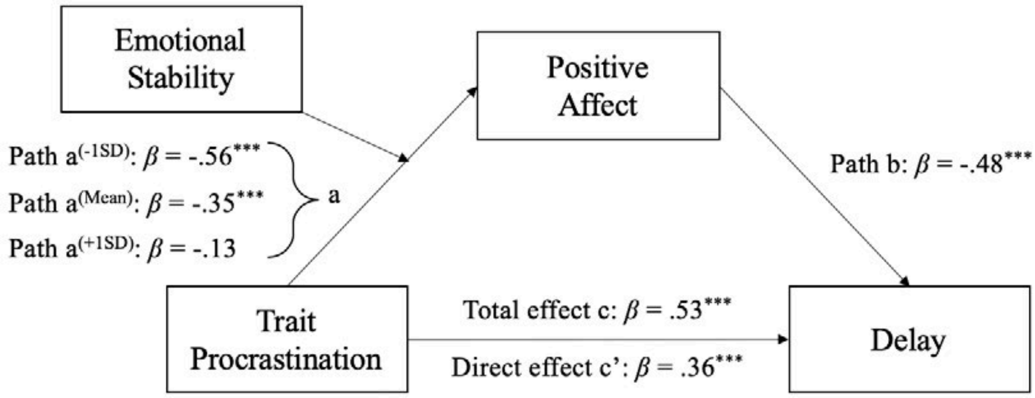
Model 2.3. *Direct, Indirect, and Total Effects of Procrastination on Delay via Affect Across Three Levels of Emotional Stability (-1 SD, Mean, +1 SD)*

Moderator levels					95% C.I.[a]			
Emotional Stability	**Effect**	**Path**	**B**	**SE**	**Lower**	**Upper**	**β**	**p**
-1 SD	Indirect	a × b	0.04	0.01	0.02	0.06	0.27	< .001
-1 SD	Component	a	-0.18	0.04	-0.26	-0.12	-0.56	< .001
-1 SD		b	-0.22	0.04	-0.30	-0.14	-0.48	< .001
-1 SD	Direct	c	0.05	0.01	0.03	0.08	0.36	< .001
-1 SD	Total	c + a × b	0.08	0.01	0.05	0.10	0.53	< .001
Mean	Indirect	a × b	0.02	0.01	0.01	0.04	0.17	< .001
Mean	Component	a	-0.11	0.03	-0.16	-0.06	-0.35	< .001
Mean		b	-0.22	0.04	-0.30	-0.14	-0.48	< .001
Mean	Direct	c	0.05	0.01	0.03	0.08	0.36	< .001
Mean	Total	c + a × b	0.08	0.01	0.05	0.10	0.53	< .001
+1 SD	Indirect	a × b	0.01	0.01	0.00	0.03	0.06	.29
+1 SD	Component	a	-0.04	0.04	-0.12	0.03	-0.13	.25
+1 SD		b	-0.22	0.04	-0.30	-0.14	-0.48	< .001
+1 SD	Direct	c	0.05	0.01	0.03	0.08	0.36	< .001
+1 SD	Total	c + a × b	0.08	0.01	0.05	0.10	0.53	< .001

[a] CI = Confidence intervals computed with method: Bias corrected bootstrap.

Figure 5.6

Full Moderated Mediation Model (Model 2.3), Including Standardized Coefficients



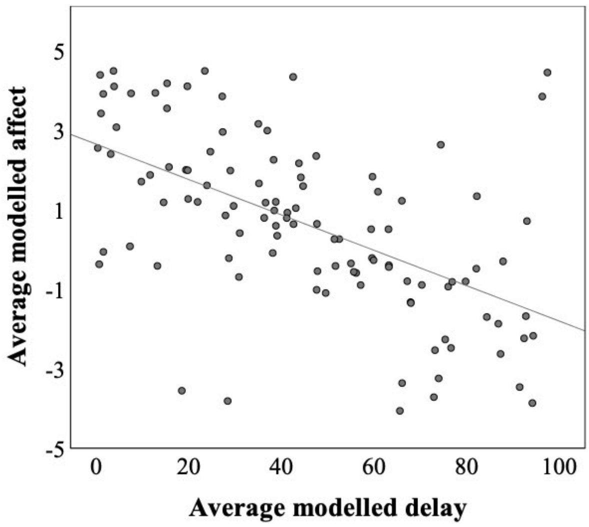
*** $p < .001$. All statistical tests were two-tailed.

5.3.4 General Cross-Lagged Panel Models (GCLM)

So far, we have provided evidence that (a) much of the variance in whether people feel positive or negative affect towards their progress on an assignment can be explained by actual progress made (delay $r = -.56$, $p < .001$; see Figure 5.7), and (b) that progress- or delay-related affect mediates the relationship between trait procrastination and behavioural delay, except in those participants high in emotional stability. However, it is unknown whether these results are indicative of a causal, reverse causal, or reciprocal effect. That is, does affect at Time 1 influence progress at Time 2, does progress at Time 1 influence affect at Time 2, or are there reciprocal effects operating? As affect and progress were both measured over 28 waves of data collection, we were able to employ a General Cross-Lagged Panel Model (GCLM) controlling for unit effects, auto-regression, moving averages, and impulses (i.e., indirect effects over time) to explore intertemporal relationships between these two variables (Model 3.1: see Hamaker et al., 2015; Zyphur et al., 2019a; Zyphur et al., 2019b for descriptions of these terms). To account for the within-person trait-level variance in assignment progress and affect over time identified in models 1.1 – 2.3, we also tested a second GCLM model (Model 3.2) that included the additional effects of emotional stability on affect, and of procrastination on assignment progress. Where models previously reported herein utilised behavioural delay as an outcome computed from assignment progress over time, the following GCLM models utilise assignment progress (also referred to percentage of assignment completed) relative to other study participants at each observation. Models were run in Mplus (Muthén & Muthén, 1998-2017).

Figure 5.7

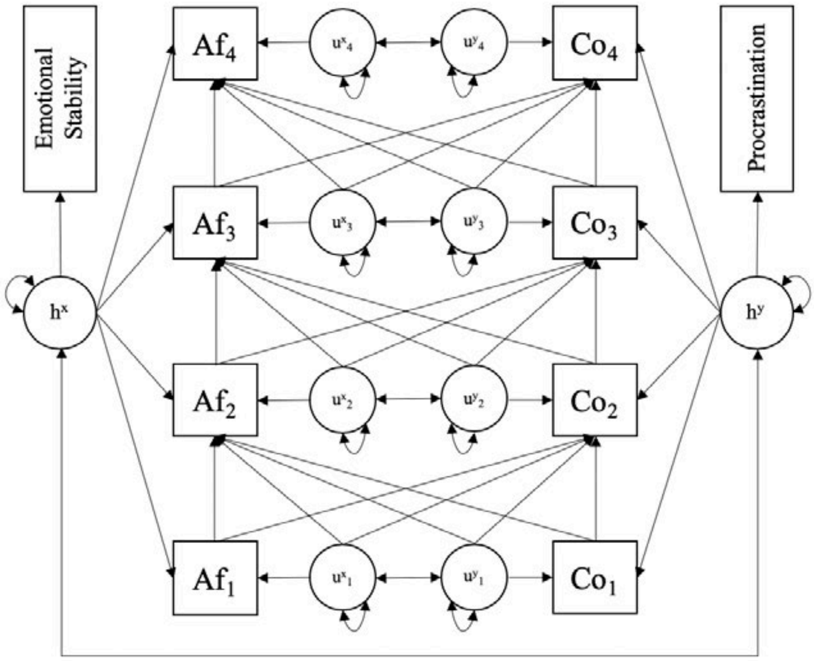
Scatter plot with fit line showing affect with delay (r^2 = -.32)



Most respondents had not started the assignment on the early observation days and many had already completed and submitted their assignment by the later observation days. Thus, with substantial floor and ceiling effects existing in the percentage of assignment completed (i.e., progress) at these times, the model was unable to be meaningfully run using all 28 observations. To overcome this problem, we excluded ESM data collected from the first four and the final four days, and we split the remaining six days (or 12 observations) into blocks of 4 observations (i.e., three 2-day blocks), converted the variable values to *z*-scores, and stacked the 3 blocks of 4 observations together. Transforming dependent variable data into *z*-scores for each observation meant within-person levels of affect and progress are relative to levels of affect and progress between-person at each observation. For example, if ‘Participant A’ reports the same level of affect at times 1 and 2, but the average level of affect among all participants at time 2 increases compared to time 1, then Participant A’s *relative* level of affect (*z*-score) will be lower at time 2. By retaining only data collected on the middle days (days 5-10), relative values of affect and percentage of assignment completed generally represented Gaussian distributions. As depicted in Figure 5.8, the GCLM tests the effects of prior affect (‘Af’) on percentage of assignment completed (‘Co’) measured either nine hours later (if the two observations were taken on the same day) or 15 hours later (if taken on consecutive days), and vice versa, while controlling for unit and trait procrastination and emotional stability effects (model 3.2). Model fit indices of models 3.1 and 3.2 are presented in Table 5.5 (see Zyphur et al., 2019a for details on model specification).

Figure 5.8

General Cross-Lagged Model (GCLM), with Unit Effects, Impulse, AR, MA, CL Terms (Model 3.1), and Time-Invariant Trait Variables (Model 3.2)



Note. Af = affect at each observation 1-4: Co = percentage assignment completed at each observation 1-4 (i.e., progress), with 'Co' used instead of 'Pr' to avoid confusion with procrastination. AR = auto-regression, MA = moving average, CL = cross-lagged effect.

Table 5.5

GCLM Model Fit Indices

GCLM model	AIC	RMSEA	χ^2/df
Model 3.1 – unaltered	2,465.16	.038	1.46***
Model 3.1 – altered	2,470.03	.061	2.15*
Model 3.2	2,382.10	.070	2.55***

* *p* < .05, *** *p* < .001

The unaltered model 3.1 returned a non-positive definite error in the latent variable (unit effect) covariance matrix (see Note under Table 5.6). To permit convergence, the correlations between percent assignment completed observations (Co 1-4 in Figure 5.8) and the assignment completed latent unit effect (h^x) were constrained to 0.01 as recommended by Blozis et al. (2016). By contrast, the correlations between observations and unit effects in the unaltered models (3.1 – unaltered and 3.2) were constrained to zero (0) as specified by Zephur et al. (2019a). As shown, the fit of models 3.1-altered and 3.2 did not differ greatly, with the former having a superior RMSEA value and the latter having the better (i.e., lower) AIC value. Full model results presenting auto-regression (AR), moving average (MA), AR and MA effect (ARMA), cross-lagged effect (CL), cross-lagged moving average (CLMA), and lag effect summing CL and CLMA (CLCL; Zephur et al., 2019a) are presented in Table 5.6.

Table 5.6

GCLM Results for Models 3.1 - Altered and 3.2

Model 3.1 – altered	β	*p*	β	*p*
Within variable	Affect		Progress	
AR[1]	.50	.31	.75	<.001
MA[1]	-.46	.27	.04	.36
ARMA[1]	-.04	.80	.80	<.001
Cross-lagged effects	Affect on Progress		Progress on Affect	
CL[1]	**.06**	.05	.02	.68
CLMA[1]	-.15	.02	.28	.13
CLCL[1]	**-.10**	.12	.30	.05

Model 3.2	β	*p*	β	*p*
Within variable	Affect		Progress	
AR[2]	0.4	0.41	. 91	<.001
MA[2]	-0.42	0.34	0.03	0.52
ARMA[2]	-0.02	0.86	0.94	<.001
Cross-lagged effects	Affect on Progress		Progress on Affect	
CL[2]	**0.01**	0.67	0.14	0.08
CLMA[2]	-0.14	0.03	0.23	0.22
CLCL[2]	**-0.13**	0.03	**0.37**	<.01

Note. Progress = percentage of assignment completed ‘Co’ in Figure 5.8. All statistical tests were two-tailed. CLCL values of greatest relevance to the study hypothesis are highlighted in bold.

Differences in statistical significance of effects between models 3.1-altered and 3.2 have been highlighted in bold in Table 5.6. Of particular note to H5, the GCLM controlling for unit effects but not time-invariant trait variables (model 3.1), revealed a positive cross-lagged effect of assignment progress on affect. That is, individuals who had made greater progress on their assignment relative to others were more inclined to feel better about that progress at the next observation (H5b) between 9 to 15 hours later (CLCL^1: $\beta = 30$, $p = .047$). This effect was also significant in model 3.2 when trait procrastination and emotional stability were included in the model (CLCL^2: $\beta = 37$, $p < .01$). These findings indicate an intertemporal ‘causal’ influence of progress on affect, where higher progress on an assignment at time 1 leads to more positive affect at time 2.

In Model 3.2, there was a weaker, but nonetheless significant, cross-lagged effect of affect on progress (CLCL^2: $\beta = -.13$, $p = .03$). This effect was not present in (the unaltered) model 3.1. In simple terms, after controlling for trait level procrastination and emotional stability, if students were feeling better than their peers about their progress at time 1, they made less progress relative to their peers at time 2 (H5a). Therefore, there is evidence that after controlling for individual differences in emotional stability and procrastination, students make relatively less progress on their assignments at a later time if they are feeling positive at a prior time.

5.4 Discussion

We tested the relationships between procrastination and delay-related affect (i.e., feelings towards delay behaviour) over time. These relationships were examined in the context of progress on completing an undergraduate university assignment over two weeks, with trait levels of procrastination and emotional stability taken into account.

Trait procrastination was correlated positively with delay (H1a) and negatively with affect (H1c), but not with emotional stability (H1b). We found affect increased over the two weeks of observation (H2a), with mean affect starting at marginally negative levels (anxious, worried, guilty) and ending with students, on average, reporting positive affect just before assignment submission date (i.e., being relatively relaxed and/or comfortable with their progress). Those scoring higher in trait procrastination reported lower levels of positive affect at the start (i.e., two weeks before the assignment due date). A large proportion, but not all, of the variance in state delay-related affect was explained by progress made on the assignment. After controlling for individual differences in state delay-related affect, emotional stability (H2b), but not trait procrastination, moderated base-level (i.e., intercept) state affect, while trait procrastination (H2c), but not emotional stability, was related to change in affect over time.

Affect partially accounted for the relationship between trait procrastination and delay (H3), with increasing levels of positive affect being associated with a weakening of the procrastination-delay relationship. A moderation effect was also evident; higher levels of trait procrastination were related to lower levels of positive affect, except in the case of those high (+1SD) in emotional stability (H4), whose levels of trait procrastination did not significantly change their feelings towards assignment progress. These findings are reflective of Sirois and Giguère's (2018) moderated mediation model. Where they found availability of social distractors moderated the relationship between procrastination and affect, we found emotional stability to have a similar moderating effect. This suggests there are multiple moderators of the relationship between procrastination and affect.

When analysed in a GCLM, greater progress on an assignment was shown to lead to more positive feelings regarding progress over the following 9 to 15 hours (H5a). However, after controlling for individual differences in emotional stability and procrastination, students who felt positive about their progress were more likely to make less progress on their assignment 9 to 15 hours later (H5b). This could also suggest, conversely, that negative affective states (like guilt and anxiety) resulting from (slow) task progress may have motivating properties.

Evidence that positive affect or comfort with the progress made is related to reduced short-term task progress may be conceptually related to the phenomenon of coasting (Louro et al., 2007), which derives from control theory (Carver & Scheier, 1990). That is, receipt of feedback that one is doing better than needed tends to increase self-efficacy and positive affect and lead to a withdrawal of effort (Carver & Scheier, 2014). Coasters are thought to do so because (a) effort is a scarce resource and (b) they can divert this resource to other goals that are not progressing so well. The reduction in effort then has the effect over time, through feedback channels, of informing coasters that not enough progress is being made, leading to a reduction in self-efficacy and positive affect, which triggers self-regulatory behaviour to increase effort, and, thus, progress, again.

5.4.1 Strengths, Limitations, and Future Directions

The design of this research met the three criteria we argued are important for investigating the complex interactions between affect and procrastination. We (1) measured trait-levels of procrastination and emotional stability prior to (2) taking intensive longitudinal measurements of both delay and state affect (3) in the lead up to a critical event – an assignment due date. Consequently, this study represents a more comprehensive exploration of the relationship between procrastination and affect than previous research.

However, our high frequency measurements of state affect were simple, with negative affect composed of guilt, worry, and anxiety anchoring one end of the visual analogue scale and positive affect composed of relaxed and comfortable anchoring the other. Thus, nuanced differences between the individual aspects of positive or negative affect were not measured separately. This was a trade-off to keep the length of these high-frequency surveys manageable. Additionally, this bipolar visual analogue scale meant negative and positive affective states were construed as mutually exclusive, which may not reflect the complex affective states actually experienced. Thus, the use of this simple scale to measure state affect might have limited interpretation of the inter-temporal relationship between affect and delay.

Our focus was on state affect as it related to assignment progress, and not general state affect, which has been assessed in other studies (e.g., Krause & Freund, 2014; Pollack & Herres, 2020; Pychyl et al., 2000). While this was an important contribution to the literature, the study may have been enriched through the measurement of both context-specific and context-free affect. However, trade-offs needed to be made between the number of surveys completed and the number of questions that could be asked realistically per survey.

Moreover, the use of 'relaxed' and 'comfortable' as anchors on the positive end of the affect scale may explain why higher affect at one time was found to lead to lower relative progress (i.e., delay) at a subsequent time. It is possible comfort and relaxation are indicative of a perceived lack of urgency and are more related to coasting behaviour compared to other positive adjectives such as 'happy', 'joyful' or 'enthusiastic' (e.g., Sirois, 2014; Steel et al., 2001).

There are strong caveats required around the findings of an inter-temporal relationship from higher affect at one occasion to lower relative progress at the next. These results are specific to the observational data analysed; namely affect and progress over the period from 10 days to 5 days prior to the assignment due date. As procrastination is inherently dynamic and expected to change substantially relative to a deadline (Steel & König, 2006; Wessel et al., 2019), this inter-temporal relationship may not be consistent with that found either further from, or closer to, a deadline. Furthermore, removing the final four days of observation from the GCLM analyses to ensure variance in behavioural delay may have inadvertently reduced the observed variance in affect. This may be mitigated in the future by additionally asking students how they rate the quality of their work (e.g., at 100% complete) against what they feel their highest quality of work would be. This combination of a quality question and a quantity question (i.e., percentage of assignment completed) may increase variance and reduce the ceiling effect where a high proportion of participants had completed 100% of their assignment in the days prior to the due date, but may not feel quality is at their 100%. Arguably, the final few days before the due date are when high levels of delay are likely to have the most detrimental consequences on affect, or vice versa, and would be of greatest interest. Additional research on the inter-temporal relationship between affect and progress in the final days before a deadline is needed.

These findings also have substantial implications for intervention research. Given that the indirect path via affect accounted for only a minority of the variance that trait procrastination explained in behavioural delay (i.e., a strong direct effect remained), there may be merit in exploring the mediating roles of other constructs in the relationship between procrastination and delay. Wessel et al. (2020) showed that targeted cognitive aspects of delay behaviours such as perceived expectancy, value, sensitivity to delay, and metacognition can be effective in reducing procrastination. Understanding the underlying mechanisms in this procrastination-delay relationship is an important first step to devising effective interventions.

The identification of trait-level emotional stability as a moderator of the procrastination-affect relationship suggests therapeutic approaches to reducing procrastination might aim for personality-level change in affectivity (e.g., see Roberts et al., 2017). The findings herein reinforce suggestions by others (e.g., Sirois et al., 2019; Uzun et al., 2018; Wang et al., 2017; Wohl et al., 2010) that targeting improvements in emotional regulation may be an effective addition to procrastination interventions. However, the current findings suggest that interventions targeting emotion regulation should be mindful of the potentially motivating effects of negative affective states such as guilt and task anxiety.

5.4.2 Conclusion

Trait procrastination and behavioural delay are firmly associated with experiences of negative affect such as guilt and anxiety, however, high trait emotional stability may attenuate this relationship. However, whether negative affect leads to procrastination, or whether procrastination leads to negative affect has been unclear. Over the course of two weeks prior to an assignment due date, we found delay on an assignment preceded negative affect, but negative affect did not precede delay. On the contrary, feeling better about progress on one’s assignment led to subsequently lower levels of assignment progress a few hours later. Feelings of guilt, worry, and anxiety may not be states to avoid or suppress if seeking to reduce procrastination. Instead, future research should explore the benefits of harnessing task-specific negative affect to reduce task delay.

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Chapter 6: Discussion

This thesis has presented three studies, each following a similar procedure designed to more accurately measure and predict procrastination, while embedding a low-intensity high-frequency intervention to reduce procrastination. This final chapter presents a synthesis of the results from all of the papers and chapters, and provides an integrative discussion of the broad findings and implications as they relate to the research literature. In summarising previous chapters, it is asserted that (1) behavioural delay associated with procrastination can be measured and modelled with sufficient construct validity if task progress, rather than time spent on task, is measured as the primary dependent variable, (2) using the aforementioned strategy, trait procrastination scales can be compared in their predictive ability, at least in an academic setting, with some scales proving to be stronger predictors of behavioural delay than others, and (3) frequent open-ended questions designed to prompt reflection on task expectancy, value, delay sensitivity, and metacognition can aid in reducing procrastination. These findings provide a basis for assessing the construct validity of procrastination scales. Moreover, the reduced behavioural delay reported by those required to regularly reflect on task expectancy, value, delay sensitivity, and metacognition provides some evidence that these areas may be causally instrumental in behavioural delay. These areas provide a parsimonious framework for consideration when seeking to reduce behavioural delay in academic contexts, and are likely to also have application in prompting earlier action on a range of complex goals where people are prone to delay such as financial planning and health behaviour change.

6.1 Summary of Chapters

6.1.0 Introduction

A broad literature review in the introductory chapter of this thesis summarised some of the correlates, antecedents, and consequences of procrastination relating to academic pursuits and other life domains. The introductory chapter also critiqued current methods of measuring, predicting, and reducing procrastination. Measurement and prediction of procrastination are invariably linked, in that common trait measures of procrastination ought to some degree be able to predict future procrastination behaviour. As delay is a fundamental element of procrastination (Corkin et al., 2011; Harriott & Ferrari, 1996; Howell & Watson, 2007; Nguyen et al., 2013; Steel, 2010a), the measurement of delay is imperative for construct validation of procrastination scales. However, the measurement of delay behaviour has, in the past, been limited for a number of reasons, not least of which being the complexity of procrastination as a phenomenon.

For the purpose of this thesis, procrastination is understood to result from an interaction of situational and dispositional factors. Not only are individuals, whether high in trait procrastination or not, likely to experience differing levels of enthusiasm to pursue the myriad of tasks which make up their days and lives, but that enthusiasm is likely to differ greatly depending on variable features of those tasks. For example, individuals may complete an undesirable task for a close acquaintance quicker than for a stranger. Or more slowly, depending on the task. General tendencies to delay important tasks are also likely to differ between individuals. Consequently, there are complexities in capturing the competing priorities, interests, and enthusiasm across tasks and individuals. The duration available to complete a task appears elemental in predicting the speed with which that task will be completed. Thus, mapping of progress across time must occur to measure both within-person state differences and between-person trait differences.

It was argued that no study in the literature to date has reliably measured the behavioural delay associated with procrastination. As a result, the many scales designed to measure trait procrastination have not been empirically verified for their ability to predict delay. Moreover, despite many recommendations for strategies to reduce problematic procrastination, as reliable observation of dilatory behaviour has proven challenging, few suggested interventions regarding strategies to reduce procrastination in the moment have been empirically verified as efficacious in mitigating delay. In the introductory chapter, the rationale was set for the examination of a single concurrent approach to both measuring and reducing procrastination, which also has the ability to assess the predictive ability of trait measures by association with observed delay.

6.1.1 Chapter 1: Study 1 (Pilot)

Chapter 1 presented findings from Study 1. Study 1 used ESM to survey students ($N = 24$) twice daily over a period of two weeks in the lead up to an assignment due date. Students reported the percentage of their assignment they had completed at the time of responding and the amount they intended to complete by the following day. Sixteen participants were randomly selected to receive additional intervention questions at the end of each ESM survey, which were designed to prompt reflection on either task expectancy, value, delay sensitivity, or metacognition. Prior to the ESM period of the study, participants as well as a larger body of the course cohort completed a baseline survey comprised of demographic, personality, and trait procrastination scales purported to measure arousal and avoidant types of procrastination. The inclusion of numerous trait procrastination scales in the baseline survey in conjunction with the regular progress reporting in the ESM component enabled analysis of the ability for procrastination scales to predict behavioural delay.

Multiple analyses were conducted using multilevel mixed effect modelling with a (second order) hyperbolic growth function, with delay curves in assignment progress over two weeks taken as an indication of behavioural procrastination. These analyses revealed assignment progress generally followed the expected hyperbolic delay curve; however, the shape of the curve appeared muted in comparison to that theorised by TMT (Steel & König, 2006). Trait procrastination scales previously associated with avoidant behaviour and arousal or 'sensation seeking' procrastination type behaviour (Ferrari, 1992) were not associated with delay in the anticipated direction, with those highest in arousal procrastination displaying more linear modelled assignment completion trajectories than those lowest in arousal procrastination. Two measures (MDT & EVI) aiming to operationalise TMT, a dynamic formulaic theory specifically intended to describe delay curves, also failed to predict participant reported delay. However, participants allocated to the intervention condition (i.e., progress reporting and reflection prompts) demonstrated substantially lower levels of delay than those allocated to the control condition (i.e., assignment progress reporting). This provided preliminary evidence that regular reflection on task expectancy, value, delay sensitivity, and metacognition in conjunction with progress reporting was more effective at reducing behavioural delay than progress reporting alone. Study 1 results indicated that a low-intensity, high-frequency ESM approach to reducing procrastination could be effective; however, due to the small sample, caution is required in accepting the study results as generalisable and robust. Thus, there was a need for Study 1 to be replicated on a larger scale to overcome sample size limitations.

6.1.2 Chapter 2: Predicting Procrastination with Active and Passive Procrastination Scales

Chapter 2 included a larger scale replication of Study 1 (Study 2; $N = 80$), specifically exploring the ability for active and passive procrastination scales to predict behavioural delay. The included paper from Study 2 (Wessel et al., 2019) predominantly focused on a critique of active procrastination. Supporters of active procrastination (e.g., Choi & Moran, 2009) purport the construct is an adaptive form of procrastination in which individuals intentionally delay in anticipation of the eustress felt in close proximity to a deadline. Correlational analyses have identified a link between active procrastination and positive outcomes such as higher GPA, psychological wellbeing, personal growth, and environmental mastery (Choi & Moran, 2009; Habelrih & Hicks, 2015). However, active procrastination has been critiqued with some arguing that active procrastination equates to intentional delay, which is not the same as procrastination (Corkin et al., 2011; Steel, 2010). The Active Procrastination Scale (APS; Choi & Moran, 2009), which is the sole existing scale used to measure active procrastination, has also been criticised for being multi-faceted and non-homogenous as a singular construct (Chowdhury & Pychyl, 2018). Prior to an established and reliable method for quantifying behavioural delay, it has not been possible to determine whether active procrastination is associated with delay.

The design of Study 2 was similar to Study 1, except that participant recruitment for the baseline survey ($N = 395$) was conducted as part of a course practical exercise on procrastination, and the inclusion of the APS (Choi & Moran, 2009) and Passive Procrastination Scale (PPS; Chu & Choi, 2005) was not done in Study 1. Eighty students who completed the baseline survey also participated in the

ESM component and received surveys via SMS to report their assignment progress twice daily for two weeks in the lead up to the due date. Students were randomly allocated into either an intervention or a control condition, with those in the intervention condition receiving the same open-ended questions designed to prompt reflection at the end of each ESM survey as Study 1. While allocation to the intervention condition was not associated with reduced delay compared to the control condition, significant differences in delay trajectory were identified between the active and passive procrastination constructs. Specifically, trait level passive procrastination was a strong predictor of behavioural delay, while active procrastination was not. It was asserted that there is no evidence to suggest those who are high in active procrastination delay activity any more than those who are low in active procrastination, and consequently, both the construct, and the scale purporting to measure it, should be reconsidered as relating to the construct of procrastination. Thus, the paper made an important contribution by introducing a method for comparing delay trajectories based on trait measures of procrastination and randomised control trial conditions in a procrastination intervention.

6.1.3 Chapter 3: Reducing Procrastination: A Low-Intensity, High-Frequency Approach

Chapter 3 elaborated on the contextual differences between Study 1 and Study 2 in order to explain the substantial differences in delay trajectories for the intervention conditions between Studies 1 and 2. As Study 2 was intended as a larger scale replication of Study 1, there were very few methodological differences that might have explained the difference. However, on reflection, the relevant difference was the overt (transparent) versus covert nature of the study intent. The intent of the research focus on procrastination was not made explicit (i.e., was covert) to the participants in Study 1. Study 1 participants were informed the study was to learn about their 'study behaviour' to minimise the potential for demand characteristics that might have occurred if they had known that the explicit focus was procrastination. In contrast, in Study 2, in order to increase sample size for the ESM components, participants were recruited following a course practical exercise on procrastination. The possibility that the overt research focus in Study 2 explained the differences in the intervention findings across Studies 1 and 2 was discussed in the prelude to Chapter 3, with differences in the relationship between conscientiousness and delay presented as possible supporting evidence for stronger demand characteristics in Study 2. Stronger demand characteristics in Study 2 potentially influenced earlier assignment completion trajectories in that study, reducing the differences between the intervention and control conditions. In short, conscientiousness was not related to delay in Study 1 where the research focus was covert, but was strongly related to delay in Study 2 where the research focus was overt.

The prelude to Chapter 3 argues that in a randomised trial to reduce procrastination, if the intent of the study is overt, participants high in conscientiousness are more likely to comply with perceived demand characteristics, and thus display lower levels of delay. Though post-hoc and not in itself conclusive, this rationale was sufficient to justify a second replication of the Study 1 design in Study 3, albeit with a larger sample size and in a context where the aims of the study remain covert to participants.

Chapter 3 contains a manuscript re-submitted for publication following minor changes (Wessel et al., 2020) that reported findings from Study 3 ($N = 107$), in which participants allocated to the intervention condition displayed significantly lower levels of delay compared to those in the control condition. These findings provided further support for those reported in Chapter 1. This included conceptual support for interventions aimed at increasing task expectancy, value, delay sensitivity, and metacognition, as well as methodological support for delivery of a low-intensity, high frequency intervention that can directly influence earlier task progress. This approach to a behavioural intervention requires both minimal expert facilitation and minimal effort and time invested by the participant. Moreover, a low-intensity, high-frequency ESM approach to reducing procrastination can be as easily delivered to one thousand participants as it can to a single participant, and consequently may be a valuable approach to addressing the highly prevalent problem of procrastination. Although the intervention was delivered in an academic setting, this approach is likely to also have implications for other goal pursuits where individuals often procrastinate, such as health behaviour change and personal finance, and invites further studies to explore a similar approach to reducing procrastination in areas outside of academia.

6.1.4 Chapter 4: Participant Experiences of ESM and the Intervention

Chapter 4 presents the findings from qualitative semi-structured interviews held with participants ($N = 8$) from the ESM component of Studies 1 and 3. Interviewees had recently participated in either the control ($n = 4$) or the intervention ($n = 4$) condition. As Study 1 interviews were initially intended only to garner participant experiences for refining the intervention for Study 2, no interviews were held with Study 2 participants. Following the non-significant intervention effect in Study 2, interviews were planned and held with Study 3 participants to increase the qualitative sample and provide further experiential context for why the intervention may or may not have reduced procrastination beyond the control condition.

Interviewees in both intervention and control conditions spoke positively about regularly responding to the ESM surveys and described differences in the efficacy of the reflection prompts. Interviewees described particularly positive experiences with the expectancy and delay sensitivity prompts (i.e., social proof and incremental goal setting), the value prompt (i.e., visualisation) received mixed responses likely owing to the negative framing of the prompt, and interviewees gave no clear indication if the metacognition prompt was efficacious in influencing behaviour. Interviewee comments on assignment progress and intended progress reporting indicated a clear likelihood of an observer effect, with the vast majority of interviewees commenting that regular reporting of progress positively influenced their awareness of their study behaviour and their motivation to complete the assignment. These anecdotal participant reports suggest a program of brief but regular surveys of assignment progress and prompts for reflection can be both engaging and efficacious in reducing procrastination.

6.1.5 Chapter 5: Procrastination and Delay Over Time: State Affect as a Mediator and Emotional Stability as a Moderator

Chapter 5 presents an integrative series of analyses examining changes in affect over time, particularly as it relates to delay, trait levels of procrastination, and emotional stability. Negative affective states such as guilt and stress are commonly associated with procrastination (e.g., Pychyl et al., 2000). Limitations in previous attempts to experientially measure delay, however, have constrained the depth to which the concurrent relationship with affect has been explored. Chapter 5 presents an analysis of the relationship between changes in twice daily reported levels of participant affect ($N = 107$) as it related to progress on the assignment over two weeks prior to its due date. Affect generally increased over the two-week period, with participants reporting lower levels of negative affect (guilt/anxiety/stress) and higher levels of positive affect (relaxation/comfort) with progress as the assignment due date approached. This increase notably accelerated in the final days before the due date. This may, in part, be explained by those who completed the assignment early reporting higher levels of positive affect; that is, feeling more relaxed and comfortable once it was done.

Multilevel mixed effects modelling revealed participants who reported higher levels of assignment completion reported higher levels of (positive) affect both two weeks prior to the due date and in the final few days of observation. At time 1, two weeks prior to the due date, those higher in trait procrastination reported higher levels of negative affect. However, after controlling for task (assignment) progress, procrastination did not predict affect at time 1, but was related to early improvement in affect over time. By contrast, initial analyses revealed that emotional stability did not predict affect at time 1 nor change in affect over time. However, after controlling for task progress, those who were higher in emotional stability reported feeling more positive about their progress at time 1. Put simply, if those who were higher in trait procrastination made earlier progress, they reported lower levels of negative affect, while those who were lower in emotional stability (higher in neuroticism) felt more positive about their progress regardless of how much progress they had made. Further, affect generally mediated the relationship between procrastination and delay, with procrastinators feeling higher levels of negative affect, and those reporting higher levels of negative affect more likely to delay. For those highest in emotional stability, however, affect did not mediate the relationship between procrastination and delay, suggesting that high emotional stability may have insulating properties against otherwise negative emotional experiences felt by those with personal tendencies to maladaptively delay.

Finally, Chapter 5 reports the use of a General Cross-Lagged Panel Model (GCLM) to investigate the inter-temporal relationships between delay and affect. Participants who had made more progress on their assignments than others at one time (e.g., in the morning) tended to feel better about their progress at a subsequent time (e.g., in the evening). Conversely, those who felt better about their progress at one time made less progress than their peers on their assignment at a subsequent time. This runs somewhat counter to wisdom on the relationship between self-forgiveness and reduced procrastination (Wohl et al., 2010), and suggests that self-awareness of delay may trigger self-regulatory corrective action.

Though some findings from the analyses presented in Chapter 5 were unsurprising, such as emotional stability generally relating to higher positive affect regardless of task progress, other findings stood in contrast to conventional wisdom in the field, namely, the relationship between higher positive affect at one time being related to lower progress at the subsequent time. The primary strength of this chapter was a depth of data and analyses not previously seen in the literature. Novel findings suggest future researchers should approach promoting positive affect in isolation as a method of reducing procrastination with caution.

6.2 General Discussion

6.2.1 Strengths

The research presented in this thesis has numerous strengths. First, the ESM-based measurement approach is generally applicable to any complex task that can be either approximately or precisely quantified by a percentage of task completed, and can have a target (or due) date for completion defined. As a result, applications need not be restricted to academic settings, but can be extended to the workplace (e.g., features of a software product built and tested against the full specification) or one’s personal health goals (e.g., progress made towards a target weight by a specific date). Though an intensive longitudinal or ESM approach may be suitable for measuring delay, the practicality of doing so decreases substantially where individuals are pursuing different goals, with different target dates and with different constraints. Consequently, assessment of the prevalence of procrastination in an academic setting enabled measurement of procrastination to a degree unlikely to be practical in workplace settings without substantial project management demands.

I know of no precedent where a low-intensity, high-frequency intervention to mitigate the effects of psychological phenomena was embedded into an ESM study. Thus, I believe the study and intervention design is innovative among procrastination research. Moreover, the concurrent use of an active control group during the intervention, while potentially leading to an under-estimation of the intervention effect size, isolated the reflection prompts of the intervention as the only variable which can plausibly explain group difference in delay trajectories between intervention and control conditions. This is a strength, as use of a passive control or a control with less-frequent ESM surveys would have reduced the confidence with which the success of the intervention could be concluded. The efficacy of the intervention is also likely to have been bolstered by the use of randomised order in the delivery of the prompts, a strong theoretical grounding, and consistent prompt timing (i.e., not at random intervals during the day as is the norm with many ESM studies).

The replication of the generally similar study design across three cohorts adds an increased level of certainty of findings replicated across the three studies. Particularly prominent was the hyperbolic curvature of delay trajectories describing the average approach to task completion, with more curvature apparent in those who were higher in trait procrastination. Additionally, minor contextual differences between studies highlighted a potentially confounding variable affecting intervention efficacy, namely, overt awareness of the study focus and likely consequent operation of demand characteristics. The subsequent replication of the study design with covert intent, and the return of a significant intervention effect, provided compelling evidence for the important influence of context.

Another strength was the primary statistical method used for modelling longitudinal behavioural delay and affect trajectories (MLM), which becomes very sensitive with the higher number of data points (Byrne, 2012; Hoffman, 2007). This is evident where both hyperbolic trajectory and group differences in a trait measure of procrastination were statistically significant in Study 1, despite the relatively small sample size ($N = 24$, see Chapter 1, Tables 1.3 and 1.4). Additionally, longitudinally modelling trajectories through MLM enabled saving predicted trajectory values as a method for dealing with missing values and reducing repeat-measure variables such as delay (i.e., the inverse of task progress) and state affect to single values for simpler bivariate and multivariate analysis such as correlations, regressions, and *t*-tests. In short, study findings and effect sizes were sufficient to conclude the use of regular progress reporting to model delay is promising, and warrants the recommendations for future studies described below. Although Study 1 supported the novel methodology introduced in this thesis, the two replications that followed substantially increased the quality and range of conclusions possible in this thesis.

6.2.2 Limitations

Limitations have been cited relating to individual studies and investigations of specific hypotheses or aims at the end of each chapter. Here, I refer to broader limitations which I feel are pertinent to the body of research presented as a whole.

Though longitudinally modelling task progress as an indicator of delay is effective for complex tasks which are completed over time, the approach presented here does not apply to procrastination on binary activities, such as decisions, or the delay of simple tasks that tend to be completed in one bout of activity once started, such as brushing one's teeth or starting a self-paced exam. Additionally, where a complex task does not have clear progress markers of an easily quantifiable goal, such as career progression where goals may include increased work-life balance, more responsibility, and/or total compensation, an ESM approach to measurement of delay may not be suitable.

A further limitation is that this thesis and much of the procrastination literature (e.g., Ferrari et al., 1995; Krause & Freund, 2014; Steel, 2007; van Eerde, 2003) rests on the premise that procrastination is at least partially contingent on delay. However, that premise should not go unchallenged. Perhaps not all procrastination includes objectively measurable delay. Delay implies that an individual intends to complete a task at or by a specific time, with procrastination relating to consciously and voluntarily squandering precipitative moments during which they believe they ought to be pursuing the task. Perhaps not all procrastination can be associated with tangible objective delay. For example, individuals who are high in trait procrastination who are given two weeks by an external party to complete a task may feel as though they are procrastinating for the first week. Perhaps they feel an overwhelming sense of guilt, but cannot bring themselves to approach the task. However, in the second week they start and make steady progress, all the while feeling they are behind. By contrast, a group of non-procrastinators who also have two weeks available to complete a task may do so entirely in the last week, feeling they have ample time, even if another emergency arises. The two groups have the same objective progress trajectories, yet it would be inaccurate to describe both as having been procrastinating. Therefore, perhaps it is not just procrastination that is a subjective experience, but also delay – to some extent, at least. One may describe both trajectories as incorporating delay, but one delay trajectory is (subjectively) more ‘procrastinagenic’ than the other. To overcome this, researchers may ask participants responding to an ESM survey if they feel they are procrastinating, however, such an approach may increase the likelihood of an observer effect similar to that theorised to have occurred in Study 2.

My use of four specific questions aiming to prompt reflection is a course-grain distillation of a deep exploration of motivation and procrastination literature. The initial reflection prompts written for Study 1 and used in both replications (Study 2 and 3) are unlikely to be the best possible expressions of expectancy, value, delay sensitivity, and metacognition. If I take an especially critical view, it is unclear how well the questions operationalised the intended constructs. All that can be said with relative certainty is the reflection prompts were related to reduced delay in 2/3 studies. But alternative explanations of the study findings are possible. Whether it was the lengthier engagement with the surveys, the requirement for participants to write something (i.e., anything, and writing their name over and over would have been just as effective), or that the reflection prompts rendered the study focus (i.e., procrastination) more salient than in the control condition, and, consequently, promoted demand characteristics felt by those in the intervention condition is unclear. Though the conceptual design of the intervention provides support for these constructs as useful in reducing procrastination, much more work is required to understand the boundaries of this application.

It is highly likely that regular progress reporting amounted to an observer effect, and influenced behavioural delay to at least some extent in all studies. It is possible that frequent ‘observation’ influenced behaviour to such an extent that inferences made in this thesis about latent delay were specious. This would have ramifications on conclusions made about the predictive ability of trait procrastination scales. It is possible a confounding variable unrelated to procrastination moderated the relationship between progress reporting and delay. This possibility was identified prior to Study 1 (see Chapter 1), and great care was taken to assess the degree to which demographic and personality variables, such as study load, work, or caring commitments, may have played this moderating role. No evidence of such a relationship was identified. Though worth mentioning, the risk of this limitation pragmatically affecting conclusions in this thesis is likely to be minimal.

6.2.3 Future Directions

A low-intensity, high-frequency approach to reducing procrastination that is likely to limit attrition and does not require facilitation by a skilled practitioner has broad implications. This is particularly so if there is potential to reduce delay on both a specific task during the intervention and by generalising to future tasks. However, the use of brief but frequent open questions to prompt reflection is a relatively novel approach, and there is much work to be done to understand how to best customise and optimise the approach.

For example, future research also conducted in an academic setting could replicate and extend findings presented herein by reducing the frequency of ESM surveys in the control condition. A reduction of total ESM surveys sent to control participants over the same two-week study duration is likely to approach measurement of a more latent-level delay curve through reduction of the theorised observer effect. If considering replication and extension to enhance the intervention effect, all manner of alterations to the study protocol could be used to assess the effect changing ESM survey method variables such as timing, frequency, size, and duration has on delay curves. Moreover, as qualitative findings presented in Chapter 4 suggests this high-frequency, low-intensity approach may have effects lasting longer than the intervention period, including repeat measures of trait procrastination and delay post assignment submission and at a six-month follow-up may add credence to anecdotal reports. Similar use of regular progress reporting and reflection prompts may also be useful for increasing participation and reducing attrition in online-only courses. Procrastination in online courses poses significant barriers to completion, with completion rates as much as 40 to 50% lower than in face-to-face higher education courses (Patterson, 2014). Understanding the extent to which reflection prompts aiming to increase expectancy, value, delay sensitivity, and metacognition are individually efficacious in reducing procrastination would substantially increase the range of intervention options likely to be effective in reducing procrastination inside and outside of academia. However, if future research were to take this line of investigation while borrowing from the same ESM study design, researchers should also consider the effects that novelty of each prompt and a multi-construct approach are likely to have on the reduction of delay.

Procrastination is a vast phenomenon that can affect people's goals, aims, and ambitions across many of their life domains. Conceptually, there is no reason greater awareness and regular reflection on progress, efficacy, value, delay sensitivity, metacognitive planning, and salience of a deadline will not substantially reduce procrastination in other domains. For example, an application enabling those to log their weight daily, and respond to a reflection prompt offered from a pool at random, may help those seeking to lose weight stay on track (Contemplate, 2019). This may also apply to others seeking to change their health-related behaviour, such as those seeking to quit smoking, or adjust lifestyle to accommodate or prevent illness or injury. There are many applications available to support individuals in health behaviour change, however, reviews have acknowledged a generally low degree of evidence as to their efficacy (Abroms et al., 2013; Azar et al., 2013; Direito et al., 2015). Individuals seeking to rapidly reduce their debt may benefit from a budget tracking service that also provides opportunity to regularly reflect on elements related to procrastination, perhaps at each log-in. In the work place, those who regularly use SMART goals (Doran, 1981) to set goals and tasks may be better able to identify those tasks they are at risk of putting off if they have some method for assessing efficacy and value against each task. Also at work, but from a manager's perspective, research presented in this thesis suggests that regularly checking in on progress, setting concrete deadlines where practicable, and discussing expectancy, value, delay sensitivity, and metacognitions around delay with staff, may increase likelihood of smoother task progress and timely completion. The limitations to further application have closer relation to technology and imagination than the nature of the goal being pursued.

A vast majority of individuals in developed nations, as high as 80% in many countries, don't just consider climate change to be a serious problem, but also believe the time to act is now, and that climate change is already affecting them (Blau, 2020; Kennedy, 2018; Page & Page, 2014). However, much psychological research on climate change has either focused on influencing deniers or those unmotivated to act, adaptation, or sampling community levels of environmental behaviours (Bradley & Reser, 2017; Gifford, 2011; Swim, 2018). No known studies have focused on supporting those with intentions to engage in mitigation behaviours to follow through with action. Some authors have suggested that joining advocacy and activism groups may be a way of psychologically adapting to climate related anxiety and grief through social support structures (e.g., Burke, 2018; Ebi & Semenza, 2008; Ojala, 2013; Reser & Swim, 2011). It is encouraging that through joining such groups, new members are also likely to positively contribute to environmentally sustainable and reparative movements. What has not been explored is how community groups, governments, and others seeking to increase community levels of pro-environmental behaviour can use a paradigm of procrastination to aid those already motivated to follow through with their intentions. This is particularly important as a way to encourage wide-scale mitigation behaviour (Steg, 2018). A low-intensity, high-frequency approach that can be deployed at scale across social and traditional forms of media may well be one of the most effective use of limited resources if changing mass behaviour is the goal.

6.2.4 Conclusion

This thesis significantly and uniquely contributes to the body of procrastination knowledge in three ways. First, in the way procrastination is measured, not just as a latent trait construct approximated by self-report survey items, but as it is associated with behavioural delay. Second, the introduced method for measuring procrastination directly benefits our understanding of which trait scales may best predict procrastination, or at least the behavioural delay associated with procrastination. Third, the use of ESM to deliver a low-intensity, high-frequency approach to reducing procrastination through regular reflection prompts is, to the best of my knowledge, unlike any other procrastination intervention in the research literature. Related to reducing procrastination, this thesis also provides a unique perspective on the relationship between delay, affect, trait procrastination and emotional stability. Though numerous studies have sought to explore these relationships, none has done so relative to a complex task, limiting their ability to generalise findings to applied examples of procrastination. Study 3 found evidence to suggest positive affect towards task progress at one time may lead to reduced progress at a subsequent time. This finding runs counter to previous longitudinal research not anchored to a specific task, and as such should be interpreted with caution. Nevertheless, it provides a novel perspective that has implications for interventions seeking to reduce procrastination.

Procrastination is nigh on ubiquitous, with around 95% of people admitting they procrastinate, and problematic levels of delay reported by 20% of the general population and 50% of students. The complex interaction between individual, task, and temporal differences renders procrastination particularly difficult to measure and reduce. Advances in measurement, prediction, and reduction techniques, particularly approaches with the ability to scale to meet the prevalence of the problem, have the potential to significantly improve countless experiences over the lifespan. It is my hope that the research presented in thesis can in some small way contribute to that advancement.

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Appendix A

EVI Expectancy and Value Scales (Tailored)

Expectancy belief	1. How good are you at completing assignments? 1 2 3 4 5 *Not good* … *Very good*
Expectancy belief	2. If you give 5 to the best student and 1 to the worst, what you give to yourself? 1 2 3 4 5 *Worst* … *Best*
Expectancy belief	3. Some people are better in one subject than in another. For example, you might be better at maths than with reading. Compared to most of your other subjects, how are you doing in Psychology? 1 2 3 4 5 *A lot worse* … *A lot better*
Expectancy belief	4. How well do you think you are doing in Psychology overall? 1 2 3 4 5 *Very poorly* … *Very well*
Expectancy belief	5. How well are you studying in Psychology? 1 2 3 4 5 *Very poorly* … *Very well*
Attainment value	6. How important do you think Psychology is for you? 1 2 3 4 5 *Not very important* … *Very important*

Attainment value	7. Compared to your other courses, how important is it for you to learn Psychology content? 1 2 3 4 5 *Not very important* *Very important*
Intrinsic value	8. In general, how much to you enjoy Psychology classes? 1 2 3 4 5 *Very boring* *Very enjoyable*
Intrinsic value	9. How much do you like Psychology classes? 1 2 3 4 5 *Don't like them at all* *Like them very much*
Utility value	10. Some things that you learn at university help you do things better outside of university. We call this being useful. For example, learning about nutrition might help you maintain a healthy diet. How useful do you think the contents you've learned in Psychology are? 1 2 3 4 5 *Not useful at all* *Very useful*
Utility value	11. Compared to your other courses, how useful are the skills learned in Psychology? 1 2 3 4 5 *Not useful at all* *Very useful*

Appendix B

Passive Procrastination Scale (PPS)

1. I tend to finish tasks well ahead of deadlines. (reversed)

1	2	3	4	5	6	7
Not at all true						*Very true*

2. Even after I make a decision I delay acting upon it.

1	2	3	4	5	6	7
Not at all true						*Very true*

3. I prepare to study at some point of time but don't get any further.

1	2	3	4	5	6	7
Not at all true						*Very true*

4. I tend to leave things until the last minute.

1	2	3	4	5	6	7
Not at all true						*Very true*

5. I often find myself performing tasks I intended to do days earlier.

1	2	3	4	5	6	7
Not at all true						*Very true*

6. I generally delay before starting on work I have to do.

1	2	3	4	5	6	7
Not at all true						*Very true*