2023

Intentional and Unintentional Task-Unrelated Thought: Separable Associations and Outcomes in the Lab and Daily Life

Maryann Barrington

Intentional and Unintentional Task-Unrelated Thought: Separable Associations and Outcomes in the Lab and Daily Life

Maryann Barrington, BPsyc (Hons)

Supervisors:

Dr Leonie Miller

A/Prof Steven Roodenrys

A thesis is presented as part of the requirement for the award of the degree:

Doctor of Philosophy (Psychology)

This research has been conducted with the support of the Australian Government Research and Training Program Scholarship

The University of Wollongong

School of Psychology

March 2023

Certification

I, Maryann Barrington, declare that this thesis, submitted in fulfilment of the requirements for the award of Doctor of Philosophy (Psychology), in the School of Psychology, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

Maryann Barrington

30th of March

Acknowledgements

First, I would like to acknowledge and thank my mum, Dianne, for always supporting and encouraging me through life regardless of what decisions I make, and for believing in my ability. You've been a perfect role model of finding a way to overcome any adversity life throws at them and getting on with the job.

I'd also like to thank my supervisor Leonie, who has been a reliable source of calm, kindness, support, and guidance. I have greatly appreciated your optimism and ability to find a solution or new way to look at something throughout the endeavour of this thesis. I'm also grateful for the belief you've had in me, as it made it easier to push through and know there'd be a way to work it out when things were looking grim.

To my dog, Sriracha, thank you for keeping my feet warm when you slept under my desk and providing me with thousands of reasons to distract myself when I really shouldn't have. Even a stressful day isn't that stressful when there's a dog to run around with at the end of it. And also to my partner Adam for always being up for a late night snack run, and having selective amnesia to the many times I had very dramatic stress-induced breakdowns.

I'd also finally just like to thank all my friends who were a constant stream of relief, humour, happiness, and reassurance. I'm lucky to have found such wonderful people who have made this process that little bit easier. Thank you for being understanding and forgiving of the many the times when I was an asocial cave gremlin who hardly left my desk, and thank you for being available whenever I needed to take a break and reset.

COVID-19 Impact Statement

During candidature, both the COVID-19 pandemic and legislative health and social responses to the pandemic resulted in impacts to the direction and completion of the current thesis. Of most impact, social distancing policies meant that data collection was not able to be conducted using face-to-face/in the laboratory collection methods. For Study 1, this resulted in Experiment 2 having to transition to online data collection after collecting face-to-face for Experiment 1. Unfortunately, a substantial amount of work had been undertaken to begin face-to-face data collection for Study 2, which subsequently had to be abandoned when restrictions were implemented. Effort had to be redirected to placing the study online, beginning data collection from scratch, and trying to monitor and ensure data quality as much as possible. As such, all three studies included in this thesis utilise online and remote data collection methods with efforts to ensure quality of the data collected. This also meant that changes in original research questions and study designs also had to be undertaken. Namely, while the initial research plan included laboratory-based tasks and data collection for Study 3, this study was redeveloped as a way to try to overcome remote data collection limitations by investigating the construct of interest (task-unrelated thought) using experience-sampling methods.

Preface

At the time of submitting this thesis the content of Study 1 has been accepted for publication as a manuscript in *Psychology of Consciousness: Theory, Research, and Practice.* Study 3 has been published in *The Journal of Cognitive Psychology*.

Abstract

Mind wandering is a ubiquitous experience, which encompasses many different types of thought. Task-unrelated thought (TUT) is a commonly studied type of mind wandering and refers to thoughts which occur during the completion of an ongoing task, but which are unrelated to that ongoing task. Importantly, these TUTs can be engaged either intentionally or unintentionally and there is a growing body of evidence which documents and supports these types of TUTs as being meaningfully different in terms of their underpinning mechanisms, their phenomenological experience, and their outcomes. It is necessary to continue to study and document their differences, as this may assist in further understanding some of the more ambiguous or conflicting findings from TUT literature. Consequently, this thesis aims to measure and investigate differences between intentional and unintentional TUTs across three areas of interest: task context, cognitive ability, and social functioning. Examination of the variable of intention in these areas may elucidate apparent contradictory observations within them. In addition, this thesis will investigate TUTs both in the laboratory and in daily life, to contribute to an understanding of intentional and unintentional TUTs across a broader scope of situations. In doing so, this thesis supports existing arguments that intention should be explicitly considered in mind wandering theory, in order to better predict and account for the occurrence and consequences of TUTs.

Study 1 investigated how the frequency and correlates of intentional and unintentional TUTs differ between sustained attention and working memory updating tasks. The frequency of overall TUTs have been found to depend on both the difficulty *and* type of task engaged. This study aimed to investigate how different types of tasks may benchmark ease and difficulty and in turn have differential impacts on intentional and unintentional TUT rates. Working memory capacity (WMC), motivation, and perceived difficulty were also measured to better understand i) how cognitive and non-cognitive factors are associated with each type of TUT rate, and ii) whether the influence of cognitive and non-cognitive factors on TUT rates differ between task contexts. Experiment 1of Study 1 found that intentional TUTs were more common in the sustained attention task whereas unintentional TUTs were more common in the high load working memory task. These tasks were also rated by participants to be the ‘easier’ and ‘more difficult’ tasks respectively.

Experiment 2 of Study 1 further investigated how task characteristics influenced TUT rates by modifying features of the sustained attention task to be less monotonous. Experiment 2 found that

intentional TUTs decreased in the modified sustained attention task, supporting claims that monotony is an important factor for intentional TUT rates in certain task contexts. In addition, Experiments 1 and 2 found that WMC was associated with unintentional TUT rates in a number of tasks, whereas intentional TUT rates did not have any association with working memory. Instead, motivation was more consistently associated with intentional TUT rates, although in some tasks motivation also related to unintentional TUT rates. Altogether Study 1 indicates that intentional and unintentional off-task episodes are important diagnostic categories of TUTs in different task contexts, and the variables associated with these TUTs are not identical across all tasks. This then implies that their underpinning mechanisms are also distinct.

Study 2 further sought to understand how cognitive ability is associated with intentional and unintentional TUT rates. A number of mind wandering theories refer to the role of 'executive control of attention' in either inhibiting or sustaining mind wandering, yet there is little evidence for which executive processes in particular might be involved. Using a recent framework for executive control in complex cognitive abilities, Study 2 employed structural equation modelling (SEM) to observe how intentional and unintentional TUTs are associated with process-general maintenance and disengagement abilities. Study 2 found that both intentional and unintentional TUTs were associated with the ability to maintain information in working memory and avoid distractors, however neither had an association with the ability to disengage from information (at least in the context of the sustained attention task utilised). In addition, post-hoc analyses found that working memory ability was uniquely associated with the experience of fewer emotional and prospective unintentional TUTs. Findings from this study differ to those in Study 1 (which did not find any association between intentional TUTs and WMC), therefore highlighting the complicated nature of associations between TUTs and cognitive ability.

Finally, Study 3 investigated roles of the intentionality of TUTs in daily life using a combination of experience-sampling methods and multi-level model data analysis. Although this study was conducted during initial lockdown measures undertaken in Australia as a response to COVID-19, nonetheless Study 3 aimed to build on arguments that TUTs (and other types of mind wandering) may have an important function as a type of social cognition. In this study intentional and unintentional *social* TUTs were documented by participants (i.e., TUT content involving other people), who answered a number of questions regarding the content and emotional outcomes of their daily social TUT episodes. Participants also completed questionnaires measuring schizotypy and loneliness, to further understand how personality may influence the phenomenological experience of TUTs. Intentional social TUTs were found to have more constructive social content, including being more positive, realistic, constrained, and future-focussed, when compared to unintentional TUTs. In addition, intentional TUTs tended to have more constructive problem-solving content (i.e., being more approach-based and featuring positive resolutions to social dilemmas) and tended to predict greater post-TUT positivity and lower post-TUT loneliness. Interpersonal schizotypy was associated with greater experiences of daily unintentional social TUTs, as well as having content which tended to be more fantasy-prone, less focussed on self-concept, and more avoidance-based when considering an interpersonal dilemma. Trait loneliness tended to be associated with content that was less positive, more constrained, and more prospective. These results support both differences between intentional and unintentional TUTs outside of laboratory contexts, and arguments that TUTs are not innately harmful but may confer benefits in certain circumstances. Results also indicate that individual differences in personality can influence the types of TUTs one may be prone to experiencing. However, reiterating the social distancing and lockdown context of these results, they may also reflect social TUT processes during particularly lonely or isolated times rather than during more typical contexts of individuals daily lives.

Overall, the current body of work further demonstrates that intentional and unintentional TUTs can differ in associated mechanisms, phenomenological experience, and socio-emotional outcomes. In addition to replicating past findings, this thesis documents novel differences between each type of TUT both in laboratory contexts and in daily life, which together reiterate the call to explicitly delineate the role of intention of an off-task thought in theory and empirical study. Accordingly, theories of mind wandering which are more nuanced and flexible in their approach to the mind wandering construct will be better placed to account for its occurrence and impacts across circumstances and individuals.

Table of Contents

List of Figures

List of Tables

Table of Abbreviations

ACN	Anti-Correlated Network
ADHD	Attention Deficit/Hyperactivity Disorder
CRT	Choice Reaction Task
DMN	Default Mode Network
EEG	Electroencephalography
ERP	Event-Related Potential
ESM	Experience-Sampling Method
FPN	Fronto-Parietal Network
Gf	Fluid Intelligence
ICC	Intraclass Correlation Coefficient
LTM	Long Term Memory
mPFC	Medial Prefrontal Cortex
MRI	Magnetic Resonance Imaging
MRT	Metronome Response Task
MW-D	Mind Wandering Deliberate
MW-S	Mind Wandering Spontaneous
OCD	Obsessive-Compulsive Disorder
PCC	Posterior Cingulate Cortex
PVT	Psychomotor Vigilance Task
PWW	Puzzle of the Wilful Wandering
RT	Reaction Time
SART	Sustained Attention to Response Task
SEM	Structural Equation Modelling
SPQ	Schizotypal Personality Questionnaire
STM	Short Term Memory
TUT	Task-Unrelated Thought
ULS-8	UCLA Loneliness Scale Short Form
WMC	Working Memory Capacity

Chapter 1: Overview of Thesis Aims and Structure

1.1 Thesis Background and Motivations

The ability to maintain attention on an ongoing task and avoid or inhibit external and internal distractions is a critical attribute of a functioning cognitive system. Despite this, up to 50% of daily thought can be categorised as 'mind wandering' (Killingsworth & Gilbert, 2010). According to the family-resemblances framework (Seli et al., 2018a) mind wandering is an umbrella term encompassing a range of cognitions which have both overlapping and non-overlapping features, such as daydreams and unconstrained thoughts. Most commonly, "mind wandering" has been used to refer to self-generated task-unrelated thoughts (TUTs) (Stawarczyk et al. 2011), which often by their nature distract from the performance of an ongoing (usually external) task. It is this variant of mind wandering which is the focus of the current thesis. The negative impacts of TUTs on the performance of cognitive tasks in the laboratory (Kane & McVay, 2012) and on mood (Killingsworth & Gilbert, 2010), driving (Yanko & Spalek, 2014), reading comprehension (Feng et al., 2013), and classroom learning (Was et al. 2019), have been well documented in the literature. Conversely potential benefits of certain forms of mind wandering for creative thinking (Agnoli et al. 2018), autobiographical planning (Baird et al., 2011), social functioning (Poerio & Smallwood, 2016), and problem-solving (Baird et al., 2012 but see Murray et al.,2021), have also been observed. Adding to the ambiguity of the nature and causes of TUTs, these thoughts have been documented to both increase (Feng et al., 2013) and decrease (Rummel & Boywitt, 2014) with task difficulty, often depending on the type of task being performed, and have been associated with both cognitive (e.g. attention control, working memory) (Robison & Unsworth, 2018; Robison et al., 2020) and non-cognitive (e.g. personality, mood, motivation) (Kane et al., 2016; Robison & Unsworth, 2018) mechanisms. In light of this complex pattern of findings, there is ongoing theoretical debate regarding the underpinning processes that lead to TUTs, as well as their subsequent functional or dysfunctional outcomes.

Initially there were two key accounts for TUTs. Proponents of an executive resources (or resource competition) hypothesis argue that mind wandering involves the employment of cognitive resources to both create and maintain an internal stream of thought. This viewpoint states that TUTs are in direct competition for the same executive resources needed to complete a given ongoing task (Smallwood & Schooler, 2006). The executive resources hypothesis aligns neatly with findings that TUTs increase in easier task conditions (Rummel & Boywitt, 2014; Teasdale et al., 1993; 1995) (where presumably there would be excess resources to do so) and are inversely associated with motivation (Seli et al., 2019a). Alternatively, those arguing for an executive failure (or control failure) viewpoint of mind wandering propose that TUTs result from failures in executive attention and as such do not result from the allocation of executive resources but rather a failure to maintain attentional focus on a task (McVay & Kane, 2010). This perspective is able to account for increases in TUTs during difficult tasks (where more control failures are likely to occur), as well as the commonly observed inverse association between TUTs and cognitive ability (e.g. Robison & Unsworth, 2018; Soemer & Schiefele, 2020).

Despite occasional attempts in the literature to place these two explanations in competition, it is increasingly evident from the conflicting pattern of findings that both theories make useful arguments for understanding the occurrence and consequences of TUTs across the many varied circumstances in which they arise. Demonstrating this point, the family-resemblances framework argues that depending on the variety of mind wandering in question, and the context in which it occurs, different theories will be best suited to account for these phenomena. Correspondingly, many emerging perspectives take into consideration the changing nature of *both* cognitive and non-cognitive determinants of mind wandering across varying contexts, which is likely to provide a fuller account of TUTs. This is important as it acknowledges the limitations that arise in homogenous conceptualisations of mind wandering, and offers a more nuanced understanding and account for the cognitive phenomena which fit under this umbrella term. That is, these approaches acknowledge that both mind wandering and TUTs can fluctuate along a number of dimensions, and different types of TUT may occur, with each underpinned by different mechanisms. In line with this approach, the current body of work focuses on the dimension of the intention with which TUTs are engaged (Seli et al. 2016a; 2016b; 2019a).

Intentionality refers to the deliberateness of a mind wandering episode. Intentional episodes of mind wandering involve deliberate shifts of attention away from the task at hand, while unintentional episodes are spontaneous and characterised by the capturing of attention by some (often internally cued) distracting thought. Current evidence suggests that these two forms of off-task thought differentially relate to measures of executive control and motivation, as well as task context (Seli et al., 2019a). The pattern of associations for each type of mind wandering suggests that it may be intentional TUT episodes which reflect the purposeful use of executive resources to engage in such thoughts (Seli et al., 2016a). By extension, these purposeful mind wandering episodes may result in more functional uses of TUTs for planning or problem-solving. Conversely, unintentional TUTs appear to have a stronger inverse relationship with cognitive abilities such as working memory capacity (WMC) (Robison & Unsworth, 2018), suggesting it may be the result of failures to maintain attention toward the task. Working memory capacity is a measure which reflects an individual's ability to simultaneously hold and manipulate information in mind (see Chapter 3 for further discussion). Unintentional TUTs may also be experienced as more intrusive and negative by the individual due to their uncontrolled nature. In consequence, these differences in determinants and outcomes for different forms of TUTs have motivated theoretical approaches which acknowledge the diverse nature of mind wandering, and in so doing resolve apparent contradictions. This includes the context-regulation and content-regulation hypotheses (Smallwood & Andrews-Hanna, 2013) (which argue that the frequency, nature, and consequences of mind wandering are dependent on when these thoughts occur and their characteristics respectively), as well as resource allocation frameworks (Thomson et al., 2015; Randall et al., 2019; 2022) (which argue that mind wandering reflects the redistribution of attentional resources through cognitive-motivational processes).

While there is growing interest in the differences between these types of TUTs, intention is not yet widely measured in research (although efforts to do so are increasing) and is still overlooked in theory (Seli et al., 2015b). This thesis aims to extend upon growing empirical evidence demonstrating the utility in measuring the intention of a TUT episode. To do so, a body of work is undertaken which documents whether observing differences in associations between intentional and unintentional TUTs can assist in understanding some of the seemingly ambiguous findings which have appeared in the literature. Specifically, findings regarding how TUTs relate to task context and difficulty, how they relate to cognitive and non-cognitive mechanisms, and whether they are helpful or harmful in daily functioning, are documented in this thesis and support the call for the explicit integration of intention into future theory and prediction.

These studies will assist in resolving often difficult or contradictory findings in the literature by highlighting the nuanced and heterogenous nature of mind wandering as a construct. That is, by acknowledging during both the design and interpretation of research that mind wandering is associated with cognitive and non-cognitive variables, that it can take different forms, and that it is often influenced by the context in which it occurs, this allows researchers to better understand and predict the frequency, content, and outcomes of different types of TUTs across task environments. These findings also strengthen arguments by the family-resemblances framework that researchers must be clear on the type of mind wandering they are studying in order to accurately classify and interpret phenomena. The present work draws upon several theoretical accounts to inform, design, and interpret the patterns of findings observed in empirical work. Specifically, the executive control failure, executive resource, resource allocation, content- and context-regulation hypotheses influenced both the design and interpretation of the studies included in this thesis.

1.2 Structure of Thesis Chapters

Chapters 2-10 of this thesis will be structured as follows; Chapter 2 provides an overview of the history, definition, and measurement of mind wandering in general, and TUTs specifically. The aim of this chapter is to provide a framework of understanding for how mind wandering and TUTs are conceptualised, and a justification for how they will be measured in this thesis. Following this, Chapter 3 outlines and describes the cognitive architecture of working memory and executive attention, as these are commonly used constructs for understanding the cognitive mechanisms of TUTs. Specifically, Chapter 3 will provide an outline of the concepts of working memory and working memory capacity (WMC), how WMC relates to attention control and executive processes, and the significance of this association for understanding the occurrence of TUTs. This chapter will also present the diversity and ambiguity of what is encompassed under 'executive processes' and the implications of such ambiguity for understanding the specific mechanisms involved in TUTs.

Chapter 4 considers the current accounts of mind wandering. In particular, discussion of the executive resources or resource competition, executive control failure, content and context-regulation hypotheses, as well as resource allocation frameworks, is presented. This chapter also highlights ongoing debates and key findings in the literature, with a consideration of how each theory can (or cannot) account for specific findings. In particular this chapter will review findings of both cognitive and non-cognitive mechanisms associated with TUTs, the relationship between the frequency of TUT episodes and task contexts, and helpful and harmful outcomes of off-task thoughts. Chapter 5 then introduces the difference between intentional and unintentional TUTs and discusses the separable links to the other variables discussed in Chapter 4 (i.e., associations with cognitive and non-cognitive abilities, task context, and helpful or harmful outcomes). This chapter again focuses on the limitations of the explanatory power of theories as they currently stand in accounting for variable findings, and describes how intention can be included to better integrate theory with the observations in the literature.

In the final review chapter, Chapter 6 will summarise the argument of the current thesis that intentional and unintentional TUTs are anticipated to reveal different relationships with key variables of interest outlined in prior chapters. By documenting cross-domain differences in each type of TUT, this thesis will contribute to the growing argument that intention should be explicitly considered as a key variable in future theories of mind wandering to facilitate a more nuanced and satisfactory understanding of TUTs. This chapter will also summarise the aims of the studies included in this thesis, and present the associated research questions.

Chapters 7-9 will then present the studies of this thesis. Study 1 contains two experiments which are presented in Chapter 7. These experiments were motivated by conflicting findings that TUTs both increase and decrease with task difficulty and/or complexity. In Study 1 the aim was to compare the relationship of intentional and unintentional TUT frequency with cognitive ability and motivation during a sustained attention (i.e., the sustained attention to response task or SART) and working memory updating (i.e., the *n*-back) task, in order to observe how different task characteristics influence these off-task thoughts and their associations. In these experiments perceived task difficulty was also measured in order to document the association of subjective appraisals with TUTs in different tasks, and expand the knowledge of non-cognitive determinants of TUTs. These experiments make two contributions: i) the documentation of differences between intentional and unintentional TUTs when directly comparing two commonly used tasks in the literature, and ii) investigating how cognitive ability, motivation, perceptions of tasks, and task characteristics can differentially influence TUT rates.

Study 2, presented in Chapter 8, utilises a new framework of executive functions (introduced in Chapter 3) which differentiates between the cognitive abilities of maintenance and disengagement (Shipstead et al., 2016). The aim was to further explore cognitive determinants of intentional and unintentional TUTs, and investigate whether specific types of executive processes had unique associations with each type of off-task thought. The rationale for this study is based in arguments that TUTs are associated with "executive function", yet "executive function" is often ambiguously defined and encompasses a number of mechanisms. There are a limited number of studies investigating the specific types of executive functions that may be involved in TUTs, and even fewer studies documenting differences in the association between specific executive functions (beyond 'working memory') for intentional and unintentional TUTs. Study 2 measured TUTs during a sustained attention task as well as measuring WMC, fluid intelligence, and updating ability and used structural equation modelling (SEM) to observe the associations between these variables. A series of post-hoc analyses also investigated how the valence and temporality of intentional and unintentional TUT episodes may further reveal dissociations in underpinning mechanisms. Results from this study are discussed in light of common theoretical assumptions regarding the mechanisms underpinning 'mind wandering' and the conditions under which these mechanisms differ in their associations or their magnitude of associations in certain tasks.

The final study in Chapter 9 utilises an experience-sampling method and multi-level modelling data analysis method to observe state-level *social* TUT episodes in daily life (i.e., TUTs involving other people). The aim was to understand how such episodes differ in content and outcomes based on their intention, as well as to determine relationships with two personality variables associated with social cognition – namely, schizotypy and loneliness. These personality variables were measured because they offer a means of exploring other types of non-cognitive associations of intentional and unintentional TUTs. The motivation for this study was twofold; i) daydreaming literature has posited that certain types of mind wandering may be socially functional in daily life, and ii) there is ongoing debate regarding whether TUTs are helpful or harmful. The results of this study offer insights into how intention can be an important determinant of socially functional outcomes of TUTs.

Subsequent to the presentation of these three studies, Chapter 10 presents the General Discussion of the results, including a synthesis of the key findings with both the overarching aims of the thesis as well as the current literature and theories in this area. That is, Chapter 10 discusses how these results provide further evidence that intentional and unintentional TUTs exhibit meaningful cross-domain dissociation with key variables and therefore form an important consideration in future theory building. This General Discussion also highlights how including intention in the measurement of TUTs can resolve commonly conflicting or debated associations between TUTs and task context, cognitive abilities, and functional outcomes. Finally, Chapter 10 expands on consistencies and inconsistencies between each study and identifies and generates ideas for future research on the basis of the results presented.

Chapter 2: The History, Definition, and Measurement of Task-Unrelated Thought

2.1 Introduction

This chapter begins by providing a working definition and overview of mind wandering as a general construct as well as TUTs specifically. It then discusses the measurement of TUTs and issues in current measurement and methodology. The aim of Chapter 2 is to provide contextual background for the literature within which this thesis is situated, while explaining and justifying the measurement methods that are used in the studies of this thesis. Mind wandering is a relatively young area of research in psychology – while studies have aimed to investigate types of mind wandering as early as the 1970s, research interest was scant until the beginning of the 2000s (Callard et al., 2013). Given the rapid and recent advancement in the area, it is important to clearly lay out how this thesis will be defining TUTs, and the historical and theoretical contexts in which this definition was developed.

2.2 Defining Mind Wandering and Task-Unrelated Thought under a Family-Resemblances Framework

Generally speaking, attention can be conceptualised as the direction of our cognitive resources toward a stimulus, either internal or external, in order to process information (Mancas et al., 2016). Mechanisms underpinning how we switch our attention from one external stimulus to another, and how our attentional state may fluctuate from stimulus to stimulus, and over time, have been of interest in psychology since its conception. This is perhaps best demonstrated by William James' (1890) definition of consciousness (which James equated with attention) as a "*stream of thought*" (p.239) that has both a "*jointing and separateness among the parts*" (p. 239). Yet the processes underpinning the switch between internal and external attention have, until recently, been overlooked. The attentional switch from engagement in an external task, toward internal streams of thought unrelated to that task, is often termed *"mind wandering".*

Defining mind wandering can be a difficult endeavour, because it has been given a number of definitions (both operationally and generally) depending on the theoretical framework and empirical methodology in question (McVay & Kane, 2010; Smallwood & Schooler, 2006; Stawarzcyk et al., 2011; Seli et al., 2018a). Yet clarity of definition is especially important given that there are several ways for researchers to define mind wandering, as well as differences between folk theories of mind wandering and researcher definitions (Irving et al., 2020). While a common definition of mind wandering in the extant literature is thought that is unrelated to the task - task-unrelated thought (TUT) (Giambra, 1989; McVay & Kane, 2010; Murray et al., 2020; Smallwood et al., 2008; Smallwood & Schooler, 2015; Stawarczyk et al., 2011) - mind wandering has also been investigated as unguided thought, spontaneous thought, daydreaming, and task-free thought (among other conceptualisations).

Clearly then, there is much heterogeneity in the construct of mind wandering, and one common criticism levelled against the field is that the diversity included under the umbrella of 'mind wandering' leads to difficulties and confounds when comparing studies which use the term. Addressing this criticism, the family-resemblances framework of mind wandering (Seli et al., 2018a) aims to capture the heterogeneity present in the field and argues that research can move forward in investigating this plural construct. It proposes that mind wandering is a 'natural kind' similar to other constructs (like cognition, mindfulness, intelligence, and memory) and accordingly different definitions and candidates for mind wandering can be seen as complementary rather than competitive forms of the construct. To describe a construct as a 'natural kind' is to acknowledge that there can be a number of candidates which fit under the construct, and that there is a graded membership whereby some candidates may be more 'prototypical' exemplars than others. Problematic overgeneralisations can therefore be overcome if researchers clearly define the specific class of mind wandering they are investigating, and limit conclusions to that particular exemplar of mind wandering (Seli et al., 2018a). In this way, heterogeneity is not a limitation nor weakness but simply a reflection of the many overlapping forms that mind wandering can take.

Adhering to this view, the studies of the current thesis concern the aforementioned definition of mind wandering as 'task-unrelated thought' (TUTs). This thesis aims to measure and observe mind wandering which occurs during engagement with an external task, and of which the content is unrelated to that external task and its stimulus environment. As will be further outlined in Chapter 5, this thesis neither assumes that TUTs are innately intentional nor unintentional, but rather that intentionality is an important dimension associated with possible differences in the underpinning mechanisms, content, and outcomes of TUT episodes. This thesis also acknowledges that TUTs themselves can vary in form and content and, where appropriate for research goals, will consider these within-TUT differences. Section 2.4 further elaborates upon the task-unrelated definition of mind wandering in the context of mind wandering measurement, as different approaches to measuring the construct have also influenced its definition.

2.3 The History and Meta-Theory of Mind Wandering Methodology

Mind wandering research has only recently gained impetus, with a majority of related articles being published from the 2000s onward (Callard et al. 2013, Smallwood & Schooler, 2015). The lack of research prior to the 21st century has been attributed to the scientific zeitgeist of the behaviourist era, which regarded the empirical study of consciousness and internal cognitive processes as lacking measurement rigor (Skinner, 1953; Watson, 1913). Up until the 1970s psychology was dominated by the restrictive meta-theory of behaviourism as pioneered by Watson (1913) and Skinner (1953). This meant that only behaviourist methodology was accepted as a legitimate and rigorous form of psychological research in many universities and peer-reviewed journals. Psychology was restricted to the study of observable and objectively measurable actions (Callard et al., 2013) and research on self-generated mental activity was disregarded during this time. However, in contrast to these early, dismissive attitudes towards internal cognitive processes, contemporary psychology acknowledges their importance to psychological functioning and the need to include them in the explanation of phenomena, in keeping with *the cognitive revolution (*Miller, 2003; Sperry, 1993*).* That is, internal mental operations are not only accepted as explanations for the relationships between stimuli and responses, but also generally regarded as a central component for a more complete understanding of human psychology.

Following the historical and meta-theoretical shift of the cognitive revolution, one of the earliest attempts to measure mind wandering was undertaken by Giambra (1989). This study investigated age-related effects of mind wandering, using a probe-caught method, where a participant is asked to provide intermittent report of the content of their cognition during performance of a task. Such a method is now widely used throughout TUT research [see Section 2.4.1], although much work has been done since to modify probes (e.g. in their timing, quantity, and wording) to better capture the construct of interest. The following sections overview methods of measuring mind wandering, in particular the probe-caught method as it is most relevant to the current thesis, while acknowledging issues and limitations in self-report measurement and methodology.

2.4 Self-Report Measurement of Task-Unrelated Thoughts

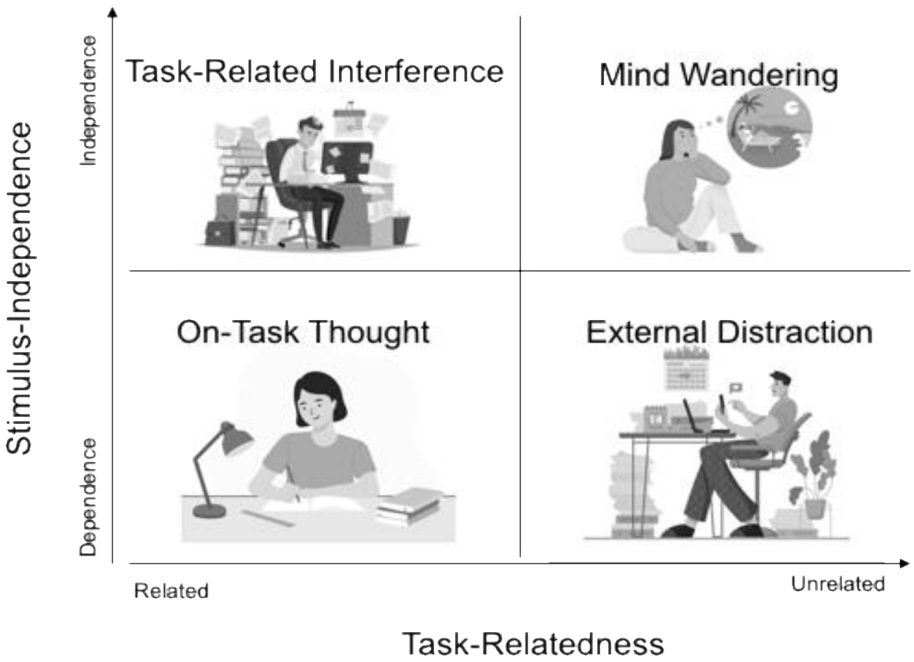
2.4.1 Probe-Caught Method

The probe-caught method is one of the most commonly used measures of TUTs (Kane et al., 2017; McVay & Kane, 2009; Seli et al., 2018c; Stawarczyk et al., 2011). It involves asking participants to perform an external task (e.g., a working memory, reading comprehension, or sustained attention task), during which participants are randomly presented with thought-sampling probes. These probes often take one of two forms: forced-choice or open-ended. Open-ended response options allow the participant to write down the contents of their thought prior to the probe, and the investigators subsequently categorise these reports according to their dimensions of interest (e.g., on/off task, prospective/retrospective, positive/negative valence). An issue with this method is that researcher bias can influence the categorisation of the mind wandering reports, and in addition categorisation can be time-consuming and inefficient in certain contexts (e.g., when a high number of probes are taken from a large sample of participants).

In contrast, forced-choice probes provide a list of pre-defined options for thought content which participants must select from. There is no standard forced-choice probe format, and in the literature there is diversity in the options provided, making studies difficult to compare and synthesise. For example, some probes will only provide a dichotomous on-task or off-task response option. Others may differentiate between type of off-task thought (e.g., prospective or retrospective off-task thought), or may differentiate between off-task thought, external distraction, and task-related interference. Stawarczyk et al. (2011) demonstrated the issue of overly simplistic and confined probe-response options, and developed a classification system that attempts to more accurately measure TUTs (see Figure 1). Under this taxonomy, thoughts during completion of an external task can vary along two key dimensions; task-relatedness and stimulus-independence.

Figure 1

Stawarczyk et al.'s (2011) Taxonomy of Thought Content During Task Performance



Note. This figure illustrates the four categories of thought content as identified by Stawarczyk et al. (2011) when completing an external task. These four categories vary along the two dimensions of stimulus-relatedness and task-relatedness. On-task thought refers to thoughts which are linked to task stimuli and related to task completion. Task-related interference refers to thoughts which are related to the task, but not necessarily tied to a stimulus (e.g., thoughts about how well the individual believes they are doing, how long the task is taking, how interesting or boring the task is deemed to be, among other types of thought). Mind wandering is both unrelated to the task and stimulus environment. External distraction is unrelated to the task but tied to another stimulus in the environment (e.g., a phone ringing, someone speaking, birds chirping).

This classification system allows researchers to differentiate the TUT variety of mind wandering from external distractions (which are task-unrelated but stimulus-dependent) and task-related interference (which are task-related but stimulus-independent), both of which have shown separable relationships with attention and behavioural measures when compared to TUTs. In particular, external distraction is usually defined in the literature as the shift in external attention from one stimulus to another (Unsworth & McMillan, 2014), contrasting with TUTs as a shift from an external task toward internal mentation. Research has established that while these two attentional shifts have similar correlates and consequences, and that one may lead to another, they nonetheless have unique variances (Casner & Schooler, 2015; Unsworth & McMillan, 2014). Additionally, Stawarczyk et al. (2011) observed that during a sustained attention task, self-reported task-related interference were preceded by equal reaction times (RT) to task-related thought reports, whereas TUTs tended to be preceded by slower RTs. Task-related interference is not equivalent to task-related thought either, as this same study found that where on-task thought had stable RTs, there was more variability in external distraction, TUTs, and task-related interference.

Since this initial work, the tendency amongst researchers is to argue that at minimum, participants should be given the options of on-task thought, off-task thought, external distraction, and task-related interference (Robison et al., 2019; Stawarczyk et al., 2011). As outlined in Figure 1, on-task thought refers to thoughts about the task at hand and how one should complete it – the opposite, in a way, to mind wandering. Off-task thought refers to task unrelated thought (i.e. mind wandering), which differs from external distraction (being distracted by external stimuli in the environment), and stimulus-independent task related interference, which refers to evaluative thoughts about the task that are independent of task stimuli (e.g. thinking about how well one is performing, how long the task is taking, or if the task is enjoyable). Consequently, this classification system will form the basis of the probes used to measure mind wandering across the studies included in this thesis, due to its ability to differentiate between categories of thought with established differences in associated mechanisms and outcomes.

2.4.2 Experience-Sampling Methods

Experience-sampling methods (ESM) sample the contents of thoughts in daily life (McVay & Kane, 2009; Poerio et al., 2016), although they can also be applied in laboratory studies (Kane et al., 2017). In ecological studies assessing mind wandering in daily life, a participant may download an app or other form of electronic probe, which will probe their current or most recent mind wandering experience several times a day, over a set number of days. Experience-sampling methods provide greater insight into the content and phenomenological experiences of different types of mind wandering. Researchers can ecologically measure the temporality, intention, valence, realism, and constraint of mind wandering episodes among other dimensions. Promisingly, McVay and Kane (2009) compared daily life mind wandering using ESM with laboratory TUTs using probes in a SART and found that mind wandering propensity was stable across the two contexts. That is, participants who mind wandered more frequently during the sustained attention task in the laboratory also tended to mind wander more during daily life. Nonetheless, tasks engaged during daily life are innately different from those performed in laboratories

(Murray et al., 2020), and the available environmental cues that may trigger mind wandering [see Chapters 3 and 4] are likely to be richer and more personally salient outside the laboratory. As such, it is critical to observe mind wandering both in the laboratory and in daily life to more fully understand its mechanisms and consequences.

The multi-dimensional attributes of ESM also allow for a more flexible perspective of mind wandering. Rather than simply conceptualising mind wandering as on-task or off-task thought, researchers can investigate how the intention, valence, and temporal nature of mind wandering (among countless other potential dimensions of interest) influences (dys)functional outcomes such as daily mood.

2.4.3 Self-Caught Reports and Retrospective Questionnaires

In addition to probe-caught methods, researchers sometimes use self-caught reports. In this case an individual presses a key or button each time they catch themselves mind wandering. Nonetheless, this method is limited by the degree of meta-awareness of the participant regarding their mind wandering. There is also the possibility that requiring participants to monitor their own cognition results in an increase in mind wandering, as occurs in thought-suppression studies (e.g. Wegner, 1994).

Finally, retrospective reports involve a participant filling out a questionnaire or scale after a given task in order to provide a report on how often they estimate they were engaging in off-task thoughts during the task. An issue with these retrospective reports is that they are confounded with awareness/memory of mind wandering as they depend on the individual's ability to both accurately monitor and recall attention. Nonetheless, some researchers may opt for this measurement due to concerns that in-task probes interrupt ongoing task performance [although see Section 2.6 for contrary evidence], or because particular tasks may not easily lend themselves to having probes embedded within them. For example, Randall et al. (2019) used a retrospective questionnaire to assess mind wandering during a set of math tasks.

2.5 Limitations in Objective Measurement of Task-Unrelated Thoughts

Thought probe methods, while the most commonly utilised, are also heavily criticised due to their reliance on self-report and thus their susceptibility to subjective bias and other influences. Consequently, researchers will sometimes use a triangulation method which involves looking for concomitants among physiological, behavioural, and subjective data (Smallwood & Schooler, 2006). Behavioural indicators of TUTs during simple sustained attention tasks include increases in error rates (Mooneyham & Schooler, 2013; Robertson et al., 1997), anticipatory responses (Gouraud et al., 2018), response omissions (Gouraud et al., 2018), RT variability (McVay & Kane, 2009), and an overrepresentation of long RTs during self-reports of off-task thought (Leszczynski et al., 2017). Eye tracking studies have demonstrated reliable relationships between TUTs and divergent eye movements (Foulsham et al., 2013), greater pupil dilation (Franklin et al., 2013), and more frequent eye blinks (Smilek et al., 2010). Neurocognitive markers have also been a focus in research, with changes in electroencephalography (EEG) readings (Barron et al., 2011; Kam et al., 2014) correlating with self-reported off-task thought.

Together these behavioural and neurocognitive markers are argued to help validate subjective measures and further increase the ability to observe and understand mind wandering and its consequences in different contexts. Perhaps more to the point these methods also indicate that indirect markers could eventually be employed to measure TUTs without needing to rely on self-report or task interruptions by probes. However, these behavioural indices of mind wandering, such as quicker RTs to non-targets (Weissman et al., 2006) and more errors to targets (Mooneyham & Schooler, 2013), could also reflect different cognitive lapses or errors that are not necessarily TUTs. This is a ubiquitous issue with objective measurements in that different types of thought might not be uniquely indicated by some index; TUTs, task-related interference, mind blanking or zoning out could lead to similar changes in eye movement, RTs, and other related measures.

The relationship between objective and subjective measures also becomes circular as such bio- and behavioural markers are often used to cross-validate probe-responses and vice versa, and there have been failures in replicating some of the associations, particularly behavioural associations such as correlations with RTs (McVay & Kane, 2012) and errors (Thomson et al., 2013). A final drawback with objective measures is that at present they can only attempt to detect whether one is ‘on-task’ or ‘off-task’ and cannot tell us anything more about the nature of the mind wandering episode (e.g., its intention, valence, temporality). Noting the above - that work in this area is still early and is yet to fully resolve some uncertainties - this thesis will use both probe-caught and experience-sampling methods as is appropriate to study aims, to measure TUTs.

2.6 In Defence of Self-Report in the Probe-Caught and Experience-Sampling Methods

Just as current objective measures of TUTs have issues, self-report data have limitations. Namely, self-report relies on the participant’s capacity for accurate and reliable introspection. However, a common problem in a wealth of psychological literature is that self-report data cannot be taken at face value (Nisbett & Wilson, 1977) due to the potential for response bias to occur in participant responses to probes. For example, demand bias refers to participants responding based on their perception of task demands rather than as a reflection of the content of their thoughts prior to a probe. Accordingly, when a task is more difficult, a participant may report more TUTs because they perceive their performance to be worsening and as such use TUT reports as a means to justify this performance decline (Seli, et al., 2016a).

Vinski and Watter (2012) compared probe responses, during a SART, of participants who had completed an honesty prime with a control group. These authors correlated behavioural indices of RT and no-go trial accuracy with probe responses. They found that whilst there was no difference in RT and false alarm rates for the groups, the congruency between behavioural indices and self-report was higher for participants who had completed the honesty prime. That is, these participants were more likely to indicate their attention was off-task when they were exhibiting behavioural indicators of mind wandering. Such findings indicate that problems do exist within the probe-caught method whereby participants may provide misleading or untrue responses.

While these issues are of concern, there are also promising findings in relation to the use of thought probes as a measurement tool (Kane et al., 2021; Weinstein, 2018). For example, while some have questioned if the act of asking a participant whether they are mind wandering or on-task will influence participant performance on a task, Wiemers and Redick (2019) investigated whether the inclusion of thought probes influenced SART performance (selecting this task due to its widespread use for mind wandering research). They had a probe and no-probe condition and found no differences in SART performance as a function of the presence or absence of probes. Similarly, Varao-Sousa and Kingstone (2018) compared an ecologically valid self-caught probe condition to a condition with both self-caught and probe-caught measures. The aim here was to investigate if adding probe-caught measures influenced the self-caught behaviour. Again, results contradict the concern that thought-probes inflate or influence mind wandering rates.

There are also questions about whether TUTs should be measured as a dichotomous (on-task/off-task) or continuous (or Likert scale-type) variable, and whether the order of response options influences response behaviour. Reassuringly, Robison et al. (2019) found that there were no systematic effects of probe-framing (i.e. whether probes started with an on-task or off-task response option) on mind wandering rates in a SART. Providing further confidence in probe-caught methods, Schubert et al. (2020)

varied the frequency and framing of probes and found that associations between probe-caught mind wandering and performance on a SART, WMC, and trait-level questionnaire measures were not dependent on the variation of the probe-caught procedure used. Overall, it seems that well-designed self-report probes are capable of providing reliable data about mind wandering experiences in both daily life and laboratory tasks.

2.7 Neurocognitive Perspectives: The Default Mode Network

Although this thesis is not an investigation into the neural structures underpinning mind-wandering, a brief overview of the conceptualisation of mind wandering from neurocognitive literature is presented. Mind wandering was first linked to activity in what is known as the brain's "default mode network" (DMN) by Raichle et al. (2001). The DMN encompasses a network of brain regions, including the posterior cingulate cortex (PCC), the inferior parietal and lateral temporal cortices, the precuneus, and the medial prefrontal cortex (mPFC), which are active when the mind is not consumed with external tasks or demands (Christoff et al., 2009). This may account for the pervasive and frequent nature of mind wandering – because it reflects the activity of the "default" state of a mind "at rest" (i.e., in the absence of an ostensible to-be-performed task). Mason et al. (2007) propose that brain activity associated with mind wandering is a sort of psychological baseline that emerges when the brain is unoccupied, and which is suppressed during demanding task performance.

In contrast, during external task demands a different network of brain regions becomes active, comprising the lateral prefrontal and parietal cortex, otherwise known as the "task-positive" network (Fox et al., 2015). This is an anti-correlated network (ACN) as it is negatively correlated with activity in the DMN. Mittner et al., (2014) found that activation of the DMN was consistently higher and activation in the ACN was consistently lower in trials of a stop-signal task that were classified as off-task. Similarly, Zhou and Lei (2018) used a SART and found that negative activation in the DMN increased and positive activation in the fronto-parietal network (FPN) decreased during mind wandering episodes. That mind wandering has been reliably linked to the DMN is supportive of the possibility that off-task thought reflects a type of psychological baseline (or 'default mode').

Given the increases in activity in this network during self-reported off-task thought, self-generated thought, and daydreaming, it is likely that this network is reflecting a type of internally generated cognition. Therefore, one way to define and understand mind wandering is as a default state of self-generated cognition, which may occur at inappropriate times when cognition and attention should be focussed on external tasks. Nonetheless, this is not to say that all mind wandering is lacking goal-direction and is simply distraction [see Chapter 4]. While the DMN is occasionally referred to as the 'task-negative' network, such a title does not seem to be appropriate. This network has been linked to unconstrained and internally-focussed thoughts as well as more active goal-directed processes such as future planning and social cognition (Spreng et al., 2017).

2.8 Summary

To summarise, this thesis is measuring the task-unrelated thought (TUT) variety of mind wandering, and studies in this thesis will employ probe-caught and experience-sampling methods to measure TUTs. While there are often concerns about self-report measures in psychological sciences, prior research on the probe-caught method in the literature indicates it is a valid and reliable tool for measuring TUTs. Particularly when using probes which appropriately differentiate between TUTs and other types of thought (e.g. external distraction and task-related interference). With the definitions and measurements used in this thesis identified, the next chapter outlines the cognitive architecture of working memory and attention. These constructs feature in a number of theories of mind wandering and have influenced explanations regarding how TUTs are initiated and maintained in specific contexts.

Chapter 3: Working Memory and Executive Attention – The Cognitive Architecture of Task-Unrelated Thought

3.1 Introduction

This chapter provides a background of some of the cognitive architecture often invoked to explain the initiation and/or maintenance of TUTs (and from which much mind wandering theory has generally developed). Specifically executive functions, attention control and working memory are frequently measured constructs in the mind wandering literature. Here models of attention and working memory that have influenced theoretical developments in mind wandering are presented. In addition, remaining questions about the role of executive functions in TUTs are explored. Following this, a fuller discussion of mind wandering and TUT theory, as well as key empirical findings, are included in Chapter 4.

3.2 Working Memory and Executive Attention

Two key constructs cited by mind wandering accounts are executive control (or executive attentional control) and WMC, with the latter often being considered an indirect measure of the former (Engle et al. 1999). The construct of working memory originated within the short-term memory (STM) literature. STM was argued to be a simple unitary temporary memory system that could store and recall small amounts of information (Baddeley, 2007). However, STM could not account for broader and more complex functions such as reading, problem-solving, or reasoning. As such, working memory is a construct which encompasses higher order attentional control and information manipulation processes – that is, it was seen as responsible for both storing and manipulating information (Baddeley & Hitch, 1974). Over time, working memory became credited as the cognitive system that enables individuals to perform complex tasks such as speech planning (Kellogg et al., 2016; Martin, et al., 2014), reasoning (Gilhooly, 2004), problem-solving (Korovkin, et al., 2018) and reading (Nouwens et al., 2021) through the representation, maintenance, and manipulation of information. Importantly, working memory achieves this through controlled attention toward task-relevant goals and inhibiting task-irrelevant distractions.

An early and influential conceptualisation of working memory is the working memory model (Baddeley & Hitch, 1974), which aims to elucidate the *structure* of the working memory system. This model features domain-specific subsystems as well as a separate executive control system which interacts with, but is distinct from, long-term memory (LTM), the latter being a repository for learned knowledge. In contrast, alternative working memory models emphasise *functional* aspects of working memory, such as the control and allocation of attention resources (Atkinson & Shiffrin, 1968; Cowan, 1999; Engle, 2002**)** either as a separable system (Atkinson & Shriffin, 1968) or as activated LTM (Cowan, 1999; Engle, 2002). Regardless of theoretical position, one uniting thread is the agreement that working memory involves the simultaneous maintenance *and* processing of goal-relevant information. It is important to have a background understanding of working memory for TUTs, as most theories assume a role for attentional focus and information maintenance in inhibiting off-task thought and by extension most studies measure WMC as a reflection of this ability.

3.3 The Multicomponent Model

The model by Baddeley and Hitch (1974) guided earlier studies of mind wandering (Teasdale et al., 1993; 1995), although more recently broader working-memory-as-attention perspectives have shaped the literature. The multicomponent model features two domain-specific subsystems (a phonological loop and visuo-spatial sketchpad) and a domain-general central executive. The central executive is responsible for *attentional/executive control* and general storage mechanisms and as such is of most relevance to TUT literature. The central executive is hypothesised to involve a domain-general executive processing capacity that differs between individuals (which is now often referred to as WMC). However, what exactly is meant by *central executive* or *executive processes* is one of the more contentious issues, with no unanimous or explicit explanation being offered (Botvinick & Braver, 2015; Miyake et al., 2000, Miyake & Friedman, 2012) [see Section 3.6 for further discussion on this issue].

Baddeley (2000; 2007; 2012) argues that the central executive is principally responsible for the conscious control and coordination of tasks that require planning, decision-making, or problem-solving. The role of the central executive is aligned to four main candidate processes; this includes focussing attention, dividing attention between two concurrent tasks, switching attention, and integrating working memory and long-term memory (Baddeley, 2007; Baddeley & Logie, 1999). While the central executive remains the least defined structure in the multicomponent model (Baddeley, 1996), it is also the component with the greatest importance for the TUT literature. Particularly in light of its focussing function, which presumably involves the inhibition or avoidance of internally distracting thoughts.

The multicomponent model offered an important initial step in conceptualising a system for executive attention, which is considered to underpin TUT propensity in most theories (see Chapter 4). For example, Teasdale et al. (1993) adopted the multicomponent model to investigate mechanisms underpinning TUTs and found evidence for the central executive in the production of TUTs. They observed TUT rates when participants were asked to either shadow an auditory task or perform a recall task (which places greater demands on attentional control/the central executive). The recall task at slow presentation rates was observed to induce TUTs more than the shadowing task. In addition, faster presentation rates resulted in the task interrupting TUT production more than slower presentation rates. This demonstrates that tasks which place greater demands on the central executive due to their greater difficulty/cognitive load result in fewer TUTs – perhaps because there is a reduction in available attentional resources to engage in mind wandering while trying to perform the task. This is the earliest evidence for the role of the central executive (and as such for executive attention) in the production of TUTs.

A second study conducted a systematic investigation into the potential links between TUTs and the central executive and the two domain-specific subsystems (Teasdale et al., 1995). Across four experiments, dual-task conditions with verbal and visuospatial tasks as well as central executive tasks such as random number generation, while also measuring TUT production, were utilised. There was evidence that a domain-general capacity, rather than domain-specific components, was responsible for mind wandering production. These early works using the multicomponent model as a framework were a keystone for contemporary experiments investigating TUTs and their relationship to central executive attention abilities. Accordingly, the central executive (or executive attention) has been retained as an important factor in determining mind wandering during performance of an external task.

3.4 Working Memory as Attention

The history of executive attention research can be traced to two key origins. One of these is the testing Baddeley's (1974; 1996; 2000; 2012) theoretical claim about a central executive component. The other is the development of theories conceiving working memory to be the product of a domain-general attentional system (Cowan, 1999; Engle, 2002; Kane & Engle, 2003). These latter theories of working memory differ from the multicomponent model in one key, way; where the multicomponent model often emphasises the *structure* of the memory system, executive attention theories such as that of Engle et al. (1999, 2002) place importance on the *function* of working memory. The functional position is perhaps best encapsulated in the statement *"memory is an activity not a thing"* (Kane et al., 2008, p 4). Researchers who adopt this stance often emphasise the domain-general, rather than the domain-specific, aspects of working memory. That is not to say that these theories deny the existence of domain-specific processes but instead that they focus on the associations these general and specific capacities have with other cognitive abilities, and the implications of these associations for the general functioning of the cognitive system.

Kane et al. (2001) described their working memory model as a system where goal-relevant long-term traces were activated above threshold (also see Cowan 1988, 1995), and controlled attentional processes maintained these traces in consciousness. This controlled attention (akin to the central executive in many ways) is considered to be pivotal to the functioning of working memory, as it allows access to goal-relevant information and suppresses or blocks the access of task-irrelevant information to consciousness. There are two components to executive attention as it relates to WMC (Engle & Kane, 2004; Kane et al., 2007b): goal maintenance and competition resolution. Goal-maintenance refers to the processes that allow access to task-relevant information despite the presence of distractors (habit, environmental distractors, or – as is most central to this thesis – irrelevant thoughts). Competition-resolution on the other hand refers to the ability to inhibit or overcome interference from other irrelevant stimuli as they occur. In particular, the ability to overcome goal-inappropriate, stimulus-driven responses (McVay & Kane, 2012).

This viewpoint is important for understanding theories of mind wandering. For example, McVay and Kane (2010) propose that TUTs reflect attention control failures within such a system, so that irrelevant thoughts enter the working memory space and disrupt focus on an external task [see Section 4.3]. The argument follows that if the information activated in working memory is goal-relevant then we can predict participants will perform well on the ongoing task. However, if the set of activated information included irrelevant thoughts (i.e., TUTs), then the processing of these irrelevant thoughts would create a situation analogous to a divided-attention task. As a result, performance would decline, as attention is not focussed effectively on the designated task. This is corroborated by findings that TUTs are associated with performance impairments during a range of tasks including reading (Unsworth & McMillan, 2013), driving (Yanko & Spalek, 2014), and sustained attention (Thomson et al., 2015). In contrast, there are theories to suggest that executive attention is used to support and sustain TUTs in the working memory space. That is, TUTs are the result of allocating executive attention to the production and maintenance of task-irrelevant thoughts (Teasdale, 1993; 1995). These theories will be discussed further in Chapter 4, but the main consideration for now is that executive attention – and by extension the working memory space – are key to understanding how TUTs can occur (either as a result of failure or re-allocation of executive attention resources).

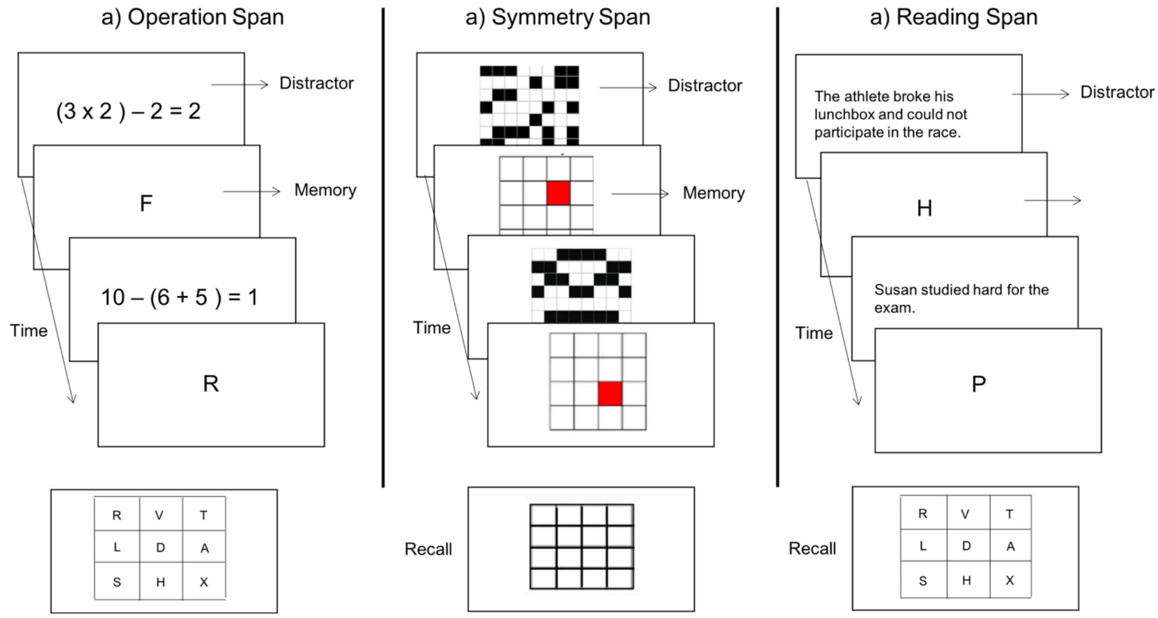
3.5 Measuring Working Memory Capacity

Thus far, this chapter has outlined how working memory is associated with executive attentional control and reviewed early research linking this executive attention control to TUTs. Given these inter-relationships, it has become common practice to measure WMC, an index of individual differences in the functioning of the working memory system which is assumed to reflect differences in attention control ability, in order to observe associations between WMC and TUT propensity (Jonkman et al., 2017; Soemer & Schiefele, 2020; Unsworth & McMillan, 2013). In doing so, researchers can further understand how executive attention influences TUT rates across task contexts and between individuals.

Working memory capacity is measured using complex span tasks, which have shown theoretically consistent associations with a range of cognitive outcomes including list interference in verbal fluency tasks (Rosen & Engle, 1997, but see Engle, 2018 for an alternative account), and inhibiting response competition from irrelevant target information (Conway & Engle, 1994). The complex span tasks traditionally used to measure WMC evolved from the simple span tasks used to measure STM. Simple span tasks involve presenting participants with lists of to-be-remembered stimuli (e.g. letters, words, digits, images) and asking them to immediately recall the list in serial order (i.e. in order from the first item presented to the last item). Complex span tasks extend on this paradigm with a test of the key distinction between STM and working memory. That is, these tasks challenge memory maintenance with the presentation of a second processing task. This processing task is presented in alternation with each memory item to be recalled in a trial, as illustrated in Figure 2.

Figure 2

Complex Span Tasks Used to Measure Working Memory Capacity



Note. This figure illustrates a range of complex span tasks that may be used to measure an individual's WMC. a) The operation span task involves the recall of a sequence of alphabetical letter stimuli. The presentation of these letters alternates with a simple arithmetical problem that provides a solution. The participant must decide whether the provided solution is true or false. Upon making the decision, the next letter in the sequence is presented. b) The symmetry span task involves presenting the participant with a matrix, in which a square will light up in red. The participant must remember and recall which squares lit up, and the order in which they lit up. This matrix sequence is interrupted by a symmetry decision distractor, whereby the participant is presented with an image and must decide whether the image is or is not symmetrical down the centre. c) The reading span task involves the presentation of a sequence of alphabetical letters which the participant must recall. This sequence is interrupted by a sentence that requires a logic decision. The participant must read the sentence and decide whether the sentence does or does not make logical sense.

Daneman and Carpenter (1980) originally developed the reading span task, which became one of the most widely used complex span tasks to measure WMC. The reading span task requires participants to read increasingly longer sets of sentences out loud (the processing requirement) while also being required to remember the final word of each sentence in the set for later recall (the storage requirement). In this way, the reading span task aligned quite neatly with the conceptualisation of WMC as a measure of an individual's ability to maintain attentional focus in the face of distraction. Reading span tasks have been linked to higher order cognitive functions assumed to require attentional control such as reading comprehension (Friedman & Miyake, 2004) and reasoning (Barrouillet, 1996). It was argued that this task also reflects the use of a language-specific memory system (Daneman & Tardif, 1987) and in response Turner and Engle (1989) developed the operation span task. As shown in Figure 2, this task involves the same demands as the reading span task but the processing component requires the completion of simple mathematical operations. Over time other variants, including the symmetry span task, came into use. These variants demonstrated equal strength of association with reading comprehension ability as the reading span tasks (Turner & Engle, 1989). The specific domain of the processing component is thus not considered crucial to the predictive power of complex span tasks, instead these tasks are assumed to reflect a general WMC. Performance on complex span tasks has since been useful in predicting performance on a range of higher-order cognitive tasks including second language learning (Linck & Weiss, 2015), emotional expression and responding (Schmeichel et al., 2008), metaphor production and processing (Chiappe & Chiappe, 2007), rejection of false memories (Leding, 2011) and susceptibility to misinformation (Calvillo, 2014).

Redick et al. (2007) argued that this reliable relationship between complex span tasks and higher order cognition exists because executive attention (the ability to control attention in a goal-directed manner) which is indirectly measured through WMC is critical for efficient cognitive functioning. However, no task is process pure - these tasks partly measure domain-general executive attention processes that contribute to complex span performance regardless of the stimuli involved, but they also reflect the contributions of domain-specific rehearsal, coding, storage, processing skills, and strategies, which will vary depending on the nature of the task itself (e.g. operation span tasks versus reading span tasks). It is therefore common – where possible – to use multiple complex span tasks from the different domains, in order to gain a WMC composite score that better estimates the latent domain-general capacity by avoiding some of these task-based idiosyncrasies in the measurement (Redick et al., 2012). Studies 1 and 2 of this thesis will utilise WMC to understand how TUTs relate to executive functioning in different task contexts.

3.6 Issues in Studying Executive Functions

This chapter has outlined how working memory is associated with attentional control processes and/or executive functions. Specifically, WMC is considered an indirect measure of executive attention as it relies on executive attentional control to maintain goal-relevant information. However what is meant by these terms has not yet been clear; what exactly is *executive functioning* and *executive attention*? These questions have not been answered because most attempts in the literature to define executive functions have been equally vague and failed to yield a concrete operational definition for the concept. This is highlighted in a paper by Miyake and Friedman (2012) which refers to executive functions as the *"general-purpose control mechanisms that moderate the operation of various cognitive subprocesses and thereby regulate the dynamics of human cognition"* (p. 1). This definition does not provide any testable theory for what constitutes an executive function – they are seen as a collection of "cognitive mechanisms".

3.6.1 Miyake et al. (2000)

A keystone work by Miyake et al. (2000) attempted to address this issue with the use of SEM. This is a statistical technique which combines factor analysis and multiple regression in order to look at structural relationships between measured variables (e.g. complex span tasks) and latent constructs (e.g., WMC), and interrelationships between latent constructs. Miyake et al. (2000) analysed performance on a series of experimental tasks that they believed tapped into three candidates for executive functions: task shifting (which involves the disengagement of an irrelevant task set and the engagement of a relevant task set, (Monsell, 2003)), working memory updating (which involves updating information and representations in the working memory space, (Jonides & Smith, 1997)) and inhibition (which involves the ability to deliberately prevent dominant and habitual responses when necessary). Through the use of SEM these authors found that the three identified candidate functions were moderately correlated with each other, but nonetheless separable. In addition, these functions had unique contributions to performance on a set of complex executive tasks such as an operation span task and a random number generation task. The conclusion of this study was that executive functions have distinct features, and that there are multiple processes which fit under this umbrella term. Important to note, there are more executive functions than just these three candidates. Other conceptualisations will be discussed in Section 3.7.

3.6.2 Kam and Handy (2014)

The association between WMC tasks and TUT propensity is argued to be a reflection of differences in executive functioning which allow people to avoid or sustain these distracting thoughts. Indeed, executive attention is a common component of most theories of mind wandering, and yet it is often spoken about in inexplicit and unitary terms. That is, these theories state that mind wandering is related to an individual's "executive resources" or "executive attention," but do not clearly state if all candidate functions are equivalently involved in TUT production or prevention. Kam and Handy (2014) attempted to expound on the association between TUTs and "attentional processes" beyond just their association with the indirect measure of WMC. These authors investigated whether specific executive functions are affected by the occurrence of TUTs by observing how these thoughts were associated with performance on inhibition, updating, and shifting tasks. The rationale for this study was that if TUT production interrupts task performance, this would be evidence for the employment of the processes associated with those tasks in TUT production. That is, if TUT production interrupted performance on an updating task, then this would suggest that updating functions are involved to some degree in TUTs. These authors found that TUTs impacted performance on inhibition and updating but did not relate to performance in task shifting. This indicates that TUTs do not unitarily capitalise on executive functions during task completion. While the similarities shared by executive functions are assumed to be a consequence of the processes of goal maintenance, thus linking executive attention to working memory, Kam and Handy's (2014) study highlights that there is still a necessity to understand the specific nature of these associations.

3.7 Executive Functions: Maintenance and Disengagement

Miyake et al.'s (2000) work provided an early attempt at unpacking executive attention, but acknowledged that there may be functions outside the three candidates identified. More recently an attempt to define domain-general executive attention was undertaken by Shipstead et al. (2016), whereby they reconceptualised executive attention as the deployment of resources toward *either* the maintenance of, or disengagement from, information (see Figure 3). Maintenance and disengagement are considered in a process-general manner. For example, when measuring these abilities specific processes of disengagement (e.g. inhibition or decay mechanisms) are not considered but rather a more general latent measure of disengaging from information is the focus. The goal of such a framework was to return to parsimony in accounting for relationships between executive attention and cognitive outcomes, instead of relying on increasingly specified and fragmented frameworks (e.g. Miyake et al., 2000). In addition, this proposal may be able to better account for the large correlation between measures of working memory, and a cognitive ability known as fluid intelligence (Gf).

3.7.1 Working Memory and Fluid Intelligence

Cattell (1963) proposed that general intelligence can be demarcated into fluid intelligence and crystallised intelligence. Fluid intelligence refers to the ability to reason, process information, and solve novel problems. In contrast, crystallised intelligence refers to the accumulation of general procedural and declarative knowledge. These two intelligences, while related, are nonetheless separable to each other (Cattell, 1963; Horn & Cattell, 1966). Studies have found that fluid intelligence ability is related to executive functioning (Ren et al., 2017; Saggino et al., 2006), and more importantly, that it shares a large correlation with measures of WMC. In fact, correlations often range anywhere between .5-1.0 (Kane et al., 2005; Unsworth et al., 2009).

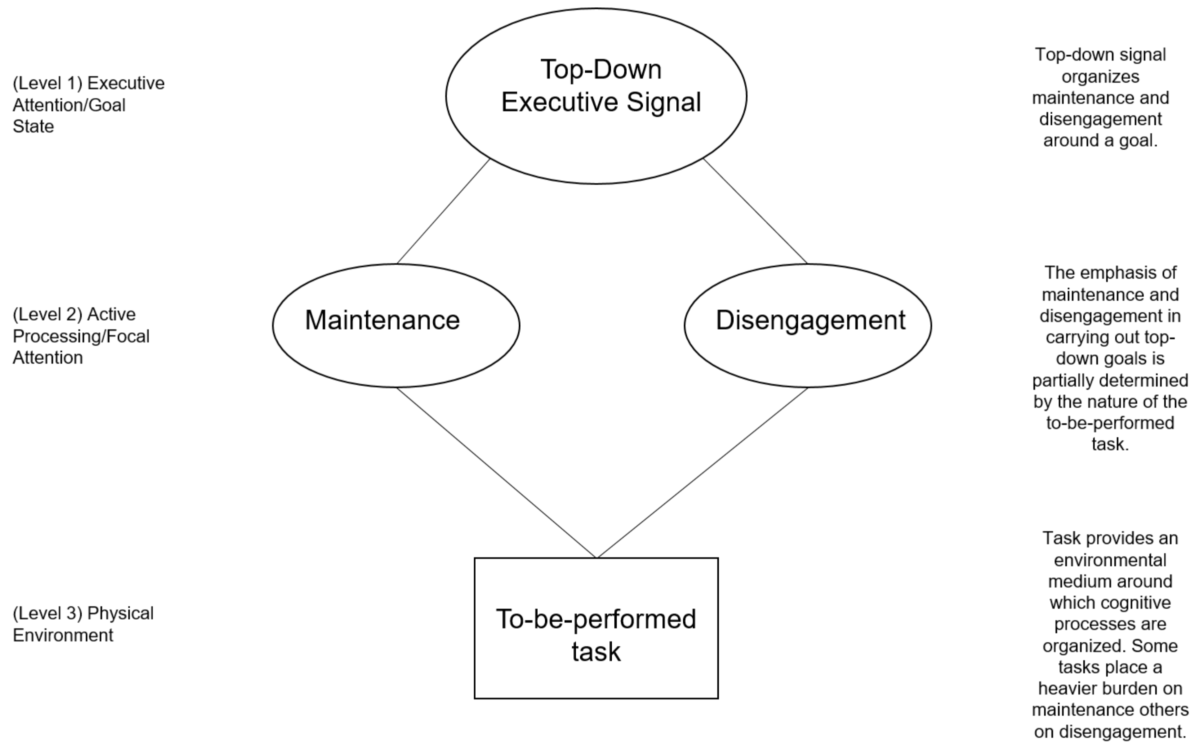
Historically, the large correlation between WMC and fluid intelligence has been explained by the former being a determinant of the latter (e.g. Au et al., 2015; Melby-Lervåg et al., 2016). This is reflected in the argument that in order to solve a novel problem, some form of mental representation is required to maintain the problem in the cognitive workspace. Given working memory is a system for representing and manipulating information, and it has such a strong empirical relationship with fluid intelligence, it has been considered causally related to Gf. However, representing a problem is only one half of the picture. If an individual formulates inaccurate hypotheses or answers for this problem, they need to be able to update these hypotheses to allow new information in, and discard irrelevant information (Shipstead et al., 2016).

This is where the process of disengagement becomes pivotal. The ability to disengage from outdated information facilitates a reduction in information interference within the focus of attention. In consequence, it is likely to be an important process for efficient executive functioning – without such a process competition among goal-relevant and irrelevant information would inhibit effective cognition (Lewis-Peacock et al., 2018). It should be noted that while the role of such disengagement processes had previously been minimised by some working memory theorists, interference theorists have often included mechanisms for updating working memory contents and discarding outdated information (Ecker et al., 2014; Lewis-Peacock et al., 2018).

Shipstead et al. (2016) argued that WMC tasks tend to emphasise the use of maintenance processes over disengagement processes by requiring the retention of goal-relevant information in a heightened state of accessibility when faced with distractors [see Section 3.4]. In contrast, tasks measuring fluid intelligence involve retrieving information which may be important in the moment, but once this information becomes irrelevant, disengaging or removing that information from conscious awareness. Although in such tasks maintenance processes are utilised, they play a minor role relative to disengagement processes. In addition, while working memory and fluid intelligence are relying on different processes, the implementation of these processes both depend on executive attention. Therefore, this framework separates broad abilities (e.g., working memory and fluid intelligence tasks) from the domain-general executive attention processes (e.g., maintenance or disengagement) which underpin these abilities (see Figure 3).

Figure 3

Shipstead et al.'s (2016) Proposed Model of Executive Attention



Note. Taken from Shipstead et al. (2016), this demonstrates the proposed roles of maintenance and disengagement in the overall control and deployment of executive attentional resources. Importantly, this viewpoint explicitly differentiates between processes and the tasks used to measure them.

3.7.2 Martin et al. (2020)

The explanatory power of the maintenance and disengagement model has been demonstrated in problem-solving contexts (Harrison et al. 2015) and reading comprehension and vocabulary learning (Martin et al., 2020). Martin et al. (2020) aimed to both validate and extend upon Shipstead et al.'s (2016) framework by investigating whether this process-general explanation of maintenance and disengagement could better account for variance in reading comprehension abilities. Reading comprehension has reliably been associated with working memory ability, however there is still unexplained variance in reading comprehension scores. While increasingly fractionated approaches to executive function have been used to try to understand this, Martin et al. (2020) propose that measuring general disengagement processes may allow for a fuller (and simpler) picture of the association.

In addition to measuring WMC and fluid intelligence, Martin et al. (2020) also measured updating ability. The rationale for this inclusion was to investigate whether disengagement occurs in tasks other than fluid intelligence tasks. Updating as an executive function is an appropriate candidate to investigate this proposition as it has both maintenance and disengagement requirements. Updating tasks involve maintaining relevant working memory representations in mind, and then disengaging from these representations when they become outdated or no longer relevant. Martin et al. (2020) used SEM with working memory, fluid intelligence, and updating tasks, to isolate maintenance and disengagement processes. These authors demonstrated that both maintenance-related variance (measured as the common variance in fluid intelligence and WMC tasks) and disengagement-related variance (measured as the unique variance in fluid intelligence tasks) had separable and significant predictive relationships with reading comprehension performance scores. Results also indicated that disengagement could be further isolated by employing updating tasks and cross loading these tasks onto both the updating and WMC latent constructs to isolate their unique variance. The addition of updating tasks further demonstrated how disengagement can be isolated, and how reading comprehension ability is associated with not only maintenance mechanisms but also the disengagement construct.

3.7.3 Implications for Task-Unrelated Thought

Separating process-general maintenance and disengagement functions has interesting implications for the mechanisms underpinning TUTs, especially considering Kam and Handy's (2014) dissociations of executive functions with TUT outcomes. Under Shipstead et al.'s (2016) framework, TUTs may be argued to rely heavily on the deployment of attention control for maintenance processes rather than disengagement. For example, there is theoretical emphasis on the maintenance of task-relevant information which allows for avoiding task-irrelevant thoughts entering consciousness (Kane et al., 2007a; Robison & Unsworth, 2018).

However, disengagement defined as the ability to remove irrelevant information from working memory may also influence the frequency of TUTs. Consistent with this, there is evidence for an inverse association between TUTs and fluid intelligence (Frith et al., 2021; Robison & Brewer, 2022). There is also evidence that updating tasks (which are thought to reflect both maintenance and disengagement, Martin et al., 2020) are interrupted by TUTs (Kam & Handy, 2014). It may then be that once TUTs are engaged and an individual becomes aware of it, those with greater disengagement ability are better able to remove these task-irrelevant thoughts from working memory more effectively than those with lower disengagement abilities. As such, the precise roles of maintenance and disengagement in TUT episodes are yet to be separated and observed. Furthermore, this is important as a more precise understanding of how 'executive control of attention' influences the occurrence of TUTs can further inform both theory and intervention for mind wandering.

3.8 Summary

Chapter 3 has outlined the conceptualisation of working memory as controlled attention, which has influenced theories of off-task thought. The key assumption underpinning mind wandering literature is that WMC (which is equated with attentional control ability) reflects the ability to inhibit internal and external distractors and focus on task-relevant information. This has clear implications for TUTs, which are often considered to be internal distractors. However, this chapter has also highlighted that 'executive function' is a vaguely defined umbrella term, and to do date there is little understanding of which specific functions are associated with TUTs outside of WMC. Moreover, WMC itself has been argued to be an indirect measure of other more general functions such as maintenance processes. As such one aim of this thesis will be to explore how the functions of WMC as well as maintenance and disengagement, are related to TUT propensity. Further still, as discussed in Chapters 4 and 5, mind wandering is not a singular phenomenon and so it is possible that different forms of off-task thought, in particular those varying in intentionality, will be associated with different types of cognitive mechanisms. Chapter 4 will outline the most common theories of mind wandering, with reference to this concept of working memory as controlled attention.

Chapter 4: Synthesis of Theory and Empirical Literature on Task-Unrelated Thoughts

4.1 Introduction

This chapter provides an overview of the key accounts of mind wandering and the empirical evidence supporting them. It then outlines ongoing debates and areas of investigation in the literature which form the basis of the studies in this thesis. To note, this thesis does not argue for or against any one theory of mind wandering. Instead, it aligns with the aims of research demonstrating that the heterogeneous nature of mind wandering indicates a number of different interacting determinants which influence the occurrence of TUTs across contexts. As such, discussions of results of the studies in Chapters 7-9 draw upon arguments from the theories presented here.

4.2 Executive Resource Hypothesis

The executive resource hypothesis is one of the earlier formal accounts for mind wandering and argues that TUTs require the employment of the same pool of executive resources that are used to maintain focus and performance on the task at hand (Smallwood & Schooler, 2006). According to this account TUTs involve the automatic activation of information and so do not require conscious intention. That TUTs are both unintentional but also utilising executive resources seems paradoxical at first given that intention is the core component of *controlled* (i.e., executive) processing, differentiating it from automatic processing. However, this viewpoint also assumes that individuals have goal hierarchies, and that goal-driven processing can be initiated automatically (Klinger, 1999). Therefore, TUTs are goal-related (but external task-unrelated) thoughts which can occur without intention when one of these goals becomes activated in the absence of meta-awareness (that is, a higher-level awareness of a goal). These two processes, automatic goal activation and meta-awareness, are critical in overcoming the paradox.

Automatic goal activation relies on attention being sensitive to environmental opportunities that facilitate a given behaviour for satisfactory goal completion (Gollwitzer, 1999; Klinger, 1999). This sensitivity has been demonstrated in dichotic listening tasks. When self- or goal-relevant information are presented in one channel, attention is drawn to this channel and the instances of goal-related thought increases in response (e.g., Bargh & Pietromonaco, 1982). Goal-driven sensitivities have been labelled by Klinger (1999) as '*current concerns'*, and they guide behaviour by heightening the accessibility of goal-relevant stimuli to working memory [see Section 4.3.1 for a more complete review of current concerns].

According to auto-motive theory, because goal-relevant information remains in a state of heightened accessibility, this can result in goal-relevant information being processed ‘preconsciously’. As such, this provides a pathway for goal-relevant (yet unconscious) behaviours to be activated or initiated without conscious intent. In relation to mind wandering, TUTs can unintentionally occur due to the activation of personally relevant, but external task-irrelevant, goals drawing attention away from that task. This activation is the result of internal or external cues. Awareness will be absent in TUTs if goal-driven processes attract attention without the individual perceiving the conflict between their current psychological state and the external task demands (i.e., without *meta-awareness*). In this way, TUTs are also conceptualised as a state of *perceptual decoupling* [see Section 4.2.2]. Note that, as mentioned in Chapter 3, this theory does not state whether all executive processes are equally involved in producing TUTs. That is, for example, whether inhibitory processes are responsible for allowing the thoughts into consciousness by weakening the gateway for allowing thoughts into working memory, and/or whether set-shifting processes are responsible for shifting the mental set to cued thoughts.

4.2.1 Empirical Support

The main argument of the executive resource hypothesis is that TUTs involve a controlled stream of thought which uses the same executive resources that are required for external task performance and are believed to require a level of *controlled processing* (Baddeley, 1996). Controlled processes have four key features: i) a conscious understanding of what attentional control is trying to accomplish, ii) a conscious feeling of exercising control, iii) effort which is required to control attention and a given action, and iv) continuous monitoring and evaluating of control and its output. From these components two predictions can be made; i) tasks that require controlled processing will suppress TUTs due to a lack of resource to complete both, and ii) performance on a given task will be impaired by TUT episodes as resources required for task completion will be directed elsewhere.

To support the claim that increased controlled processing requirements result in less frequent TUTs, Smallwood and Schooler (2006) cite the finding that TUTs decrease as a task becomes increasingly difficult (Forster & Lavie, 2009; Giambra, 1995). This was first demonstrated in early work by Antrobus (1968) who observed a decrease in off-task thought when stimulus presentation rates increased. The decrease was interpreted as reflecting a trade-off between task performance and engagement with off-task thought. As the task becomes more difficult, the amount of available resources to dedicate to TUTs is reduced. The decrements seen in task performance when individuals are engaging in TUTs have likewise been interpreted as a consequence of drawing attentional resources away from the task at hand and toward internal mentation (McVay & Kane, 2009; Smallwood & Schooler, 2006). In addition, when a task becomes more familiar and automated (and thus require less controlled attention), TUT rates increase (Geden & Feng, 2015; Mason et al., 2007). This again indicates that availability of resources underpins TUTs.

Observed decrements in task performance align with the second claim, that TUTs will interfere with controlled processing due to shared reliance on underpinning mechanisms. Performance decrements have been observed in a range of contexts, including laboratory-based memory and attention tasks (Kam & Handy, 2014; Thomson et al. 2013), reading comprehension and classroom learning (Szpunar et al., 2013; Martin et al., 2018), medical decisions (Berner, 2011), in the workplace (Dane, 2018), and driving (Burdett et al., 2019). Such performance impairments due to attentional lapses can have significant real-world consequences. For example, attentional lapses in the form of TUTs place road users at a higher risk of crashing (Gil-Jardiné et al., 2017). In another study investigating the effects of TUTs in pilots' vigilance performance, pilots were observed to engage in TUTs even when it would be detrimental to performance, and subsequently missed targets in an altitude callout task (Casner & Schooler, 2015). As such, it is clear that when TUTs occur, attentional resources that are necessary to maintain task performance are no longer allocated to the task and impairments in performance occur.

4.2.2 Perceptual Decoupling Hypothesis

In concert with the argument that TUTs involve the use of executive resources to initiate and maintain an off-task stream of thought, the executive resources view also argues that perceptual decoupling occurs during TUTs. Perceptual decoupling refers to a shift in attention away from the external task environment, and toward the internal psychological environment. By directing attention toward a goal, this allows for goal-directed actions as cognitive resources are navigated toward the processing of relevant external stimuli (Posner & Peterson, 1990). In contrast, when attention is given to internal mentation, it becomes disengaged from the external world in order to process this internal information effectively. As a consequence, representations of the external world are superficial when compared to the detailed representations that are achievable when an individual is focussing on the external environment (i.e., 'perceptual decoupling'). This decoupling can allow TUTs to persist and lead to errors during external task performance.

Evidence for this comes from EEG studies whereby researchers can examine the temporal relationship between self-reported instances of mind wandering and any changes in the cortical processing of external information. In particular by quantifying the amplitude of 'event-related potentials' (ERPs) which can be measured and derived from EEGs, researchers can understand and compare cortical responses which are time-locked to a particular stimulus. The P3 ERP component is considered to be an index for task-relevant attentional processing. This ERP occurs approximately 300 milliseconds after task-relevant events occur (Polich, 1986). Studies have shown that the P3 is reduced for individuals who retrospectively report experiencing greater TUTs during a task (Barron et al., 2011). Additionally, a reduction in ERP amplitude also occurs in ERP components that indicate other sensory processing such as in domains of auditory or visual processing (Kam et al., 2011). As such, this suggests that TUTs result in changes to early perceptual processes.

4.3 Executive Failure Hypothesis

In contrast to an executive resources perspective, the executive failure hypothesis argues that TUTs are the result of a failure to maintain attentional control, thus allowing TUTs to intrude into consciousness (McVay & Kane, 2010). Under this framework, TUTs are thought to be generated and maintained automatically and the likelihood of off-task thoughts occurring is jointly determined by i) attention control (e.g., working memory) capabilities of the individual and ii) the extent to which the interfering thoughts are cued and automatically generated in the moment. Similar to the executive resources perspective, TUTs are argued to reflect goal-relevant thoughts that have been cued to consciousness either internally or externally. Task-unrelated thought can therefore be prevented in two ways: first, by applying the proper level of control to attention and thought regulation, and proactively preventing the initiation of mind wandering; second, by reactively inhibiting or suppressing TUTs as they are cued to activation. Recall the working-memory-as-attention frameworks from Chapter 3. Under the executive failure account, TUTs are just another kind of distractor which attention control must prevent from accessing the working memory space in order to maintain task-oriented thought.

4.3.1 Current Concerns x Control Failure

Under both the executive resources and executive failure perspectives the personally-relevant goal-driven nature of TUT content has been described using the term "*current concerns".* Current concerns refer to ongoing sensitivity to goals that are still yet to be achieved. This concept features in both repetitive thought literature and in Klinger's (1971, 2009) extensive work on the nature of daydreaming and fantasy. Mind wandering in general shares a degree of overlap with repetitive thought, a term used to refer to cognitions which are attentively, repetitively, and/or frequently about one's self and one's world (Segerstrom et al., 2003). Repetitive thought includes, but is not limited to, worry and rumination, problem-solving, and counterfactual thinking. Klinger (1971) argued that when a goal is formulated it becomes a '*current concern'*, and it is kept in an accessible state until it is resolved or abandoned. These concerns are cued by both the external environment and other internal streams of thought and can form the basis of repetitive thoughts (and TUTs according to some mind wandering theorists).

More recently, Watkins (2008) proposed a control-theory explanation of repetitive thought, which later informed the executive failure hypothesis. This explanation argues that repetitive thought results from a feedback loop whereby an individual evaluates the discrepancy between end goals (i.e., current concerns) and their current status. In this way these thoughts are beneficial when they assist someone in resolving these discrepancies by moving toward their desired goal state. However, if an unattainable goal is not abandoned, repetitive thought can be detrimental and result in rumination. Furthermore, the regulation of thought content is based on the level of construal of the goal, a concept from socio-cognitive literatures. Goals can have abstract or concrete construal (Dweck & Leggett, 1988). Abstract construal refers to a level of mental representation that conveys the essential gist of actions and events needed to achieve a goal. This construal allows for higher order, and more vague goals to be constructed. For example, the goal of *learning a language*. In contrast, a lower level construal is more concrete, and includes subordinate, contextual and specific details of actions and events. In the above example, these would constitute specific plans for attending language learning classes, completing homework, and practicing with peers. In this way, a concrete level of construal allows for a more focussed attainment of the goal. At each level of the goal hierarchy there is a discrepancy with the current state, and environmental cues can bring these discrepancies into conscious awareness.

In the context of TUTs, McVay and Kane (2010) argue that goal discrepancies result in the occurrence of TUTs. Goal evaluation is continuous but occurs outside of awareness, and so when these goal-related thoughts compete for entry into awareness, executive control of attention is required to suppress them and maintain current external task focus. A concrete level of construal is required for demanding tasks, whereas easy or automatic tasks can be performed with a more abstract level of construal. Accordingly, McVay and Kane (2010) argue that a concrete level of construal reduces the accessibility of off-task thoughts to consciousness.[1] By extension, individuals with greater attentional control (often reflected in WMC) will be better able to apply the appropriate level of construal over thoughts. Whilst Watkin's perspective is not a theory of mind wandering specifically, it has been used to form the basis of the *current concerns x executive failure* hypothesis.

4.3.2 Empirical Evidence

The executive failure hypothesis is supported by a number of findings in individual differences research. This account predicts that a person with lower executive control capabilities (as reflected by measures such as WMC), relative to someone with higher control capabilities, will be less able to apply the appropriate level of construal over their thoughts that is needed to meet the demands of the current external task (i.e., will not be able to prevent internal cued distractions). As a consequence, this individual will experience more TUTs, increasing the risk of poorer performance on the task. Such a prediction is supported in the literature (Kane et al., 2007a; Kane et al., 2017; McVay & Kane, 2009; McVay & Kane, 2012; Robison & Unsworth, 2018; Rummel & Boywitt, 2014; Unsworth & McMillan, 2013), but is in direct opposition to the prediction drawn from the resources perspective. Under a resources view, those with reduced cognitive capacity in a comparative sense should actually mind wander *less* during demanding tasks as they do not have the sufficient excess capacity to simultaneously engage with mind wandering and the task at hand.

The demonstrated inverse association between WMC and TUTs is often interpreted as the result of attention control ability being used to maintain task-relevant information and suppress distractors or irrelevant information (Engle et al., 1999) (see Chapter 3). For example, Robison and Unsworth (2018) measured participants' WMC and TUT frequency during three attention tasks, including an anti-saccade, Stroop, and psychomotor vigilance task. They found that individuals with greater WMC scores and higher self-reported alertness had fewer instances of unintentional (i.e. automatic or spontaneous) TUT episodes. Likewise, in an earlier study by McVay and Kane (2009), WMC was measured and found to correlate negatively with TUT frequency in a SART. This pattern of findings aligns with predictions that higher WMC individuals who presumably have greater ability to avoid distraction – both internal and external – are better able to maintain task focus. Again, the candidate executive functions which allow an individual

[1] Note that the elaborated control theory of repetitive thoughts proposed by Watkins (2008) does not make assumptions regarding the influence of construal on the accessibility of thoughts (see Watkins, 2010). This is an extension of the theory proposed by McVay and Kane (2010) specifically in their account for TUTs.

to avoid these TUTs are unspecified, although there is an implicit assumption that these processes will involve maintenance of information through inhibition of distractors, in order to keep irrelevant thoughts out of consciousness. In addition, while this theory states that TUTs enter awareness due to failures in executive attention, it makes no argument in regards to whether or not resources are used to maintain a train of thought once it enters the working memory space.

4.4 Process-Occurrence Framework

Smallwood's (2013) process-occurrence framework aims to reconcile claims from the executive resource and executive failure perspectives, by separating explanations for the initiation of TUTs from explanations for their maintenance. This highlights the two central questions for TUT research. First, what initiates off-task thoughts? This is a question of *occurrence*. Second, how are these thoughts sustained? This is a question of *process*. The answer to the former requires a consideration of the environmental context and events that may trigger the onset of an off-task episode, the potential constructive value of the episode, and an individual's ability to regulate the occurrence of these episodes. The latter requires considering specific processes that allow self-generated thought to persist against external tasks and stimuli.

This approach draws on both an executive resource and perceptual decoupling explanation in assuming that domain-general executive processes are necessary for maintaining TUTs (Smallwood et al., 2012). Notably, the extent that attention is decoupled after the initiation of a TUT episode could determine the duration of the episode, but these perspectives do not provide an adequate explanation for its initial occurrence. Therefore, the executive resource and decoupling hypotheses seem to provide an explanation for the continuity of TUTs rather than a proposal for why these episodes begin. The executive failure hypothesis, on the other hand, offers a mechanism of mind wandering initiation. According to this perspective, TUT occurs due to a failure in maintaining sufficient attentional control which results in attentional lapses that allow TUTs into consciousness.

The process-occurrence distinction argues that each theoretical framework is accounting for different elements of mind wandering (i.e., initiation versus maintenance). This framework marks an initial attempt to reconcile accounts of mind wandering, rather than place them in opposition. It also highlights a limitation in current theories to make explicit whether they are attempting to explain the occurrence or maintenance of mind wandering. The lack of direct control experimenters have over the occurrence of self-generated thought further exacerbates the difficulties in isolating process from occurrence in the research. In most experimental settings the goal is to identify the causal relationship between the construct under examination and any preceding events (the latter of which are often known as imperative stimuli). Nonetheless, the largely spontaneous nature of TUTs means experimenters can only observe and measure the occurrence of the experience (Smallwood & Schooler, 2006). Currently there are no universally agreed, objective physiological markers for TUT initiation (see Chapter 2) so there is no consensus as to when events begin. The measurement of TUTs, then, cannot be confidently separated into an imperative stimulus and a subsequent process, as is typically the case in other experimental fields.

4.5 Content and Context Regulation Hypothesis

While early research focussed on the occurrence and impact of TUTs (as a singular construct) on the performance of laboratory tasks (Kam & Handy 2014; McVay & Kane, 2012; Randall et al., 2014), recent efforts have aimed to investigate differences within TUTs in terms of both their content and the context in which they occur. In doing so, examination of the possible influences of TUTs extending beyond the completion of cognitive tasks and toward psychological wellbeing and constructive outcomes, has become more common. Furthermore, bidirectional relationships between TUTs and the task contexts in which they occur have been acknowledged. Indeed, there is ongoing debate regarding whether TUTs are helpful or harmful [see Section 4.8.5], and the content and context of these episodes are likely important determinants in this regard. This is what Smallwood and Andrews-Hanna (2013) argued when proposing the content- and context-regulation hypotheses.

4.5.1 Content-Regulation Hypothesis

The content-regulation hypothesis attempts to provide a clearer articulation of the role of thought content in mind wandering episodes, especially with regard to outcomes of psychological wellbeing. This hypothesis argues that the relationship between TUTs (or any other type of mind wandering) and psychological wellbeing will depend on the content of thought, and how people regulate such thoughts in the face of those assessments. In particular, individual differences exist in the abilities of people to self-regulate their thought content, and this has implications for the potential constructive (or maladaptive) outcomes of TUTs (Killingsworth & Gilbert, 2010; Marchetti et al., 2016; Shrimpton et al., 2017; Smallwood et al., 2009). This perspective widens the scope of investigation for TUT outcomes, as under previous theories these thoughts were often evaluated as detrimental due to their negative impacts on laboratory task performance. In addition, cognitive ability was the focus of mechanistic explanations in these theories. The content-regulation hypothesis, by contrast, highlights that depending on the content of a TUT, these thoughts could at times be beneficial for individuals. For example, TUTs with a prospective focus could allow individuals to anticipate and plan for future events and goals (Baird et al., 2011; Smallwood et al., 2009; Song & Wang, 2012). The capacity to regulate thought content in order to capitalise on constructive outcomes is indicative of the constructive functioning of an individual's cognitive system.

Supporting this proposal, Poerio et al. (2015) found that thought content which included 'close others' increased the socio-emotional benefits of what they termed *social daydreaming* (a daydreaming episode involving other people). Indeed, social thought is a major dimension of mind wandering content, with a number of studies demonstrating that mind wandering thoughts feature a large amount of social content which can in turn improve socio-emotional regulation (Linz et al., 2021; Poerio et al., 2015; 2016). To note however, much work investigating mind wandering in daily life does not necessarily measure the TUT variety specifically. Furthermore, thought content with a retrospective bias can, in some situations, indicate distress and unhappiness. Retrospective mind wandering has been linked to depressive symptoms such as rumination, and can emphasise a focus on negative matters leading, or contributing, to conditions of unhappiness (Smallwood & O'Connor, 2011; Stawarczyk et al., 2013). Nonetheless, this is not to say all retrospective thought is negative or ruminative in nature. Indeed, retrospective thought may also take the form of reminiscences or nostalgic memories.

Differences in the content of TUTs can also impact outcomes in the laboratory. Banks et al. (2016) investigated the role of emotional valence of TUTs on performance in a working memory and SART context. They found that neutral and negative TUTs predicted performance on the working memory task, and negative TUTs predicted no-go performance lapses on the SART. Positive TUTs, in contrast, did not have a predictive association with performance. Banks and Welhaf (2022) again examined emotional valence during a SART and found that positive and negative TUTs were associated with cognitive ability but that neutral TUTs had no such association. Together, this highlights that content also has implications for regulatory mechanisms underpinning thought in controlled laboratory settings.

Self-regulation of thought content is influenced not only by cognitive ability but also by individual differences in personality, disposition, mood, and psychopathology among other possible factors. Some people may be more inclined to capitalise on productive/constructive thoughts and minimise or reduce thoughts that are detrimental/unhelpful to achieving happiness or life goals (Hoffman et al., 2016). For example, Welhaf et al. (2020) investigated whether TUTs measured in the laboratory are associated with schizotypy. Schizotypy is a personality construct which has been described as a risk-factor for the development of schizophrenia and other psychoses. Schizotypy has three factors – positive/cognitive-perceptual, negative/interpersonal, and disorganised. Welhaf et al. (2020) found that positive and disorganized schizotypy were associated with fantastical daydreams and a higher daydreaming frequency. Both positive and disorganised schizotypy were also more likely to endorse worry-based TUTs, consistent with symptomatology and revealing a potential role for TUTs in maintaining and exacerbating symptoms. Clearly then, the content of TUTs (e.g., their emotional valence, their temporality) can determine the types of outcomes experienced (e.g., changes in mood, functionality of the episode), and dispositional factors (e.g., personality, traits, and/or psychopathology) can influence the nature of the TUTs an individual tends to experience.

4.5.2 Context-Regulation Hypothesis

The context-regulation hypothesis predicts that the rate of TUTs, their impacts on performance, and their relationship with cognitive abilities, will depend on the nature of the task being performed. This perspective highlights that researchers must be considerate of the tasks they select when investigating off-task thought, as task context will influence the results of the study, and therefore the interpretation of the data. Complex and demanding experimental conditions may result in an increase in TUTs through cognitive overload and/or demotivation which can result in more executive attention failures (Randall et al., 2019; Xu & Metcalfe, 2016). In turn these off-task thoughts can lead to significant disruptions in behavioural performance, including response errors and lapses in attending to stimuli (Thomson et al., 2015) and poor reading comprehension (Reichle et al., 2010; Smallwood et al., 2008). By contrast, many constructive features of self-generated thought are observed in less demanding tasks (e.g., breath counting or low-load vigilance tasks), including future planning (Smallwood et al., 2009) and creativity (Baird et al., 2012). In these easier task-contexts, these benefits may reflect the ability for those with greater cognitive ability to utilise excess resources for constructive off-task thought.

In addition, individuals who are both better able to regulate TUTs to capitalise on its use in non-demanding task settings, and prevent its occurrence during demanding task settings, should experience greater benefits and fewer costs related to these thoughts. There is some evidence from the individual differences literature supporting this claim. People with higher WMC have exhibited relatively more TUTs in simple task conditions and less TUTs in difficult task conditions (Kane et al., 2007a; Levinson et al., 2012; McVay and Kane, 2009). Furthermore, participants with higher WMC are able to more flexibly adjust their coordination of off-task thought as task demands change (Rummel & Boywitt, 2014). Once more, this highlights the value of appraising task context in the broader understanding of off-task thought. The role of task context is an integral part of ongoing debates regarding how difficulty of a task, and characteristics of a task, can influence TUTs. This issue will be discussed further in Section 4.8.2.

4.6 Resource Allocation Frameworks

A final line of theory to review is that of resource allocation frameworks, which are often mentioned in sustained attention and vigilance decrement literature. Sustained attention and vigilance are important concepts in mind wandering research as a large number of studies utilise some variation of a sustained attention task (e.g., a SART, the Metronome Response Task (MRT)) in order to investigate TUTs during these tasks (e.g., Martínez-Pérez et al., 2021; McVay & Kane, 2009; Stawarczyk et al., 2013). Mind wandering literature has not only *been informed by* models of sustained attention but has also *informed* theories of vigilance decrement in sustained attention tasks – namely the *mindlessness* hypothesis of vigilance (Thomson et al., 2015). One key advantage of these resource allocation frameworks is their ability to explicitly integrate the role of cognitive ability together with a number of other important non-cognitive factors – such as motivational processes, perceptions of tasks, and other self-regulatory factors including personality– when accounting for the occurrence of TUTs across contexts.

Sustained attention tasks require the maintenance of focussed attention over a relatively long duration of time, and have shown a "vigilance decrement" effect. This refers to an increase in errors as time on task increases – reflecting a decrement in how vigilantly an individual can attend to the signals or stimuli in the task. There are two traditional schools of thought regarding this decrement. The first draws upon overload theories such as the resource depletion hypothesis, which argue that vigilance tasks are effortful (Warm et al., 2008) and the vigilance decrement occurs due to a depletion of attentional resources. The second position, of greater relevance to TUTs, includes underload theories which posit that vigilance decrement occurs because sustained attention tasks are monotonous and do not stimulate participants. As such, over time participants withdraw resources from the task and this withdrawal results in mindless and automatic behaviour (i.e., the *mindlessness* hypothesis) (Robertson et al., 1997). These resources are then presumed to be allocated to internal mentation (TUTs), which may work to alleviate boredom or frustration with the task.

4.6.1 Thomson et al.'s (2015) Resource-Control Framework

Thomson et al. (2015) combined underload and overload perspectives in their resource-control theory, arguing that TUTs occur due to a failure in distributing a limited attentional capacity among both the internal thoughts and external task. In turn, this leads to errors in responding or excess variability in RTs (Thomson et al., 2015; Smallwood & Schooler, 2006; McVay & Kane, 2010). According to this theory, failures can occur for a number of reasons such as excessive task difficulty or ease, lack of motivation, lack of alertness or arousal, and time-on-task. This approach therefore not only unites explanations from overload and underload accounts, but also opens the door for multiple variables to determine TUT rates.

The key assumptions of Thomson et al.'s (2015) resource-control perspective are first, as is widely accepted throughout literature on working memory and attentional control (see Chapter 3), that attentional resources are fixed and capacity limited and individuals exhibit differences in this capacity. These attentional resources are used for the completion of external tasks and are also used in the maintenance of TUTs. Further still this account assumes that TUTs reflect the default state of cognition resulting in a bias toward resources being used for TUTs and that due to this bias, executive control is necessary for goal-maintenance of external tasks and this prevents internal distraction. Accordingly, it is predicted that tasks which place high demands on executive control will tax the cognitive workspace and over time this will result in control failures, increasing the risk of intrusions by off-task thoughts. Likewise, tasks which do not require the full extent of executive attention can enable co-occurring TUTs as a function of under-stimulation, excess resource, and/or boredom among other factors.

4.6.2 Resource Allocation Policies

Resource allocation frameworks emphasise the role of allocation policies which distribute attentional resources according to interactive processes between cognitive, motivational, and contextual factors. Recall for example that Thomson et al.'s (2015) resource-control theory speaks of 'distributed attentional capacity'. Kurzban et al. (2013) proposed that a cost-benefit analysis of mental effort occurs when people are determining how much mental effort to apply to a given task. Accordingly, variables like task motivation and interest, that wane as the duration of monotonous tasks increases, will have an influence on this top-down cost-benefit regulation of attentional control. Task-unrelated thought may then occur intentionally due to a deliberate decision to withdraw attentional resources from the external task because it is not perceived as 'worth' the effort required for completion. Alternatively, TUTs can occur unintentionally due to increased demands on resources which increase the risk of attentional failures. This distinction between mechanisms that promote intentional and unintentional TUTs is critical to the current thesis, and is discussed fully in Chapter 5. Kanfer and Ackerman's (1989) allocation policy of resources similarly argues that allocation is influenced by cognitive ability, task demand, and motivational factors. Of importance, self-regulation plays a key role in allocation of resources, and this self-regulation is controlled by affective, cognitive, and behavioural processes.

Consistent with the context-regulation hypothesis, these frameworks also consider the role of task context in determining TUT frequency. Under resource allocation frameworks TUTs, during certain tasks, may be the result of a learnt reduction in the executive control needed for an ongoing task. Vigilance tasks, for example, are monotonous in nature and the low frequency of 'critical' trials is learnt by the individual. Over time (through self-regulatory allocation policies) individuals may reduce attentional focus in response to the most common trial type in the task. Task-unrelated thoughts consequently occur and indeed increase over time, as the individual adopts less effortful processing strategies. Alternatively, highly demanding tasks (e.g. difficult reading tasks, high-load working memory tasks) may overload cognitive ability and result in failures of the executive system which allow irrelevant thoughts into consciousness. In addition, mood and personality can be integrated into accounts as they represent an influence on how the individual regulates thoughts, whether or how they prioritise given task performance, and subsequently how individuals allocate resources to the task.

4.7 The Family-Resemblances Framework

Chapter 4 has outlined the many different theoretical perspectives regarding the initiation or consequences of TUTs in varied contexts. Some arguments centralise the role of cognitive determinants, following research in the working memory literature. Namely, the executive resource and executive failure hypotheses are rooted in working memory and executive resource theory. These perspectives conceptualise TUTs as automatically cued distracting thoughts which attention control must work to prevent from entering the conscious space in order to meet demanding tasks. In contrast more integrative frameworks (such as content and context regulation hypotheses and resource allocation frameworks) tend to balance both cognitive and non-cognitive determinants. These frameworks also emphasise that the causes and consequences of TUTs can evolve across contexts.

The varied accounts presented here need not be considered in competition with each other. Seli et al. (2018a, 2018b) proposed a family-resemblances framework [see Section 2.2] as a means to both contend with the heterogenous nature of mind wandering, and to connect the different accounts proposed. If it can be accepted that mind wandering is a natural kind, encompassing a variety of thought types which have overlapping and non-overlapping characteristics, then it is reasonable by extension to hold that these varieties of mind wandering can have different underlying mechanisms and outcomes. As such, it seems that each of these theories are accounting for specific types of TUTs, arising in particular contexts. For example, in very simple or automated tasks TUTs may not necessarily be the result of executive failures that allow thoughts to slip into consciousness. Instead, these TUTs may represent moments of attentional reallocation in response to excess available resources. In contrast, in challenging tasks where participants are making an effort to perform well, TUTs are perhaps more likely to reflect attentional lapses which allow distracting thoughts to slip into the working memory space. Section 4.8 overviews key debates and areas of research in the literature, which demonstrate the necessity of flexible approaches to TUTs.

4.8 Key Areas of Debate and Investigation

4.8.1 Cognitive Ability and TUT Frequency

There are seemingly inconsistent findings in regards to the relationship of TUT frequency with cognitive abilities. Most commonly WMC is measured as an indirect assessment of the link between TUTs and executive attentional control [see Section 3.5]. While a majority of findings support an inverse association between WMC and TUT frequency (consistent with executive failure predictions) (Kane et al., 2007a; McVay & Kane, 2009; Robison & Unsworth 2015; Unsworth & McMillan, 2013), there is also limited evidence that TUTs have a positive relationship with WMC in certain task contexts such as breath-awareness tasks (Levinson et al., 2012). To account for this, it has been argued that those with greater excess resource during a simple low-load task are able to utilise such resources for TUTs while also completing the concurrent external task, consistent with an executive resource perspective. Similarly, Baird et al. (2011) measured TUT frequency, as well as whether these thoughts were prospective or retrospective, during a simple choice reaction time (CRT) task. In a CRT, there are two possible key-press responses which depend on which of two possible stimuli are presented on the screen. They found that during the CRT higher WMC participants engaged in greater prospective TUT than lower WMC participants. This was interpreted as evidence that WMC underpins the ability to engage in future-oriented TUTs, consistent with executive resource predictions.

Despite these findings, Meier (2019) failed to replicate Levinson et al.'s (2012) observation of a positive relationship between TUTs and WMC, and likewise McVay et al. (2013) failed to replicate Baird et al.'s (2011) positive relationship between WMC and prospective TUT. Indeed, a majority of research tends to find an inverse relationship between working memory and TUT frequency (Kane et al., 2017; McVay & Kane, 2009, 2012; Robison & Unsworth, 2017; Unsworth & Robison, 2016), an outcome that is consistent with an executive failure hypothesis. Further complicating matters however, there are also studies showing a null relationship between WMC and TUTs. For example, Smeekens and Kane (2016) measured TUTs during a SART and found no association with WMC, arguing that certain task features such as duration will influence the TUT-WMC association. As such, while there is a general pattern to support that those with greater WMC experience less TUTs, there are important task boundaries influencing this association.

For further consideration, WMC is an indirect measure for executive attentional control and many theories of TUTs refer to executive attention in some manner to account for their occurrence. Yet Miyake et al. (2000) demonstrated that there are a number of candidate functions for executive processing, and Kam and Handy (2014) found that TUTs do not impact or associate with all executive functions equally [see Section 3.6.2]. While it is assumed that the ability to maintain task focus is integral to avoiding off-task thoughts, it may also be the case that other processes or abilities play a role in their occurrence (e.g. disengagement abilities). Hence further work is needed to elucidate both the relationship between TUTs and general WMC measures as well as the more nuanced nature of candidate executive processes in the prevention or maintenance of TUT episodes.

4.8.2 Task Difficulty and TUT Frequency

Objective task difficulty is traditionally manipulated through cognitive load (Seli et al., 2018c), within and between a number of task paradigms (e.g. sustained attention tasks, working memory tasks, and reading tasks). However, the TUT-task difficulty relationship changes depending on the nature of the paradigm used. When using tasks such as the (SART) (Robertson et al., 1997) or similar (e.g. CRT) the general finding is that TUTs are more common in easy task conditions than when these tasks are modified to be relatively more difficult (e.g. through modifying their target-non-target ratios) (Giambra et al., 1989; Levinson et al., 2012; Seli et al., 2016b; Seli et al., 2018c; Smallwood et al., 2011). In contrast, during higher order cognition tasks such as working memory or reading tasks, the opposite pattern has been found – TUTs are reported as more frequent in difficult task conditions (Adam & Vogel, 2017; Feng et al., 2013; Kahmann et al., 2022). To illustrate, Feng et al. (2013) used a reading comprehension task and found that participants reported more TUTs during hard than easy passages. Adam and Vogel (2017) similarly found greater TUT frequency during more difficult whole-report than partial-report memory tasks.

While sustained attention and working memory task are two commonly used paradigms, they fundamentally differ in the processes and effort required to perform them. The SART for example, is a variant of the go/no-go task, that has proven effective in provoking TUTs (Bozhilova et al., 2018; Jonkman et al., 2017; Kam et al.; 2011; Randall et al., 2014). This is likely due to its repetitive and seemingly undemanding nature (Robertson et al., 1997). In this paradigm, a participant must respond rapidly and accurately to a non-target stimulus and withhold their response when a target stimulus appears. In contrast, working memory tasks tap into specific executive processes needed not only to attend and respond to information but also manipulate information in mind. When attempting to generalise findings from one type of task across task contexts this overlooks differences in cognitive load and degree of difficulty between particular paradigms. It is necessary to directly compare different types of tasks, such as working memory versus sustained attention tasks, and document the similarities and differences of TUTs across these diverse contexts.

The decision on whether a simple or complex task will be used in an experiment can lead to non-trivial differences in the results and the subsequent theoretical interpretations of the findings. Indeed, authors conducting experiments with complex tasks may inevitably turn to an executive-failure account of mind wandering. Under conditions when the external environment demands attention and carries with it significant risk of inappropriate response, the occurrence of TUTs likely reflects a failure in cognitive control (i.e., the executive failure hypothesis).By contrast, in simple, monotonous, or automated task conditions, the environment facilitates an individual in re-allocating attentional resources for constructive outcomes (i.e. future planning, or even simply avoiding states of boredom) (i.e., the executive resources hypothesis). Neither set of outcomes is necessarily inaccurate in their indication of the phenomenon, but a false equivalence of task, or the neglect of the role of task context, does appear to represent a failure in the literature to cultivate a more nuanced view of mind wandering. The role of task-context in the regulation of TUTs and the mechanisms underpinning TUTs is explicitly integrated into resource-control and context-regulation hypotheses. Both of these accounts argue that the task context will influence how participants regulate their attention through both cognitive and motivational processes

4.8.3 Curvilinear TUT-Task Difficulty Associations

That TUTs are documented to both increase and decrease with task difficulty, and that this association is dependent on task contexts, has been perplexing for certain theories to reconcile. One influential attempt to account for this association is the proposal that that TUTs and task difficulty demonstrate a curvilinear association (Xu & Metcalfe, 2016). Xu and Metcalfe (2016) examined the possibility of a U-Shaped TUT-task difficulty relationship using the educational framework of the 'region of proximal learning' (RPL), which refers to a level of task difficulty calibrated to the individual's level of knowledge. Accordingly, the task is challenging enough to elicit interest, but not so challenging that it is unachievable. In this way a participant is more motivated to apply attention toward the task.

Over three experiments the authors used Spanish-English word pair learning tasks to test how the level of task challenge interacted with TUTs and task mastery. Combined analysis across the experiments demonstrated that participants tended to engage in TUTs more frequently during the easier *and* more difficult learning phase of the word-pairs, compared to the moderate learning phase of the word pairs. The results were interpreted as evidence that tasks with difficulty lying within an individual's RPL minimise mind wandering. Xu and Metcalfe (2016) argued that these results demonstrate a plausible means of accounting for the apparent inconsistencies in the literature. Studies that observed TUTs increase with task difficulty may have used tasks beyond an individual's RPL – as the task became more difficult, more attentional failures were experienced. In contrast, studies showing a decrease in mind wandering with task difficulty may have been using tasks that were essentially too easy – in this part of the difficulty spectrum increasing task difficulty brings the task closer to, or within, the RPL.

Likewise, Randall et al. (2019) used a resource allocation framework to account for the curvilinear task difficulty-TUT association they observed across varying levels of math difficulty. They highlight that such frameworks allow for the consideration of how task characteristics, cognitive ability, and motivation and disposition influenced the U-Shaped association between task difficulty and TUTs (Kanfer & Ackerman, 1989; Norman & Bobrow, 1975). Strategies for self-regulation of attentional states were assumed to be informed and determined by the myriad of person-based and task-based factors (Kanfer & Ackerman, 1989). One particular task-based factor is the 'resource sensitivity' of the task. High and low difficulty tasks are considered resource *in*sensitive because additional effort on these tasks will not alter performance. Specifically, tasks which are very easy will not require additional resources as performance is already at ceiling and tasks which exceed one's ability will likewise not benefit from extra effort on the individual's part.

Randall et al. (2019) predicted that mind wandering will occur most often during high and low demand math task conditions due to this resource insensitivity. However, it is notable that they measured mind wandering during task performance using a post-task scale rather than typical within-task probes. Combined analyses from data across the three experiments indicated a U-shaped association of mind wandering frequency with task difficulty whereby the lowest and highest difficulty tasks were associated with the greatest mind wandering frequency compared to the moderately difficult tasks. Additionally, a task difficulty x WMC interaction was found. This interaction reflected lower rates of mind wandering for higher WMC individuals during high-demand tasks.

Importantly, it has been suggested that the curvilinear association found within a given task may also go some way in explaining the variability of associations found *between* tasks (Seli et al., 2018c; Robison & Unsworth, 2018; Xu & Metcalfe, 2016). For example, Seli et al. (2018c) compared a CRT with a working memory task and found TUTs were more common in the CRT, positing this is due to the task having a lower cognitive load, thus allowing for more TUTs. More recently, Martínez-Pérez et al. (2021) compared a psychomotor vigilance task (PVT) to a SART. A PVT is a sustained attention task whereby a participant must press a key response whenever a stimulus (e.g. a light) appears on the screen. These authors argue the former is less demanding than the latter in terms of the cognitive mechanisms required to complete the tasks respectively, and found more overall TUTs in the PVT than the SART. However, both of these studies only compared an 'easy' to a 'difficult' condition, and thus could not test a curvilinear association across task paradigms.

Studies documenting curvilinear associations between task difficulty and TUTs represent a pivot towards better integration of the proposed mechanisms that underpin mind wandering. In difficult tasks it is argued that participants may experience more executive failures, or withdraw cognitive effort due to perceptions of difficulty, or frustration with the task and limited cognitive ability. In contrast, in low-demand tasks mind wandering may occur due to lack of challenge, perceived ease, boredom, or excess resources that can cater for both task performance and mind wandering. As such acknowledging the role of task context and cognitive and motivational factors supports the real possibility that TUTs may have different mechanisms according to the context in which they occur.

4.8.4 Non-Cognitive Determinants of Task-Unrelated Thoughts

4.8.4.1 Motivation

This chapter has referred to both cognitive and *motivational* processes influencing TUTs. Motivation has been identified as a critical variable that influences TUT frequency during reading comprehension, attention, and cognitive tasks (Robison & Unsworth 2015; Seli et al., 2015b; Unsworth & McMillan, 2013). Greater motivation is often associated with lower TUT frequency (Seli et al., 2015b; Seli et al., 2016a). This association is important as it demonstrates that having greater attentional control alone will not necessitate the experience of fewer TUTs, as there are other processes that will also determine their occurrence. This is unsurprising given the applied psychological literature which shows that motivation influences the intensity and persistence of a range of human behaviours and can influence the degree of attentional self-regulation during task performance (Campbell & Pritchard, 1976). Furthermore, research on the interactions between motivation and cognitive control has also gained traction, with demonstrations that cognition is a *motivated* act (Botvinick & Braver, 2015), influenced by subjective appraisals by the individual (Kanfer & Ackerman, 1989). Attentional regulation and WMC therefore do not exist in vacuums – they reflect the cognitive capability of the individual when the individual is *motivated* to engage in the activity.

4.8.4.2 Task Perception and Characteristics

Top-down subjective appraisals of tasks can also influence resource allocation policies toward TUTs during laboratory task performance. Studies have demonstrated the separable roles of subjective evaluation and objective task demands on TUTs during reading comprehension tasks (Forrin et al., 2018; 2021). Forrin et al. (2018) investigated whether the subjective evaluations individuals make about long versus short reading passages modulated their mind wandering rates. They hypothesised that when compared to short passages, longer text would be perceived as onerous and this would result in an increase in mind wandering rates. Notably the text used in long and short passages were objectively the same in terms of difficulty but it was argued that if subjective appraisals of text length and subsequent subjective difficulty influence mind wandering then the frequency of mind wandering should be greater in long passages in a within-subjects design but not a between-subjects design. This is because the between-subject design did not allow participants to compare passage lengths. This pattern of findings was confirmed leading the authors to argue that subjective difficulty and participant appraisals of tasks can influence how resources are directed to and from a task. In addition, Forrin et al. (2021) replicated the finding that longer texts which are controlled for difficulty exhibit greater TUT rates. Together these findings highlight that grasping how participants perceive and interact with tasks – how task features feedback to these perceptions – is important for understanding subjective influences on TUT engagement.

4.8.4.3 Personality and Disposition

Individual differences in personality and disposition have been found to influence the self-regulation of TUTs, and have implications for how they are experienced. Studies have found associations between TUT content and frequency with traits such as mindfulness (Agnoli et al., 2018; Seli et al., 2015c), neuroticism (Robison et al., 2017), narcissism (Kanske et al., 2017), and schizotypy (Kane et al., 2016). Indeed, Section 4.5.1 highlighted associations between schizotypy and TUTS. While research into associations between TUTs and schizotypy is underdeveloped, there are some noteworthy findings in the literature. Kane et al. (2016) measured executive control, schizotypy, and TUT frequency during laboratory tasks. They found that while no measure of executive ability predicted schizotypy, greater TUT frequency consistently predicted positive, disorganised, and paranoid symptoms. Welhaf et al. (2020) found differences in the associations of positive and disorganised schizotypy with TUT content [reviewed in Section 4.5.1]. Most recently, Zhang et al. (2022) investigated the relationship between trait-level general schizotypy, mind wandering, and anxiety. They found that schizotypy was associated with lower life satisfaction and that this association was mediated by anxiety and mind wandering. These studies suggest that personality traits have an important role to play in the type of TUTs individuals are inclined to experience, and their subsequent (dys)functional consequences.

4.8.5 TUTs: Helpful or harmful?

Throughout much of this thesis and the literature more broadly, off-task thoughts have been understood in relation to their negative impacts on task performance across a range of contexts. However, the executive resource framework argues that TUTs utilise the same pool of controlled resources that underpin the performance of many external tasks, and the content-regulation hypothesis highlights that certain types of TUT can improve wellbeing. In addition, the current concerns x executive failure perspective argues that these TUTs reflect discrepant goal states of the individual. It is reasonable then to suggest that these thoughts could – at times – possess constructive or functional characteristics (Mooneyham & Schooler, 2013). Indeed, just as forms of mind wandering in the laboratory have been associated with performance decrement in educational (Was et al., 2019) and laboratory contexts (Xu & Metcalfe, 2016), they have also been linked to the ability to plan for the future and creatively problem-solve (Baird et al., 2012). Yet it is still not well documented whether, and how, TUTs can confer benefits to the individual.

It is unsurprising that TUTs occurring during laboratory tasks, which frequently require a level of ongoing attentiveness to complete, often demonstrate negative impacts. However, TUTs experienced in daily life may reveal the more functional aspects of these thoughts. For example, Poerio et al. (2015; 2016) highlighted the functional role that *daydreaming* can play as a form of social cognition. The link between mind wandering and social cognitions was demonstrated in a large-scale survey which found that other people feature in 71% of daydreaming episodes (Song & Wang, 2012). Neurocognitive studies have also found overlap in the DMN (see Sections 2.7 and 5.6.5), a network of brain regions active during mind wandering, and regions associated with social cognition (Mars et al., 2012; Xie et al., 2016). This has led some to argue that human cognition defaults to social thoughts (Spunt & Lieberman, 2013), and depending on the nature of such thoughts this can improve or diminish wellbeing (Mar et al., 2012; Poerio et al., 2015; 2016). This is consistent with the content-regulation hypothesis (Smallwood & Andrews-Hanna, 2013) which predicts that the content of mind wandering determines its functional outcome. When these thoughts are negative in nature they can maintain and exacerbate unhappiness, whereas positively valenced thoughts maximise constructive outcomes (Smallwood & Andrews-Hanna, 2013; Shrimpton et al., 2017).

While daydreaming of course differs to TUTs, this construct is often placed under the umbrella category of *mind wandering*. Poerio et al. (2015; 2016) found that *social* daydreams during daily life (i.e., daydreaming that involves other people in its content) were associated with greater socio-emotional regulation and goal-pursuit, highlighting one avenue for different types of mind wandering to adaptively interact with well-being and social functioning. Poerio et al. (2015) used an ESM paradigm to sample daily social and non-social daydreaming and compared them in terms of post-daydreaming feelings of love and connectedness. They found that only social daydreams had an immediate socio-emotional benefit by increasing these post-daydreaming feeling states. A second study by Poerio et al. (2016) induced loneliness in participants, and found that daydreaming about close others after the loneliness induction resulted in greater feelings of connectedness, love and belonging than a control condition without a loneliness induction. This body of work seems to suggest that mind wandering can confer social benefits depending on the content of the episode. Nonetheless, this work measured ‘daydreaming’ as a form of mind wandering, and not the TUT variant in particular. As such, it is still unknown whether such constructive benefits conferred by daydreams are also present in episodes of TUTs.

4.9 Summary

Traditional accounts of mind wandering, namely executive resource and executive failure theories, are not sufficient on their own to explain the multi-faceted determinants of TUTs across diverse types of tasks and with variations in task difficulty. There is evidence to suggest that there is a reallocation of executive attention toward TUT episodes in some contexts, and likewise failures in attentional control which lead to TUTs in other contexts. Resultantly, integrative approaches have been proposed such as the content and context regulation hypotheses and the resource allocation frameworks, which may better take into account the multiple determinants of TUTs across different contexts. These approaches are not in conflict with executive resource or failure theories, but instead highlight how integrating features from different frameworks can increase explanatory power for TUTs. Explanations for TUTs must acknowledge its dynamic determinants which include not only cognitive ability but also self-regulatory factors such as motivation and personality.

Such flexible theoretical approaches may help to understand inconsistencies in the literature regarding TUTs, task difficulty, and WMC/executive process associations. Indeed, these areas of research will form the basis of investigation for the three studies in this thesis. The first area of interest is the documentation of a curvilinear task difficulty-TUT relationship within a given task context. This association indicates that the contradictions in past findings between different tasks may be due to the interaction between task demand, individual differences in cognitive ability and motivation, and participant evaluations of task characteristics. Second, a common assumption among all theories is that "executive processes" are utilised to avoid or sustain TUTs. Yet, as discussed in Chapter 3, there is little work investigating whether all executive processes are equally associated with TUTs or if specific candidate processes play a role in their occurrence. Third, explanations such as the content-regulation hypothesis can reveal whether, or under which circumstances, TUTs are beneficial or detrimental in nature.

Importantly, in trying to understand how TUTs behave across these domains it is also necessary to consider the intentionality of the off-task thought. That is, whether it involved the conscious decision by an individual to shift attention away from the external task or not. The role of intentionality in demarcating the relationships between TUTs and those factors defining the context in which the phenomenon arises is a relatively recent addition to the literature, and forms the focus of Chapter 5.

Chapter 5: Intentional and Unintentional Task-Unrelated Thought

5.1 Introduction

The chapters of this thesis have so far defined the TUT variety of mind wandering and provided an overview of both the cognitive architecture and theoretical explanations for these off-task thoughts. Importantly, this thesis has also highlighted three key research areas which often feature perplexing findings; i) the association of TUTs with specific executive processes (Chapter 3), ii) the association of TUTs with task context and level of difficulty (Chapter 4), and iii) the uncertainty regarding whether TUTs are innately detrimental or can confer benefits (Chapter 4). This thesis will argue that by distinguishing between intentional (deliberate) and unintentional (spontaneous) episodes of off-task thought, progress can be made in understanding the determinants of TUTs and their outcomes across these domains. Demonstration of a broad utility of intention can support arguments that intention should be explicitly considered in theory.

Theories of mind wandering initially assumed that TUTs were generated *spontaneously* and therefore lacked conscious intent. The assumptions of both the executive resource and executive failure hypotheses were that TUTs are goal-related thoughts remaining in highly accessible states. Namely, they are *automatically* triggered into consciousness when internal or external cues are present. However, there is growing evidence in the literature that TUTs can vary in their self-reported intention; participants endorse both unintentionally and intentionally experiencing TUTs. It is the central argument of this thesis that intention is an important dimension for future theories to explicitly integrate so that they more adequately predict and account for the diverse associations that TUTs demonstrate in theoretical, clinical, and applied research.

5.2 The Heterogeneity of Task-Unrelated Thought

Historically experimental designs and research questions had settled on a common – yet overly simplified – definition of TUTs. That is, TUTs had been singularly defined as off-task thoughts that were assumed to occur *involuntarily* (McVay & Kane, 2010; Smallwood & Schooler, 2006). Given that much of the early work in this area has developed from theories or models of attentional control, and has utilised WMC as a proxy measurement for it, such a restrictive definition is unsurprising. The role of attention control is to ensure that attention is focussed on the task, and that distractors do not enter consciousness [see Chapter 3]. As a consequence, if a distracting thought were to enter consciousness and become the focus of attention this would be conceptualised as a failure of control. Moreover, the thought probes used as measurement most often only differentiated whether an episode constituted off- or on-task thought (e.g. Andrillon et al., 2019; Kahmann et al., 2022; Kane et al., 2007a; Levinson et al., 2012; Meier, 2019). Naturally then, the theoretical background of working memory and attention control combined with the more-or-less dichotomous measurement used in early research shaped the discussions of TUTs in general monolithic terms that considered differences between on- and off-task thought states but did not consider differences *within* off-task thoughts. This understandable oversight has contributed to the limitations of theories of TUTs in being able to reliably and accurately make predictions about mind wandering phenomena.

Notably however, aligning with the development of perspectives such as the content-regulation hypothesis, there are researchers who have made the case against this strict taxonomy (see Seli et al., 2015b; Seli, et al., 2016; Stawarczyk et al., 2011). These researchers have highlighted the heterogeneity in mind wandering episodes, including differences in TUT content (e.g. valence, temporal focus) (Linz et al., 2021; Smallwood & Andrews-Hanna, 2013), its social orientation (Poerio & Smallwood, 2016), constraint (Smith et al., 2022) and, of most relevance to the specific aims of this thesis, the intentionality of its initiation (Seli et al., 2015b). The family-resemblances framework argues that by acknowledging the heterogeneity of TUTs and being precise in the way researchers measure and understand these thoughts, investigation of TUT causes and functions will be more exact. Further still, by differentiating between types of TUTs it becomes clear that multiple theoretical viewpoints can exist in cohesion. This is because these theories are best placed to predict particular kinds of TUTs in specific contexts. However, if researchers do not aim to document the different varieties of TUTs and their respective correlates, then potentially conflicting and non-generalisable conclusions are likely to ensue.

5.3 The Case for Intentional and Unintentional Task-Unrelated Thought

The definition of TUTs as unintentional task-irrelevant thoughts that enter consciousness during completion of external task goals (Kane et al., 2007a; McVay & Kane, 2012; Randall et al., 2014; Robison & Unsworth, 2015) aligns neatly with the concept of working memory as the ability to inhibit or suppress irrelevant information and distractors [see Chapter 3]. As a result, working memory functioning is used to account for TUTs, sometimes assuming they are a product of executive failure (Conway & Engle, 1994; Engle et al., 1999; Kane & Engle, 2003). Seli et al. (2015b) criticised this approach, noting that the assumption that TUTs occur unintentionally is based on a further assumption that participants' goals align with that of the researcher. That is, the participant has made the laboratory task their main goal and is applying cognitive control to maintain focus on this goal. Accordingly, the assumption that participants exclusively select and attend to information (and thus select the contents of working memory) based on *experimenter* goals forms the justification that TUTs are an *unintentional* or *spontaneous* phenomenon.

Yet it cannot be taken as a given that a participant's singular, or even partial, goal is the current external task, and by extension that TUTs are therefore unintentional. A seminal work by Giambra (1995) argued that TUTs can occupy consciousness for two reasons: i) because they capture our attention (an *uncontrolled* shift) or ii) because there has been a deliberate shift in attention toward them (a *controlled* shift) (see Table 1 for definitions and overview). The former is consistent with the assumptions of much of the early mind wandering literature, but the latter directly contradicts the definition of all TUTs as spontaneous. Seli et al. (2015c) explored the utility of this distinction in intention by observing whether dissociations exist between these two types of mind wandering. They used a correlational design to investigate associations of trait-level intentional and unintentional mind wandering (measured with the Mind Wandering-Spontaneous and Mind Wandering-Deliberate questionnaires) and trait mindfulness (measured using the Five-Factor Mindfulness Questionnaire, FFMQ). They found that spontaneous mind wandering was negatively associated with non-reactivity to internal experiences, whereas deliberate mind wandering was positively associated with non-reactivity. This marked the beginning of a body of work identifying dissociations in the relationship between intentional and unintentional mind wandering and variables such as ADHD (Seli et al., 2015a), task difficulty (Seli et al., 2016b), obsessive-compulsive symptoms (Seli et al., 2017a) and thought content (Seli et al. (2017b).

Accordingly, the implication for perspectives such as the current concerns x executive failure hypothesis [that mind wandering is the result of failing to inhibit internal distractors, McVay & Kane, 2010 – see Section 4.3] and executive resources hypothesis [that mind wandering *"lacks deliberate intent"*, Smallwood & Schooler, 2006, page 131 – see Section 4.2] is that such theories, in failing to delineate these forms of TUT, will misclassify intentional shifts of attention as unintentional ones. The critical argument of this thesis is that is it necessary to continue to establish meaningful differences between intentional and unintentional episodes across various domains of mind wandering research. In doing so, it can be determined whether current approaches to mind wandering need revision to explicitly integrate intention in their predictions. While emerging research does acknowledge the diversity within mind wandering and the implications of such diversity for theory, dimensions such as intention are still not *explicitly* acknowledged in theory itself. If research continues to document and demonstrate their separate determinants and outcomes this would further support calls for this dimension to be regarded as pivotal to understanding TUTs.

Table 1

Definitions and Examples of Intentional and Unintentional TUTs

TUT Type	Definition	Example
Unintentional TUTS	Task-unrelated thoughts that occur despite intentions to focus attention on an external current task.	A student trying to complete an exam, but finding themselves thinking about an upcoming coffee date.
Intentional TUTs	Task-unrelated thoughts that occur due to an intention to think about something unrelated to the external task.	An unmotivated office worker creating a spreadsheet and choosing instead to think about their next vacation.

5.4 Measuring Intention

Thought probes that enable greater distinction between categories of thought can be used to provide information that tests the assumption about the genesis of TUTs. For example, if a participant reports off-task thought the probe can then provide the opportunity to report whether this off-task episode was engaged intentionally or unintentionally (Arabaci & Parris, 2018; Banks & Welhaf, 2022; Seli et al., 2016a). In doing so, it is possible to then associate propensity to each type of mind wandering with contextual and cognitive variables and gain insight into the potential mechanisms underpinning each. These in-the-moment measures provide state-based indicators of the proportions of intentional and unintentional TUTs and will be used in the studies of this thesis. As in past literature the thought prompts used in the current work will ask participants to report on the intention of the *initiation* of the off-task thought (e.g., "was this mind wandering episode *engaged* intentionally or unintentionally?"). Indeed much work on the role of intention in mind wandering tends to focus on the mechanisms underpinning the ignition of TUT episodes rather than their maintenance per se (McVay & Kane, 2010; Seli et al., 2015a).

As such, differences regarding the intentional or unintentional *maintenance* of the TUT episode will not be captured in these measures.

In addition, Carriere et al. (2013) have developed a measure of differences in trait-level spontaneous and deliberate mind wandering, known as the Mind Wandering Spontaneous (MW-S) and Mind Wandering Deliberate (MW-D) scales. Each scale contains four items, such as *"I allow my thoughts to wander on purpose"* and *"I find my thoughts wandering spontaneously".* These items are scored on 7-point Likert scales. It should be noted that the MW-S and MW-D measure 'mind wandering' as a broad concept, and not specifically the TUT variety of mind wandering. Nonetheless, Seli et al. (2016c) confirmed the validity of this trait-level measure, observing that measures on this scale corresponded with state-level measures taken during an MRT.

5.5 A Note on Defining Intention in the Context of Mind Wandering Research: Intention as a Problem of Goal Selection

The distinction of the level of intention is important given current theories either explicitly or implicitly assume that TUTs are by default spontaneous in nature. Indeed, there are theorists who argue that conceptually TUTs must *always* be a passive form of cognition distinguished from controlled thought and therefore inherently unintentional and goal-irrelevant (Irving, 2016; Murray & Krasich, 2022; Murray et al., 2020). Murray and Krasich (2022) presented what they refer to as the *puzzle of the wilful wandering* (PWW). The PWW refers to the idea that we cannot *intend* to have TUTs because the very intention to have such thoughts makes them task-related (i.e. the intention to mind wander *changes* the current task or goal). These authors instead argue that there are times that participants deliberately distract themselves during a task (what other researchers have referred to as *intentional* mind wandering), and other times that they mind wander (what researchers have referred to as *unintentional* mind wandering).

There is however empirical support for the argument that *intentional* TUTs are a genuine event, at the very least at an experiential level. Across a number of studies participants have reported intentionally mind wandering (e.g. Seli et al, 2015; Giambra, 1995), indicating there is some form of off-task thought which people at least *believe* or *experience* as occurring intentionally. Anecdotally people believe there are times they mind wander when wanting to pay attention to their external task, and other times when they let their mind wander (perhaps because the current external task is too tedious, difficult, or uninteresting). Murray et al. (2020) argue that this is simply the re-orientation from an externally directed goal to an internally directed one, and does not constitute TUTs as they must be goal-unrelated.

Yet, the theoretical assumptions of executive failure and resource hypotheses include that TUTs reflect the automatic activation of goal-related material (Smallwood & Schooler, 2006; McVay & Kane, 2010). That is, there are goal hierarchies which form an individual's default state of thought (current concerns) and these must be supressed during task completion. When these thoughts enter consciousness this is because executive control has failed (or been captured), and the individual is now attending to thoughts regarding another goal separate to the to-be-completed task. That a thought is unrelated to an externally defined task-goal is not to say TUTs in and of themselves are without a goal – even if they are unintentional. By extension, if a TUT has a goal this does not necessitate that it is not a TUT if researchers define TUTs in relation to primary external task demands. These TUTs would still be considered task-unrelated in so far as they are unrelated to an externally defined task that was intended at some level to be completed.

In response to these ongoing philosophical debates, Arango-Muñoz and Bermúdez (2021) proposed an account for intentional TUTs by arguing that they reflect an intentional omission of cognitive control toward an external task, rather than necessarily an intentional initiation of off-task thought. Hence, in the context of experimental and task-based research, intentionality of TUTs might reflect the decision to allow thoughts pertaining to another goal to enter consciousness during task performance. Perhaps then when the term intentional TUTs is used, researchers are referring to those moments when there is an intended task one is ostensibly trying to complete (e.g., an experimenter defined task, or a personal task they have some level of intention to complete such as homework), and yet due to reasons such as boredom, motivation, cognitive (in)ability, under-stimulation, or other factors, a decision is made to relax cognitive control. This then increases the occurrence of TUTs entering consciousness. This TUT is not intentionally engaged, but it has entered consciousness through an intentional release of control. Whether intentional TUTs occur due to a decision to engage or a decision to omit control is not yet known, but clearly there exist times when this occurs and it is the argument of this thesis that it is worth studying and understanding the differences between these intentional moments of self-distracting thought and unintentional moments of TUT.

Given disagreements in defining what is meant by TUTs and the nature of intentional mind wandering, the assumptions that underpin this thesis should be made clear. In the studies included here, it is assumed that there is a type of off-task thought which is experienced and reported by participants as being 'intentional' in nature. This type of off-task thought has demonstrated differences in its occurrence and association to unintentional off-task thought. Acknowledging that there are different arguments about what 'intentional' mind wandering is, the purpose of this thesis is to document differences between these two types of off-task thought across a variety of domains and relationships to factors pertaining to them. In doing so, this thesis goes some way in answering calls to further inspect the issue and utility of intention and contribute to a clearer understanding of TUTs (Seli et al., 2015b; Smallwood & Schooler, 2015). Further still, even in accepting the argument that 'intentional' TUTs are not representing a true TUT but instead a change in the self-determined goals and tasks of the individual, it is still necessary to measure and differentiate between these types of thought in order to make conclusions about unintentional TUTs, which some may argue are the more 'genuine' occurrences of TUT. As such when the term 'task-unrelated' is used in this thesis it is in reference to externally defined tasks intended to be completed at the time of the mind wandering episode. In Studies 1 and 2 this will be in reference to experimenter-defined tasks. In Study 3, this will be in reference to tasks individuals have set out to complete in their daily lives, but during execution have nonetheless experienced off-task thought.

Furthermore, the conceptual definition of intentional and unintentional TUT used in this thesis is that of Seli et al. (2015c), whereby intentional TUTs refer to episodes of off-task thought that the individual engages in purposely or wilfully. In contrast, unintentional episodes are those which the individual believes occurred more spontaneously or without intention. To note, the terms deliberate and spontaneous and intentional and unintentional will be used interchangeably within this thesis in keeping with the current literature on this construct (Arabaci et al., 2018; Banks & Welhaf, 2022; Carriere et al., 2013; Christoff et al., 2016; Forrin et al., 2020; Forster & Lavie, 2009; Ju & Lien, 2018 Martínez-Pérez et al., 2021; Robison & Unsworth, 2018; Seli et al., 2015a; 2017a; 2019a; Subhani et al., 2018). Intentional mind wandering has often been defined as instances of deliberate disengagement from a task in order to engage in an unrelated stream of thought (e.g., Banks & Welhaf, 2022; Robison & Unsworth, 2018; Seli et al., 2015a; 2017a; 2019a). Unintentional mind wandering in contrast is often seen as involuntary and spontaneous (Martínez-Pérez et al., 2021), with the individual having little control over the occurrence of these thoughts. These definitions have evolved from Giambra's work on 'controlled' and 'uncontrolled' shifts of attention, and the extensive body of work by Seli and colleagues which argues that while traditionally mind wandering has been defined as spontaneous or unintentional, there are genuine moments of deliberate or intentional TUTs.

It should also be noted that there are those who contemplate nuance within the construct of intention and measure different features of thought generation including how intentional the thought was and how wanted the thought felt (e.g.,Ho et al., 2020; Turnbull et al. 2021). Nonetheless, while in future there may be greater distinction between intention, spontaneity, and voluntariness of the generation of thoughts, the current thesis will continue to use deliberate and spontaneous as interchangeably with intentional and unintentional.

Additionally, this thesis will measure state-level intention by providing participants with thought prompts which allow for selecting either intentional or unintentional TUTs. This is comparable to methods used in past work as well (Arabaci et al., 2018; Forster & Lavie, 2009; Ju & Lien, 2018; Kruger et al., 2020; Robison & Unsworth, 2018; Seli et al., 2015a). As such intentional TUTs will be operationalised as the proportion of prompts whereby participants report intentional TUTs as occurring. Likewise, unintentional TUTs will be the proportion of prompts whereby unintentional TUT is selected as a response. When measuring trait-level deliberate and spontaneous TUTs we will use scores on the MW-S and MW-D questionnaires again in keeping with past work (Carriere et al., 2013; Seli et al., 2019).

This approach is also consistent with the family-resemblances framework (Seli et al., 2018a; 2018b), which views mind wandering as a set of heterogeneous phenomena with similar but separable exemplars. As such, while unconstrained unintentional TUTs are thought to be the prototypical exemplar of mind wandering, to *only* consider this category of off-task thought as mind wandering is too restrictive. Other types of thought, for example, constructive daydreaming, prospective planning, and ruminative thought, considered by some to be distinct from mind wandering (Irving, 2016; Murray & Krasich, 2022), are included under the umbrella of the family-resemblances framework. Accordingly, this thesis also adopts the perspective that mind wandering is multi-faceted and varies along *many* important dimensions. This thesis focusses specifically on the dimension of intentional and unintentional TUTs, but acknowledges that ongoing research will continue to uncover, and indeed already has uncovered, other important characteristics that differentiate categories of off-task thoughts (for example see Murray et al., 2020).

5.6 Dissociations of Intentional and Unintentional Task-Unrelated Thoughts

If it is the case that intentional and unintentional TUTs share identical cognitive, contextual, and behavioural correlates, and produce the same outcomes, then making the distinction between them would be without purpose. However, there is a growing body of literature mapping clear independence between these thought types. In particular, intentional and unintentional mind wandering have shown distinct outcomes and theoretical implications in diverse experimental (Forrin et al., 2021; Robison & Unsworth, 2018; Seli et al., 2015b; Subhani et al., 2019) and clinical contexts (Seli et al., 2015a; Seli, et al., 2017; Seli et al., 2019a). In prior chapters the ambiguous results regarding TUTs in relation to executive functions/cognitive ability, task difficulty, and constructive or unconstructive outcomes were presented. In the following sections, the potential for intention to provide a clearer picture on these uncertainties is discussed.

5.6.1 Cognitive Ability

Intentional and unintentional TUTs at times have separable associations with measures of cognitive ability, such as WMC. The general pattern of findings indicate that unintentional TUTs exhibit associations aligning with ideas that executive failures lead to TUTs (Ju & Lien, 2018; Robison & Unsworth, 2018**)**. In contrast, intentional TUTs seem to reflect a decision to allow the capacity of working memory to be allocated away from task-focussed thought and toward other thoughts unrelated to the ongoing task. These distinctions are important given that when TUTs are measured monolithically, inconsistent associations have been observed. Delineating between intentions of the episode offers a window for clarifying these findings.

Robison and Unsworth (2018) measured intentional and unintentional TUTs during a range of cognitive tasks and measured WMC as well as dispositional variables (e.g., motivation, perceived task difficulty, pleasantness). Using latent correlational analyses they found that the relationship between WMC and TUTs was driven by WMC's ability to predict resistance to spontaneous TUTs, consistent with an executive-failure perspective. Motivation strongly predicted both deliberate and spontaneous TUT rates. Notably however there are studies that have found contrary associations. There have been observations that measures of attention control and WMC were modestly negatively associated with *both* intentional and unintentional TUTs (Robison et al., 2020; Soemer & Schiefele, 2020). These authors argue this pattern of responses reflects low WMC participants' choice to withdraw attention from tasks they find to be too difficult. Furthermore, there have been instances where intentional *but not* *unintentional* mind wandering was associated with WMC (Banks & Welhaf, 2022). Factors such as task demands, and characteristics and participant dispositions and perceptions may influence these fluctuating associations. McVay and Kane (2012) suggested for example that the duration of a sustained attention task influences presence and strength of a TUT-WMC associations.

5.6.2 Task Difficulty

Intentional and unintentional TUTs have shown separability under experimental manipulations of task difficulty (Seli et al. 2016b; Seli et al., 2018b). Seli et al. (2016b) had participants perform easy and difficult variants of the SART and measured the frequency of intentional and unintentional TUTs during both. They manipulated SART difficulty via the predictability of target digits (i.e., the easier task had more predictable targets). This difficulty manipulation had no effect on overall rates of TUTs, but it did produce very different distributions of TUT types. Intentional TUTs were more common in the easy SART, but unintentional TUTs occurred more often in the harder task. A second study by Seli et al. (2018c) used alternating task blocks of a CRT and a working memory task, to represent easy and difficult task conditions respectively. Consistent with past findings, intentional TUTs were more common in the CRT task (‘easy’ condition). However, they failed to find an increase in unintentional TUTs during the more difficult task blocks. This suggests that not all task difficulty manipulations are equal and calls into question how different task characteristics can influence each type of TUT. Moreover, these findings suggest that the curvilinear association between task difficulty and TUT rates is differentially driven by intentional and unintentional mind wandering.

A similar relationship also occurs across different types of vigilance tasks. Martínez-Pérez et al. (2021) investigated intentional and unintentional TUT rates in an arousal (i.e. PVT) and executive attention (i.e., SART) task. They argue the former is less demanding than the latter in terms of the cognitive mechanisms required to complete the tasks. These authors found more overall TUTs in the PVT than the SART. Importantly, intentional TUTs were more frequent in the PVT compared to the SART, whereas unintentional TUTs were more frequent in the SART compared to the PVT. They argue that this is due to differences in vigilance demands, as the PVT is more monotonous than the SART and therefore it should encourage relatively more intentional disengagement. In contrast, compared to the PVT, the SART involves the use of more executive vigilance to detect infrequent targets that can lead to more unintentional attentional lapses.

Comparisons between tasks with differing demands also raises the possibility that a factor other than task difficulty *per se* might underlie the associations with the intentionality of mind wandering [See Section 5.6 for greater discussion]. That is, more difficult tasks tend to also involve more engagement with the task (the participant has to respond/attend more to the task due to the task demands rather than the task difficulty). This in turn may also influence engagement with different types of mind wandering. Indeed, Martínez-Pérez et al. (2021) acknowledge the possibility that the PVT had greater TUTs because it involved fewer behavioural responses (i.e., compliance) which further under-stimulates participants and encourages disengagement from the task.

5.6.3 Non-Cognitive Correlates

5.6.3.1 Motivation

While unintentional TUTs perhaps reflect the influence of executive control capabilities (Robison & Unsworth, 2018**)**, intentional TUTs may demonstrate a stronger relationship with motivational variables (Seli et al., 2015b, 2016; 2019; Robison & Unsworth, 2018). Using a correlational design, Seli et al. (2015b) demonstrated that participants with lower motivation to perform on the MRT were more likely to engage in intentional TUTs relative to unintentional TUTs. However, a second study by Seli et al. (2015b) investigated motivation and TUTs during a lecture, and found a negative relation between intentional TUT and motivation, as well as a marginally significant inverse relation between unintentional TUT and motivation. Furthermore, in an experimental design, Seli et al. (2019a) manipulated motivation using a time incentive, to investigate whether increasing motivation would influence intentional and unintentional TUT frequency during an MRT. Participants in the motivation condition were informed that they may be able to leave the experiment early based on whether they achieved a satisfactory performance on the MRT after approximately 30 minutes (halfway through the task). Participants in the control condition were not provided with this information. Participants in the motivation condition displayed lower rates of intentional and unintentional TUTs compared to the control group.

The implication from this work is that both forms of TUTs can be reduced when a participant has greater motivation to perform a task. By increasing motivation to perform well, the participant's goals are more likely to align with that of the researcher (albeit for different reasons). In the case of the aforementioned experiment, the participant will want to focus on the external task and do well so they may exit participation more quickly. The participant will increase their on-task focus, which in turn will increase their control of attention on task-related information. Therefore, the increase in performance driven processing on task-based information will decrease the likelihood that attention is unintentionally co-opted by TUTs. This increase in task focus will also lead to a decrease in deliberate TUT episodes. That is, increasing motivation decreases both spontaneous and deliberate TUTs. Importantly, these relationships between motivation and intentional and unintentional TUTs suggest that executive control is innately a *motivated* behaviour; the experimenter cannot assume that participant control over their attention is automatic and reliable. Furthermore, it is apparent that the rate of unintentional TUT can be used as a proxy for participant task engagement and motivation via the application of control 'gateways' that inhibit or do not allow intrusive/unrelated thoughts into the conscious space.

5.6.3.2 Perceptions of Task Difficulty

Participant assessments of task characteristics can also have unique influences on intentional and unintentional mind wandering. Subhani et al. (2019) investigated whether task compliance (i.e., response requirements) could be a factor influencing intentional TUT rates. In their study, compliant activity was defined as the requirement to provide more frequent behavioural responses to a task within a certain time window (that is, pressing a key in response to a particular target stimulus). To test this idea, these authors used two sets of tasks: a gaze-fixation task with and without a reaction to interference (i.e., a grey screen which would obstruct view of the fixation cross), and a go/no-go task with low or high response-target frequency. Importantly, the conditions with greater compliant activity (i.e., with reaction to interference, and higher target frequency) were not necessarily more difficult, but required greater interaction from the participant. The authors found that compliant activity inhibited deliberate TUTs but did not influence unintentional TUT rates. The increase in compliant activity may have influenced cognitive-motivational evaluations of the task, and made participants perceive the task as perhaps more interesting and/or more difficult when greater response behaviour was required.

An association between perceptions of difficulty and unintentional TUTs has also been observed in the context of reading tasks, where longer text segments were perceived by participants as more difficult than shorter text segments (Forrin et al., 2021). By extension, this also encouraged more unintentional TUTs suggesting that unintentional TUTs may also be influenced by top-down appraisal of tasks. It seems then that top-down evaluations of tasks in conjunction with task characteristics can have influences on intentional and unintentional TUTs, but perhaps for different reasons. Where intentional

TUTs have been reduced by increased behavioural response requirements, unintentional TUTs are increased by perceptions that greater effort is required at least in reading contexts.

5.6.4 TUTs: Helpful or harmful?

Trait-level characteristics and certain (sub)clinical presentations have also revealed dissociations between intentional and unintentional TUTs. This includes separable associations with mindfulness traits, subclinical depression and anxiety (Seli et al., 2019b), problem gambling (Kruger et al., 2020), self-rumination and self-reflection (Vannucci & Chiorri, 2018), and OCD (Seli et al., 2017). Given the nature of these associations, there is reason to believe that intentional TUTs can uniquely confer positive psychological, social, and emotional benefits for individuals. On the other hand, unintentional TUTs might indicate the tendency for more ruminative or intrusive TUT content that can act as an impairment to general wellbeing. As there is ongoing debate regarding whether TUTs are helpful or fundamentally harmful, the possibility that types of TUTs have different psychological outcomes is consequential.

Consistent with this proposal, Seli et al. (2017b) investigated the content of intentional and unintentional TUTs during a laboratory task (the CRT). They found that intentional TUTs tended to be future-oriented and less vague compared to unintentional TUTs, potentially reflecting that intentional TUTs contribute to goal-pursuit, which would likely lead to more positive mood states for the individual. This seems especially likely, given that trait-level intentional TUT has also been observed to positively correlate with mindfulness (specifically the trait of non-reactivity to inner experiences, Seli et al., 2015c), and self-reflection (Vannucci & Chiorri, 2018). In contrast, unintentional TUTs are more intrusive and uncontrolled in nature. Seli et al. (2017a; 2019b) found spontaneous mind wandering rates predicted OCD symptom frequency as measured by a self-report questionnaire, and subclinical stress, anxiety, and depression. These relationships are unsurprising given that OCD, depression and anxiety are associated with a decreased sense of control over one’s thoughts, and likewise decreased executive control.

Despite the possibility that intentional and unintentional TUTs could play a role in respective benefits and disadvantages on wellbeing and function, intentionality continues to be overlooked in measures of TUTs. Indeed, in Chapter 4 [Section 4.8.5] it was highlighted that *daydreaming* about others (i.e., social daydreaming) can have beneficial results such as increases in happiness (Poerio et al., 2015), connectedness (Poerio et al., 2015), and decreases in loneliness (Poerio et al., 2016). Again this literature focussed on *daydreaming*, however the pattern of findings suggest that perhaps intentional and unintentional episodes of social TUT could differentially shape or interact with the way an individual views their social world. Given a number of personality traits and clinical presentations are associated with impaired social functioning in a host of populations, the role that ongoing spontaneous and deliberate mind wandering plays in broader conditions such as loneliness, is worthy of pursuit.

Documenting the social and emotional dissociations of these two forms of thought would further indicate separable mechanisms are responsible for their respective occurrence, and have implications for theory, practice, and application. If both forms of TUT have separable impacts on wellbeing and social function, then interventions aiming to target cognition and off-task thought need to be designed in light of these differences in order to better target maladaptive forms of TUTs, and capitalise on adaptive ones. Task-unrelated thoughts are a part of everyday life, and so grasping the manner in which these cognitions manifest in different groups allows us to more clearly form an appreciation of the various phenomenology of particular traits and psychopathologies. In relation to the goals of this thesis, demonstrating that in both experimental and cognitive domains as well as social and everyday life domains there are separable implications for intentional and unintentional TUTs, will strengthen arguments for including this dimension as an explicit aspect of theory.

5.6.5 Evidence from Neuroanatomical Associations: Default Mode Network

The DMN seems to deactivate during task demands, and become activated during "rest", a finding that led to the discovery of its link with mind wandering. However, recent studies have found that the DMN is also able to contribute to active and controlled cognitive processes during tasks by increasing connectivity with regions that support cognitive control (Piccoli et al., 2015). This evidence for both an inverse correlation with DMN and executive control at rest, as well as a positive correlation between these same systems (the DMN and executive control regions) which allows for information from memory to support controlled thought, informs how the DMN could be relevant in both unintentional and intentional mind wandering episodes respectively. At times when these regions are anti-correlated, spontaneous mind wandering may occur due to failures of executive control allowing default mind wandering activity to enter consciousness. However, instances where these regions are active together may support controlled thought and underpin intentional mind wandering.

Supporting this possibility, Golchert et al. (2017) employed magnetic resonance imaging (MRI) to investigate the role of intentionality in determining relevant brain regions for mind wandering. They used trait-level mind wandering scales (i.e., the MW-S, MW-D), and observed structural and functional brain organisation differences between participants who experience more deliberate or spontaneous mind wandering. These authors observed that people who endorse engaging in more deliberate mind wandering had a heightened integration between the DMN and the FPN. In contrast, greater spontaneous mind wandering was related to cortical thinning in the right parietal cortex encompassing the regions of both the DMN and FPN. These authors interpreted the findings to support that mind wandering aligning with an individual's intentions is supported by connectivity between the DMN and FPN network, whereas spontaneous mind wandering seems to reflect executive control difficulties.

5.7 Intention and Theory

Thus far, this chapter has demonstrated that intentional and unintentional TUTs show interesting similarities and distinctions in their relationships to cognitive and non-cognitive mechanisms, task difficulty, and functional outcomes. Unintentional TUTs appear to have a relationship with variables that reflect difficulties in controlling attention and sustaining thoughts on task-relevant content. The relationship of unintentional TUTs with high-load/high-difficulty tasks (Seli et al. 2016; 2018), WMC and attention control (Robison & Unsworth, 2018), depression and anxiety (Seli et al., 2019b), ADHD (Seli et al., 2015a), and OCD (Seli et al., 2017) best demonstrate this. Although, these associations seem to be interdependent and dynamic, with unintentional TUTs occasionally having no association with cognitive ability in certain studies (Banks & Welhaf, 2022). In contrast, intentional TUT tends to occur in contexts when people are either unmotivated to maintain attention on a task or perceive a task to be easy enough that they can mind wander concurrently (Martînez-Pérez et al., 2021; Robison & Unsworth, 2018; Subhani et al., 2019).

This distinction has implications for theories of off-task thought. The current concerns x executive failure hypothesis is best placed for predicting and explaining unintentional TUT episodes particularly in difficult task contexts. These episodes, given they seem to reflect off-task thoughts where people intend to keep focus, and are more common in difficult contexts and in people with lower WMC, are likely reflecting failures in maintaining attention. In contrast, intentional episodes could reflect the conscious and volitional decision to think about an alternative task-unrelated goal. This is reflected in its positive association with mindfulness and inverse association with motivation, and aligns with the notion that TUTs can reflect re-allocation or a capturing of resources. Indeed, Kahneman's (1973) allocation policy for attention argues that the distribution of attention is decided by a number of factors including involuntary attentional processes, as well as transient intentions of the individual. If this is the case, distinguishing between the intentions of an episode and how this interacts with other variables of interest in the mind wandering literature can potentially go some way toward reconciling at least some of the ambiguous findings. Furthermore, examination of TUT content as a function of intentionality offers the opportunity to identify the conditions under which TUTs have constructive or unconstructive outcomes.

5.7.1 Recent Evidence for the Explanatory Power of Intention

Ju and Lien (2018) proposed an integration hypothesis to explain how intentional and unintentional TUTs could reconcile inconsistent TUT, WMC, task difficulty associations. These authors examined how TUT frequency was associated with mindfulness, task load, and intentionality in a pair of *n*-back task conditions, where participants must identify whether a stimulus is the same as that presented *n* events prior. They found that participants with greater mindfulness were less likely to experience intentional TUTs in the low-load (0-back) task condition. There was no relationship between intentional TUTs and WMC. In contrast, unintentional TUTs had a negative relationship with WMC in the high-load (2-back) task only, and mindfulness predicted fewer unintentional TUTs in *both* high and low load tasks. Together, these results suggest that people engage in TUTs based on their self-regulation and executive control abilities, as well as the context of the task. In difficult tasks, people exert more effort toward controlling TUTs, and this leads to the negative relationship between unintentional TUTs and WMC. In contrast, in easier conditions, people may believe they can afford to mind wander or may not feel challenged enough, and as such they may choose to mind wandering if they are not able to self-regulate, which results in a lack of a WMC-TUT relationship and a greater reliance on mindfulness-related processes.

Supporting the idea that individuals can modulate their engagement with TUTs depending on the objective or perceived demands of the task, Seli et al. (2018d) investigated TUT frequency during a simple clock task. The task involved an analogue clock face whereby the hand ticked once per second, making a full revolution every 20 seconds. Participants had to press a button each time the hand pointed at 12:00, making the task highly predictable with a low executive demand. Findings demonstrated that participants modulated their mind wandering according to task demands, and that mind wandering during this low demand task had no influence on performance. As such it seems that participants can allocate their attention to both the current task and TUT content in a strategic manner.

Robison et al. (2020) also investigated the benefits of a multi-faceted approach to predicting TUTs. They utilised a large sample to investigate TUTs in relation to cognitive, contextual, and dispositional factors and found that as task demands increased, TUTs decreased, as has been observed in previous research. However, the rates of intentional TUTs were zero-inflated[2], and this skewness in outcome distribution may have led to their failure to replicate a specific negative relationship between intentional TUTs and task demand. They also found that TUTs negatively correlated with measures of both WMC and attentional control, confirming that higher WMC individuals can better modulate and control their TUTs to suit the task demands. Task-unrelated thought was also found to be more frequent with negative mood, and intentional TUTs were less frequent in highly conscientious individuals. Together, these relationships highlight that intentional and unintentional TUTs are complex, and determined by multiple factors and mechanisms.

5.8 Summary

Chapter 5 has defined intentional and unintentional TUTs, and reviewed the empirical evidence for their distinct and theoretically meaningful associations. It seems essential that theories formally acknowledge and even integrate how intentional and unintentional TUTs manifest. In doing so, they may be better able to account for patterns of association in the literature. In addition to intentionality, several other variables have also been shown to influence TUT activity. Factors such as valence, temporal focus, and constraint among others, have been shown to cast influence on the manner in which TUTs manifest. It is the position of this thesis that some of the complex findings in the literature that have been identified thus far can be better understood by measuring TUT intention. Thus, this thesis aims to further consider how differences of intentional and unintentional TUTs across domains can offer the opportunity to more precisely outline and describe the nature of these thoughts.

[2] Zero-inflation refers to models with excessive zero counts in the data. This causes a bias in the distribution and can lead to inaccurate interpretations of parametric analyses (because the analysed data do not readily fit a normal distribution. In mind-wandering research, zero-inflation occurs when a large number of participants report no mind-wandering during the task/s performed.

Chapter 6: Summary of Thesis Aims and Study Designs

6.1 Introduction

This chapter summarises the rationale, aims and design for each of the three studies of this thesis, on the basis of the mechanisms, theories, and dimensions of TUTs outlined thus far. This thesis aims to document variation in TUTs across selected domains to inform areas of the literature where acknowledging heterogeneity in off-task thoughts can potentially clarify opaque and inconsistent associations. In sampling behaviour across domains, evidence which counters the practice of measuring TUTs as a unitary phenomenon can be amassed, and the broad ranging utility of theories explicitly integrating this difference in intention can be illustrated. This collection of studies can then demonstrate that measurement of intention should be a more common exercise in mind wandering research, rather than an optional measure of interest. Study 1 will observe differences between intentional and unintentional TUTs in terms of WMC, task difficulty, motivation, and subjective evaluations. Study 2 focusses on the association of TUTs with specific executive processes using Shipstead et al.'s (2016) model of executive attention. Study 3 observes how TUTs relate to socio-emotional content and outcomes in an attempt to document the determinants of helpful and harmful TUT outcomes.

6.2 Study Aims

Study 1 involves two experiments which aim to observe whether the frequency of intentional and unintentional TUTs differs across sustained attention and working memory updating task contexts. In addition, it will document how the association between TUTs and motivation, WMC, and perceived task difficulty changes depending on the task and type of TUT. The motivation of this study is first, that curvilinear associations between task-difficulty and TUT frequency (Xu & Metcalfe, 2016) have been documented within task paradigms. There is a possibility that such associations can also account for between-task differences in TUTs, as certain tasks may represent different benchmarks of ease and difficulty. Furthermore, intentional TUTs occur more commonly in easier or monotonous tasks whereas unintentional TUTs can occur most often in high-load cognitive tasks (Forrin. 2021; Seli et al. 2016; Subhani et al., 2019) and this pattern may expand upon the non-linear associations of TUTs with tasks and task difficulty. That is, monotonous tasks may be more likely to be perceived as easy than high-load tasks and this in turn may encourage deliberate TUTs. Second, given Subhani et al. (2019) and Forrin et al. (2021) have found evidence that perhaps the way participants perceived task demands depends on the task features, in Study 1 subjective perceptions, cognitive ability, and motivation were also measured to examine their roles in the variation of TUTs. Generally, unintentional TUTs were predicted to be more common in tasks exceeding participant ability (high-load/demanding tasks), and most clearly associated with cognitive ability (as measured by WMC). In contrast, intentional TUTs were predicted to be most common in easier or repetitive tasks, and due to the deliberate nature of this type of TUT, predicted to show a greater or more consistent association than unintentional TUTs with motivation and perceived difficulty (or ease) of the task itself.

Study 2 aimed to investigate associations between intentional and unintentional TUTs with specific executive functions. As highlighted in Chapter 3, working memory is believed to reflect executive attentional functioning. However, executive processes are part of an umbrella concept that encompasses a number of candidate functions (Miyake et al., 2000; Shipstead et al., 2016). In their re-conceptualisation of executive attention and working memory, Shipstead et al. (2016) argue that maintenance and disengagement are two key candidate functions of executive attention. These reflect the ability to hold information in mind (i.e., to maintain), and release information when it is no longer relevant to the task (i.e., to disengage). Study 2 aimed to investigate the associations of intentional and unintentional TUTs with these processes, in order to further elaborate on the underlying mechanisms associated with the occurrence of these thoughts, and any differences between them. This is important as a number of theories call on executive functioning as a means to account for TUTs, yet fail to address the specific nature of executive functioning in preventing or promoting TUTs. It was predicted that unintentional TUTs would be associated with maintenance processes as reflected in performance on complex span tasks as the maintenance of task content is critical to limiting the occurrence of TUTs. It was also predicted that unintentional rather than intentional TUTs would be associated with disengagement abilities as reflected in performance on fluid intelligence tasks, given that how well an individual can refocus on engaging with the external task after spontaneous TUT might reflect disengagement ability. Intentional TUTs in contrast are more or less consciously engaged, and therefore are likely influenced by variables such as interest and perceived difficulty.

Study 3 employs an experience-sampling method to measure state-level intentional and unintentional social TUTs in daily life. Task-unrelated thoughts in daily life were the focus of this study as functional uses of off-task thoughts may be more readily observable in ecological settings rather than performance-heavy laboratory tasks. In addition, *social* TUT episodes were the focus of this study because: i) previous research has identified that social content in daydreaming confers socio-emotional benefits through engagement in self-generated thought (Poerio et al., 2015; 2016); ii) differences in intentional and unintentional TUTs as they relate to dispositional variables of interest (in this case schizotypy and loneliness) further highlight their non-cognitive associations; iii) TUTs are argued to be both beneficial and detrimental, and so it is possible that intention is an important determinant of cost/benefit. It was predicted that, based on past literature of general mind wandering and wellbeing, and mind wandering in (sub)clinical groups, that intentional social TUTs would be associated with more constructive social content and emotional outcomes. In contrast, unintentional TUTs would be associated with maladaptive content and outcomes, due to its link to spontaneous, ruminative, and intrusive cognitive mechanisms. As such, this study uses intention as a means to understand the factors which influence the (mal)adaptive outcomes of TUTs.

6.3 Study Design

Study 1 includes both experimental and correlational design features, while Studies 2 and 3 are correlational in nature. When investigating cognitive processes, it is standard to manipulate variables thought to be central to the process in question. Typically this involves presenting an imperative stimulus to participants, and measuring and recording their response to that stimulus. By varying the nature of this stimulus, the experimenter can then measure changes in the behavioural, neural, or physiological response of interest and make inferences about the underlying process. Study 1, which involves two experiments, will utilise this methodology by measuring intentional and unintentional TUT rates (the behavioural response of interest) in different task contexts (the independent variables). Specifically, Study 1 investigates whether intentional and unintentional TUT rates differ in a SART versus working memory updating task. In addition, a correlational design is used to observe how rates of intentional and unintentional TUTs in different tasks are associated with cognitive ability (WMC), motivation, perceived difficulty, and interest. The determination of whether intentional and unintentional TUT rates differ in different tasks contexts, and disassociate from variables of interest, adds to the growing body of evidence that TUTs with and without intention are independently related to both the task context, and cognitive and non-cognitive abilities of the individual. As the literature reveals conflicting findings in the individual reports of different task contexts, a direct comparison of the frequency of intentional and unintentional TUTs in popularly applied tasks may go some way in accounting for these discrepancies.

In Studies 2 and 3 correlational designs are adopted, to investigate different associations of each type of TUT with specific executive abilities (i.e., maintenance and disengagement) and with social functioning, respectively. Study 2 employs a standard probe-caught method during a SART and utilises SEM to investigate whether intentional and unintentional TUTs load differently onto maintenance and disengagement functions as highlighted by Shipstead et al.'s (2016) re-conceptualisation of executive functions. Study 3 employs an experience-sampling method and multi-level modelling analysis to investigate differences in the content and outcomes of daily *social* TUT episodes, as well as their relation to socially-relevant personality traits of interest (i.e., loneliness and schizotypy). This extends on the finding by Poerio et al. (2016) that social *daydreaming* confers benefits to the individual, by observing whether similar benefits occur for other types of mind wandering such as TUTs.

6.4 Summary

To summarise, the studies in this thesis aim to investigate;

i) Differences in intentional and unintentional TUT rates during different task contexts, (namely during a SART and *n*-back task), which benchmark task ease and difficulty (Study 1)

ii) Whether working memory, subjective task appraisals, and motivation have differential associations with intentional and unintentional TUTs across different tasks (Study 1)

iii) How different types of executive mechanisms (i.e., maintenance and disengagement processes) relate to intentional and unintentional TUT rates (Study 2)

iv) The content and phenomenology of intentional and unintentional TUTs in daily life in relation to social cognitions (Study 3)

v) Whether intentional and unintentional social TUTs differ in relation to their socio-emotional regulatory outcomes and personality traits (Study 3)

Chapters 7-9 report the empirical work conducted in fulfilment of these aims.

Chapter 7: Study 1 – Cognitive and Non-Cognitive Correlates of Intentional and Unintentional TUTs in a Sustained Attention and Working Memory Task

7.1 Background

Off-task thoughts have been found to both decrease (Seli et al., 2016b; Robison & Unsworth, 2018) and increase (Adam & Vogel, 2017; Kahmann et al. 2022) with task difficulty, often depending on the type of task in question. Past research has investigated differences in easy and difficult task conditions both within a given task paradigm (Xu & Metcalfe, 2016, Randall et al., 2019) and between different tasks which benchmark ease and difficulty (Martínez-Pérez et al. 2021, Seli et al., 2018c). Generally, it has been argued that easier tasks encourage more TUTs due to excess resources or processes such as boredom and under-stimulation (Smallwood & Schooler, 2006). In contrast, more difficult task contexts may encourage greater TUTs as they overload cognition, leading to more attentional failures (Ju & Lien, 2018; Xu & Metcalfe, 2016). Additionally, evidence suggests that task features (Subhani et al., 2019; Forrin et al., 2021), and subjective perceptions of tasks (Forrin et al., 2021), can differentially influence the rates of TUTs.

The current study aims to extend the understanding of the task difficulty-TUT association by comparing rates and correlates of intentional and unintentional TUTs during sustained attention and working memory tasks. These tasks were chosen as they are commonly used in the literature and elicit comparable TUT frequencies (McVay & Kane, 2013). By directly comparing them, while also measuring variables known to influence task engagement, the influence of these variables on each type of TUT among commonly used tasks can be observed. Indeed, Randall et al. (2014) prescribed SART tasks as relatively simple tasks compared to working memory tasks (which tend to be more complex). In this way, the SART and updating tasks can be seen to benchmark a certain level of ease and difficulty, respectively. To indicate possible underpinning mechanisms of each type of TUT in different task contexts, this study also measures motivation and WMC, and perceptions of task difficulty. In doing so, a direct comparison of the association of TUT rates with these variables between tasks can further suggest both i) the underpinning mechanisms of each type of TUT and ii) how these mechanisms differ between different types of tasks. Documenting differences between the rates and correlates of intentional and unintentional

TUTs across tasks may further knowledge of what underpins internal off-task thoughts in different contexts.

7.1.1 Task Difficulty

Chapters 3 and 4 outlined how the TUT-task difficulty association changes depending on the task paradigm. For example, when using tasks such as the SART (Robertson et al., 1997) or those that are similar (e.g. CRT) the general finding is that TUTs are more common in easy task conditions than when these tasks are modified to be relatively more difficult (e.g. through modifying their target-non-target ratios) (Giambra et al., 1989; Levinson et al., 2012; Seli et al., 2016b; Seli et al., 2018c; Smallwood et al., 2011). In contrast, during higher order cognition tasks such as working memory or reading tasks, the opposite pattern has been found – TUTs are reported as more frequent in difficult task conditions (Adam & Vogel, 2017; Feng et al., 2013; Kahmann et al., 2022; Xu & Metcalfe, 2016).

To account for this pattern of results, Xu and Metcalfe (2016) proposed that TUTs and task difficulty demonstrate a curvilinear association [see Section 4.8.2]. While this curvilinear association is mostly demonstrated when difficulty is manipulated within a paradigm (Randall et al., 2019; Xu & Metcalfe, 2016; although see Kahmann et al., 2022 for evidence of a linear association in reading contexts), it has also been suggested that this association can go some way in explaining the variability of associations found *between* tasks (Seli et al., 2018c; Robison & Unsworth, 2018; Xu & Metcalfe, 2016). For example, Seli et al. (2018c) compared a CRT with a working memory task and found TUTs were more common in the CRT, positing this is because the task has a lower cognitive load allowing for more TUTs. More recently, Martínez-Pérez et al. (2021) compared a PVT to a SART. They argue the former is less demanding than the latter in terms of the cognitive mechanisms required to complete the tasks and found more overall TUTs in the PVT than the SART. However, both of these studies only compared 'easy' to 'difficult' conditions, and thus could not test non-linear associations.

The current study samples across easy, moderate, and difficult conditions using both sustained attention and working memory tasks as the benchmarks. These are two commonly used paradigms, which are fundamentally different in the processes and effort required to perform them. Past attempts to generalise findings from one type of task across task contexts had originally overlooked differences in cognitive load and degree of difficulty between these paradigms. For example, a vigilance task relative to a working memory task, can seem simple and monotonous to a participant, and accordingly encourage TUTs (Manly et al., 1999; Robertson & O'Connell, 2010). While vigilance can tap into working memory it is unlikely that these tasks can equate to the level of difficulty that complex higher order cognitive tasks requiring executive control possess. Directly comparing a monotonous attention task to an updating working memory task can reveal how particular task features interact with TUT rates. This leads to the first goal of the current study; to employ sustained attention and working memory tasks and directly compare and observe whether a curvilinear association in TUT rates occurs across these tasks.

7.1.2 Intentional and Unintentional TUTs, Task Difficulty, and Cognitive Ability

Seli et al. (2018c) demonstrated an intention by task difficulty interaction using alternating blocks of a CRT (low-load) and working memory task (high-load). They observed that overall TUTs were more frequent in the CRT, but intentional TUTs were more frequent in the easy task blocks. However, these authors failed to find an increase in unintentional TUTs during the difficult task condition and argued this may be because the tasks did not sample across the full range of difficulty. In contrast, Robison and Unsworth (2020) used two levels (high load, low load) of an *n*-back and visual search task and did not replicate the finding that intentional TUTs decreased as demand increased. However, in their sample intentional TUT was zero-inflated in the *n*-back task, and this may have influenced observed associations. Perhaps the cognitive load in their *1*-back condition (low load) was too much to facilitate more intentional TUTs relative to the high load condition. Finally, Martínez-Pérez et al. (2021) found intentional TUTs to be more common in their PVT, and unintentional TUTs more common in their SART. They argue the PVT was monotonous and simple relative to the SART, leading to more deliberate disengagement.

There is also ongoing debate regarding how individual differences in cognitive abilities underpin the regulation of intentional and unintentional TUTs in different contexts. Unintentional TUTs are often argued to be the result of failures in executive control. Indeed, an inverse association between unintentional TUTs and WMC is frequently observed (Robison & Unsworth, 2018; Ju & Lien, 2018; Robison & Brewer, 2022). In contrast, intentional TUTs are argued to be a product of motivational processes as they often exhibit an inverse association with self-reported motivation to perform the external task (Seli et al., 2015b; Robison & Unsworth, 2018). Further complicating the matter, the nature of these associations can change depending on the task being completed. Ju and Lien (2018) documented that intentional and unintentional TUTs had differing associations during a *0*-back and *2*-back task. They found that unintentional TUTs were associated with WMC in the *2*-back task but not in the *0*-back. This suggests that the mechanisms leading to TUTs will differ depending on the task context. As such, it is important to compare tasks which have differing cognitive demands to better understand the task and cognitive mechanisms which influences intentional and unintentional TUTs (consistent with a context-regulation perspective).

7.1.3 Non-Cognitive Determinants: Motivation and Task Perception

Finally, this study is interested in the roles of subjective assessments of a task, together with its features, in the manifestation of different types of TUTs. Greater motivation is often associated with lower TUT frequency (Seli et al., 2015b; Seli et al., 2016a), particularly lower intentional TUTs (Seli et al., 2015b). However, there are other top-down regulatory processes can influence perceived difficulty and subsequently also influence TUT rates. Perceived difficulty seems an especially important endeavour given it is not yet understood what contributes to the perception of a task as being ‘difficult’. Cognitive load is often a default index of difficulty, but there are other task features which can influence how participants engage with a task. For example, Subhani et al. (2019) found that increased compliant activity inhibited deliberate TUTs in comparison with spontaneous TUTs (but did not inhibit TUTs overall) [see Section 5.6]. While it is uncertain whether compliance changed the level of difficulty of the task, these results do imply that cognitive load may not be the only determinant of intentional TUTs. Similarly, Martínez-Pérez et al. (2021) presented the possibility that intentional TUTs were more common in the PVT relative to the SART because the PVT required a lower response rate. Features of a task such as response requirements and monotony can therefore influence deliberate TUT rates, perhaps due to their effect on interest, motivation, and engagement (Seli et al., 2015b; Soemer & Schiefele, 2020).

Increases in interactive demands may be perceived by participants as an increase in difficulty which in turn may make the task seem more challenging or increase participant arousal. Subjective interest and difficulty are related under a resource allocation framework where low-load or simple tasks may not engage cognitive or motivational mechanisms, resulting in increases in TUTs (Campbell, 1988; Thomson et al., 2015). While it is not fully understood how subjective assessments of difficulty relate to the occurrence TUTs, recent efforts have been made to explore this association in the context of reading tasks (Forrin et al., 2021; Kahmann et al., 2022). Notwithstanding the issues in subjective assessments, perceptions of difficulty might act as an additional dimension that contributes to an informed picture of the experience of effort or engagement required for a task, and the degree of off-task thought associated with that experience. Consequently, the third goal is to measure subjective perceptions of task difficulty to observe their influence on intentional and unintentional TUT rates.

7.1.4 Experiment 1

Experiment 1 aims to observe differences in intentional and unintentional TUT rates across levels of difficulty which are benchmarked by two commonly used tasks in the literature; a standard SART (representing a relatively simple or easy task) and a working memory *n*-back task (with *1*-back and *3*-back tasks representing moderate and difficult levels). In addition, this experiment will measure WMC, motivation, task interest, and perceived difficulty and observes whether these variables differ in their associations with TUTs depending on either the intention of the episode (for perceived difficulty) or the type of the task (for WMC and motivation).

7.1.5 Hypotheses

Based on the reasoning above, the following predictions are made for Experiment 1:

i) Overall TUTs will be more common during low-load sustained attention tasks compared to high-load working memory updating tasks.

ii) Intentional TUTs will increase in the SART as it is more likely to be perceived as easy, unintentional TUTs will increase in the *3*-back as this task will be perceived as hard.

iii) Intentional TUTs will have a stronger association with perceived difficulty than unintentional TUTs due to their shared reliance on conscious processes.

iv) Intentional, but not unintentional, TUTs will be associated with motivation and this association may differ depending on tasks.

v) Unintentional, but not intentional, TUTs will be associated with cognitive ability (i.e., WMC) and this association may differ depending on tasks.

7.2 Method

7.2.1 Participants

Approval was obtained from the Human Research Ethics Committee at the University of Wollongong and 112 undergraduate students (85 females, m_{age} = 21.28 years, SD = 6.22 years) participated for course credit. Participants completed all measures in a single 2-hour session. Due to failure to follow task instructions, data for two female and ten male participants were removed from the analyses (final *N* = 100, 78 females, m_{age}= 21.45 years, SD = 6.47 years).

7.2.2 Apparatus

Stimulus presentation was controlled by a Dell desktop computer. The SART and *n*-back were administered using OpenSesame 3.2.8 software (Mathöt et al., 2012) and the WMC tasks were administered using Inquisit 5 software (Conway et al., 2005). All stimuli subtended a visual angle of 4.04 degrees.

7.2.3 Motivation Questionnaire

The experiment used the motivation questionnaire by Robison and Unsworth (2018). Participants were asked, "*How motivated were you to perform well on the task?*", "*How interested were you in the task?*", "*How unpleasant did you find the task?*", *"How easy did you find the task?", "How alert do you feel right now?",* and "*How would you best describe your performance on the task?*" Participants responded to these measures on a 5-point scale, ranging from 1 (Not at all) to 5 (Extremely). The questions about unpleasantness and ease were reverse scored. The final question was categorical with response options:1 (*I think I did well, and I put forth a lot of effort*); 2 (*I think I did well, but I did not put forth a lot of effort*); 3 (*I put forth a lot of effort, but I do not think I did well*), and 4 (*I did not put forth a lot of effort, and I do not think I did well*). This questionnaire was completed with pencil and paper.[3]

[3] Previous literature in this area has also relied on single-item self-report motivation questionnaires (e.g. Seli et al., 2015b; Seli et al., 2017; Unsworth & McMillan 2013). These studies have reliably found relationships between such measures of motivation and TUT rates, and as such single-item self-report is employed in this study as well.

7.2.4 Working Memory Capacity Tasks

A series of working memory tasks were utilised to estimate participants' WMC (Conway et al., 2005).

Automated reading span (Daneman & Carpenter, 1980). This task involved presenting participants with a sentence on the screen and asking participants to decide on its logic, after which a single letter was displayed on the screen for 1000ms. Each trial was made up of multiple sentence-letter couplets (ranging from 3-7) and at the end of the trial participants had to recall, in serial order, the letters that were presented within the trial. In addition to this, participants were asked to maintain 85% accuracy on sentence decisions to ensure they focussed on both components of the task. Feedback was provided on the screen for accuracy, and performance below this would result in data removal. Response time averages on the practice trials were used to create a timeout for the processing components of the tasks in the test trials.

Automated operation span (Conway & Engle, 1996). The procedure for operation span paralleled reading span and applied the same conditions of presentation and range of to-be-remembered items (i.e., 3-7). In each trial participants evaluated the correctness of arithmetic equations of low difficulty and memorized a single letter displayed after each equation. The task requirement was to recall all the letters presented in a trial in the correct serial order after evaluating the last equation. Participants were asked to maintain 85% accuracy on the operations, and again practice trial RTs were used to create a timeout for test trial processing components.

Automated symmetry span (Redick et al., 2012). Participants were presented with a series of 4 x 4 grids within which a single grid location appeared in red. Between each 4x4 grid the participant determined whether an 8 x 8 matrix with several filled cells formed a symmetrical pattern, or not (and maintain 85% accuracy). The participant was tasked with recalling the 4x4 grid locations and the order in which they appeared by clicking on the cells of an empty grid on the screen. The range of to-be-remembered locations/grids was 2-5. Practice trial RTs were used to create a timeout for the processing component windows.

7.2.5 Task Demand

Objective task demand was operationalised as the type of processing required of a task (i.e. sustained attention versus working memory).

Sustained Attention to Response Task (SART). The SART was the easy or simple task. In this task the participant was instructed to press the "SPACEBAR" for all digits (digits ranged from 1-9) except for the digit '3'. When a '3' appeared on the screen, the participant was required to withhold the prepotent "SPACEBAR" response. Non-target stimuli (1, 2, 4-9) in the SART were presented 728 times, while the target stimulus was presented 95 times at random. Stimuli were presented for 300ms, with a 900ms inter-stimulus interval. Participants were asked to give equal weight to both speed and accuracy.

n-back. The moderate and difficult task conditions were comprised of a *1*-back and *3*-back respectively. The *n*-back is a working memory updating task that involves the retrieval, transformation, and substitution of information (Ecker et al., 2014). The process of updating has been identified as one of three correlated factors that capture individual differences in executive function (Miyake et al., 2000). In this way it involves more demand and cognitive processing of the executive system than the SART. Whilst not as taxing as a *3*-back task, the *1*-back task requires the updating and reshuffling of information in working memory. At the start of each *n*-back task, the participant first performed a practice block of 40 trials. They then performed 10 critical blocks of between 15-25 trials each. Trials began with a centred fixation cross on-screen for 200ms, followed by the stimuli presented for 500ms with 2000ms ISI. Participants were instructed to respond as quickly and accurately as possible when the current letter matched the *n*-back letter by pressing the space bar. Stimuli were eight phonologically distinct letters (B, R, M, F, Q, X, K, and H). Each *n*-back included near lures on 15% of the trials. For the *3*-back this included *2*-back (e.g. 5, 4, 5) and *1*-back (e.g., 9, 5, 5) lures, and for the *1*-back this included *2*-back and *3*-back (e.g., 5, 4, 3, 5) lures.

7.2.6 Thought Probes

A probe-caught method was used to sample participants' thought content throughout the task (Smallwood & Schooler, 2006). Twenty probes were placed within both the SART and *n*-back. There were constraints on the placement of probes within the SART; probes could not occur within quick succession of each other (i.e., being at minimum more than 10 trials apart). In the *n*-back task probes appeared after a randomised number of blocks, with blocks varying in number of trials and in randomised order. The reason for separating the *n*-back into blocks and probing after a block was to ensure that participants did not have an extra memory load from interruption that would inadvertently increase the difficulty of the task. To ensure probes were still unpredictable the number of trials within the blocks were varied. When a probe was presented, the task stopped, and the participant was presented with the following question: *"Which of the following responses best characterises your mental state just prior to the presentation of this screen?"* There were five possible response options as displayed in Table 2. Of these five response options, only intentional and unintentional task-unrelated thoughts were considered as mind-wandering.

Table 2

Thought Probe Response Options

Probe	Description
Task-related thought	Focussing on the task stimuli.
Task-unrelated thought (intentional)*	Choosing to think about something unrelated to the task (e.g., future, or past events, what they are having for dinner).
Task-unrelated thought (unintentional)*	Experiencing task-unrelated thoughts despite intentions to remain focussed (e.g., finding themselves thinking about an upcoming exam when they are trying to focus on the task).
Stimulus-independent task-related thought	Thoughts about performance or task duration, and other task evaluations.
External distraction	Attending to an external stimulus (e.g., noise, object).

Note. * These items are considered instances of TUTs in this study.

7.2.7 Procedure

After providing informed consent, participants were given instructions to familiarise themselves with the task. Following this, participants were given detailed instructions regarding definitions of the thought-probe responses, provided in Table 2. Participants were told that intentional TUTs are defined as moments where they *chose* to begin thinking about something other than the task, such as deciding to think about plans they might have later in the evening. Unintentional TUTs on the other hand are unrelated cognitions that occurred despite their best efforts to concentrate on the task, and occur at moments where they find themselves thinking about something else or when a thought enters their mind without a feeling of control. Prompt responses and definitions are based on both the taxonomy of Stawarczyk et al. (2011) [see Chapter 2], and the method of prior literature for measuring these thought content constructs (e.g., Martínez-Pérez, 2021; Robison & Unsworth, 2018; Seli et al., 2019a).

Participants completed the complex span tasks (symmetry, operation, and then reading) followed by a motivation questionnaire. The focus of the study was not motivation levels of the participants during WMC tasks per se, but motivation was measured to conceal the goals of the study from participants. Participants then performed the SART and *n*-back tasks, in a systematically counterbalanced order. There were 6 possible order combinations that participants could be assigned, and this was based on recruitment order. Participants required between 15-20 minutes to complete each task, and after each task they completed the motivation questionnaire. In between the working memory tasks and the thought-probe tasks, participants were given the opportunity for a 10–15-minute break to avoid fatigue.

7.2.8 Analysis

Working memory capacity was calculated using the span score for each task, which was the sum of items recalled correctly in serial position. The span scores were then converted into z-scores, and these were averaged into a WMC composite for each participant (see Conway et al., 2005). Performance measures for the SART and *n*-back included overall accuracy percentages, percentage of correct hits and misses, false alarms, and *d'* which is a sensitivity index measuring how well participants were able to detect targets and reject non-targets. TUT rates were calculated as the proportion of each type of response provided divided by the total number of thought probes presented in each condition.

7.3 Results

7.3.1 Descriptive Statistics

Descriptive statistics for rates of TUTs on the SART and *n*-back tasks are illustrated in Table 3, and performance measures are in Table 4. Performance measures were as expected with better performance in the *1*-back than the *3*-back. Given high performance and high TUT responses in the *3*-back, analyses have been included in the supplemental materials of the Appendix A, which support the reliability of self-reported TUTs. Appendix A also contains correlations between performance measures and thought prompts (Tables 35, 36, and 37). The '*MASS'* package in R was used to check for over-dispersion in TUT responses, including intentional and unintentional TUTs separately. This involves investigating whether the conditional variance exceeds the conditional mean (Long, 1997). All variance: mean ratios were less than 1.0 confirming that over-dispersion was not an issue in the data. As can be seen in Table 3, a greater proportion of intentional than unintentional TUTs were observed in the SART, whereas during the *3*-back a considerable proportion of TUTs were engaged unintentionally. Given tasks were counterbalanced, the supplemental materials in Appendix A include analyses which include task order to confirm there are no task order effects. As there were no effects, here the analyses without task order are report to be concise.

Table 3

Descriptive Statistics for Thought Probes in Each Task (N = 100)

Task	TRT	TUT – In	TUT – Un	SITRT	ED
SART	.34 (.20)	.23 (.12)	.18 (.12)	.17 (.12)	.08 (.08)
1-back	.45 (.23)	.14 (.12)	.06 (.08)	.25 (.16)	.10 (.11)
3-back	.42 (.27)	.08 (.10)	.31 (.22)	.13 (.16)	.06 (.10)

Note. Means are reported in the table and standard deviations are reported in parentheses. TRT refers to task-related thought. TUT – In refers to intentional task-unrelated thoughts. TUT – Un refers to unintentional task-unrelated thoughts. SITRT refers to stimulus independent task related thought. ED refers to external distraction.

Descriptive statistics for performance on the SART and *n*-back tasks are reported in Table 4. Performance on the *3*–back was high (M = .85) however not inconsistent with previous literature – the current sample was comprised predominantly of young adults (M_{age} =21.28 years) and meta-analysis has found an average continuous accuracy of just over .8 in this age group (Bopp & Verhaeghen, 2020). Additionally, short-term learning and improvement in *n*-back performance over the course of the task has previously been observed (Khaksari et al., 2019), which may have also contributed to the *3*-back performance.

Table 4

Descriptive Statistics for Performance on SART and N-Back (N = 100)

Task	RT (ms)	Accuracy	False Alarms	*d'*
SART	329.50 (53.16)	.89 (.09)	.50 (.22)	1.27 (.80)
1-back	985.14 (177.96)	.94 (.08)	.04 (.06)	3.89 (1.29)
3-back	1279.94 (142.58)	.85 (.09)	.08 (.06)	2.72 (.81)

Note. Means are reported in the table and standard deviations are reported in parentheses.

7.3.2 Perception of Task Difficulty

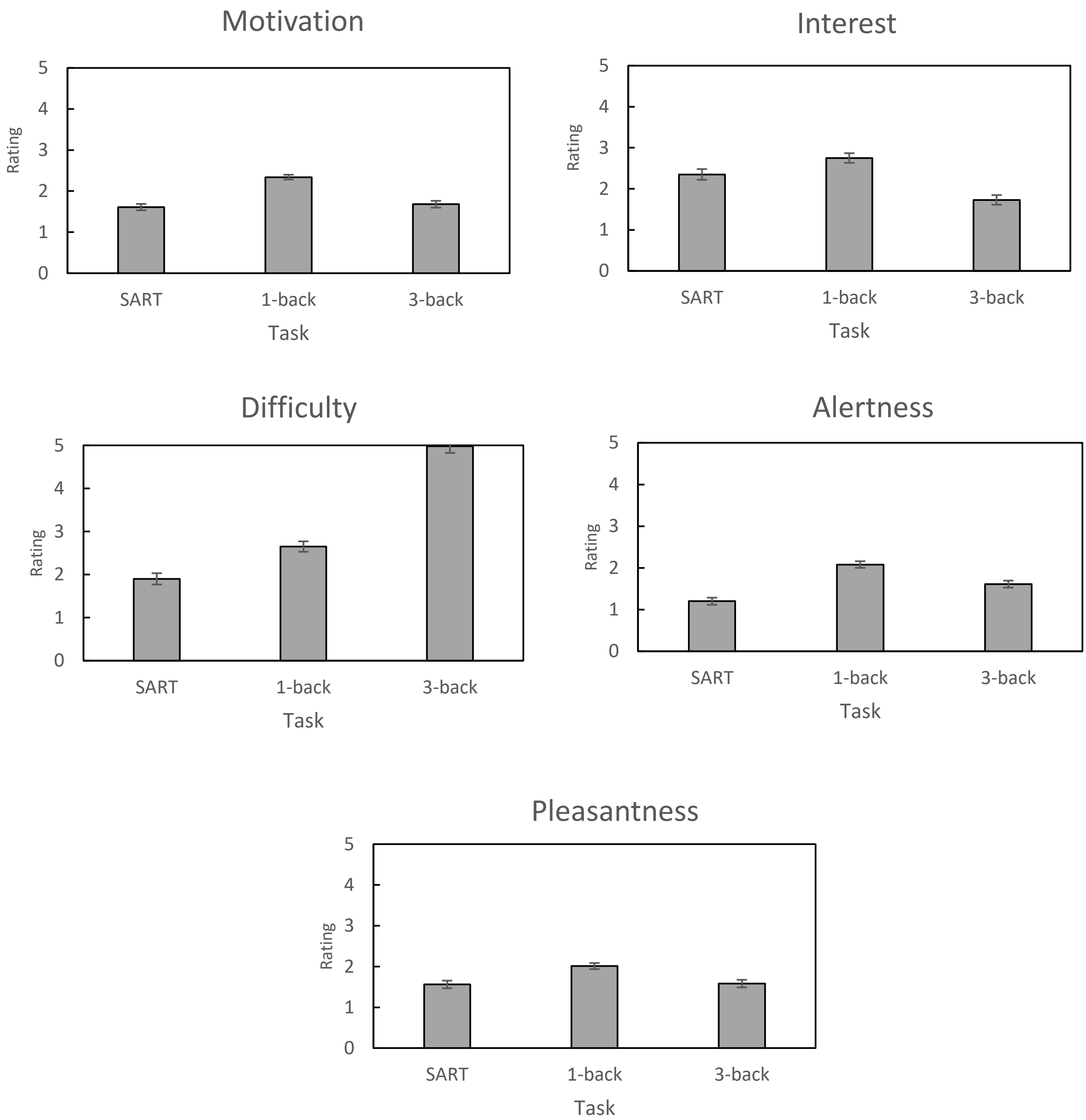
First, differences in how participants perceive task demands and how this interacts with TUTs were investigated. Measures of perceived difficulty and interest were used to determine whether, as expected, participants would find the SART easiest, and the *1*-back and *3*-back progressively more difficult. Descriptive statistics for the questionnaire responses are displayed in Figures 4 and 5, with Figure 5 showing self-categorisation of both participants' performance and the effort they feel they exerted. This figure demonstrates that in the SART many participants reported feeling that they performed well without exerting effort, whereas in the *3*-back participants felt they did not perform well despite applying effort.

A repeated measures ANOVA was performed on participants' self-reported perceptions of difficulty and interest across the three tasks. Distributions of responses for intentional and unintentional TUTs show violations of normality (see Appendix A, Figure 18). However, the dependent variable of thought probe response is ipsative, and Gaussian models have generally been demonstrated to be robust against violations resulting from ipsativity (Greer & Dunlap, 1997). As such, parametric analyses were performed and are reported with Greenhouse-Geisser corrections where applicable, and Bonferroni corrections as necessary. All reported CIs are unadjusted, and Cohen's d_{av} is reported as the effect size for all comparisons. The formula for this estimate is provided in Appendix A.

Greenhouse-Geisser corrected results demonstrated a significant difference in participants' perceptions of task difficulty, F (1.82, 179.89) = 155.69, p <.001, MSE = 1.82 η_p^2 = .61. Multiple comparisons were conducted at a Bonferroni corrected α of .017 (.05 / 3) and indicated the SART was perceived as easier than both the *1*-back (Cohen's d_{av} = -0.69, [CI = -1.16, -.34]) and *3*-back (Cohen's d_{av} = -2.66, [CI = -3.49, -2.68]). The *3*-back was also perceived to be more difficult than the *1*-back (Cohen's d_{av} = -1.98, [CI = 1.82, 2.84]). All p <.001, suggesting that the perceived difficulty of tasks was as expected.

Figure 4

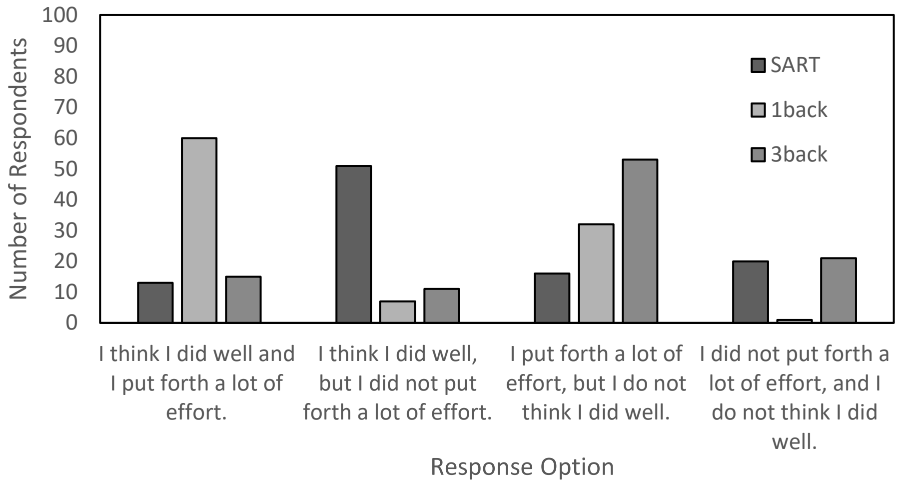
Mean Responses to the Motivation Questionnaire within each Task



Note. Error bars represent +/- 1 standard error of the mean.

Figure 5

Frequency Distribution for Final Categorical Item on the Motivation Questionnaire



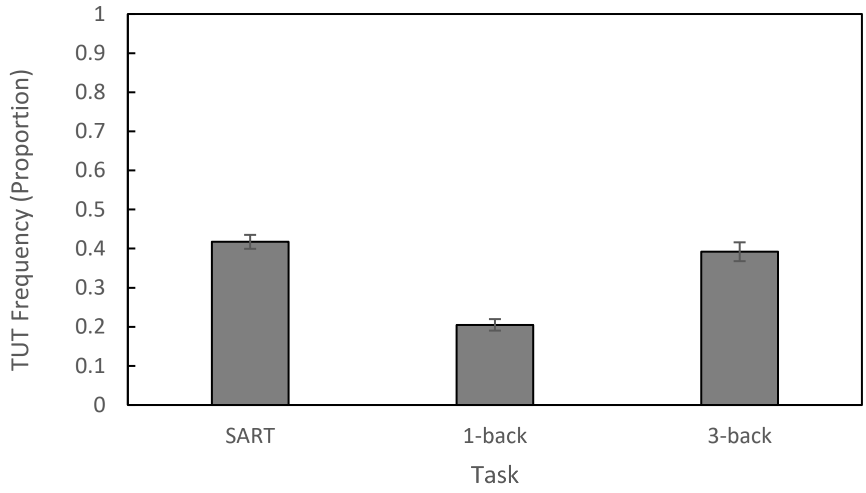
Subjective interest also showed significant differences, F (2,198), = 26.89, p <.001, MSE = .98, η_p^2 = .21. Post hoc comparisons with an adjusted α confirmed that the SART was perceived to be less interesting than the *1*-back (Cohen's d_{av} = -.36, [CI = -.76, -.04]), but more interesting than the *3*-back (Cohen's d_{av} = .56, [CI = .28, .96]). The *3*-back was also perceived to be less interesting than the *1*-back (Cohen's d_{av} = -.94, [CI = -1.34, -.70]). All p <.01. For completeness we also report analyses for motivation, alertness, and pleasantness in Appendix A. To summarise the findings, participants reported being most alert in the *1*-back and least alert in the SART. The *1*-back was also associated with the greatest motivation and pleasantness scores.

7.3.3 TUTs Between Tasks

A repeated-measures ANOVA was used to observe whether perceived task demands were associated with the rate of overall TUTs (collapsed across intention) consistent with a curvilinear pattern. Of the 100 included participants, 61% displayed a pattern of increased TUTs during the SART and 3-back relative to the 1-back. This pattern illustrated in Figure 6 is consistent with a U-shaped relationship with task context, with the tasks rated by participants to be more difficult or easy exhibiting higher TUT rates. A repeated measures ANOVA confirmed that overall TUT frequency differed among the tasks, F (2, 198) = 46.42, MSE = .03, p < .001, η_p^2 = .32. Pairwise comparisons confirmed that TUT rates were greater during the SART (Cohen's d_{av} = .53, [CI = .16, .27]) and 3-back (Cohen's d_{av} = .42, [CI = .12, .25]) compared to the 1-back (both p < .001). TUT rates between the SART and the 3-back were equivalent (p = .90).

Figure 6

Overall TUT Rates in Each Task (SART, 1-Back, 3-Back)



Note. Error bars represent +/- 1 standard error.

7.3.4 Intention x Task Interaction

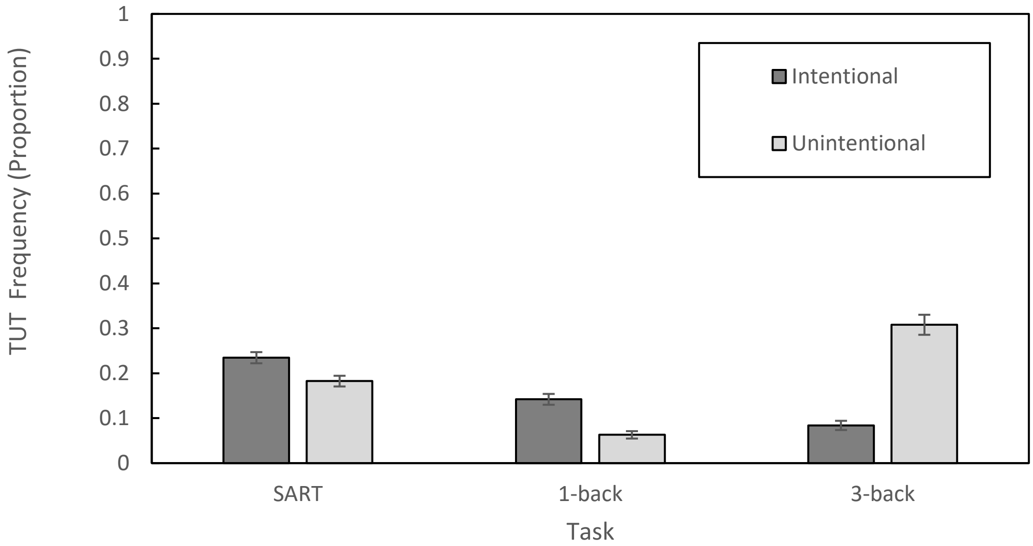
Differences in the frequency of intentional and unintentional TUT rates in each task visualised in Figure 7 indicate that they differ from each other in their associations with perceived task difficulty. To investigate whether intentional and unintentional TUTs differed among tasks, a 3 x 2 repeated measures ANOVA was conducted. The independent variables were task type (SART, *1*-back, *3*-back) and TUT type (intentional, unintentional). The dependent variable was the frequency of reported intentional and unintentional TUT. The ANOVA revealed a significant main effect of type of TUT, F (1, 99) = 7.51, p = .007, MSE = .02, η_p^2 = .07, and a main effect of task, F (2, 198) = 46.42, MSE = .02, p <.001, η_p^2 = 32. The TUT x task interaction was also significant (Greenhouse-Geisser correction applied), F (1.79, 177.12) = 78.13, MSE = .02, p < .001, η_p^2 = .44.

Simple effects were performed as two repeated measures ANOVAs on intentional and unintentional TUTs in each task, with a corrected α of .025. The first ANOVA revealed that intentional TUTs were significantly different between tasks, F (2, 198) = 55.31, p <.001, MSE = .01, η_p^2 = 36. Intentional TUT was more common in the SART compared to the *1*-back (Cohen's d_{av} = .26, [CI = .05, .13]), and *3*-back (Cohen's d_{av} = .45, [CI = .12, .18]). Intentional TUT was also more common in the *1*-back compared to the *3*-back (Cohen's d_{av} = .17, CI = [.03, .09]). All differences were significant at p <.01. However of the 100 participants, only 24% demonstrated this linear decrease across the tasks. A more common pattern displayed by 29% of participants was highest intentional TUTs in the SART and equivalent TUTs in the *1*-back and *3*-back. A further 19% showed a U-shaped association across the tasks (although increases in intentional TUTs in the *3*-back were still not numerically equivalent to their rate in the SART).

Likewise, the second ANOVA revealed that rates of unintentional TUTs differed among tasks (Greenhouse-Geisser correction applied), F (1.6, 158.63) = 68.07, p <.001, MSE = .03, η_p^2 = 41. Pairwise comparisons demonstrated that unintentional TUTs were more common in the SART than the *1*-back (Cohen's d_{av} = .38, CI = [.08, .16]), but more common in the *3*-back than the SART (Cohen's d_{av} = .30, CI = [.07, .18]) and *1*-back (Cohen's d_{av} = .63, CI = [.19, 30]). All comparisons were significant at p <.01. Of the 100 participants, 59% demonstrated this pattern, and a further 20% showed a linear increase in unintentional TUTs from the SART to the *3*-back.

Figure 7

Interaction Between Frequency of Types of TUT and Tasks (SART and 3-Back)



Note. Error bars represent +/- 1 standard error.

7.3.5 Correlations for Perceived Difficulty

Correlations between WMC, intentional and unintentional TUTs, and questionnaire measures within each task are illustrated in Table 5. Using the '*cocor'* package in R, the correlation between intentional and unintentional TUTs and perceived difficulty in each task was compared to investigate whether these TUTs have significantly different associations with difficulty in certain tasks. Dunn and Clark's *z* tests for dependent and overlapping correlations are reported. First, the correlations of intentional and unintentional TUTs with difficulty in the SART were compared. These tests are one-tailed as it was specifically argued that intentional TUTs would have a stronger association with perceived difficulty than unintentional TUTs due to the shared reliance on top-down subjective processes. To note, it was not argued that unintentional TUTs do not have an association with perceived difficulty at all, but simply that intentional TUTs will be more strongly associated. Dunn and Clark's z test confirmed that the inverse association between intentional TUTs and perceived difficulty was stronger than the association with unintentional TUTs in the SART, $z = -1.70$, $p = .04$.

In the *1*-back, there was no significant difference between the correlation for intentional and unintentional TUTs with difficulty, $z = 0.43$, $p = .67$. However, in the *3*-back, intentional TUTs significantly differed in their inverse association with perceived difficulty compared to the association with unintentional TUTs, $z = -1.65$, $p = .04$. The relationship was stronger between perceived difficulty and unintentional TUTs.

7.3.6 Correlations for Working Memory Capacity

Correlations between WMC and intentional and unintentional TUTs were statistically compared between tasks to examine if the mechanisms underpinning TUTs differed depending on task context. First intentional TUTs were compared, with a Bonferroni correction of .017. Intentional TUTs did not differ in their correlation with WMC between the SART and *1*-back tasks, $z = .92$, $p = .36$, between the SART and *3*-back tasks, $z = .08$, $p = .94$, or between the *1*-back and *3*-back tasks, $z = -.89$, $p = .37$.

There was a trending difference in the association of unintentional TUTs with WMC between the SART and *1*-back tasks, $z = -2.25$, $p = .02$ but this was not significant after the α was adjusted. There was no difference in the associations between the SART and the *3*-back tasks, $z = -.1.15$, $p = .25$, or between the *1*-back and *3*-back tasks, $z = 1.10$, $p = .27$.

7.3.7 Correlations for Motivation

Corresponding analyses were also performed with the correlations of intentional and unintentional TUTs with motivation between tasks. Dunn and Clark's *z*-test for dependent but non-overlapping variables with a corrected α of .017 were reported. First, tasks were compared with the SART and found intentional TUTs did not differ in their correlation with motivation in the SART and *1*-back, *z* = -1.01, *p* = .31, or the *3*-back, *z* = -.81, *p* = .42. There was also no difference in association between the *1*-back and *3*-back, *z* = .23, *p* = .81.

For the association of unintentional TUTs and motivation, there was a trend toward significant differences between the correlation coefficients in the SART and the *1*-back, *z* = -2.30, *p* = .02 and there was a significant difference between the *3*-back and *1*-back, *z* = -2.74, *p* =.006, with a stronger relationship being found for the 3-back. However, the correlations were equivalent between the *3*-back and SART, *z* = .47, *p* = .64.

Table 5

Correlations between Motivation Questionnaire Responses and Intentional and Unintentional TUTs

Task	Variable	1.	2.	3.	4.	5.	6.	7.	8.
SART	1. WMC	-							
	2. Motivation	-.02	-						
	3. Interest	.09	.29**	-					
	4. Difficulty	.05	.24*	.23*	-				
	5. Alertness	.19^t	.41**	.30**	.28**	-			
	6. Pleasantness	.10	.29**	.73*	.26**	.29**	-		
	7. Intentional TUT	.00	-.35**	-.20*	-.25*	-.10*	-.19^t	-	
	8. Unintentional TUT	-.36**	-.23*	-.21*	-.02	-.34**	-.06	.07	-

			1.	2.	3.	4.	5.	6.	7.	8.
***1*-back**	1.	WMC	-							
	2.	Motivation	.20*	-						
	3.	Interest	.24*	.30**	-					
	4.	Difficulty	.12	.15	.25*	-				
	5.	Alertness	.12	.09	.52**	.33**	-			
	6.	Pleasantness	.09	.20*	.38**	.09	.17^t	-		
	7.	Intentional TUT	-.12	-.22*	-.29**	-.13	-.15	-.13	-	
	8.	Unintentional TUT	-.04	.10	-.07	-.19^t	-.22*	-.13	.02	-
			1.	2.	3.	4.	5.	6.	7.	8.
***3*-back**	1.	WMC	-							
	2.	Motivation	.10	-						
	3.	Interest	.28**	.26**						
	4.	Difficulty	-.20^t	-.22*	-.21*	-				
	5.	Alertness	.04	.44**	.23*	-.09				
	6.	Pleasantness	.14	.14	.26*	-.17	.11			
	7.	Intentional TUT	-.01	-.25*	-.11	-.05	-.24*	-.08		
	8.	Unintentional TUT	-.20*	-.29**	-.27**	.18^t	-.26**	-.04	.04	

Note. Correlations with * are significant at an α of <.05, whereas ** indicates significance at an α of <.01. The superscript ^{t} indicates the correlation trended toward significance between an α of .05 and .09.

7.4 Discussion: Experiment 1

Experiment 1 found evidence that the non-linear pattern between TUT frequency and task difficulty observed within task paradigms (Randall et al., 2019; Xu & Metcalfe, 2016) can also be observed when using sustained attention and updating tasks as benchmarks for difficulty. Task-unrelated thoughts were most common in the SART and *3*-back, which were selected (and participants perceived) as the easy and difficult tasks respectively. This pattern was argued to emerge because the SART is a monotonous attentional task which does not necessarily place large demands on executive resources and may encourage TUTs through participant perceptions of underload or boredom (Neigel et al., 2019). In contrast, the *3*-back is a higher-order memory updating task generally agreed to be difficult to perform (Jaeggi et al., 2009), and therefore is more likely to trigger TUTs by executive failures and/or cognitive overload (McVay & Kane, 2010).

Findings from Experiment 1 extend on the work of Seli et al. (2018c) who observed a difference in intentional, but not unintentional, TUT rates between an 'easy' CRT and a 'difficult' working memory task. Here there were differences in *both* intentional and unintentional TUTs when using a high-load updating task to benchmark the extreme end of difficulty. In the monotonous SART, intentional TUT rates indicated participants did not feel engaged by the task, further supported by the association between intentional TUTs and difficulty in this task as subjective assessment of greater task difficulty predicted fewer TUTs. It can be suggested that perceiving the task as more difficult leads to greater arousal through being challenged. As such, participants may limit intentional TUTs to meet the expected demands. This is consistent with a number of TUT accounts which argue that in situations where participants feel under-stimulated or have excess resources (perceived or real), they will re-allocate cognitive resources to mind wander (e.g., the context-regulation hypothesis, executive resource hypothesis, and resource allocation frameworks).

Altogether, this pattern supports arguments that mind wandering literature must further understand what type of tasks result in changes in both objective and subjective difficulty of a task, and how different manipulations of difficulty are similar and distinct in their impact on TUT rates (Seli et al., 2018c). In addition, research from reading task contexts has begun to investigate how subjective perceptions as well as task characteristics can influence TUT rates (Forrin et al., 2021). Experiment 2 aims to manipulate features of the standard SART in an attempt to go some way in investigating the impact of both subjective and objective difficulty on TUTs. In doing so, this will contribute to an outline of how certain manipulations of difficulty may influence TUT rates.

7.5 Experiment 2

To assess how task characteristics and subjective difficulty is associated with TUTs, the same tasks were employed in Experiment 2, with the addition of a fourth task - a modified SART. In this SART, from here on referred to as the changing-target SART, the target digit to which participants had to withhold their key-press response changed in each block of the task. This modification was made to further investigate the role of subjective task perceptions, and objective difficulty, and extend on the findings of Experiment 1. Prior work suggests that people may mind wander during a sustained attention task because it is monotonous and under-stimulating (e.g., the *mindlessness* hypothesis, Thomson et al., 2015). Consistent with this, Subhani et al. (2019) observed that increases in compliant activity reduce intentional but not unintentional TUTs. As such modifying the SART to include more instructional changes which participants need to attend to may also decrease intentional TUTs relative to the standard SART. While the underlying demands of each task are similar (i.e. to withhold a key-press response from target digits), and the proportion of target to non-targets are equivalent between both SARTs, the modified task features target identity changes and requires attention to these changes by the participant and so may seem less monotonous to perform or may be perceived as more challenging.

If it is the case that participants perceive the changing-target SART to be significantly more difficult than the standard SART, but task requirements and objective performance on the tasks are similar, this would provide some evidence for a role of task characteristics in perceptions of difficulty. In addition, it would support arguments that monotony is a key feature of sustained attention tasks which encourages TUTs. Furthermore, if intentional TUT rates are lower during the changing-target SART than the SART, then this would support the role of task characteristics beyond objective demands influencing engagement with TUTs.

7.5.1 Hypotheses

In Experiment 2 the aim was to replicate the non-linear TUT frequency between tasks found in Experiment 1, and so the predictions from Experiment 1 are also made here. In addition, the following are also predicted;

i) TUT rates during the *1*-back and changing-target SART would be similar because both tasks engage attention from the participant due to low-level changes but neither task exceeds the participants' cognitive abilities.

ii) Intentional TUT will be lower in the changing-target SART than the SART based on the findings of Subhani et al. (2019).

iii) There will be equivalent performance on both the SART and changing-target SART, but that;

iv) Participants would perceive the changing-target SART to be more difficult than the SART

7.6 Method

7.6.1 Participants

Participant recruitment and data collection occurred online for Experiment 2 to comply with social distancing policies during the COVID-19 pandemic. This experiment was approved by the Human Research Ethics Committee at the University of Wollongong and undergraduate students from the university were recruited and received course credit. The initial sample was 124 participants (98 female, 2 preferred not to disclose) with a mean age of 21.42 years (*SD* = 5.78). However, data from 21 participants were removed either due to exiting the experiment window before completing all tasks (*N* = 17) or performance at floor in one or more of the tasks (*N* = 4). The final sample comprised 103 participants (81 female, 2 preferred not to disclose) with an average age of 21.36 years (*SD* = 5.79 years).

7.6.2 Apparatus

The questionnaires, SART and *n*-back programmes, and working memory task were designed using Gorilla Experiment Builder for remote execution.

7.6.3 Questionnaires

The same 5-item motivation questionnaire was employed as in Experiment 1.

7.6.4 Working Memory Task

As this experiment was being completed online the decision to use only a single working memory task was made to avoid participant fatigue and disengagement with the testing session, especially given the researcher would not be present to encourage breaks and monitor engagement. In addition, being mindful of concerns around participants' ability to write down to-be-remembered items in unproctored settings, a picture span task as designed by Hicks et al. (2016) for web-based testing of WMC was used.

Automated picture span (Hicks et al., 2016). This task is modelled on both the operation span task and Hicks et al. (2016) use of images to create a picture span task for online testing. The key difference from the operation span being that the to-be-remembered stimuli consist of pictures of object silhouettes, such as a frog, umbrella, or plane. Each object was interleaved with simple arithmetic problems. Each participant received 15 trials of the Picture Span, each set size (2, 3, 4, 5, 7) a total of 3 times each. At the end of the set a matrix of all 12 possible stimuli (both presented and not presented) appeared with a text box beneath each stimulus. To recall the set, participants numbered the images which they recalled in the order they recalled them being presented. The trials were randomised for each subject. As in Experiment 1 participants were required to maintain a minimum of 85% accuracy on the equations to ensure they were attending to the entirety of the task. RT averages from the practices were used to timeout the processing items in the test trials.

7.6.5 Task Demand

As in Experiment 1, task difficulty was operationalised as a function of task demand defined by whether tasks required sustained attention or working memory processing. The same tasks were used as in Experiment 1 with slight modifications in task duration in order to make the tasks more appropriate for a remote testing session (i.e., to encourage task completion by minimising fatigue). In addition, a changing-target SART was added to investigate whether intentional TUTs in the SART could plausibly be a function of the monotonous and repetitive nature of the task.

Sustained Attention to Response Task (SART). This task was the same as in Experiment 1, with the only modification being that non-target stimuli (1, 2, 4-9) in the SART were presented 616 times, while the target stimulus was presented 45 times at random.

n-back. These tasks were designed and performed as in Experiment 1. At the beginning of both the *1*-back and *3*-back task, there was a practice block of 16 trials each. After this practice block, participants then performed 12 critical *n*-back blocks of 24 trials each. Trials began with a centred fixation cross on-screen for 200ms, followed by the stimuli presented for 500ms with 2000ms ISI. Participants were instructed to respond as quickly and accurately as possible whether each letter matched the *n*-back letter. Participants pressed the spacebar when they believed it was the same. Stimuli were eight phonologically distinct letters (B, R, M, F, Q, X, K, and H). Lures were included on 15% of trials as in Experiment 1.

Changing-Target Sustained Attention to Response Task (Changing-target SART). This task was designed to be similar in interest and perceived challenge to the *1*-back. In this task the participant is instructed to press the "SPACEBAR" key for all digits (digits ranged from 1-9 excluding the target) and withhold a response to the target digit. However, unlike the standard SART, in this version the target digit is changed periodically. Non-target stimuli were presented 616 times, while the target stimulus was presented 45 times at random. The target digit changed 6 times at random intervals during the task. When the stimuli changed a screen appeared for 5000ms to inform the participant of the new change, followed by a 2500ms screen asking the participant to prepare for the task to resume. Stimuli were presented for 300ms, with a 900ms inter-stimulus interval.

7.6.6 Thought Probes

As tasks were shortened for online participation, 12 probes were randomly placed within both the SART and *n*-back tasks to ensure that the participants could not readily predict the occurrence of a probe. There were constraints on the placement of probes within the SART; probes did not occur within quick succession of each other (i.e., being at minimum more than 10 trials apart). In the *n*-back task probes appeared after each block, with blocks varying in the number of trials and being randomised in order of presentation. As in Experiment 1, this was done so participants could not predict when a probe would appear and so probes would not interrupt the task. Reaction time was recorded for the thought probes, and could be checked to ensure appropriate RTs given the online completion of these tasks. For each of the tasks the RTs for probes were as follows; in the SART the mean RT was 7.43 seconds (SD = 1.27), in the changing-target SART the mean RT was 8.73 seconds (SD = 2.80), in the *1*-back mean RT was 9.64 seconds (SD = 2.04), and in the *3*-back the mean RT was 8.15 seconds (SD = 1.14).

7.6.7 Procedure

Participants provided informed consent and were presented with definitions of each thought probe response to ensure they understood the probe categories and how to respond to them. Participants were asked to ensure they completed the tasks in a quiet space and allowed enough time to complete the tasks in one session.

Participants then completed the picture span task. After this, each participant performed the SART, changing-target SART, and, *1*-back, or *3*-back task in a counterbalanced order. There were 4 tasks and 8 possible order combinations were used to which participants could be assigned. Participants were assigned an order based on their recruitment order. Participants required 10-15 minutes to complete each task. After each task, participants completed the motivation questionnaire.

7.6.8 Analysis

All calculations for performance on each task was the same as in Experiment 1, except for WMC where the span score from the picture span task was used (rather than a composite) (see Conway et al, 2005).

7.7 Results

7.7.1 Descriptive Statistics

Descriptive statistics for thought probe responses are illustrated in Table 6, and response distributions graphs for TUTs for all tasks are in Appendix B (Figure 19). Appendix B also contains correlations between performance measures and thought probe responses (Tables 39, 40, 41, and 42). A greater proportion of TUT probe responses in the SART were endorsed as episodes arising from intentional engagement compared to all other tasks. In contrast, during the *3*-back a considerable proportion of TUTs were engaged unintentionally As in Experiment 1, R was used to investigate over-dispersion, and for all probe-responses (including assessing intentional and unintentional TUT rates separately) across all four tasks. Again, the conditional variance did not exceed the conditional mean, with all variance to mean ratios being less than 1.0 (Long, 1997). Additionally, as the tasks were counterbalanced analyses are reported in the appendices which confirm there were no task order effects (Table 38 and following analyses in Appendix B).

Table 6

Descriptive Statistics for Thought Probes in each Task (N = 103)

Task	TRT	TUT-In	TUT-Un	SITRT	ED
SART	.39 (.22)	.25 (.19)	.10 (.09)	.17 (.18)	.09 (.12)
Changing-target SART	.55 (.24)	.04 (.06)	.13 (.14)	.18 (.18)	.10 (.11)
1-back	.58 (.22)	.06 (.07)	.11 (.10)	.11 (.11)	.14 (.13)
3-back	.41 (.27)	.06 (.07)	.27 (.18)	.16 (.16)	.10 (.13)

Note. Means are reported in the table and standard deviations are reported in parentheses. TRT refers to task-related thought. TUT – In refers to intentional task-unrelated thoughts. TUT – Un refers to unintentional task-unrelated thoughts. SITRT refers to stimulus independent task related thought. ED refers to external distraction.

As would be predicted participants performed better in the *1*-back compared to the *3*-back (see Table 7), but interestingly performed better on some measures in the changing-target SART compared to the standard SART (Tables 7 and 8).

Table 7

Descriptive Statistics for Performance on Tasks (N = 103)

Task	RT (ms)	Accuracy	False Alarms	*d'*
SART	409.49 (107.17)	.86 (.19)	.50 (.27)	1.93 (1.34)
Changing-target SART	426.24 (105.12)	.92 (.09)	.46 (.23)	2.25 (1.19)
1-back	697.21 (144.94)	.91 (.21)	.02 (.02)	3.43 (.90)
3-back	934.48 (284.21)	.82 (.11)	.09 (.08)	1.76 (.70)

Note. Means are reported in the table and standard deviations are reported in parentheses.

7.7.2 Performance on SART and Changing-Target SART Tasks

It was hypothesised that both tasks would be similar in difficulty, as indexed by objective performance between the SART and the changing-target SART. To confirm comparability between the two SART variants, a series of paired-samples t-tests compared performance metrics, as presented in Table 8. There were no differences in the number of false alarms nor average RTs yet interestingly participants were more responsive to frequent 'GO' stimuli in the changing-target SART, reflected through higher accuracy rates. Differences in *d'* suggest there was a small but reliable increase in performance in the changing-target SART against the SART. Therefore, given that task performance is considered to be negatively related to difficulty (e.g. Randall et al., 2019; Xu & Metcalfe, 2016), the changing-target SART does not seem to be objectively greater in difficulty compared to the SART.[4]

Table 8

Comparisons of Standard and Changing-Target SART Performance Measures

Performance Variable	SART	Changing-target SART	*t-value*	*p-value*	d_{av}
Accuracy	.86 (.19)	.92 (.09)	-3.61	<.01	-.16
Hit Rate	.92 (.19)	.96 (.09)	-2.41	.02	-.10
False Alarms	.50 (.27)	.46 (.23)	1.57	.12	.08
d'	1.93 (1.34)	2.25 (1.19)	-2.71	.01	-.28
RT	409.49 (107.17)	426.24 (106.12)	-1.70	.09	-1.63

Note. Means presented for performance measures, with standard deviation in brackets. Cohen's *d* was calculated for effect sizes.

[4] Post-hoc correlations between WMC and the SART and changing-target SART supported this argument. WMC did not correlate with *d'* in either the standard (r = .19, p =.06) nor changing-target (r = .06, p = .56) SART suggesting the changing-target SART did not require more executive control than the standard SART. Likewise, when comparing the correlations between WMC and SART with WMC and the changing-target SART, they did not differ, Dunn and Clark's z = 1.43, p = .16.

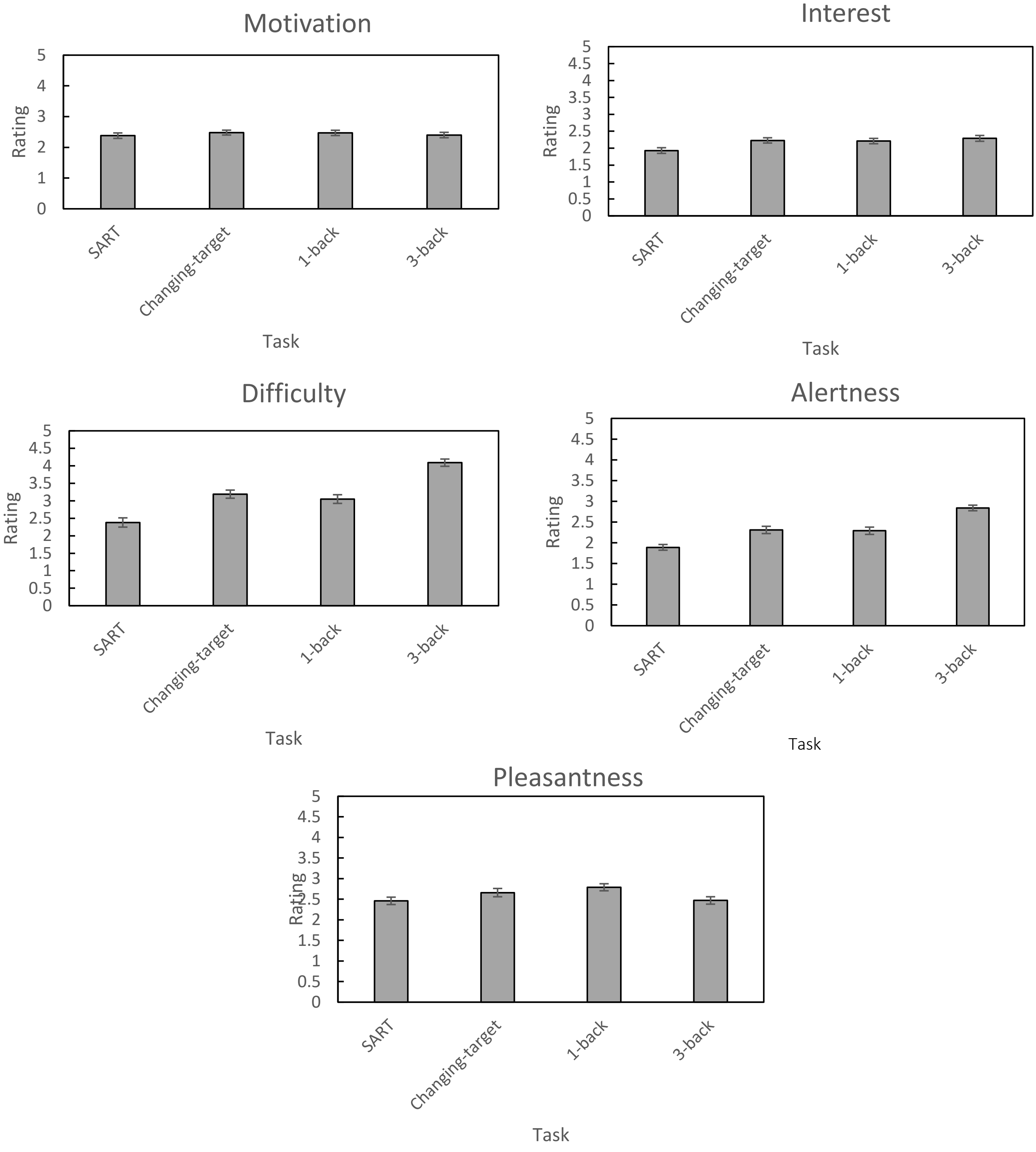
7.7.3 Participant Perceptions of Task Demands

As in Experiment 1, participant perception of task demands was measured using a questionnaire (shown in Figures 8 and 9). Figure 9 demonstrates the self-categorisation of both participants' performance and the effort they feel they exerted. In contrast to Experiment 1, many participants reported exerting effort but not feeling that they did well in all tasks except the *1*-back where participants felt they did well with minimal effort. A repeated measures ANOVA was performed on self-reported difficulty and interest of each task. There was a confirmed difference in self-report ratings of task difficulty, F (3, 306) = 35.21, MSE = 1.45, p <.001, η_p^2 = .26. Follow-up comparisons confirmed the SART was perceived as easier than the changing-target SART (Cohen's d_{av} = -.72, [CI = -1.28, -.35]), the *1*-back (Cohen's d_{av} = -.59, [CI = -1.13, -.21]), and the *3*-back (Cohen's d_{av} = -1.56, [CI = -2.15, -1.27]). In addition, the *3*-back was more difficult than the changing-target SART (Cohen's d_{av} = .84, [CI = .48, 1.31], and the *1*-back (Cohen's d_{av} = .97, [CI = .59, 1.49]). All p <.01. However, reported difficulty for the *1*-back and changing-target SART were not reliably different.

Results suggested a difference in interest ratings between tasks, F (3, 306) = 4.51, MSE = .59, p = .004, η_p^2 = .04. Pairwise comparisons found that the SART was rated as less interesting than the *3*-back (Cohen's d_{av} = -0.39, [CI = -.66, -.06], p =.006) which is the opposite pattern to Experiment 1. However, there was no difference in interest ratings in other task comparisons. For completeness we also report analyses for motivation, alertness, and pleasantness in Appendix B. Participants were again least alert on the SART, but there were no differences in motivation and pleasantness between tasks after Bonferroni corrections were applied.

Figure 8

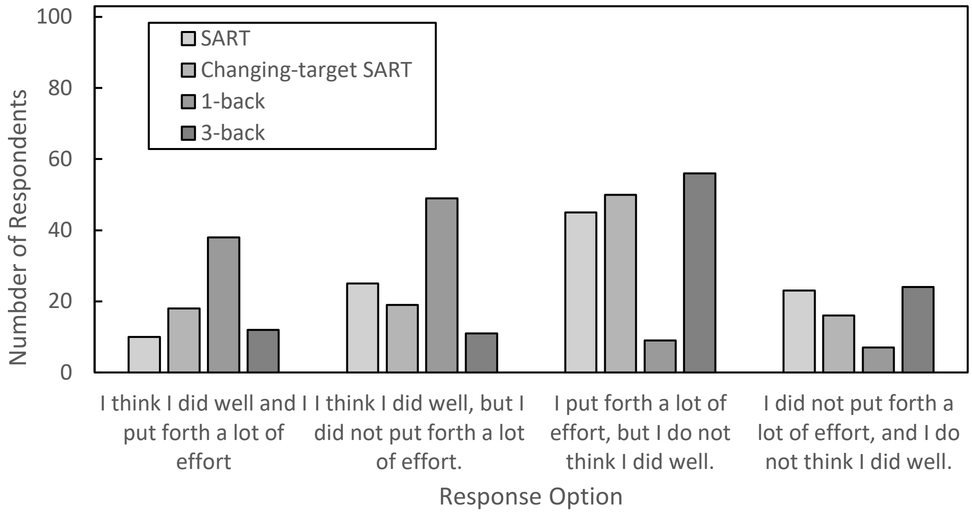
Scores for Each Outcome of the Motivation Questionnaire within each Task



Note. Error bars represent +/- 1 standard error of the mean.

Figure 9

Frequency Distribution for the Final Categorical Measure of the Motivation Questionnaire

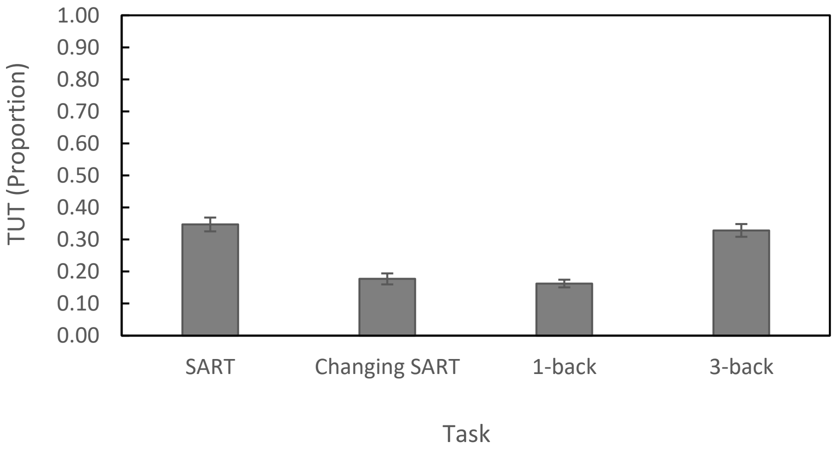


7.7.4 TUTs Between Tasks

As shown in Figure 10, the means of overall TUTs within each task align with a U-shaped relationship between task contexts and TUT rate, which is consistent with the pattern of perceived difficulty of tasks. Indeed, 54% of participants showed a pattern of increased TUTs in the SART and *3*-back compared to the changing-target SART and *1*-back.

Figure 10

Overall TUT Rates in Each Task (SART, Changing-Target SART, 1-Back, and 3-Back)



Note. Error bars represent +/- 1 standard error.

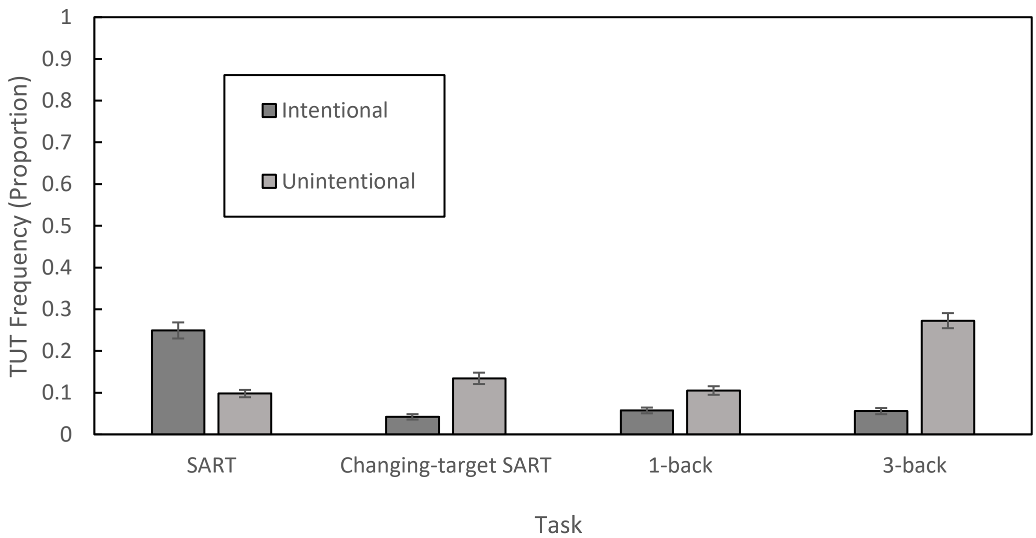
A repeated measures ANOVA confirmed a difference in TUT rates between tasks, $F(3, 306) = 43.53$, $MSE = .02$, $p < .001$, $\eta_p^2 = .30$. Pairwise comparisons with Bonferroni adjusted α (.05/4 = .0125) confirmed that TUT rates did not differ between the SART and *3*-back nor did they differ between the changing-target SART and *1*-back. However, there was a significant difference between the SART and changing-target SART (Cohen's $d_{av} = .40$, [CI = .11, .23]), and the *1*-back (Cohen's $d_{av} = .45$, [CI = .13, .24]). Likewise, there was a difference between the *3*-back and changing-target SART (Cohen's $d_{av} = .36$, [CI = .10, .20]) and the *1*-back (Cohen's $d_{av} = .42$, [CI = .11, .22]). All $p < .01$.

7.7.5 Intention x Task Interaction

Rates of intentional and unintentional TUTs were compared by task in a 2 x 4 repeated measures ANOVA. This revealed a main effect of task, $F(3,306) = 43.54$, $MSE = .01$, $p = < .001$, $\eta_p^2 = .30$ and intention, $F(1,102) = 41.30$, $MSE = .01$, $p = < .001$, $\eta_p^2 = .29$. There was also a significant task x intention interaction, Greenhouse-Geisser corrected, $F(2.34, 238.86) = 78.01$, $MSE = .02$, $p < .001$, $\eta_p^2 = .43$, shown in Figure 11. To further investigate this interaction simple effects of intentional and unintentional TUT within each task type were performed as two repeated measures ANOVAS with a corrected α (*.05/2* = .025).

Figure 11

Interaction Between Frequency of Type of TUT and Tasks (SART, Changing-Target SART, 1-Back, and 3-Back)



Note. Error bars represent +/- 1 standard error.

Intentional TUT rates differed significantly between task, Greenhouse-Geisser corrected *F* (1.65, 168.19) = 88.11, *MSE* = .02, *p* = <.001, η_p^2 = .46. Pairwise comparisons revealed that intentional TUT was more common in the SART than the changing-target SART (Cohen's d_{av} = .58, [CI = .16, .26]), the *1*-back (Cohen's d_{av} = .53, [CI = .14, .25]), and the *3*-back (Cohen's d_{av} = .53, [CI = .14, .25]), all *p* <.01. However, intentional TUT rates were equivalent between the changing-target SART and the *1*-back ([CI = -.04, .01, *p* = .45,]) and the *3*-back ([CI = -.04, .01], *p* = .90). Of the 103 participants, 46.6% demonstrated this pattern. An additional 7.77% of participants followed a U-Shape association for intentional TUTs.

Unintentional TUT also differed significantly between tasks, Greenhouse-Geisser correct *F* (2.57, 262.51) = 44.97, *MSE* = .02, *p* <.001, η_p^2 = .31. Pairwise comparisons showed that unintentional TUT was more common in the *3*-back compared to the SART (Cohen's d_{av} = .48, [CI = .12, .23]), the changing-target SART (Cohen's d_{av} = .34, [CI = .09, .19]), and the *1*-back (Cohen's d_{av} = .45, [CI = .12, .22]), all *p* <.01. Unintentional TUT did not significantly differ between the SART and the changing-target SART ([CI = -.01, .08], *p* = .11]), nor did it differ between the SART and the *1*-back ([CI = -.04, .03], *p* = 1.00]). Finally, the changing-target SART and the *1*-back had equivalent unintentional TUT rates, ([CI= -.01, .08], *p* = .37). The data of 55.34% of the 103 participants followed this pattern, and a further 14.56% followed a U-shape association across the tasks when ordered by difficulty.

7.7.6 Correlations for Perceived Difficulty

Correlations between intentional and unintentional TUTs, WMC, and questionnaire measures are demonstrated in Table 9. The correlation coefficients between intentional and unintentional TUTs with difficulty were once again compared within each task. The tests were one-tailed, as it was predicted that intentional TUTs would show a greater inverse association with perceived difficulty. In the SART, there was a significant difference, *z* = -1.72, *p* = .04. This indicated that intentional TUTs had a greater inverse association with perceived difficulty. Interestingly, there was no significant difference between the associations in the changing-target SART, *z* = -.82, *p* = .21. In the *1*-back task there was likewise no significant difference between the associations, *z* = 1.86, *p* = .97, as occurred with the 3-back task, *z* = .88, *p* = .81.

7.7.8 Correlation for Working Memory Capacity

As in Experiment 1, the association of WMC with intentional and unintentional TUTs were compared across tasks. The significance criterion was set to α =.008 to adjust for the number of comparisons and Dunn and Clark's *z* tests are reported. A comparison of the correlations between intentional TUTs and WMC found there was no difference in the associations between the standard SART and the changing-target SART, Dunn and Clark's *z* = 1.40, *p* = .16, the standard SART and the *1*-back, *z* = 1.65, *p* = .10, or the standard SART and the *3*-back, *z* = .78, *p* = .43. There was also no difference between the *3*-back and *1*-back, *z* = .95, *p* = .34, or between the *3*-back and changing-target, *z* = .51, *p* = .61. The *1*-back and changing-target SART were also equivalent, *z* = .39, *p* = .69.

Unintentional TUTs and WMC were then compared across tasks. The association between the SART and changing-target SART was not significant after α adjustment was applied, *z* = 1.98, *p* = .04. It was not different between the SART and *1*-back, *z* = 1.66, *p* = .10, or the SART and the *3*-back, *z* = 1.89, *p* = .06. The association with the changing-target SART was equivalent to the *1*-back, *z* = -0.16, *p* = .87 and the *3*-back, *z* = 0.09, *p* = .93. The *1*-back and *3*-back were also equivalent, *z* = 0.23, *p* = .82.

7.7.9 Correlations for Motivation

The correlations for intentional TUTs and motivation were also compared at an α of .008 using Dunn and Clark's z test. The correlations did not differ for the SART and changing-target SART, *z* = -0.08, *p* = .94, nor the SART and *1*-back, *z* = -.46, *p* = .65, or SART and the *3*-back, *z* = .16, *p* = .88. The changing-target SART and *1*-back were equivalent, *z* = -.38, *p* = .70, as was the changing-target SART with the *3*-back, *z* = .23, *p* = .82. The *1*-back and *3*-back were equivalent, *z* = .62, *p* = .54.

Unintentional TUTs and motivation were compared, and these associations did not differ amongst the SART and changing-target SART, *z* = -1.10, *p* = .27, the *1*-back, *z* = .91, *p* = .36, and *3*-back, *z* = .92, *p* = .36. Coefficients were also equivalent in the changing-target SART and *1*-back, *z* = -.71, *p* = .48. However, it did trend toward a difference between the changing-target SART and the *3*-back, *z* = 2.06, *p* = .04. There was a significant difference between the *3*-back and *1*-back, *z* = 2.72, *p* = .007. The correlation was stronger for the *3*-back than the *1*-back.

Table 9

Correlations between Motivation Questionnaire Responses and Intentional and Unintentional TUTs

Task		Variable	1.	2.	3.	4.	5.	6.	7.	8.
SART	1.	WMC	-							
	2.	Motivation	-.04	-						
	3.	Interest	.02	.46**	-					
	4.	Difficulty	.01	.27**	.24*	-				
	5.	Alertness	.06	.22*	.22*	.13	-			
	6.	Pleasantness	.17^{t}	.27**	.40**	.24*	.22*	-		
	7.	Intentional TUT	.06	-.28**	-.26**	-.30**	-.07	-.12	-	
	8.	Unintentional TUT	.03	-.19^{t}	-.22**	-.07	-.24*	-.23*	.04	-
			1.	2.	3.	4.	5.	6.	7.	8.
Changing-Target SART	1.	WMC	-							
	2.	Motivation	-.10	-						
	3.	Interest	.00	.66**	-					
	4.	Difficulty	.27**	-.24*	-.21*	-				
	5.	Alertness	-.02	.26**	.22*	.10	-			
	6.	Pleasantness	-.05	.04	.00	-.15	.30**	-		
	7.	Intentional TUTs	-.11	-.26**	-.22*	-.22*	-.03	.00	-	
	9.	Unintentional TUTs	-.23*	-.04	-.09	-.11	-.25*	-.20*	.06	-
			1.	2.	3.	4.	5.	6.	7.	8.

			1.	2.	3.	4.	5.	6.	7.	8.
***1*-back**	1.	WMC	-							
	2.	Motivation	.17[t]	-						
	3.	Interest	.25*	.52**	-					
	4.	Difficulty	-.11	-.14	-.04	-				
	5.	Alertness	.09	.19[t]	.23*	.33**	-			
	6.	Pleasantness	.06	.34**	.25*	.03	.12	-		
	7.	Intentional TUT	-.16	-.21*	-.28**	.06	-.17[t]	-.19[t]	-	
	8.	Unintentional TUT	-.21*	.06	-.06	-.22*	-.25*	-.11	-.17[t]	-
***3*-back**	1.	WMC	-							
	2.	Motivation	.20*	-						
	3.	Interest	.10	.70**	-					
	4.	Difficulty	.18[t]	-.23*	-.30**	-				
	5.	Alertness	-.04	.43**	.39**	-.13	-			
	6.	Pleasantness	-.06	.17[t]	.25*	-.19[t]	.18[t]	-		
	7.	Intentional TUT	-.04	-.29**	-.36**	.17[t]	-.33	-.25*	-	
	8.	Unintentional TUT	-.24*	-.31**	-.23*	.05	-.20*	-.23*	.07	-

Note. Correlations with * are significant at an α of <.05, whereas ** indicates significance at an α of <.01. The superscript [1] indicates the correlation trended toward significance between an α of .05 and .09.

7.8 Discussion: Experiment 2

The results of Experiment 2 are mostly consistent with, and extend on, the findings from Experiment 1. The SART was perceived as the least difficult task, whereas the *3*-back was the most difficult. The *1*-back and changing-target SART were equally rated as moderately difficult. TUT rates also covaried with these ratings of difficulty; the overall TUT rate was the greatest in the SART and *3*-back tasks, and examination by TUT type revealed a task x intentionality interaction whereby intentional TUTs were most common in the SART and unintentional TUTs occurred most in the *3*-back.

Intentional TUTs were selectively limited during the changing-target SART, consistent with the findings of Subhani et al. (2019). This indicates that decreasing the repetitiveness of a task can inhibit intentional TUT. Importantly, performance measures on the SART and changing-target SART revealed equivalent false alarms and reaction times, but a higher hit rate for the changing-target SART. Greater hit rates in the changing-target SART could be explained by a greater arousal and responsiveness to the frequently occurring GO stimuli which in turn limited intentional TUT. Supporting this possibility, further analyses in Appendix B compared self-rated alertness in each task and found that alertness was lower in the SART compared to the changing-target SART. Critically, that participants performed better on this measure but perceived this task as more difficult goes some way in suggesting different influences of subjective and objective difficulty on TUTs.

Intentional TUT was correlated with subjective difficulty in both the SART and changing-target SART (although associations did not differ from unintentional TUTs in the changing-target SART) suggesting that a plausible mechanism through which this modulation occurs is the participant's perceptions of the task. It seems in certain contexts (e.g. traditionally repetitive task contexts) if a participant perceives the task to be more difficult, they are more motivated to remain on task than to engage in TUTs. Unintentional TUTs were consistently associated with WMC across tasks as well, with the exception of the SART. In contrast, intentional TUTs did not correlate with WMC, and instead were associated with subjective difficulty only in the SARTs, and with motivation. This supports the view that unintentional TUTs reflect cognitive ability, whereas intentional TUT is associated with top-down consciously controlled resource-allocation decisions and motivational mechanisms.

7.9 General Discussion for Study 1

7.9.1 Overview

A curvilinear association has been observed between task difficulty and TUT rates, within task paradigms (Xu & Metcalfe, 2016, Randall et al. 2019). Efforts had also been made to observe the influence of task ease and difficulty when these extremes are benchmarked by different types of tasks (Seli et al., 2018c; Martínez-Pérez et al., 2021), although clear differences in intentional and unintentional TUTs were not consistently observed. The current study aimed to extend on this work by observing whether such an association occurs when commonly used sustained attention and working memory updating tasks are employed as the benchmark of ease and difficulty. It was hypothesised that increases in TUTs would emerge in the SART and *3*-back tasks relative to a *1*-back. It was also hypothesised that factors of intention, subjective perceptions of tasks, motivation, and cognitive ability would influence these association. In addition, in Experiment 2 the SART was modified to further investigate the influence of task characteristics and demands on TUTs.

Results from Experiment 1 supported the hypothesis that, in comparison to the moderately difficult *1*-back task, TUTs would be more frequent in the SART and *3*-back. Further consistent with predictions, intentional TUTs increased in the SART, whereas unintentional TUTs occurred most frequently in the *3*-back. Correlations between TUTs, WMC, and measures from the motivation questionnaire revealed that unintentional TUTs tended to be inversely associated with WMC and motivation, whereas intentional TUTs were inversely associated with interest, motivation, and perceptions of difficulty. Experiment 2 confirmed these correlations and found that by decreasing the monotony of the SART, through changing the target digit in each block, intentional TUTs were selectively inhibited. The results will be discussed in light of past findings and theory.

7.9.2 Intention and Task Difficulty

Results of the current study are consistent with arguments that TUTs during easy task contexts occur due to a lack of challenge and over-availability of cognitive resources (Smallwood & Schooler, 2006; Taatgen et al., 2021; Thomson et al., 2015), whereas difficult tasks overload cognition resulting in more attentional failures allowing TUTs into consciousness (Adam & Vogel, 2017; Thomson et al., 2015; Xu & Metcalfe, 2016). The SART and *3*-back conditions resulted in more TUTs, compared to the moderately challenging *1*-back and changing-target SART task. This suggests that when a task is more engaging (or at least less monotonous) but also within participants' ability levels, it may challenge and capture a participant's attention and this interaction of cognitive-motivational processes can protect against TUTs.

Additionally, the correlations between TUT type, motivation, and WMC indicated that task context affects certain associations. Namely, motivation had a stronger inverse relationship with unintentional TUTs in the 3-back compared to the 1-back across both experiments. Perhaps in highly challenging tasks (i.e., the 3-back) motivation helps to limit spontaneous disruptions by facilitating the application of cognitive control or increasing the occurrence of on-task thoughts, relative to intermediate tasks. There was also a significant inverse association between intentional TUT and subjective difficulty in both standard SARTs, but neither n-back. This may indicate that for those who are challenged by more repetitive tasks, conscious engagement with the task is more likely than for those who view the task as overly simple or easy. Cognitive ability (i.e., WMC) on the other hand tended to have a more stable association across tasks. Together, these results may indicate subtle differences in the roles of certain variables in controlling TUTs depending on the task.

That unintentional TUTs were inversely correlated with WMC and alertness during the *3*-back supports the position that these TUTs result from control failures (McVay & Kane, 2010, Robison & Unsworth, 2018). When tasks overload cognition (such as a *3*-back) it diminishes the ability to effectively block out internal distractors. Higher WMC individuals are better able to control their attention, and so experience these control failures less frequently (McVay & Kane, 2010). The distribution profiles for TUT proportions in the *3*-back compared to the SART (see Figures 18 and 19) further substantiate the link between control failures and unintentional TUTs. During the SART participants almost uniformly reported TUTs on just less than half the probes, but in the *3*-back the rates of TUT across participants was far more variable. This variability likely reflects a more complex pattern of responding, driven by individual differences in WMC that influenced the inhibition of unintentional TUTs.

The association between motivation and unintentional TUTs – particularly in the *3*-back- while not predicted, is also not unprecedented (see for example Robison & Unsworth, 2018; Robison, et al., 2020). It is possible however that there was a confound in the way TUTs were measured. Smith et al. (2022) examined the relationship between unintentional TUTs and motivation and found that participant judgements of intentionality were contaminated by judgements about the degree of constraint exerted over thoughts. Constraint refers to how the TUT is experienced – whether it shifts from topic to topic or is focussed on one item (Christoff et al., 2016; O'Neill et al., 2021). Episodes with less constraint may be misconceived as being less intentional. When Smith et al. (2022) provided participants with both intentionality and constraint as self-report options they found the relationship between unintentional TUT and motivation disappeared.

Alternatively, there may be a genuine relationship between motivation and unintentional TUT, because executive control requires motivation to be applied (Yee & Braver, 2018). Seli et al., (2019a) first noted the possibility that when a participant is motivated, they may decrease TUT through greater attention to the task. This is broadly supported by evidence for interactions between motivation and cognitive control (see Botvinick & Braver, 2015 and Yee & Braver, 2018 for review) and arguments from allocation frameworks that people distribute their attention according to cost-benefit analyses. If participants have made performance of the external task their primary goal, they will be more motivated to apply cognitive control to focus on the task and inhibit distracting information. This association with motivation and unintentional TUTs also seems to be relatively stronger in high-load tasks such as the *3*-back. However, it has been noted by Seli et al. (2015c) that it cannot be assumed that participants make experimenter-assigned tasks their primary goal. In this case a participant may be more susceptible to distracting internal thoughts which represent their more salient personal goals.

For both Experiments 1 and 2 there were some variations from the grand mean in terms of patterns of TUT across tasks. Where some participants demonstrated U-shape associations across the tasks, others showed linear increases or decreases in certain types of TUTs and others showed sharp or sudden increases in intentional or unintentional TUTs in the SART or *3*-back respectively. These variations in person-centred effects indicate that perhaps there are influences of other task-based, cognitive, and dispositional variables which play a role in how TUTs are regulated for different individuals. Future studies could explore whether these person-centred effects are reflecting differences in self-regulatory abilities like mindfulness and cognitive regulation, which would further support that these thoughts have multi-dimensional determinants. To note, while there were variations in exact patterns of how these thoughts decreased or increased across tasks, these variations still supported that intentional TUTs were most common in the SART and unintentional TUTs most common in the *3*-back.

There were also subtle differences in the pattern of TUTs across tasks between both experiments. In Experiment 1 unintentional TUTs showed a U-shaped pattern across difficulty levels, whereas intentional TUTs decreased linearly from the SART to the *3*-back. In Experiment 2 however, intentional TUTs were highest in the SART and equivalent across other tasks, and unintentional TUTs were highest in the *3*-back with equivalent rates in other tasks. One possible explanation for these differences is the environment in which tasks were completed. Diede et al. (2022) found counterintuitive evidence to suggest that TUTs are more common in the laboratory than in home environments when they compared TUTs during a SART in older and younger adults in both environments. If this is the case, the linear decrease in intentional TUTs in Experiment 2 may reflect this greater ability to reduce TUTs in home environments, when tasks are more interesting and/or challenging. Likewise, individuals may engage greater executive control to minimise unintentional TUTs in these environments, however when a task exceeds this ability this may then lead to a sharp increase in the occurrence of these off-task thoughts. Ultimately however there is a lack of work investigating differences in TUTs between home and laboratory environments when completing experimental tasks.

7.9.3 Subjective Processes and Task Characteristics

Researchers have called for further examination of how task difficulty is defined and manipulated (Seli et al., 2018c), as well as how perceptions of tasks influence engagement in TUTs (Forrin et al., 2021). Experiment 2 included a modified SART designed to be less monotonous, but not necessarily more difficult. This modification was based on results from Subhani et al. (2019) suggesting that compliance inhibits intentional TUTs, as well as general arguments that sustained attention tasks may trigger TUTs through their monotony (Thomson et al., 2015). Performance measures between the SART and changing-target SART were comparable for false alarms and reaction times, and showed a higher hit rate on the changing-target SART. As such, while it is possible that changing the target digit in the modified task places more demands on the executive control system to monitor the target, this does not seem to have resulted in any more errors than in the typical SART. Indeed post-hoc correlations also confirmed that the *d'* for both tasks did not differ in associations to WMC, indicating executive control did not uniquely relate to performance in either condition. The tasks could reasonably be considered similar in difficulty, yet the modification of the SART resulted in perceptions of that task being significantly more difficult. These modifications also selectively inhibited intentional TUTs relative to the standard SART, with the effect being moderate (Cohen's d_{av} = .58).

There are two possible explanations for these results. First, during simple unchanging tasks participants perceive the demands to be low and believe they can afford to allocate resources to current concerns (regardless of actual performance). When performing a low-demand monotonous task for an extended time, attention can withdraw from the primary task and a new internal focus of attention is generated (Malkovsky et al., 2012). This alternate focus of attention can consist of TUTs, which an individual may maintain if they do not believe the primary task requires all their focus (Smallwood, 2013; Thomson et al., 2015). By changing the target, the participant may perceive that more resources are necessary for task performance and inhibit intentional TUTs. The false alarm response patterns in both SART conditions are consistent with this argument. In the standard SART more false alarms occur in the second half of the task compared to the first half, indicating more inattention and disengagement as time on task increases. In contrast in the changing-target SART more false alarms occurred after each target-digit change occurred and lessened toward the end of a block, when participant were able to more completely update target-digit identities in mind. This seems to suggest that while changing the identity of the target did in fact influence when false alarms occurred in the task, it did not translate to a difference in the frequency of false alarms, and actually improved attentiveness to the non-target hit stimuli.

However, as mentioned, it is also possible the changing-target SART not only resulted in more arousal and attentiveness because of its reduced monotony, but also because it was more challenging. In this case, it could be argued that the changing-target SART increased participant arousal due to the greater actual (rather than perceived) challenge it posed, and thus resulted in less TUTs. This could still indicate that easy tasks are unengaging and encourage the participant to choose not to focus on the current task due to disinterest (Neigel et al., 2019), and this withdrawal of attention allows for more TUTs to enter consciousness. Supporting this view, this task had a poorer d' which suggests that on average participants were not attentive during the task and were prioritising speed over accuracy perhaps. In addition, a repeated measures ANOVA on self-rated alertness in Appendix B found that alertness was lower in the SART than the changing-target SART. These results support views that research needs to further explore how task characteristics can influence the way a participant engages with and perceives a task, and subsequently how they allocate attention toward a task or toward internal thought.

So far 'task difficulty' has been used to refer to the differences between the SART and n-back tasks. This is consistent with the literature, including a meta-analysis by Randall et al. (2014) that refers to SARTs as simpler tasks relative to working memory tasks and reading comprehension tasks which require more higher order cognition. However, there are other innate differences between these tasks beyond their level of difficulty. Namely, one relies on inhibitory ability and the other on working memory updating ability. As such, these results may also indicate that different types of tasks (rather than just different levels of difficulty for tasks) encourage different types of mind wandering. It may be that as inhibitory tasks often tend to be repetitive (in order to build up a habitual response and test performance on a rare target), it is the repetitiveness which encourages mind wandering and not the level of difficulty per se. Again, this possibility motivated the addition of the changing-target SART in Experiment 2 which did indicate less repetitive inhibitory tasks result in less intentional TUTs with no change in unintentional TUTs. Unintentional TUTs may have increased in the updating task as in a way this has an opposing issue to the SART – rather than being monotonous it involves continuous changes in the target stimuli which are increasingly difficult to track.

This speaks to a wider issue identified by Seli et al. (2018c) that there is no universal definition or explicit understanding of what is being manipulated when researchers manipulate or compare the 'difficulty' of tasks. Manipulating difficulty often involves changes in working memory demands, task characteristics, interest and motivation in the task, perceptions of the task and response demands of the task. Moreover, while researchers may traditionally manipulate cognitive load as an index of difficulty there are other domains which can also be manipulated, such as perceptual load (Forster & Lavie, 2009). Indeed load theory argues that where increasing executive load can increase susceptibility to distraction increased perceptual load will decrease distractability. Forster and Lavie (2009) found support for this argument when manipulating perceptual load and observing lower TUT frequency in the high load tasks compared to low-load tasks. This further highlights the potential for different manipulations of task difficulty having divergent influences on TUT rates. Future work should focus on whether it is particular features and types of difficulty manipulations which are driving observed task difficulty effects, and work toward a clearer understanding of how difficulty is to be defined.

While these results are largely consistent with prior work, there are some discrepant findings. In both the current experiments intentional TUTs were more common than unintentional TUTs during the SART, which diverges from previous findings (Banks & Welhaf, 2022; Robison & Unsworth, 2018). Yet, participants were also much less motivated on average in the current study than previous work (e.g., Robison & Unsworth, 2018) which may account for the greater disengagement by these participants. Indeed, prior work has found that intentional TUTs can be more common in certain low-level task contexts (Giambra et al., 1989). Nonetheless, the overall TUT rates reported here are consistent with prior work (Seli et al., 2018c; Banks & Welhaf, 2022). Lastly, unintentional TUTs increased in a 3-back task, which is consistent with findings from Shin et al. (2020), yet Robison and Unsworth (2018) found that TUTs decreased in this task. This may be due to differences in task durations, for example the current 3-back lasted between 10-15 minutes, compared to 10 minute durations in Robison and Unsworth (2018).

Time on task has been found to influence and increase disengagement, and in addition prolonged demand on working memory would likely also increase control failures (Thomson et al., 2015; Martínez-Pérez et al., 2021).

7.9.4 Theory

The pattern of findings in the current study are broadly consistent with a number of theories of mind wandering. As predicted by the current concerns x executive failure hypothesis, WMC and alertness were inversely related to unintentional TUTs in high load tasks, suggesting these episodes occur as a result of attentional failures. Also, while some authors have found intentional TUT to be related to cognitive ability (Banks & Welhaf, 2022; Soemer & Schiefele, 2020; Robison et al., 2020) these results align with authors who have not found such a relationship (Robison & Unsworth, 2018; Ju & Lien, 2018). Therefore, while it is possible that in some circumstances intentional TUTs can be influenced by the ability of the individual to control their focus, it is clear that there are also circumstances where this is not the case. Indeed, the reported rate of intentional TUT during the SART in the current study, which participants perceived as less difficult, is unlikely to be driven by executive failures.

Our results also align with an executive resources perspective, which might argue that resources were available during the SART (or perhaps more likely that participants believed resources were available) to intentionally engage in off-task thought while maintaining task performance. This is corroborated by the reduction in intentional TUTs during the changing-target SART despite equivalent or higher performance on certain measures. Furthermore, ratings of the SART as more difficult, and greater participant motivation, were associated with less intentional TUT. These results indicate that if participants expect a task to require attention, and if they are more motivated or interested in performing, then they will allocate their attention to the external task and avoid TUTs (Danckert et al., 2018; Isacescu et al., 2017).

Finally, results are also consistent with resource allocation frameworks and the context-regulation hypothesis. Intentional TUT was found to be most common when low-level sustained attention abilities were required of participants, however when a task required higher-order processes and placed a high cognitive load on participants, unintentional TUT became more common. These results indicate that while low and high cognitive load contexts seem to encourage TUT, they do so for different reasons, and participants modulate their engagement in intentional TUT according to the task being performed (Seli et al., 2018c). In addition, changes in subjective assessment of difficulty observed between the two SARTs in Experiment 2 may have resulted in participants modulating their intentional TUT rates to better meet the expected demands of the task. Notwithstanding, a collective issue among all theories of TUT is the lack of distinction between intentional and unintentional TUTs (Seli et al, 2016a; Seli et al., 2016b), which future work must continue to address.

7.9.5 Limitations

One limitation in the current study is that participants were asked to rate their motivation levels and interest levels after each task was completed. It is possible that participants intentionally reported to be less interested or motivated in tasks they believe they performed poorly on. However, most participants during the post-experiment debriefing phase were unaware of the link between the motivation measures, TUT, and performance on the task. In addition, there was no feedback provided on performance of the tasks after the practice phase. As such, participants had no concrete knowledge of the accuracy of their performance.

Relatedly, evidence from both the current work and past literature suggests people can adjust their motivation which then influences TUT rates (Seli et al., 2019a). In the current study, state-level motivation measures were used within each task to understand how this influences TUT rates when completing the tasks. However, future work should incorporate measures of trait-level motivation prior to experimental tasks to observe the impacts this also has on engagement in TUTs, or whether it may mediate associations of TUTs with other variables (e.g., cognitive ability). For example, Kawagoe et al. (2020) found unique associations of trait- and state-level motivation measures with mind wandering propensity during a SART suggesting both variables differentially influence TUT engagement. Additionally, given the large number of tasks participants were asked to complete in Experiments 1 and 2, it may be helpful to measure fatigue in future. Fatigue impacts attention regulation (Holtzer et al., 2011) and is likely to then have an impact on TUT rates. This could further account for differing patterns of TUT engagement between participants.

The questionnaire used in the present work relied on single-item self-report measures for several variables. The rationale for using such a measure was to maintain consistency with the previous literature which has found reliable relationships between motivation and TUTs (e.g. Seli et al., 2015a; Seli et al., 2019a; Unsworth & McMillan, 2013). Despite this, there are potential problems when using single-item measures, including invalid responses and participant misinterpretation of the question yielding distorted measures. To better understand the relationship between TUTs and the participant-related variables an important avenue for future work will be to develop more detailed questionnaires that ensure valid and reliable responding.

To comply with social distancing policies Experiment 2 had to be completed online, and there are innate differences between online and laboratory environments. Indeed, there were subtle differences in intentional and unintentional TUT patterns across tasks between these environments. Nonetheless, the overall consistency of findings between Experiments 1 and 2, despite the difference in methodology, suggests that many aspects of the fundamental relationships are robust and replicable and therefore many of the associated phenomena can tolerate this variation in experimental design.

It also needs to be acknowledged that there are ongoing questions regarding the conceptual validity of intentional TUTs (Murray & Krasich, 2022). Namely, there are questions of whether the mind can truly wander 'intentionally', with proposals that if intentional TUTs involve the purposeful engagement in thought regarding an alternative goal then is this truly "task-unrelated" or does the new goal not become the new "task" (thus making the thought task-related)? Arango-Muñoz and Bermúdez (2021) offer a surrealist counter-possibility to this argument, stating that intentional TUTs may not involve the intentional engagement in a stream of thought but instead the intentional "relaxing" of cognitive control which then allows external TUTs to enter consciousness. Indeed TUTs are often spoken of as reflecting the 'default' state of the mind (Christoff et al., 2016), and cognitive control is required to inhibit such TUTs to allow focus on the task (McVay & Kane, 2010). People may choose to relax such control, and this may be what is reflected in intentional TUT episodes. Future efforts should be made to refine understanding of what is meant by intentional TUTs. Doing so may even differentiate these thoughts from mind wandering eventually.

7.9.6 Conclusion

In summary, evidence was found converging with previous literature, that individuals with greater WMC had a tendency to engage in fewer unintentional TUTs, and that intentional TUTs were independent from WMC. Intentional TUTs were instead related to processes of motivation state and subjective assessments of the task. These findings also extend the literature by investigating how these relationships change between different types of tasks (i.e., sustained attention versus memory updating tasks), and found that both objective (indexed by task type) and subjective changes in difficulty to a task are associated with the modulation of TUT rates. Current theories go some way in explaining potential mechanisms responsible for these differences, but they are limited in their lack of explicit integration of the intentionality dimension of off-task thought. Further documentation of the differences between these two types of TUT and their relationships with task and individual factors will build a stronger empirical case to support the development of more nuanced theories of TUTs. Lastly, this work further raises the issue of how task difficulty is defined and suggests that the objective demands of the task as well as perceptions of performing it should be integrated into a definition, so that differing patterns of TUT by level of intention can be usefully integrated into broader frameworks. Future work should further explore how subjective processes influence TUTs, and the contexts which modulate these associations.

Chapter 8: Study 2 – The Association Between Maintenance and Disengagement with Intentional and Unintentional TUTs

8.1 Background

Traditionally, the strong correlation observed between WMC and fluid intelligence (Gf) (which can range from .5-1.0) (Kane et al., 2005; Unsworth et al., 2009) has been accounted for by claims that WMC drives fluid intelligence [see Section 3.7.1]. However, Shipstead et al. (2016) recently argued that this variance instead reflects the shared reliance on a top-down executive signal which deploys specific process-general cognitive mechanisms (namely maintenance and disengagement) as required to complete a given task (See Figure 3 in Chapter 3).

By definition, maintenance processes are extremely important in working memory tasks. In contrast, fluid intelligence tasks emphasise the ability to disengage from outdated information, in order to form novel solutions to presented problems. In this way, they are more reliant on disengagement abilities. There is of course overlap between the two tasks, with fluid intelligence tasks also requiring a degree of maintenance of information, and working memory tasks requiring a degree of disengagement from outdated information. This overlap and shared reliance on executive attention to deploy these mechanisms is what contributes to the shared variance between these constructs.

Martin et al. (2020) demonstrated the theoretical and empirical utility of this framework by using it to predict reading comprehension performance. They found that when fluid intelligence, updating ability, and working memory were measured and their unique variance isolated using SEM, the variance relating to maintenance and disengagement abilities had a significant and positive association with reading comprehension. Updating tasks were argued to reflect both maintenance and disengagement processes and so were included in latent construct modelling in order to extend the model's ability to measure disengagement and to account for reading ability. Evidence from their study suggests that this framework offers a new and fruitful perspective for understanding the roles of general maintenance and disengagement abilities and executive attention which may underpin certain complex cognitive abilities.

Task-unrelated thoughts are often discussed as being reliant on the ability to either inhibit (as per an executive failure perspective), sustain (as per an executive resource perspective), or regulate (as per context-regulation and resource control perspectives) off-task thoughts during external tasks. The ability to avoid or sustain TUTs is frequently attributed ambiguously to 'executive functions' but the specific functions which support or prevent these thoughts are not often measured or articulated outside WMC and attention control. As a result of this common use of WMC and attention control in literature investigating TUTs and mind wandering, arguments that TUTs reflect predominantly failures in maintaining task-relevant information in the working memory space are reinforced.

Nonetheless, there have been limited efforts to identify the specific candidates of executive functions involved in TUTs outside of WMC measurements. In particular, Kam and Handy (2014) investigated the impacts of TUTs on updating, inhibition and task-switching. They found TUTs only impaired performance on inhibition and updating tasks, but did not influence task-switching. This work marked an initial step to further specify the interrelationships between TUTs and conceptualisations of executive functions. However, these authors used Miyake et al.'s (2000) approach to executive function which has been criticised as being overly fractionated (Martin et al., 2020; Shipstead et al., 2016). The maintenance and disengagement framework in contrast does not focus on the specific processes underpinning each ability (e.g. inhibition, decay, switching, updating) but instead proposes a process-general solution in an attempt to provide a more parsimonious account of complex cognition.

In light of this framework, TUTs may not only be associated with the ability to maintain task-relevant information, but also the ability to successfully disengage from such distracting thoughts when they do occur. Just as there is literature to support an association between TUTs and WMC (McVay & Kane, 2009; McVay & Kane, 2012; Rummel & Boywitt, 2014), there is also evidence of an association between TUTs and fluid intelligence (Robison & Brewer, 2022; Unsworth & McMillan, 2014; Unsworth & McMillan, 2016). It is possible then that disengagement (reflected in these fluid intelligence and updating measurements) is important for releasing TUTs from the focus of attention in order to re-orient and engage ongoing focus to task-relevant information.

Further still, the degree to which TUTs are associated with maintenance and disengagement ability may differ depending on whether the episode is intentionally or unintentionally engaged. In both the literature, and empirical work in this thesis thus far, differences implicating underpinning mechanisms of each type of TUT have been documented. In Experiments 1 and 2 (Study 1), unintentional TUTs were observed to be inversely associated with WMC and motivation, whereas intentional TUTs had an inverse relationship with motivation and subjective perceptions of task difficulty. These differences are consistent with general patterns observed in the literature [see Sections 5.6], where unintentional TUTs show a consistent association with WMC (Ju & Lien, 2018; Robison & Unsworth, 2018; Robison et al., 2020; Unsworth & McMillan, 2016).

Considering these findings, it is reasonable to anticipate that intentional and unintentional TUTs might also have differential relationships with maintenance and disengagement. For example, it may be that the ability to inhibit distractors and maintain focus (as measured by working memory tasks) is important for instances of spontaneous TUTs rather than intentional TUTs. Likewise, the ability to disengage from a thought to re-orient to a task (as measured in fluid intelligence tasks) may also be important for spontaneous TUTs. Intentional TUTs in contrast seem to be consciously controlled to some extent, and therefore are perhaps more related to processes of task perceptions such as its difficulty and the participant's interest in completing the task.

8.1.1 The Current Study

Study 2 aims to investigate the associations between intentional and unintentional TUTs with maintenance and disengagement abilities to extend on efforts to identify the mechanisms that underpin each type of off-task thought. This study followed the method of Martin et al. (2020), measuring WMC, fluid intelligence, and updating ability. Using SEM, the factors of maintenance and disengagement were then isolated and their predictive relationship with intentional and unintentional TUTs was observed. In addition, interest and perceptions of difficulty were also measured as these subjective factors have been associated with TUTs in past work and have shown separable associations with intentional and unintentional TUTs in Study 1.

8.1.2 Hypotheses

The predictions for the current study are as follows:

i) Unintentional TUTs will be associated with working memory and maintenance abilities, due to their documented association with WMC.

ii) Unintentional TUTs will also be associated with fluid intelligence and disengagement abilities, as these TUTs tend to be more commonly associated with cognitive abilities compared to intentional TUTs.

iii) Intentional TUTs will be associated with subjective interest in the task and perceived difficulty consistent with both past work and Study 1 of this thesis.

8.2 Method

8.2.1 Participants

Initially 472 participants attempted to complete the battery of tasks, but there was an attrition of 43 (29 female, M_{age} = 21.56, *SD* = 5.46) participants mid-session. As such, the final sample included 429 undergraduate students (321 female) from the University of Wollongong, between the ages of 18-58 (*M* = 21.09, *SD* = 5.61). Participants completed a two-hour testing session remotely, using Inquisit Web Player. Remote collection of data was utilised in order to avoid disruption from ever-changing COVID-19 regulations in Australia during doctoral candidature. Participants received course credits in return for participation, and the study was approved by the Human Research Ethics Committee at the university.

8.2.2 Tasks

Working memory capacity. Working memory capacity was measured with the three complex span tasks described below. In each task the participant was required to recall a series of stimuli, between which a simple processing task disrupts presentation. For all three complex span tasks the dependent variable was the number of to-be-remembered stimuli recalled in the presented serial position in a series or list. Each task had a practice trial which involved practicing the to-be-remembered stimuli series and the simple processing task separately, and then practicing them together. For all tasks, list lengths varied and were presented in randomised order, and each list length was presented three times. The average RTs of each participant from the practice trials of the processing task components were used to create individualised response deadlines in the test trials. Doing so minimises the use of rehearsal or memorisation strategies during the task.

Automated operation span (Unsworth et al., 2005). In this task participants recall a series of letters from the English alphabet, ranging from 3-7 letters in length. Each letter series is preceded by a simple mathematical operation (e.g. "*(8 x 2) – 8 = ?")* followed by a proposed solution (e.g. "*9*"). The participant must decide whether the proposed solution is correct or not. Following the presentation of the entire letter series, the participant recalls the series by selecting, in serial order, from letters provided in a matrix that is presented on the screen at the end of the trial.

Automated symmetry span (Unsworth et al., 2009). Participants were presented with visual sequences of 2-5 red squares in a 4 x 4 matrix, which they were required to recall after presentation of the final stimulus. The presentation of each square in the sequence was preceded by a symmetry judgement of pixelated black and white images. Square recall was performed by clicking on the sequence of red squares in a 4 x 4 matrix provided. The participants were told that both the location and order of the squares was important to correct performance of the task.

Automated reading span (Conway et al., 2005). Participants were presented with a visual sequence of English letters ranging from 3-7 in length. Each letter was preceded by a sentence problem (*"Andy was stopped by the policeman because he crossed the yellow heaven"*) and the participant had to decide whether the sentence made sense of not. Letter recall was tested by asking the participants to select letters on the provided matrix that appeared after final letter in the sequence presented.

Fluid intelligence. For all fluid intelligence tasks, the dependent variable was the number of correct responses provided.

Letter sets (Ekstrom et al., 1976). Each problem in this task has five sets of letters with four letters in each set. Four of the five sets are alike in some way. Participants were required to find the rule that made the four sets alike, so that they could identify the fifth letter set which was different from the others and did not fit this rule. This task has two parts, each with 15 letter set problems to solve and 7 minutes were provided for each part (i.e., participants had 14 minutes in total to complete all 30 problems).

Number series (Thurstone, 1938). A series of numbers was presented on a computer screen, with a rule associating these numbers. The participants had to determine the rule so that they could provide the next number in the sequence according to that rule. Participants had five minutes to complete five problems.

Matrix matching test (Pluck, 2019). This test has two components: a visuospatial and semantic matching component. In the current study only the visuospatial test was used as this measures fluid intelligence (the semantic matching test has a stronger association with crystallised intelligence[5]). There were 12 trials in this task, which each present an abstract geometric pattern. One component of the pattern is left blank. The participant must select one of five possible options to complete the display. Participants have 10 minutes to complete 12 problems. The dependent variable is the total number of correct answers.

Memory Updating.

Running letter span. Participants are presented a sequence of letters varying in length from 3-8 items. When prompted, participants must recall the last *n* items of the sequence (e.g. last 3 items). Participants do not know the list length nor the to-be-recalled *n* until they are prompted at the end of the

[5] Crystallised intelligence (Gc) refers to a person's general knowledge including vocabulary. It also refers to their problem-solving or reasoning ability which is based on learnt information and experiences.

sequence, and the sequences are randomised in order. Sequences are recalled by clicking the items among stimuli presented on a matrix. The dependent variable was the number of items correctly recalled in their serial position.

N-back. This task presents a series of 20 letter trials presented consecutively on a computer monitor. The participant is asked to indicate whether the currently presented stimulus matches the stimulus that was presented *n* items ago (either 2 or 3 items ago) by responding with a spacebar press. In each trial there are 6 targets and 14 non-target items (i.e., distractors and lures). Participants completed 3 blocks each of *2*-back and *3*-back tasks randomly alternated (i.e., 6 blocks in total). Instructional screens were presented at the start of blocks to identify the *n*-back condition being performed. The dependent variable was *d'*, a combined measurement of hits and false alarms that measures the sensitivity of responding correctly to both target and nontarget instances.

Keep track (Yntema & Trask, 1963). This task uses sequences of items (i.e., words) from six categories: countries, relatives, metals, animals, colours, and distances. Items in the sequence are presented one at a time on the computer screen, with all sequences being 15 items in length. Before the sequence presentation, participants are assigned 2-4 categories of which to keep track of the items which relate to these categories during the presentation period. Participants must recall the last (or most recent) item presented from each of these assigned categories at the end of the sequence presentation. For example, the last animal, colour, and distance presented in the list. Responses are typed into a textbox provided at the end of the presentation. The dependent variable was the total number of correct responses across 12 sequences.

Participant interest and perceived difficulty of the task. A simple 2-item questionnaire was used following the SART to measure participant interest in the current task, as well as their perceived difficulty of the task. Participants scored their interest on a 5-point Likert scale ranging from *1 = Not interesting at all,* to *5 = Extremely interesting.* Similarly, perceived difficulty was rated on a 5-point scale, ranging from *1 = Very easy,* to *5 = Very difficult.*

8.2.3 Outcome Measures

Sustained Attention to Response Task (Robertson et al., 1997). After completing the working memory, fluid intelligence, and updating tasks, participants then completed a SART. In this task participants are randomly presented with a single digit between 1-9, in the middle of the screen and in varying font sizes (4pt, 7pt, 10pm, 13pt, 16pt). The digit is displayed for 250ms followed by a 900ms mask. Participants are required to press the SPACEBAR if any digit other than 3 is presented, and to withhold their response when the digit 3 is presented. All 9 digits are presented approximately 50 times each, for a total of 446 trials. Prior to starting the experimental trials, participants were given the opportunity to practice the task. There were 18 practice trials in total with 2 trials being 'no-go' stimuli. Participants had the option to repeat the practice trial a second time if they wanted. The dependent variables for task performance were overall accuracy, hit rates (defined as correct 'Go' responses), false alarms (defined as incorrect 'NoGo' responses), and *d'*.

During this task participants are semi-randomly interrupted by thought probes (20 in total), which ask them to report thought content just prior to the probe appearing. Participants were asked to select from the following options; 1. *On-task,* 2. *Intentionally mind wandering,* 3. *Unintentionally mind wandering*, 4. *External distraction*, and 5. *Task-related interference*. Participants were provided with a definition for each of these prior to starting the task, as shown in Table 10. The only constraint on thought probes was that they could not appear within 5-digit presentations of each other. Intentional TUT was calculated as the number of probes whereby participants selected "*intentionally mind wandering"* divided by the total number of probes. For example, if a participant reported intentional mind wandering on 3 probes this could be calculated as a proportion of 3 / 20 = 0.15. Likewise, unintentional TUT was the number of probes whereby participants selected "*unintentionally mind wandering"* divided by the total number of probes. If participants reported intentional or unintentional TUTs then a follow-up question would ask participants to categorise the TUT episode as either positive, negative, or neutral in emotional valence. Participants were also asked to report whether the TUT episode was prospective or retrospective. These follow-up questions were not part of the main aims of this current study; however they were used in post-hoc analyses. Response times for probes were also observed to ensure participants were engaging with the task appropriately, and not taking extended breaks during the tasks. The mean RTs for probes was 7.54 seconds with a standard deviation of 1.27 seconds.

Table 10

Thought Probe Response Options

Probe	Description
Task-related thought	Focussing on the task stimuli.
Task-unrelated thought (intentional)*	Choosing to think about something unrelated to the task (e.g., future, or past events, what they are having for dinner).
Task-unrelated thought (unintentional)*	Experiencing task-unrelated thoughts despite intentions to remain focussed (e.g., finding themselves thinking about an upcoming exam when they are trying to focus on the task).
Stimulus-independent task-related thought	Thoughts about performance or task duration, and other task evaluations.
External distraction	Attending to an external stimulus (e.g., noise, object).

Note. * These items are considered instances of TUTs in this study.

8.2.4 Data Preparation and Statistical Method

This study employed SEM to observe the associations between processes of working memory, fluid intelligence, and updating, as identified by Shipstead et al. (2016) and Martin et al. (2020), and their predictive relationships with intentional and unintentional TUTs rates during a sustained attention task. The approach of Martin et al. (2020), using models measuring WMC, updating, and fluid intelligence was adopted. The *'lavaan'* package in R was used to model the data.

Univariate outliers were defined as any individual score which exceeded the grand mean by 3.5 standard deviations. Of the 5,577 observations recorded, only 12 met this criteria. These scores were replaced with the cut-off value of ± 3.5 standard deviations of the grand mean. The reported fit statistics used and reported here include χ^2 and χ^2/df, although these statistics are sensitive to sample size - accordingly χ^2/df values of up to 3 are accepted, following previous published reports (Martin et al., 2020; Kline, 2016). Root mean square error of approximation (RMSEA), which estimates the model fit to the population, and standardized root mean square residual (SRMR), which estimates the average deviation of the reproduced covariance matrix from the observed matrix are also reported. For both measures, values < .05 reflect close fit, and values between .05-.08 reflect reasonable, approximate fit. Finally, both comparative fit index (CFI) and the Tucker-Lewis index (TLI) are reported, which compare the hypothesized model to a model where observed variables are assumed to have no relationship. For both the CFI and TLI values of > .90 are considered acceptable, with values closer to 1.00 indicating better fit.

8.3 Results

8.3.1 Descriptive Statistics

Descriptive statistics for all tasks used to create the latent variables of WMC, fluid intelligence, updating, and intentional and unintentional TUTs are presented in Table 11. The means and standard deviations for *all* thought prompt responses are provided in Table 12. For both intentional and unintentional TUTs, two parcels were created. Parcel 1 (i.e., ‘Intentional 1’ and ‘Unintentional 1’) consisted of the total proportion of intentional or unintentional probe responses from the first 10 probes in the SART. Likewise, Parcel 2 (i.e., ‘Intentional 2’ and ‘Unintentional 2’) consisted of the total proportion of intentional or unintentional probes from the following 10 probes in the SART (this follows methods used by authors such as Unsworth & McMillan, 2013). As performance on the SART was not a focus of the study results are included in the appendix [Table 45 of Appendix C provides the descriptive statistics for performance on the SART, and correlations between performance measures on the SART and thought probes are reported in Table 43]. Importantly, these results show that performance on this task was at a satisfactory level. Skew and kurtosis for intentional TUTs were relatively high, with these distributions being positively skewed and leptokurtic. Excessive skewness and kurtosis is common in self-reported TUT data (Robison et al., 2019; Robison et al., 2020). However, Brown (2006) indicates that skewness between -3 and +3 and kurtosis between -10 and + 10 is acceptable when utilising SEM, as it is robust to violations in normality of distributions. Notably, all values lie well within these limits.

Table 11

Descriptive Statistics for All Measures

Task	***M***	***SD***	**Range**	**Skew**	**Kurtosis**
RSpan	56.98	14.72	21 - 75	-.90	-.01
OSpan	57.06	13.83	23 - 75	-.88	.02
SymmSpan	30.01	6.94	11 - 42	-.45	-.42
MatrixMatch	7.92	1.82	4 - 12	-.06	-.64
LetterSets	18.02	5.21	2 - 28	-.32	-.52
2-back	2.89	1.52	.50 – 6.59	.48	-.50
3-back	1.85	.87	.50 – 3.81	.52	-.10
NumbSet	3.66	1.08	1 - 5	-.32	-.73
Keep Track	29.23	3.59	20 - 39	-.38	-.25
Running Span	37.10	9.78	13 - 54	-.06	-.65
Int1	.13	.07	0 - .50	2.23	6.75
Int2	.14	.07	0 - .50	1.82	3.94
Un1	.19	.09	0 - .50	.61	.26
Un2	.19	.11	0 - .70	1.10	1.29

Note. RSpan = reading span; OSpan = operation span; SymmSpan = symmetry span, MatrixMatch = matrix matching task; LetterSets = letter set task; NumbSet = number set task; Int1 and Int2 refer to the first and second parcels of probe responses, Un1 and Un2 refer to the first and second parcels of probe responses. Probes response reflect the proportion of the 10 total probes in each parcel which were reported as being intentional or unintentional TUT. All descriptive statistics were calculated following the outliers being addressed.

Table 12

Means and Standard Deviations of Each Probe Response Option

Intentional	Unintentional	External Distraction	Task-Related Interference	On-Task
.13 (*.06*)	.19 (*.09*)	.07 (*.09*)	.18 *(.16)*	.43 *(.19*)

Note. Intentional = intentional TUTs. Unintentional = unintentional TUTs. Standard deviations are in parentheses.

8.3.2 Measurement Model

Confirmatory factor analysis was used to verify the measurement model and confirm the structure of the data. Correlations between all manifest measures can be found in Table 44 of Appendix C. Each cognitive task was loaded onto its respective theoretical factor (i.e., WMC, fluid intelligence updating). Task and probe loadings for each factor are shown in Table 13, with each loading in an acceptable range, reflecting that the factors were robust. Measurement model fit indices also indicated a good model fit, χ^2 (55) = 78.88, χ^2/df = 1.43, CFI = .99, TLI = .99, RMSEA = .03, SRMR = .03.

Table 13

Confirmatory Factor Analysis of Task Loadings onto Each Factor

Task	WMC	Updating	Gf	Intentional	Unintentional
OSpan	.84				
SymmSpan	.76				
RSpan	.84				
Nback		.75			
Running Span		.76			
Keeping Track		.79			
MatrixMatch			.80		
LetterSet			.78		
NumberSet			.80		
Int1				.68	
Int2				.60	
Un1					.65
Un2					.77

Note. WMC = working memory capacity. Gf = fluid intelligence. Intentional = intentional TUTs. Unintentional = unintentional TUTs. OSpan = operation span. SymmSpan = symmetry span. RSpan = reading span. Nback = composite *z* score of the *2*-back and *3*-back tasks. MatrixMatch = matrix matching task. Int1 and Int2 = the first and second intentional TUT parcels respectively. Un1 and Un2 = the first and second unintentional TUT parcels respectively.

Correlations among the latent factors are provided in Table 14, and within each of the illustrated SEMs. Consistent with past research, the correlations between WMC, updating, and fluid intelligence were positive and high. Both forms of TUT demonstrated significant moderate inverse associations with WMC, and weak but significant inverse associations with fluid intelligence. Intentional TUTs trended toward a significant inverse association with updating (p = .06), and unintentional TUTs were significantly associated with updating.

Table 14

Confirmatory Factor Analysis: Correlations Among Latent Variables

	WMC	**Updating**	**Gf**	**Intentional**	**Unintentional**
WMC	1				
Updating	.71**	1			
GF	.73**	.74**	1		
Intentional	-.24*	-.14	-.15*	1	
Unintentional	-.31**	-.17*	-.17*	.38**	1

Note. WMC = working memory capacity. Gf = fluid intelligence. Intentional = intentional TUT. Unintentional = unintentional TUT. ** indicates significance at p <.001, * indicating significance at p <.05.

8.3.3 Structural Equation Models

For all reported models, the fit statistics are provided in Table 15. The first model examined the predictive relationship between WMC and fluid intelligence with both intentional and unintentional TUTs. As demonstrated in Figure 12, WMC yielded a significant positive relationship with both intentional and unintentional TUT, albeit a greater amount of variance was accounted for in unintentional TUTs. In contrast fluid intelligence did not demonstrate a significant predictive association with either form of TUT. This does not indicate that fluid intelligence is unrelated to intentional and unintentional TUTs, but rather that the association between these factors (at least in the context of TUTs during a SART) can be explained by shared variance between WMC and fluid intelligence.

Table 15

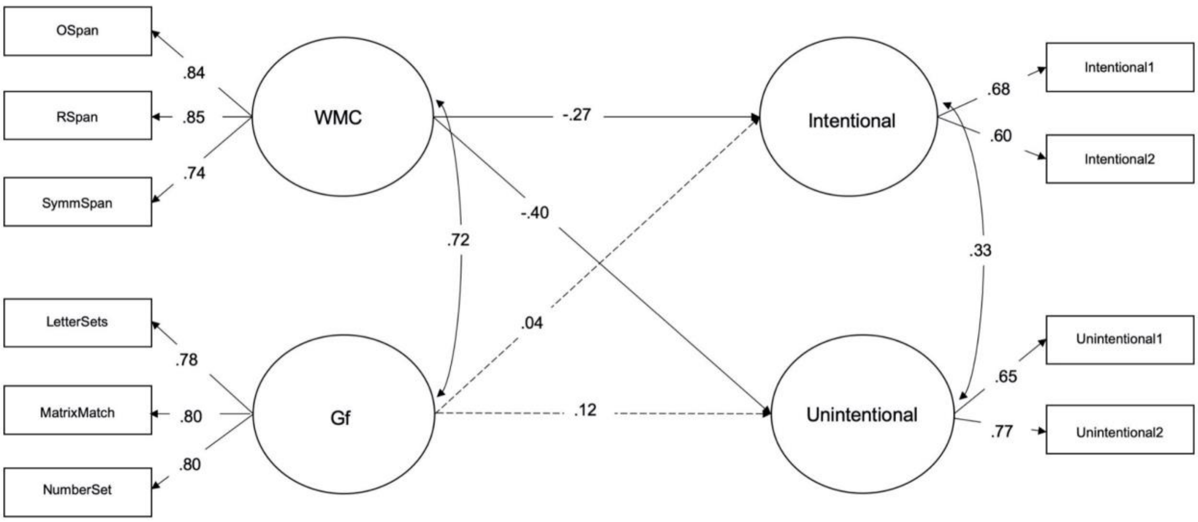
Model Fit Indices

Model	χ^2	*df*	χ^2/df	CFI	TLI	RMSEA	SRMR
WMC, Gf, and Intentional and Unintentional TUT	57.34	29	1.98	.98	.97	.05	.03
Maintenance, Disengagement, and Intentional and Unintentional TUT	56.21	27	2.08	.98	.97	.05	.03
WMC, Gf , Updating, and Intentional and Unintentional TUT	77.80	51	1.53	.99	.98	.04	.03

Note. WMC = Working memory capacity. Gf = fluid intelligence. TUT = task-unrelated thought.

Figure 12

Associations Between WMC and Gf and Intentional and Unintentional TUTs

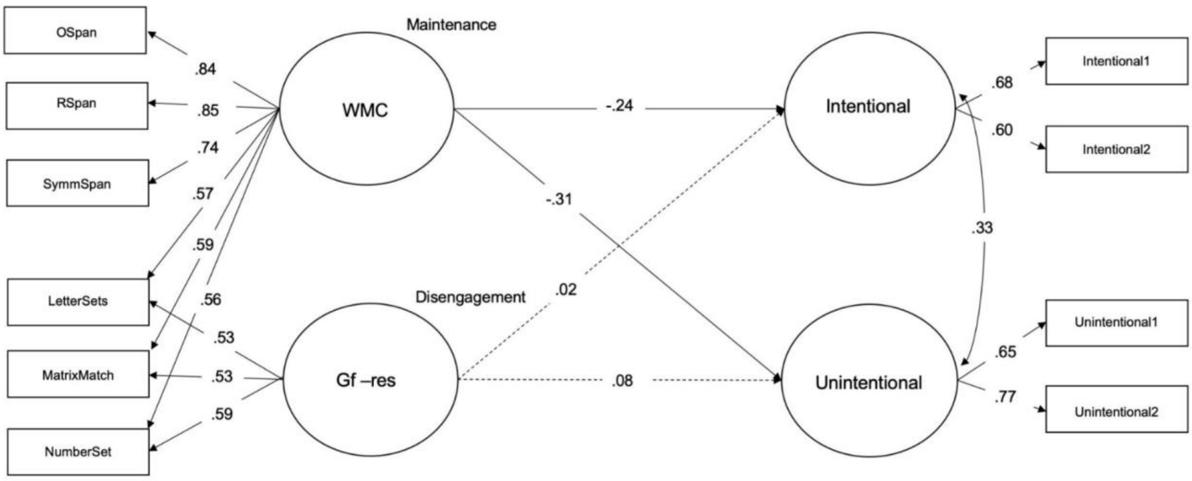


Note. Fit statistics: Model fit was good, as illustrated in Table 15. Only paths from WMC to intentional and unintentional TUT were significant. The path between WMC and intentional TUTs accounted for 7% variance in intentional TUT (obtained by squaring the regression path). The path between WMC and unintentional TUTs accounted for 16% variance in unintentional TUT. Gf = fluid intelligence. WMC = working memory capacity.

The independent contributions of processes related to both WMC (i.e., maintenance) and fluid intelligence (i.e., disengagement) were observed. Following Martin et al. (2020), disengagement processes in the fluid intelligence tasks were isolated by cross-loading the indicators onto the working memory construct. The residual variance in fluid intelligence is then suggested to reflect disengagement processes. Similar to the first model, only maintenance processes had a significant association with intentional and unintentional TUT as demonstrated in Figure 13.

Figure 13

Associations of Maintenance and Disengagement Processes with Intentional and Unintentional TUTs

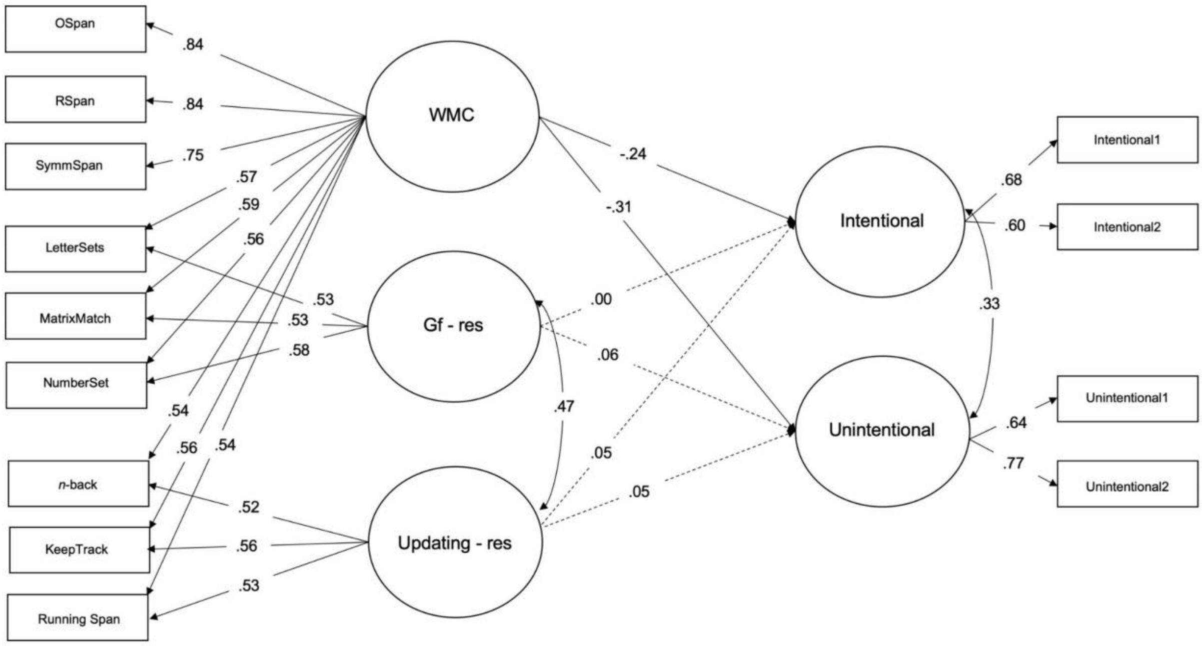


Note. Model fit was good, as illustrated in Table 15. As in the first model, only the pathways between WMC and intentional and unintentional were significant. These pathways account for almost 6% and 10% variance respectively. Gf = fluid intelligence. WMC = working memory capacity.

The final model, illustrated in Figure 14, sought to isolate general disengagement processes by also incorporating updating tasks into the model by using the same cross-loading approach. As in Models 1 and 2, only WMC predicted intentional and unintentional TUT frequencies, with fluid intelligence and updating showing no significant association with either form of TUT. Together, these models suggest that in the context of a simple and monotonous sustained attention tasks (i.e., the SART), maintenance abilities are important for inhibiting both intentional and unintentional TUT episodes. Disengagement ability does not seem to have any reliable predictive relationship in this context. The question of how generalisable this result is across task contexts in TUT research is considered in the Discussion.

Figure 14

Associations Between WMC, Gf, and Updating with Intentional and Unintentional TUTs



Note. Model fit was good, as illustrated in Table 15. Once again, even with the isolation of a general disengagement factor (measured through updating tasks) only the pathways from WMC to intentional and unintentional TUTs were significant. These pathways accounted for 6% and 10% variance respectively. Gf = fluid intelligence. WMC = working memory capacity.

8.3.4 Motivation and Difficulty Correlations

The average self-reported rating of interest in the SART was quite low (*M* = 1.58, *SD* = .89), which is unsurprising given the simple and repetitive nature of the SART. The mean subjective difficulty rating suggested the task was viewed as moderately difficult overall (*M* = 3.32, *SD* = 1.15). The correlations between TUT type and interest and difficulty were observed, and are displayed in Table 16. Interest and difficulty were inversely related to intentional TUT rates, and difficulty and interest had a positive association with each other. There was no correlation between unintentional TUTs with these variables.

Table 16

Correlations between Intentional and Unintentional TUTs and Interest and Difficulty

	1.	2.	3.	4.
1. Intentional	-			
2. Unintentional	.24**	-		
3. Interest	-.10*	-.08	-	
4. Difficulty	-.21*	-.08	.10*	-

Note. Intentional = intentional TUT. Unintentional = unintentional TUT. ** is significant at the .01 level, and * is significant at the .05 level.

Dunn and Clark's *z*-tests for dependent and overlapping correlations were used to compare the strength of the correlations of intentional and unintentional TUTs with perceived difficulty. This confirmed that intentional TUTs had a larger correlation with difficulty, $z = -2.22$, $p = .01$. However the equivalent analysis identified there was no difference between the coefficients for intentional and unintentional TUTs with interest, $z = -.34$, $p = .74$.

8.3.5 Post Hoc Analyses

Recently, research has investigated other dimensions of importance than intention to TUTs. Two variables receiving closer scrutiny are temporality and emotional valence of an episode. As such, the following regression analyses investigate differences in the cognitive predictors of intentional and unintentional TUTs that were either prospective or retrospective (i.e., temporality), and emotional or neutral (i.e., emotional valence). Positive and negative TUTs were collapsed together under the category of 'emotional' TUTs because Banks and Welhaf (2022) observed that cognitive ability as measured by WMC was associated with fewer positive *and* negative TUTs, indicating cognitive ability assists in inhibiting overall emotional off-task thoughts regardless of valence. Descriptive statistics for proportion of probes within each category can be found in Table 17. In each case, the dependent variable was the total proportion of probes that fit a target category (e.g., were both 'intentional and prospective' or both 'unintentional and emotional'). That is, if out of the 20 possible probes a participant reported 3 intentional prospective episodes the dependent variable score was 0.15.

Table 17

Proportions of Both Emotional and Neutral as well as Prospective and Retrospective Intentional and Unintentional TUTs

	Intentional	Unintentional
Temporality		
Prospective	.10 (.05)	.10 (.08)
Retrospective	.03 (.04)	.09 (.08)
Emotional Valence		
Emotional	.07 (.05)	.13 (.09)
Neutral	.06 (.06)	.07 (.07)

Note. Emotional TUTs are all positive and negative TUTs collapsed together. Mean proportion of total TUTs (out of 20) for each category are reported. Standard deviations are in parentheses.

Predictors were the saved factor scores for WMC, fluid intelligence, and updating ability. The correlations between the saved predicted values of cognitive ability (fluid intelligence (Gf), WMC, and updating ability) with each type of temporal (prospective and retrospective) TUT (intentional and unintentional) are reported in Table 18, and their association with each type of emotional/neutral TUT are reported in Table 19.

Table 18

Correlations Between Predicted Factor Scores for WMC, Fluid Intelligence (gF), and Updating with Intentional and Unintentional Retrospective and Prospective TUTs

	1.	2.	3.	4.	5.	6.	
1. WMC	-						
2. GF	.81**	-					
3. Updating	.81**	.84**					
4. Intentional Prospective	-.15**	-.13**	-.13**				
5. Intentional Retrospective	-.06	-.01	.00	-.16**			
6. Unintentional Prospective	-.14**	-.07	-.08	.22**	-.13**	-	
7. Unintentional Retrospective	-.12**	-.10**	-.09	.01	.24**	-.40**	-

Note. ** is significant at .01, * is significant at .05. Gf = fluid intelligence. WMC = working memory capacity.

Table 19

Correlations Between Predicted Factor Scores for WMC, Fluid Intelligence (gF), and Updating with Intentional and Unintentional Neutral and Emotional TUTs

	1.	2.	3.	4.	5.	6.	7.
1. WMC	-						
2. Gf	.81**	-					
3. Updating	.81**	.84**	-				
4. Intentional Emotional	-.12*	-.12*	-.07	-			
5. Intentional Neutral	-.06	-.02	-.06	-.40**	-		
6. Unintentional Emotional	-.27**	-.22**	-.21**	.18**	.01	-	
7. Unintentional Neutral	.04	.08	.06	-.09	.18	-.38**	-

Note. ** is significant at .01, * is significant at .05. Gf = fluid intelligence. WMC = working memory capacity.

Given these analyses are both post-hoc and large in number, the significance criterion was corrected to $\alpha < .01$. The regressions are reported in Tables 20 and 21. The only significant predictive relationships were that of WMC and unintentional emotional TUTs and WMC and unintentional prospective TUTs. All other predictors did not meet the significance criterion. It seems that those with greater WMC ability experience fewer spontaneous emotional and prospective TUTs during a sustained attention task. However, these regression models demonstrate a limited amount of variance explained.

Table 20

Regression Models Predicting Prospective and Retrospective TUTs

Predictor	*B*	*SE*	*β*	*t*	*p*	*F(df)*	*p*	R^2
Intentional/ Prospective						3.195 (*3*, *425*)	.023	.02
WMC	.000	.000	-.097	-1.083	.279			
Gf	-.002	.006	-.030	-.306	.759			
Updating	-.003	.009	-.031	-.319	.750			
Intentional/ Retrospective						1.605 *(3*, *425*)	.187	.01
WMC	-.001	.000	-.193	-2.155	.032			
Gf	.002	.005	.052	.539	.590			
Updating	.007	.006	.116	1.205	.229			
Unintentional/ Prospective						3.422 (*3*, *425)*	.017	.02
WMC	-.002	.001	-.246	-2.764	.006*			
Gf	.011	.010	.103	1.067	.287			
Updating	.005	.013	.035	.364	.716			
Unintentional/ Retrospective						2.006 (*3*, *425*)	.112	.01
WMC	-.001	.001	-.120	-1.342	.180			
Gf	-.001	.010	-.015	-.151	.880			
Updating	.002	.013	.018	.185	.853			

Note. * p < .01. Gf = fluid intelligence. WMC = working memory capacity.

Table 21

Regression Models Predicting Emotional and Neutral TUTs

Predictor	*B*	*SE*	*β*	*t*	*p*	*F(df)*	*p*	R^2
Intentional/ Emotional						3.133 (*3, 425*)	.025	.02
WMC	-.001	.000	-.124	-1.389	.165			
Gf	-.010	.006	-.145	-1.504	.133			
Updating	.014	.009	.151	1.579	.115			
Intentional/ Neutral						1.322 (*3, 425*)	.267	.01
WMC	.000	.000	-.104	-1.157	.248			
Gf	.010	.007	.148	1.523	.128			
Updating	-.009	.009	-.096	-.998	.319			
Unintentional/ Emotional						10.809 (*3, 425*)	<.001	.07
WMC	-.002	.001	-.271	-3.120	.002*			
Gf	-.003	.010	-.028	-.302	.763			
Updating	.005	.014	.036	.385	.701			
Unintentional/ Neutral						1.209 (*3, 425*)	.306	.01
WMC	-.001	.001	-.088	-.981	.327			
Gf	.012	.009	.136	1.395	.164			
Updating	.002	.012	.016	.169	.866			

Note. * p < .01. Gf = fluid intelligence. WMC = working memory capacity.

8.4 Discussion

This study aimed to investigate the association between process-general maintenance and disengagement abilities with intentional and unintentional TUT propensity during a sustained attention task. Using a recent framework for executive attention (Shipstead et al., 2016), this study measured WMC, fluid intelligence and updating ability in order to isolate the unique variance associated with maintenance and disengagement mechanisms and understand how these relate to TUTs. Working memory capacity is argued to reflect maintenance abilities due to the reliance of complex span tasks on the capacity to maintain information in the face of distractors. In contrast, fluid intelligence is thought to reflect the ability to disengage from outdated information or hypotheses when solving novel problems. Updating tasks feature both maintenance and disengagement components, and the addition of this latent factor can be used to further isolate and measure these processes (Martin et al., 2020).

Shipstead et al.'s (2017) process-general framework has provided an alternative means for investigating the argument that some forms of TUT (e.g. unintentional TUT) are associated with WMC due to the necessity to maintain task-related thought and inhibit off-task episodes during performance in external tasks. This is an assumption shared by a number of mind wandering theories including resource allocation frameworks (Thomson et al., 2015; Randall et al., 2019), the context-regulation hypothesis (Smallwood and Andrews-Hanna, 2013), and the current concerns x executive failure hypothesis (McVay & Kane, 2010). The intention of Study 2 was to closely interrogate this assumed association, by also observing the contribution of other related cognitive processes. Importantly, the intention of TUTs were measured to examine whether dissociations consistent with past work occur (i.e., that unintentional TUTs were uniquely associated with cognitive ability) (e.g., Robison & Unsworth, 2018). Additionally, post-hoc analyses further delineated differences between intentional and unintentional TUTs by investigating their temporal and emotional content, to observe whether certain content is associated with cognitive abilities. This approach of observing differences within intention of TUTs further highlights the heterogeneity of off-task thoughts, and the implications of this heterogeneity for a thorough and well-founded identification of the mechanisms underpinning their occurrence.

8.4.1 Maintenance and Disengagement: Intentional and Unintentional TUTs

Results from Study 2 confirmed the hypothesis that maintenance processes reflected in WMC tasks significantly predicted lower unintentional TUT rates during a SART. However, there was also evidence that greater maintenance ability predicted fewer intentional TUTs. This latter finding is contrary to predictions, and also contrary to the findings of Study 1. Nonetheless, it is not unprecedented to observe a relationship between intentional TUTs and executive abilities in some task contexts (Banks & Welhaf, 2022; Robison et al., 2020; Soemer & Schiefele, 2020). Soemer and Schiefele (2020) were the first to observe such an association, when they measured TUTs during a reading comprehension task. Drawing from their arguments, as well as those of Banks and Welhaf (2022), it may be that during the current SART, low-WMC individuals experienced more difficulties with SART performance and so intentionally engaged in off-task thoughts to alleviate stress or frustration with the task. Correlations between performance and WMC in Appendix C (Table 43) somewhat support this as greater WMC was significantly positively associated with greater overall accuracy and *d'* on this task. However intentional TUTs were also inversely associated with perceived difficulty, suggesting that individuals who reported the task to be challenging limited their intentional mind wandering experiences. This latter association may suggest that other complications outside of WMC ability also contribute to difficulty – in this case perhaps the online nature of the tasks or the home environment of the individual has made the experience of the task more challenging.

Another possibility is that those with higher WMC applied more effort to engage with the task and meet task performance, and as such maintained cognitive control for the task. This aligns with proposals by Arango-Martiñez and Bermúdez (2021) that intentional TUTs may reflect the intentional release of cognitive control allowing these thoughts to enter consciousness. Perhaps lower WMC participants do not apply cognitive control to avoid such thoughts and these intentional TUTs are thus reflecting an intentional omission of control due to a belief that extensive control is not necessary for task performance or a lack of motivation or ability to apply control in the task context. That is, perhaps in some tasks lower-WMC individuals make inaccurate assessments of tasks and their level of difficulty. In this case, the underestimation of the resources required to complete the task result in allowing off-task thoughts to enter consciousness and believing this would not impair performance.

Finally, it is also possible that because the SART occurred at the end of a large battery of tasks completed in one session, control of executive attention was impacted (e.g. fatigue, cognitive overload), increasing the need to inhibit unintentional TUTs as well as to self-regulate attention effectively to avoid engaging in intentional TUTs. While breaks were encouraged between tasks, they were nonetheless at the discretion of the participant due to the remote nature of data collection. Data from the timeout windows suggests a number of participants did not take breaks before moving onto the next task. Cognitive ability is likely associated with self-regulation (Ilkowska & Engle, 2010), and so perhaps the relationship between intentional TUTs and WMC reflects the ability of individuals with greater WMC to better regulate attention and mood over the course of a relatively monotonous and uninteresting task and to limit the inclination to deliberately disengage. Further supporting this possibility, Seli et al. (2017b) observed that participants tended to report being on-task more often at the start of a task compared to the end, when performing a CRT. In contrast, reports of both intentional and unintentional TUTs become more common toward the end of the task, with this effect being more marked for intentional TUTs.

While some results in the current study were unexpected, they nonetheless support arguments that TUTs reflect the ability to maintain focus on the current task, and inhibit internal distractions as is consistent with the current concerns x executive failure hypothesis, context-regulation hypothesis, and resource-allocation frameworks for TUTs. Each of these theories predict that those with greater cognitive abilities (e.g., WMC, fluid intelligence) will engage in TUTs less often during external tasks, because they are better able to control their attention. Specific to this study, during performance on the SART it can be argued that the participants with higher WMC were better able to maintain attentional focus and prevent distractors from entering the working memory space, rather than disengage from TUTs. That is, TUT frequency (regardless of their intention) may be the result of a domain-general attentional capacity that is reflected in WMC. This domain-general attentional control allows individuals to sustain attention on a task and increase the rate of task focus (thus limiting TUTs as a result).

Although it is possible that in other task contexts cognitive abilities such as disengaging processing might also play an equal or greater role in the control of TUT rates. Additionally, these results raise further questions about the circumstances under which intentional TUTs demonstrate relationships with measures of cognitive ability.

While both intentional and unintentional TUTs were associated with maintenance processes, greater variance was accounted for in the association between unintentional TUTs and maintenance compared to intentional TUTs. This may reflect that the ability to reduce spontaneous distraction is more strongly related to the control of attention. However, as current theory stands there is no good argument for what types of dissociations intentional and unintentional TUTs should demonstrate, if any, or if such dissociations should be as variable as they are in the literature. Kane et al. (2021) highlight this as a key limitation in better understanding the construct validity of intentional and unintentional TUTs, as without theoretical frameworks it becomes difficult to assess and integrate empirical evidence regarding the correlates and outcomes of these off-task thoughts.

Unlike maintenance abilities, the unique variance associated with fluid intelligence – and therefore disengagement mechanisms – did not predict intentional nor unintentional TUTs. Correlations did however demonstrate that fluid intelligence was inversely associated with intentional and unintentional TUTs, as has also been observed in past studies (Robison & Brewer, 2022). When both fluid intelligence and WMC were added to the predictive models, only WMC had a significant predictive association with TUTs. This does not contradict the existence of a relationship between fluid intelligence and TUTs of either type, but instead suggests that in the context of the SART that the association between fluid intelligence and TUTs is driven by its shared variance with WMC. Indeed, Robison and Brewer (2022) investigated associations between WMC and fluid intelligence with overall TUTs during a series of attention tasks. In their study they used confirmatory factor analysis but did not observe other predictive models (i.e., SEM), and concluded that overall TUTs were associated with both cognitive abilities. In contrast, the current study entered both cognitive abilities as predictors in SEM and separated intentional and unintentional TUT rates. Following this strategy only WMC and maintenance ability were found to be significant predictors of TUT rates.

It is still possible that disengagement processes are involved in limiting TUTs in task contexts other than the SART. For example, TUTs during task-switching or divergent thinking paradigms, which rely more heavily on cognitive flexibility and fluid intelligence, might demonstrate a different predictive association with disengagement processes. Alternatively, disengagement abilities (as measured by unique variance in fluid intelligence) might also facilitate TUTs in certain task contexts. For example, Wong et al. (2022) found a positive trait-level association with spontaneous TUTs and task-switching ability (which is often linked to cognitive flexibility and fluid intelligence). Unsworth and McMillan (2014) also found a positive association between fluid intelligence and TUTs when controlling for attention control abilities. These findings support the possibility for intentional and unintentional TUTs to show unique associations with particular cognitive abilities across different task types. Such a possibility is consistent with arguments from the context-regulation hypothesis, which argues that the context in which TUTs are being measured will have implications for their regulation and their consequences (Smallwood & Andrews-Hanna, 2013).

8.4.2 Subjective Perceptions of Interest and Difficulty

The current study measured participants' interest in the task and their perception of its level of difficulty. Participants indicated on average a low-level of interest in the task, and a moderate level of perceived task difficulty. As discussed in Sections 4.8 and 5.6, how participants perceive the difficulty of a task and its subsequent influence (if any) on TUTs is a relatively understudied area in mind wandering literature. For example, when a participant labels or rates a task as being 'difficult' it is not yet known what variables contribute to this perception, and to what degree **(**Seli et al., 2018c**)**. Participants may make decisions based on factors such as duration of the task, boredom felt when completing the task, level of motivation and interest toward the task, response requirements, fatigue, cognitive load as well as processes required to complete the task. Following a resource-allocation framework, top-down perceptions of the level of difficulty of a task, attention required to complete the task, and interest and motivation to sustain attention on the task will in turn influence how an individual allocates attention and effort. In the current study, participants who were less interested in completing the current external task also tended to allocate attentional resources to unrelated but perhaps more engaging thoughts instead.

Likewise supporting the importance of subjective appraisals in off-task thoughts, the SART was considered moderately difficult but very uninteresting by participants and the more difficult the SART was perceived to be, the fewer intentional (but not unintentional) TUTs would occur (consistent with Study 1). Interest was also weakly but positively associated with difficulty, indicating that if a participant felt more challenged by the SART they were also to a degree more likely to find the task more interesting. Although, as a majority of participants viewed the task as being uninteresting, and there was low variability from the mean for this rating, and so a range restriction may have weakened the ability to observe a stronger relationship between intentional TUTs and interest. Nonetheless, interest and intentional TUTs were at least correlated, indicating subjective top-down evaluations of a task are associated with deliberate TUT rates. Together these associations indicate that perceptions of difficulty are related to deliberate decisions about engaging in TUTs during tasks. A reasonable explanation is that such top-down evaluations can influence decision-making about whether or not one should withdraw attention from a task, and so will influence TUTs which are under voluntary control.

8.4.3 Content: Temporality and Valence

Post-hoc analyses on the content of the episodes also indicated there may be differences between intentional and unintentional TUT content and their relationship to cognitive ability. This highlights that intentional and unintentional TUTs are not homogenous either, with important differences occurring within them. Consistent with a content-regulation hypotheses, emotional (i.e., positive and negative TUTs) and neutral TUTs had unique associations with WMC, with greater WMC predicting fewer unintentional emotional TUTs and prospective TUTs– no such association was observed for intentional TUTs. The decision to collapse positive and negative TUTs together was based on the findings from Banks and Welhaf (2022) that people with greater cognitive abilities (as measured through WMC and attention control) had fewer positive *and* negative TUTs during a SART. The current study extends on these findings showing that the inhibition of unintentional emotional TUTs seems to be related to a greater ability to maintain task-based information in mind rather than to disengage from these thoughts when they occur. Emotional thoughts may be experienced as more intrusive or attention capturing (van Vugt & Broers, 2016), and so current results suggest the importance of inhibiting them before they are able to gain access to the working memory space. Likewise, perhaps prospective thoughts feature content such as anxiety, worry, or future-planning, which again needs to be inhibited or avoided in order to maintain focus on the current task.

"Sticky" thoughts can refer to thoughts which people have difficulty keeping out of working memory space, and so they are difficult to disengage from (Joorman et al., 2011; van Vugt & Broers, 2016). This can include negative thoughts which people begin to ruminate upon, but also positive thoughts which intrude into consciousness. Sticky thoughts are often described as being uncontrolled, rigid, and relating to unattained goals (van Vugt & Broers, 2016). In the current study only unintentional (spontaneous) emotional and prospective thoughts revealed reliable associations with WMC aligning with the nature of an uncontrolled or intrusive thought. These findings align with TUT theories such as the current concerns x executive failure hypothesis, which argues that TUTs reflect current concerns (i.e., goals) of individuals which are yet to be achieved. Executive control is required to prevent these concerns from capturing conscious attention. The current results suggest that the predictive relationship between unintentional emotional thoughts and WMC reflects a role for maintenance processes in keeping emotionally-charged goal- or concern-related thoughts from gaining access to consciousness. Consistent with this argument, Banks and Welhaf (2022) also observed an inverse association between WMC and positive and negative TUTs, and argue that perhaps emotionally valenced TUTs capture attention more easily and so require greater executive control to maintain focus on the current task.

A novel contribution of the current results are that they differ between emotional valence and temporality by intention. In doing so, this study builds on the findings of Banks and Welhaf (2022) by demonstrating that differentiating content by the intention of the TUT can elaborate further on the mechanisms underpinning their occurrence. While the evidence here suggests WMC is important for avoiding emotional and prospective TUTs, future work with expanded task contexts should also investigate the role of disengagement or fluid intelligence from sticky TUTs compared to non-sticky TUTs. Furthermore, when comparing intentional and unintentional TUTs there was a greater prospective bias in the former. This is interesting as prospective biases are often noted in TUT literature (Seli et al., 2017), and that it is greater in intentional TUTs may suggest another important line of difference between these thoughts. Prospective bias in TUTs is often associated with future planning and so perhaps the greater occurrence in intentional TUTs reflects a utility in these thoughts. Intentional TUTs may uniquely provide the opportunity for planning and anticipating future events in one's life. Indeed, TUTs are often argued to have both helpful and harmful impacts, with autobiographical functions often assumed to be one of their key adaptive characteristics (Baird et al., 2011; Poerio & Smallwood, 2016).

8.4.4 Limitations and Future Directions

A limitation to the current study design was the use of only a single task to measure TUTs. It was decided that the SART would be utilised to collect TUT data because the duration of the battery of tasks and remote nature of data collection made variables such as fatigue and participant attrition mid-session difficult to manage. This decision was further justified as 43 participants (9.11% of the original 472 sample) did exit the task mid-to-late session, indicating that attrition could have been higher with more tasks to complete. Altogether participants completed 10 cognitive tasks in the single session, which would already challenge attention control, sustained motivation, self-regulation, and level of fatigue. These constraints were an imposition of the COVID-19 pandemic. Nonetheless in future, it would be worthwhile to investigate in which tasks contexts maintenance and/or disengagement underpin TUT rates, especially given recent propositions of a task-switching perspective of TUTs (Wong et al., 2022).

Second, the remote collection of data itself may be a limitation as participants become more susceptible to external distraction and environmental cues to TUT (i.e., a home environment will have a greater number of personally salient cues compared to a sterile laboratory testing booth). Nonetheless, reliable associations were observed between tasks and factors of interests, and research has found that remote software are valid as a tool for data collection in cognitive experimental tasks (Crump et al., 2013). Additionally, there is evidence to suggest that participants may actually mind wander less when in home environments compared to the laboratory (Diede et al., 2022).

Finally, as the linear regression analyses on valence and temporality were both post-hoc and large in number they should be interpreted with caution. However, the α level was conservatively adjusted in an attempt to increase reliability of these results. In addition, findings from these analyses were broadly consistent with Banks and Welhaf (2022). Nonetheless, future research should further investigate the cognitive processes underpinning emotionally-charged TUTs as this will have implications for not only theory but also practical implications for better regulating off-task thoughts.

8.4.5 Conclusion

To conclude, the present study aimed to employ a new framework of executive control to further investigate the cognitive and self-regulatory processes associated with TUT rates during a sustained attention task. Consistent with past work and theory, Study 2 observed that unintentional TUTs were inversely correlated with both fluid intelligence and WMC. In addition, intentional TUTs had an inverse association with these cognitive variables but were also uniquely inversely related to perceived difficulty. Results from the SEM suggests that maintenance processes, which keep task-relevant information in attentional focus and inhibit access of unrelated thought, are more relevant to TUT rates in the context of a SART. Together, this study provides further evidence for the combined roles of task context, self-regulation, and cognitive ability in determining intentional and unintentional TUTs. The role of content within intention was also demonstrated, as differences in the cognitive mechanisms associated with intentional and unintentional temporal and emotional TUTs were found.Future work should investigate task and individual boundaries which influence these associations and develop theory which formally integrates different types of TUTs into explanations and predictions.

Chapter 9: Study 3 – An Experience Sampling Study of the Content and Outcomes of Intentional and Unintentional Social TUTs in Daily Life During Lockdown

9.1 Background

Mind wandering, under a family-resemblances framework, is an umbrella term referring to self-generated thoughts that take a number of forms [see Section 2.2]. Chapters 4 and 5 reviewed evidence that different forms of mind wandering can have a constructive or adaptive role. While the utility of 'mind wandering' is still debated, there are arguments that these thoughts are functionally meaningful for how we interact with our social world (Poerio & Smallwood, 2016). For example, there is some evidence to support that forms of mind wandering, such as daydreaming, feature content related to social cognitions and can influence wellbeing (Mildner & Tamir, 2021; Poerio et al., 2016), however there is less research that considers the possible social functions of the TUT variety of mind wandering specifically. This is important for two reasons; i) because the family-resemblances framework emphasises the importance of not assuming that all forms of mind wandering will be identical in their content and outcomes, and ii) because there is ongoing debate regarding whether TUTs in particular can play functional roles in daily life (e.g. Mooneyham & Schooler, 2013). Accordingly, the motivation of the current study is to investigate the nature of socially-oriented TUTs in daily life. Importantly, TUTs have shown separable content and outcomes depending on whether they are intentionally or unintentionally engaged (Seli et al., 2016a), and individual differences in personality have also been found to influence the phenomenological experience of TUTs (Kane et al., 2016). In light of this, the current study measures the intention of social TUTs and two traits that have implications for social cognition: schizotypy and loneliness. It is also noteworthy that this study occurred during the initial stage of the first COVID-19 lockdown in Australia. While this provides a unique opportunity to investigate the content and socio-emotional outcomes of social TUTs during a time of unprecedented social restrictions and potentially induced loneliness, it also means that interpretation of the study should be mindful of the context in which it occurs.

9.1.1 Mind Wandering and Social Cognition

The link between general mind wandering and social cognitions was implicated in a large-scale survey which found that other people feature in 71% of episodic daydreaming episodes (Song & Wang, 2012). Neurocognitive studies have also found overlap in the DMN, a network of brain regions active during mind wandering, and regions associated with social cognition (Mar et al., 2012; Xie et al., 2016). This has led some to argue that human cognition defaults to social thoughts (Spunt & Lieberman, 2013), and depending on the nature of such thoughts this can improve or diminish wellbeing (Mar et al., 2012; Poerio et al., 2015; 2016). This is consistent with the content-regulation hypothesis (Smallwood & Andrews-Hanna, 2013) which predicts that the content of mind wandering determines its functional outcome. When these thoughts are negative in nature they can maintain and exacerbate unhappiness, whereas positively valenced thoughts maximise constructive outcomes (Smallwood & Andrews-Hanna, 2013; Shrimpton et al., 2017). Furthermore, the current concerns x executive failure hypothesis assumes that TUT content reflects individuals' short and long-term goals which have been internally or externally cued to consciousness (McVay & Kane, 2010). Together these hypotheses suggest that TUTs will often contain content focussing on social goals, and these thoughts may allow for planning, rehearsing, problem-solving, and/or anticipating social interactions.

When investigating the nature of mind wanderings, including the TUT variety, common dimensions that are measured include their valence (Banks et al., 2016), temporality (Stawarczyk et al., 2013), constraint or free-movement (Smith et al., 2022), self-focus (Marchetti et al., 2016), and whether these thoughts involve close others (Mar et al., 2011). Certain categories of content may allow for more constructive thoughts than others. For example, the content-regulation hypothesis predicts that more positively-valenced thoughts will result in greater increases in positive mood (Smallwood & Andrews-Hanna, 2014). Other types of thought content may also be more constructive, such as prospective thought which may allow for future-planning (Baird et al., 2011). Constrained thought may also be associated with greater executive control and so may support goal-processing as well (Golchert et al., 2017). Constraint refers to whether a thought is contained or limited to a specific topic, compared to more freely-moving thought which may move from topic to topic in an unguided manner (Christoff et al., 2016). While certain categories of thought content may be more associated with controlled thought and subsequent constructive outcomes, this is not to say that these broad categories of content are always constructive. For example retrospective thought may be reminiscent in nature and confer positive emotions whereas prospective thought could be anxious or worry-based at times.

Poerio et al. (2015, 2016) have provided substantial insight into the possible functions of social mind wandering in daily life, with a series of studies establishing that social daydreams can facilitate adaptation to life transitions and enhance feelings of connectedness and happiness while reducing negativity and loneliness [see Section 4.8.5 for review]. However, no study which investigates social mind wandering has differentiated by the intentionality of the thoughts. Evidence from clinical dissociations of intentional and unintentional TUTs [Section 5.6.4] indicates the unintentional TUTs may be more maladaptive in nature. The second goal of the current study then is to observe whether intentional and unintentional social TUTs have differences in their content and outcomes. Intention may be an important dimension predicting patterns of social TUTs, and their (dys)functional outcomes.

9.1.2 Socially-Oriented Thoughts During COVID-19

The current study occurred at the initial stages of the first COVID-19 lockdown regulations in Australia. It is necessary then to consider the documented evidence of lockdown impacts and COVID-19 related distress on socio-cognitive functioning and emotional wellbeing as these 'social distancing' measures could influence the experience of socially-oriented TUTs. Zabelina et al. (2021) investigated imagined interactions during the pandemic. Imagined interactions refer to thoughts regarding interactions and communications that the individual has had or plans to have. In this way there is overlap between the content of imagined interactions and social TUTs. These authors found that lonelier individuals who spent more time imagining interactions had the largest increase in anxiety during the pandemic compared to before the pandemic. Although promisingly, positively valenced imagined interactions were found to have a protective effect against anxiety.

More specific to TUTs, Meshgina et al. (2021) found evidence for their 'distressed-to-distraction' hypothesis of attention. Across two experiments these authors observed that distress related to COVID-19 was also associated with increased distraction during academic learning conditions. That is, students who reported distress from the pandemic also reported greater mind wandering during a learning tutorial. Together these findings suggest that socially-oriented TUTs during lockdown may increase or decrease negative states such as loneliness or anxiety depending on the content of the thoughts, and that for some people the occurrence of these thoughts may increase in frequency.

However, there is also evidence to support that social TUTs during initial lockdown phases may be consistent to a degree with TUTs experienced outside of pandemic measures. Mckeown et al. (2021) compared thought patterns before and during lockdown in the UK and found that while social thinking was reduced, it did increase when social interactions were possible regardless of whether the interaction was virtual or in person. Furthermore Sealy (2011) used a large-scale survey to assess imagined interactions during COVID-19 and found that a majority of individuals did not report changes in their imagined interactions during the pandemic. Sealy (2021) also notes that while social distancing measures may increase loneliness for some individuals, it does not equate to loneliness nor lead to loneliness for all individuals. Perhaps then if participants are still engaging in permitted social interactions such as small group outdoor exercise/walking, or available social connectivity such as online tutorials, virtual meetings with friends, phone calls, and interactions with housemates and family, then social TUTs during lockdown could be more similar in nature to non-lockdown TUTs than might be assumed.

9.1.3 Personality and Social TUTs

Individual differences in disposition and personality can also influence the self-regulation of TUTs, and have implications for how they are experienced [see Section 4.5]. One of the more commonly measured personality traits in mind wandering research is schizotypy (Kane et al. 2016; Welhaf et al., 2020; Zhao et al., 2023), which is often regarded as a risk factor for, and endophenotype of, psychosis (particularly schizophrenia spectrum disorder). Schizotypy is a multidimensional trait often measured using the Schizotypal Personality Questionnaire (SPQ). The original SPQ has three factors; interpersonal (or negative), cognitive-perceptual (or positive), and disorganised (although there are also two and four factor structures, Wuthrich & Bates, 2006). Briefly, interpersonal schizotypy is a personality trait characterised by eccentricity, social anxiety, and unconventional beliefs. Cognitive-perceptual schizotypy tends to feature unusual patterns of thought and perception, and disorganised schizotypy involves disorganised thoughts, behaviours, and emotional experiences. Of further relevance to the current study goals, schizotypal traits have been linked to atypical social function generally (Henry et al., 2008; Minor et al., 2020), such as impairments in mentalising (Langdon & Coltheart, 1999) and interpersonal sensitivity (Miller & Lenzenweger, 2012).

Together, these socio-behavioural and socio-cognitive differences have led some researchers to propose that schizotypal personalities may offer insights into individual differences in social cognitions, mind wandering, and socio-emotional functioning (Zhao et al., 2023). Schizotypy (Kane et al. 2016;

Welhaf et al., 2020) has been linked to greater TUT frequency in the laboratory (Kane et al., 2016). In addition, positive and disorganised schizotypy were associated with more worry-based TUTs, and more fantasy-based content (Welhaf, 2020). Most recently, Zhang et al. (2022) investigated the relationship between trait-level general schizotypy, mind wandering, and anxiety. They found that schizotypy was associated with lower life satisfaction and that this association was mediated by anxiety and mind wandering. These studies suggest that social TUTs experienced by people scoring higher on schizotypy may also differ in content, frequency, and outcomes.

Another trait which can influence social cognitions is loneliness, defined as a negative and distressing feeling caused by the perception that one's social needs are not being met (Peplau & Perlman, 1982). It has been linked to poorer wellbeing (Hawkley & Cacioppo, 2010) and is heightened in schizotypal individuals (Chau et al., 2019). Cacioppo and Hawkley's (2009) model of loneliness argues that perceived social isolation leads to cognitive biases such as seeing one's social world as innately more threatening, and expecting negative social interactions. This bias then leads to the experience of negative social interactions thus confirming the original expectations – essentially creating a maladaptive cycle.

One might expect that TUT content can also be captured by such a threat-focussed, closed-loop of thoughts, and that these TUTs may be experienced as more intrusive and spontaneous. Indeed, McVay and Kane (2010) based assumptions of their current concerns x executive failure hypothesis on elaborated control theory (Watkins, 2008), arguing that the current concerns which form TUTs reflect discrepancies between current states and short- and long-term goals. This would include thoughts about discrepancies with social goals. Conversely, TUTs might also provide an opportunity to alleviate loneliness, as studies have observed that more frequent social daydreaming about close others is associated with less loneliness (Mar et al., 2012; Poerio et al., 2015). This may reflect the use of mind wandering to increase feelings of connectedness when such connection is not physically available (Poerio et al., 2015). Therefore, the final goal of the current study is to investigate whether schizotypy and loneliness are associated with differences in content and outcomes of TUTs.

The current study will be measuring the influence of loneliness during pandemic lockdowns. This is important to keep in mind as there is evidence that loneliness did increase for some individuals during initial lockdowns in Australia (Isaac et al., 2021; Lupton & Lewis, 2023). That is, in some ways this context may be acting as an ecological 'induction' of loneliness for certain individuals. Also important to acknowledge however is that there are individuals who reported feeling unaffected by, and some still who reported experiencing benefits of, lockdown measures for their wellbeing (Lupton & Lewis, 2023).

9.1.4 The Current Study

The current study aims to investigate the type of content featured in social TUTs recalled in daily life , potential socio-emotional outcomes of these thoughts, and how loneliness and schizotypal personality traits may influence the experience of these thoughts. This study is motivated by both the content-regulation and current concerns perspectives of mind wandering which argue that mind wandering can influence wellbeing dependent on the type of content it features, and that mind wandering content will often reflect personal goals respectively. To achieve these aims, differences in content and emotional outcomes will be examined 1) between intentional and unintentional episodes and 2) for individuals who score differently on measures of loneliness and factors of schizotypy. Loneliness and schizotypy have been selected in particular as these are two traits that have been associated with *both* social cognition and mind wandering. As such, there is existing evidence on which to build and to guide the interpretation of the current results.

Content measures of interest included the valence, constraint, and realism of an episode and whether it involved a close other, its temporality, and whether it is self or other related. In addition, questions regarding the problem-solving nature of TUTs were also asked in order to understand what kinds of functional processes may be occurring in this regard. As TUTs have been associated with creative problem-solving (Baird et al., 2012), it is likely they also feature thoughts related to other types of problem-solving such as in social dilemmas. By investigating the relationships of content with the levels of intention, research can further outline the determinants of constructive and unconstructive TUTs and contribute to efforts to identify the profiles of intentional and unintentional off-task thought. To measure this content, the current study utilised an ESM and prompted participants four times a day over seven days regarding their most recent social TUT episode. Prior to these seven days, participants were asked to complete a series of questionnaires measuring variables of interest. These included the SPQ and UCLA Loneliness Scale Short Form (ULS-8) to measure schizotypy and loneliness respectively, and the Mind Wandering-Deliberate (MW-D) and Mind Wandering-Spontaneous (MW-S) scales to measure general trait-level mind wandering tendencies.

In some ways this study is exploratory, as the investigation of social intentional and unintentional TUT content and their subsequent emotional outcomes outside of the laboratory has not yet been investigated. In addition, as these measures occur during a lockdown this further adds uncertainty to what dimensions may be particularly important for differences between each type of TUT. Consequently, there is not an overly strong basis for arguing which particular content dimensions will be more likely to show differences than others.

The present study tentatively argues that intentional TUTs will be more constructive than unintentional TUTs and that constructive social content may be characterised as being more positively valenced and realistic, less freely-moving (or more constrained), and will also be more future-focussed and will feature close others. These thoughts will also likely be more approach-based, and involve thinking of positive resolutions to problems faced in one's social world. Constructive thought may be characterised by these features in light of findings that positively valenced thoughts can increase positive mood (Poerio et al., 2015), as can thoughts about close others (Mar et al., 2012), and findings that as people adapt more to their social environments their thoughts become less fanciful (Poerio et al., 2016). Constrained future-focussed thoughts may allow for an opportunity for planning and preparing for interactions (Baird et al., 2011).

9.1.5 Hypotheses

Hypothesis 1. *1a)* Given previous associations of general intentional TUTs observed in laboratory contexts (Seli et al., 2017b), as well as the association of trait-level mind wandering with variables such as mindfulness (Seli et al., 2015c), it is predicted that intentional TUTs will be associated with greater constructive social TUT content compared to unintentional TUTs. As discussed, there is reason to believe that more adaptive or constructive social content could be characterised as prospective, constrained, realistic thoughts which involve close others, and are more positively valenced. *1b)* Greater schizotypy and loneliness will be associated with less constructive social TUT content. Schizotypy is a multidimensional construct, and given the limited but promising work investigating how the dimensions of this trait relate to content in TUTs, it is difficult to be certain about which factors (cognitive-perceptual, interpersonal, or disorganised) may be more likely to show differences in daily social TUTs.

Hypothesis 2. *2a)* Intentional TUTs will be associated with more constructive problem-solving content (that is approach-based content that may often feature a positive resolution to the problem). *2b)* Given their links to impairments in social functioning, the constructs of loneliness and schizotypy will be associated with less constructive problem-solving content.

Hypothesis 3. *3a)* On the basis of the prediction that these TUTs will tend to have more constructive content, it is also predicted that intentional TUTs will be associated with greater positivity and less loneliness post-TUT compared to unintentional TUTs. *3b)* In contrast, schizotypal traits and feelings of loneliness will be associated with less positivity and greater loneliness post-TUT compared to unintentional TUTs due to their established links to lower social functioning and mood.

9.2 Method

9.2.1 Participants

This study was approved by the Human Research Ethics Committee at the University of Wollongong. One hundred and sixty-three students from the university (*M* = 20.61 years, *SD* = 4.46 years; 127 females) volunteered to participate in the study in return for course credit, satisfying the recommendation that a minimum of 100 groups at level 2 (i.e. participants in the current study) should be used for multi-level modelling (Hox, 2002). The only eligibility criterion was that the participants had access to a smartphone with Internet access for the duration of the study (i.e. 8 consecutive days – 1 day for survey responding plus 7 days experience sampling). To note, the first 21 participants had their experience-sampling TUTs collected in the 3 days prior to lockdown regulations being initiated and completed the remainder during lockdown. In contrast, the rest of the participants completed all 7 days of experience-sampling prompts during lockdown.

9.2.2 Materials

9.2.2.1 Questionnaires

UCLA-Loneliness Scale – 8 (ULS-8) (Hays & DiMatteo, 1987). This is a short-form 8-item questionnaire focussing on feelings of loneliness and disconnection. Item responses range from 1 ("*I never feel this way"*) to 4 ("*I often feel this way"*), with two items being reversed scored. It has a unidimensional structure with scores ranging from 8-32, and higher scores indicating greater feelings of loneliness. The ULS-8 is a reliable and valid substitute for the long-form ULS-20. Hays and DiMatteo (1987) observed a Cronbach's α of .84 for the ULS-8.

Schizotypal Personality Questionnaire (SPQ) (Raine, 1991). This is a 74-item true/false self-report measure of schizotypy commonly used in healthy community samples. This measure was developed from the nine signs and symptoms of schizotypal personality disorder as listed in the DSM-III-4. Raine (1991) reported a coefficient α of .90 and .91 for the total SPQ scale. The SPQ has a three-factor structure –

cognitive/perceptual, interpersonal, and disorganised – which has been confirmed in adult samples (with subscales showing a reliability of .59-.82) (Badcock & Dragović, 2006).

The Spontaneous and Deliberate Mind Wandering Scales (MW-D, MW-S) (Carriere et al., 2013). This is a self-report instrument measuring everyday tendencies to experience spontaneous and deliberate mind wandering episodes. Each type of mind wandering is measured using four items, with the scale being eight items in total. All eight items are scored on a 1-7 scale. The anchors are "*rarely"* and "*a lot"* on all items except the third items for deliberate and spontaneous mind wandering, which were "*not at all true"* to "*very true*". Higher scores are associated with greater tendencies toward deliberate and/or spontaneous mind wandering. Carriere et al. (2013) found a Cronbach's α of .90 for the MW-D, and .88 for the MW-S scales in their study. Note that this is a measurement of general mind wandering, and not specifically TUTs.

Experience-Sampling Measures. An abridged layout of the experience-sampling questionnaire is provided in Figure 15, with a fuller version of the questionnaire provided in the supplemental materials of Appendix D. The term 'mind wandering' was used when explaining the task to participants as this is a more common term for off-task thoughts than TUTs. However the definition of mind wandering provided was "*a mind wandering episode is defined as thoughts which are unrelated to an ongoing external task (e.g. reading, driving, watching television, listening to a lecture, working), occurring either intentionally or unintentionally*". Participants were then told that a *social mind wandering episode* was when "*a mind wandering episode involved one or more other real or imagined person/s*". When probed, participants first answered "*How long ago was your most recent social mind-wandering experience?*" (With categorical options being 10 minutes prior to the probe, 10-20 minutes ago, 20-40 minutes ago, 40+ minutes ago). Subsequently, participants were asked to briefly describe the activity they were doing when the episode occurred. This was simply to verify that the episode occurred while performing an external task and therefore satisfied the definition of mind wandering that was provided. For example, if participants reported they were "relaxing" or "lying down" (thus indicating no external task being completed), the associated episodes were not included in subsequent analyses (as they would more closely resemble a 'daydreaming' or 'task-free' variety of mind wandering).

Participants then answered a series of categorical and continuous questions regarding the content of the episode. A mixture of question types were used to both a) align with how past work has measured these variables and b) to have diverse question types in an attempt to reduce inattentive responding.

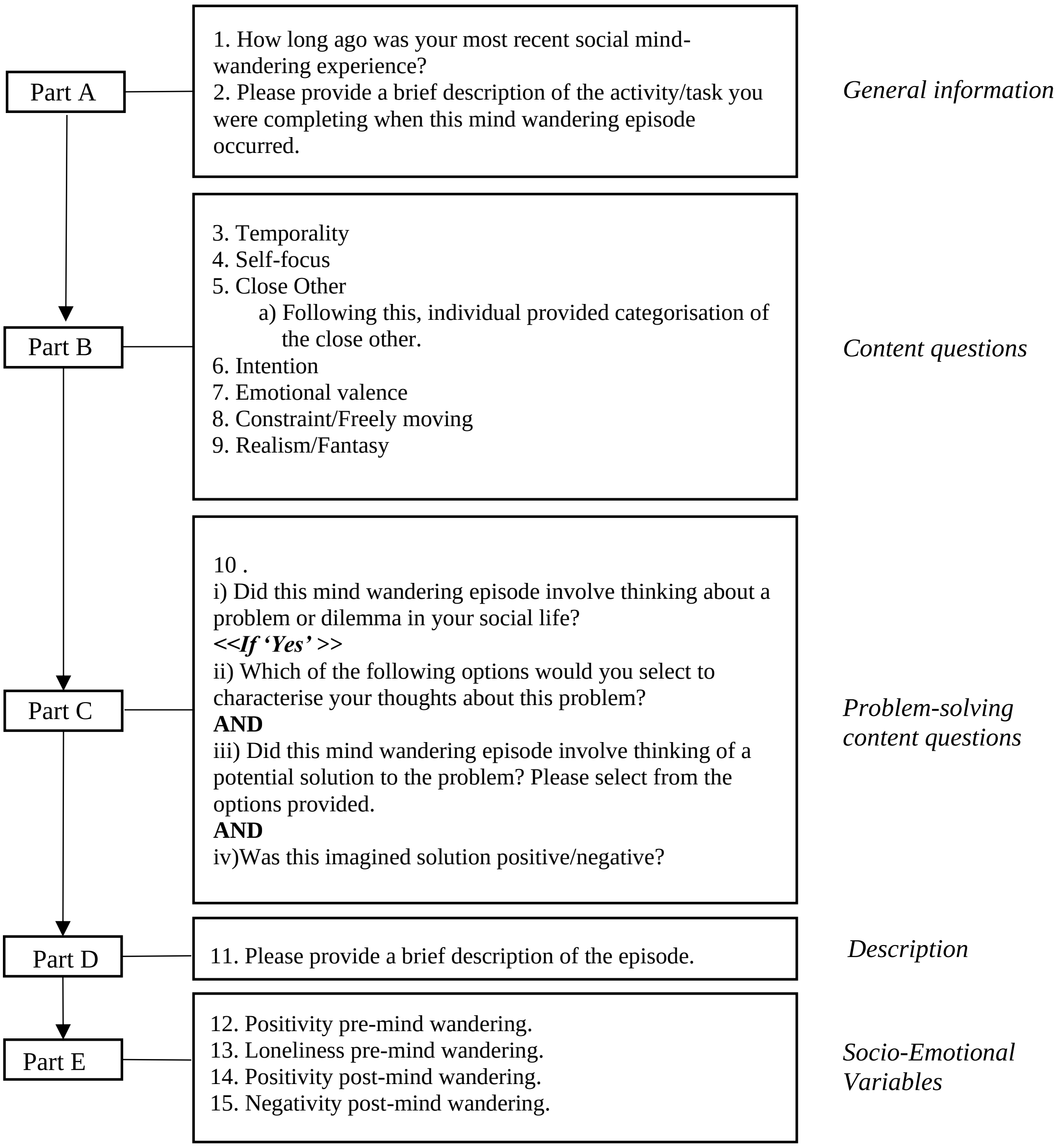
Participants were asked to categorise the time-focus of the episode (1 = *Prospective*, 2 = *Retrospective*, 3 = *No specific time or other*); whether it was self- or other- focussed (e.g., focused on their own thoughts and feelings, or focussed on others). Participants were also asked to categorise the individuals in the mind wandering episode as either a partner, family, friend, work colleague, acquaintance, made up person/s, or other. Participants then indicated whether it was an intentional or unintentional episode. Following this they answered whether it was an intentional/deliberate or an unintentional/spontaneous episode. These categories were measured dichotomously aligning with past work (Mar et al., 2012; Stawarczyk et al., 2013). Then a series of continuous measures were used, where participants rated on 7-point Likert scales the valence of the episode (1 = *Very negative*, 7 = *Very positive*), the constraint they felt the episode had (1 = *Very constrained*, 7 = *Very freely moving*), and how realistic they felt the episode was (1= *Very realistic*, 7 = *Very fanciful*).

Lastly participants were asked whether the episode was based on a particular social problem they are facing in their lives. These questions were all categorical as the plan was to analyse certain subcategories of responses and compare them to each other. If participants answered yes to this probe they were asked if they would characterise their attempt to deal with the problem as either approach or avoidance-based. Participants were informed that approach-based responses involved attempts to seek a positive and/or constructive resolution. Avoidance-based responses were described as a desire to avoid discomfort or negative interactions. Participants were then asked whether there was a resolution to the issue, and whether this imagined resolution was negative or positive. After answering these questions, participants then provided a short 1-2 sentence summary of the episode so as to confirm the episode was consistent with the self-reported information given, and met the requirements of being a social mind wandering episode.

Finally, participants were then asked to complete a short set of questions asking about their mood prior to and following the episode. Participants were asked to indicate on a sliding scale (from 0-100) how positive and lonely they were feeling prior to the episode. They were then asked to rate on two 7-point Likert scales how positive and lonely they felt after the episode relative to their mood rating beforehand. For both scales, 1 indicated less feelings of loneliness and positivity than before and 7 indicated greater feelings than before in these categories. This was used as some social TUT episodes may have occurred 40+ minutes prior to the prompt. As such, it may be easier for participants to provide a more general relative mood change (e.g., '*I recall feeling somewhat worse than before'*) than more precise numeric differences in mood before and after the episode.

Figure 15

Abridged Layout of Questions in the Experience-Sampling Prompt



9.2.3 Procedure

Upon sign-up, participants received written instructions for the study in their student emails, and had a 24-hour window to clarify any concepts and instructions with the researcher prior to commencing the study. This decision to provide instruction via email was selected out of necessity given the social distancing policies in place meant that students could not be on campus to receive instructions in person. The information sheet attempted to be as clear as possible, with students being encouraged to reach out to the researcher for clarification of any concepts or instructions. In addition, participants were also asked to provide brief summaries of the TUT episodes as well as to state the task being completed during the episode so researchers could get a better idea of whether the thoughts being reported were consistent with the prompt responses and with being considered a social TUT. Social mind wandering was defined as any task-unrelated thought where other (real or imaginary) person/s are involved. Participants received an information sheet that defined and provided examples of all variables in the questionnaires (e.g. what is meant by fantastical, valence, and constraint), as well as a definition of a social mind wandering.

On the first day, participants were asked to answer a range of measures. This included the SPQ, ULS-8, and MW-D/MW-S that were the focus of the current study. Additionally, and for the purposes of separate investigation, participants also completed the Problem-Solving Inventory, Cognitive Failures Questionnaire, and Cognitive Slippage Questionnaire online. Following this, participants were signalled four times a day over 7 days via their smartphones and reported on their current or most recent social daydream by answering the experience sampling questions. Participants received the signals at random times each day between 10:00-12:00am, 13:00-15:00pm, 16:00-18:00pm, and 19:00-21:00pm. Randomisation of signals enabled TUT sampling across an individual's daily activities each day, and limited any effects of anticipation of the signals.

9.3. Results

9.3.1. Response Rate

Data were collected from 163 participants, but 18 participants were removed from analyses (10 participants due to non-completion of day 1 questionnaires, and 8 participants due to inaccurate or inadequate completion of the daily probes). Of the remaining 145 participants, a total of 2775 out of a possible 4,060 probes were completed, corresponding to a 68.35% response rate overall (M = 19.13 , SD = 5.18, out of a maximum of 28 probes per participants). This final response rate also reflects the removal of 12 social TUT reports that did not meet the criteria of either i) involving other people (N = 7) or ii) occurring during the execution of an external task (N = 5). Promisingly, 25.59% of all episodes occurred within 10 minutes prior to the ESM probes, 28.95% occurred within 10-20 minutes prior, and 23.11% occurred 20-40 minutes prior. Only 22.35% occurred 40+ minutes prior to the probes. That most episodes were closer to the time of the probes increases reliability of participants' memories for the episode they are reporting on.

Of the social TUTs reports in this study, 49.44% were prospective, 18.99% were retrospective, and 31.57% had no specific temporal focus. This is consistent with the prospective bias in TUTs noted in previous work (Seli et al., 2017b; Stawarczyk et al., 2013). Furthermore, 50.92% of episodes were self-focussed, whereas 49.08% were focussed on others, and 55.32% of these involved close others (e.g. close friends, family, partners) whereas the remainder involved non-close others (e.g. co-workers, parasocial relationships, acquaintances). A total of 38.49% of social TUTs were reported to be intentional, whereas 61.51% were unintentional. Lastly, in order to investigate the possibility that TUTs can be used to navigate problems that arise in the social world consistent with a problem-solving function, participants were asked whether or not their TUT was about a particular dilemma they were facing in their social world. A total of 73.66% of reported TUTs in some way involved an issue in the participants' social worlds. Tables 22 and 23 provide the means or percentages for each of the continuous and categorical content factors respectively, separated by intentional and unintentional TUTs.

Table 22

Descriptive Statistics for Valence, Fantasy, and Constraint for Intentional and Unintentional TUTs

Content	**Intentional** (n = 1068)	**Unintentional** (n = 1707)
Valence	4.67 *(1.65)*	4.41 *(1.51)*
Fantasy	2.57 *(1.50)*	2.92 *(1.54)*
Freely Moving Thought	3.65 *(1.71)*	3.91 *(1.75)*

Table 23

Percentages of Categorical Content Variables for Intentional and Unintentional TUTs

Content	Intentional (n = 1068)	Unintentional (n = 1707)
Temporality		
Prospective	55.52%	31.69%
Retrospective	19.48%	18.67%
Approach-Avoid		
Approach-Based	43.07%	27.30%
Avoidance-Based	10.77%	12.95%
Neither/Not Applicable	46.16%	59.75%
Resolution		
Yes	39.79%	25.13%
No	38.58%	46.16%
Neither/Not Applicable	21.63%	28.71%
Resolution		
Positive	32.40%	16.99%
Negative	7.39%	8.14%
Neither/Not Applicable	60.21%	74.87%
Self/Other		
Self-Focus	58.71%	46.05%
Other-Focus	41.29%	53.95%
Closeness		
Close	54.03%	56.12%
Not Close	45.97%	43.88%

Note. Temporalty does not add to 100% because the remainder were reported to be atemporal.

9.3.2 Reliability Analyses

Tables 24 and 25 report the Cronbach's α and McDonald's ω (Hayes & Coutts, 2020) for the three factors of the SPQ, which demonstrated acceptable reliability. The three factor scores and total scores of the SPQ, revealed reliabilities larger than .80 and are similar to those reported in other studies (e.g., Raine, 1991). Nonetheless, there were numerically lower values of internal consistency for the subscales of ideas of reference and odd beliefs/magical ideation. Additionally, the reliability scores for the ULS-8 and MW-S and MW-D were all above .70, indicating good reliability (see Table 26). Skew and kurtosis for all questionnaires are within +/- 1 indicating that the distributions were appropriate for inclusion in subsequent correlational analyses and multi-level models.

Table 24

Internal Consistencies and Descriptive Statistics for SPQ Factors

Scale	Cronbach's *α*	*ω*	M *(SD)*	Skew	Kurtosis
Interpersonal	.89	.90	12.93 *(7.97)*	.464	-.562
Cognitive-Perceptual	.87	.83	12.14 *(7.41)*	.451	-.515
Disorganisation	.83	.83	5.89 *(4.15)*	.415	-.758
Total Scale (based on 74 items)	.92	.92	27.85 *(14.45)*	.439	-.248

Table 25

Internal Consistencies of the SPQ Subscales

Items	Cronbach's *α*	*ω*	Raine (1991) Sample 1	Raine (1991) Sample 2
Social Anxiety	.79	.80	.72	.88
Constricted Affect	.73	.75	.66	.65
No Close Friends	.78	.79	.67	.74
Unusual Perceptual Experiences	.73	.74	.71	.73
Suspiciousness/Paranoid Ideation	.73	.74	.78	.73
Ideas of Reference	.63	.65	.71	.71
Odd Beliefs/Magical Ideation	.67	.67	.81	.75
Eccentric Behaviour	.81	.82	.78	.74
Odd Speech	.71	.70	.70	.74

Table 26

Internal Consistencies, Descriptive Statistics

Scale	Cronbach's *α*	*ω*	M *(SD)*	Skew	Kurtosis
1. MW-S	.77	.77	5.17 *(1.11)*	-.895	.512
2. MW-D	.79	.80	5.15 *(1.15)*	-.634	.424
3. ULS-8	.78	.79	19.60 (*4.81*)	.004	-.553

9.3.3 Trait-Level Coefficients

A Pearson product-moment correlation was run on all variables derived from the totals of the questionnaire measures, as shown in Table 27. Pearson product-moment correlations indicated a positive relationship between trait loneliness (i.e., ULS-8 scores) and schizotypy (i.e., SPQ scores) such that higher self-reported loneliness was associated with higher schizotypy. Cognitive-perceptual, interpersonal, and disorganised schizotypy were also positively associated with trait loneliness. Additionally, there was a positive correlation between schizotypy and MW-S scores, and the disorganised schizotypy had a positive association with MW-S. This indicates that trait general schizotypy, and the disorganised factor in particular, is related to the experience of more spontaneous general mind wandering. Accordingly, it was next sought to determine deliberate and spontaneous mind wandering's unique contributions to schizotypy and disorganised schizotypy.

A hierarchical model was run with schizotypy as the dependent variable, entering MW-D scores at the first step, and then MW-S scores at the second step. Unstandardised beta coefficients are reported. At step one there was a non-significant relationship between deliberate mind wandering and schizotypy, F (1, 143) = .21, p = .65, R = .04, B = .48, t = .46. At step two the overall model remained non-significant, F (2, 142) = 2.02 p = .14, R = .17, as did MW-D as a predictor, B = 0.19, t = 0.18, p = .86. However, MW-S trended toward significance as a predictor of schizotypy, B = 2.13, t = 1.95, p = .05.

The same was performed on the disorganised factor to further understand the association of deliberate and spontaneous mind wandering scores with disorganised schizotypy. At step one MW-D was added to the model, and had a non-significant predictive association, B = 0.07, t = 0.24, p = .82. The overall model was also non-significant, F (1, 143) = 0.06, p = .82, R = .02. But when MW-S was added at step two, the model became significant, F (1, 142) = 5.26, p = .01, R = .26. MW-D remained non-significant, B = -.07, t = -.22, p = .83, but greater MW-S scores predicted greater disorganised schizotypy, B = 0.99, t = 3.24, p = <.01.

Table 27

Pearson Product-Moment Correlation Coefficients for the MW-S, MW-D, UCLA (ULS-8), and SPQ Scales

	1.	2.	3.	4.	5.	6.	7.
1. MW-S	-						
2. MW-D	.14	-					
3. ULS-8	.07	.08	-				
4. Cognitive-Perceptual	.14	.01	.23**	-			
5. Interpersonal	.06	.04	.57**	.54**	-		
6. Disorganisation	.26**	.02	.32**	.57**	.56**	-	
7. SPQ	.17*	.04	.46**	.83*	.87**	.80**	-

9.3.4 Multi-Level Modelling

A series of nested models were used to investigate whether type of TUT (i.e., intentional and unintentional), trait loneliness, or different factors of schizotypy, predicted unique patterns of social TUT content. Both previous work (Badcock et al., 2016), as well as the current study, have found that loneliness and schizotypy are associated with each other, and therefore by including both variables in the models the aim is to investigate the unique associations of each with TUT content could be observed. The interpersonal, cognitive-perceptual, and disorganised clusters showed high reliability, so they are also used to investigate whether different schizotypal factors predicted content.

Because some multidimensional measures of schizotypy, including the 3-factor model of Raine (1991) used in the current study, involve factors which share certain subscales (such as the paranoia scale) the decision was made to run separate models according to schizotypy factors to avoid masking any associations that may occur in schizotypy profiles with shared scales (Wuthrich & Bates, 2006). The decision to observe separate models also aligns with what has previously been done in schizotypy literature (Goulding et al., 2009; Le et al., 2019). Observing each factor is important as schizotypy is not a unidimensional structure, and each factor has shown differences in their associations with socio-cognitive variables, including in their TUT profiles (Kane et al., 2016; Welhaf et al., 2020).

To further note, of the 163 participants the first 21 participants (of which 17 were included in analyses) began experience sampling measures 3 days prior to the lockdown measures officially being put into action but at a time where nonetheless limited social interaction was heavily encouraged and already occurring. In the supplemental material of Appendix D there are tests which confirm that the TUTs of these participants before and after the implementation of official lockdown measures are comparable and so they are safe to collapse together. These analyses confirm that reported loneliness was equivalent before and after the lockdown, and that the rate of intentional TUTs were also equivalent. There was a difference in reporting more prospective thought and more thought about close others during lockdown, as well as a tendency to report more avoidance-based coping in TUTs. All other measures were equivalent. The significant differences were based on analyses with a small sample size (n = 17) but nonetheless these differences will be considered when interpreting the current results in the Discussion.

Multi-level models were selected because these models account for correlated observations within individuals, and perform well with missing or unequal data points (Hox, 2002). These data have a natural two-level structure, with each TUT episode nested within a participant, so data were analysed using the Mixed Models procedure in IBM SPSS version 28 software. To account for non-independence of observations, an autoregressive correlation structure (AR1) was fitted to Level 1 residuals. Level 1 continuous variables (prompt responses) were centred within clusters, and grand mean centering was performed for the Level 2 variables (schizotypal factors and trait loneliness), in order to increase convergence of the models and interpretability of results.

For linear mixed models, the null model *ICC* is reported as well as f^2 as the effect sizes for the random and fixed effects respectively (Lorah, 2018), whereas the *ICC* and odds ratios are reported for the logistic mixed models. The null model *ICC* measures the proportion of total variability in the dependent variable which is explained by Level 2 (cluster) membership, whereas f^2 reflects the variance of the dependent variable that is explained by the covariates included in the full model. According to guidelines for interpreting f^2, .02 is considered to be a small effect, .15 is medium, and .35 is a large effect (Lorah, 2018). Interaction terms were not included as they created issues in model convergence and therefore bring into question reliability and interpretation of any results with interactions.

Most reported social TUT episodes occurred within 40 minutes of the prompt, however as TUTs are transient and often short-lived cognitions the reliability of self-report of thoughts that occurred more than 10 minutes after the prompt can be called into question. This limitation will be reviewed in the discussion but to address this, multi-level logistic and linear regressions are included in the supplemental materials [Appendix D] which use only the prompts reported < 10 minutes prior to the prompt. The results of these models are consistent with the ones reported here, with the only difference being that some variables no longer meet significance criteria due to the reduced sample size. Nonetheless, all associations are in the same direction and variables which are no longer significant do trend toward significance. This consistency supports reliability of the reported models here.

9.3.5 Hypothesis 1: Content of Social Task-Unrelated Thoughts

The first set of multi-level models examined whether intention, schizotypy, and/or trait loneliness predicted differences in TUT content. Table 28 illustrates the outcomes of the linear mixed-models investigating valence, fantasy, and freely-moving thought in social TUT episodes. In terms of differences in valence, across all three models it was found that intentional TUTs were associated with more positively-valenced TUT episodes than unintentional TUTs, whereas trait loneliness had a small but significant negative association with episode valence. None of the three schizotypal factors predicted any differences in the valence of an episode.

Results from the models predicting fantasy found that again intentional TUTs were significantly associated with less fanciful social TUT content relative to unintentional episodes, and neither trait loneliness nor disorganised schizotypy scores had an association with fantasy-based content. However, greater interpersonal and cognitive-perceptual schizotypy predicted more fantasy content. Finally, freely-moving thought was not associated with any schizotypy factor but across all three models intentional TUTs and higher trait loneliness did predict less freely-moving thought. All models in Table 28 indicated medium effect sizes for the covariates included in the models, and the *ICCs* were above .10 justifying the use of multi-level modelling.

A set of logistic multi-level regressions, predicting the self-focus of TUTs (with other-focussed being the baseline), the presence of close-others in TUTs (with non-close others as the baseline), and the prospection of episodes (compared to the baseline of retrospective thought) (see Table 29) were conducted. For prospection, the decision was made to compare retrospective and prospective thoughts (N = 1899) without the ‘other’ category as the main interest of the current study was the relative experience of these two temporalities, given their possible links to (mal)adaptive outcomes. Across all three models predicting self-focus, intentional TUTs predicted more self-focussed thought. Interestingly, in the cognitive-perceptual and disorganised factor models, higher trait loneliness predicted less self-focussed thought, whereas in the interpersonal schizotypy model trait loneliness was not associated with differences in self-focus, but interpersonal schizotypy did predict less self-focussed thought. Across all three models predicting episodes involving close-others, only trait loneliness was associated, showing a small but significantly greater likelihood of close-others featuring in TUTs of participants with higher loneliness scores. Finally, greater prospection was predicted by intentional TUTs and loneliness across all models, and interpersonal schizotypy trended toward less prospective thought but did not reach significance (p = .07). Odds ratios for personality predictors (i.e., loneliness and schizotypy) indicated small effects, but intention had a stronger predictive association with outcomes. All *ICCs* were above .10 indicating multi-level modelling was appropriate.

Table 28

Associations between Valence, Fantasy, Freely Moving Content and Social TUTs for Different Factors of Schizotypy as Estimated with Linear Multi-Level Models

Dependent Variables	Valence				Fantasy				Freely Moving Thought			
	ICC	f^2	**B *(SE)***	**CI**	***ICC***	f^2	**B *(SE)***	**CI**	***ICC***	f^2	**B *(SE)***	**CI**
Cognitive-Perceptual Schizotypy, Full Model	.15	.13			.21	.17			.30	.25		
Intentional			.26 *(.07)***	[.12, .39]			-.28 *(.08)***	[-.43, -.13]			-.30 *(.10)***	[-.49, -.11]
Trait Loneliness (ULS-8)			-.04 *(.01)***	[-.06, -.01]			.00 *(.01)*	[-.02, .03]			-.04 *(.02)**	[-.08, -.01]
Cognitive-Perceptual			.00 *(.01)*	[-.01, .02]			.02 *(.01)**	[.01, .04]			.01 *(.01)*	[-.01, .03]
Interpersonal Schizotypy, Full Model	.15	.13			.21	.18			.30	.25		
Intentional			.26 *(.07)***	[.12, .39]			-.27 *(.08)***	[-.42, -.12]			-.30 *(.10)***	[-.48, -.11]
Trait Loneliness (ULS-8)			-.04 *(.01)***	[-.07, -.01]			-.02 *(.02)*	[-.05, .02]			-.05 *(.02)**	[-.09, -.01]
Interpersonal			.00 *(.01)*	[-.02, .02]			.03 *(.01)***	[.01, .05]			.01 *(.01)*	[-.02, .03]
Disorganised Schizotypy, Full Model	.15	.13			.21	.17			.30	.25		
Intentional			.26 *(.07)***	[.12, .40]			-.28 *(.08)***	[-.43, -.13]			-.30 *(.10)***	[-.49, -.11]
Trait Loneliness (ULS-8)			-.04 *(.01)***	[-.07, -.02]			.01 *(.01)*	[-.02, .03]			-.04 *(.02)**	[-.08, -.01]
Disorganised			.01 *(.01)*	[-.01, .04]			.01 *(.02)*	[-.02, .05]			.00 *(.02)*	[-.04, .04]

Note. $p < .01$, **, $p < .05$, *, [t] trending toward significance ($p < .10, > .05$). For the factor variable of ‘intention’, intentional mind wandering is dummy coded as 1, and unintentional as 0 (baseline).

Table 29

Associations between Self-Focus, Close-Others, and Prospection and the Content of Social TUTs for Factors of Schizotypy as Estimated with Logistic Multi-Level Models

Dependent Variables	Self-Focussed				Close Others				Prospection			
	ICC	**B *(SE)***	***Odds Ratio***	**CI**	**ICC**	**B *(SE)***	***Odds Ratio***	**CI**	**ICC**	**B *(SE)***	***Odds Ratio***	**CI**
Cognitive-Perceptual Schizotypy, Full Model	.21				.13				.18			
Intention		.53*(.13)***	1.70	[1.31, 2.20]		-.06*(.09)*	0.95	[.79, 1.13]		.28*(.13)**	1.33	[1.03, 1.71]
Trait Loneliness (ULS-8)		-.06*(.02)***	0.94	[.91, .97]		.05*(.01)***	1.05	[1.02, 1.08]		.04*(.02)**	1.04	[1.01, 1.08]
Cognitive-Perceptual Schizotypy		-.01*(.01)*	0.99	[.97, 1.02]		-.02*(.01)*[t]	0.98	[.97, 1.00]		-.02*(.01)*	0.99	[.96, 1.01]
Interpersonal Schizotypy, Full Model	.21				.13				.18			
Intention		.51*(.13)***	1.66	[1.28, 2.16]		-.06*(.09)*	0.94	[.79, 1.12]		.27*(.13)**	1.31	[1.01, 1.69]
Trait Loneliness (ULS-8)		-.03*(.02)*	0.97	[.93, 1.01]		.05*(.02)***	1.05	[1.02, 1.09]		.06*(.02)***	1.06	[1.02, 1.11]
Interpersonal Schizotypy		-.04*(.01)***	0.96	[.94, .99]		-.01*(.01)*	0.99	[.97, 1.01]		-.02*(.01)*[t]	0.98	[.95, 1.00]
Disorganised Schizotypy, Full Model	.21				.13				.18			
Intention		.53*(.13)***	1.69	[1.30, 2.20]		-.06*(.09)*	0.95	[.79, 1.13]		.28*(.13)**	1.32	[1.02, 1.71]
Trait Loneliness (ULS-8)		-.06*(.02)***	0.94	[.91, .98]		.04*(.02)***	1.04	[1.01, 1.08]		.04*(.02)**	1.05	[1.01, 1.09]
Disorganised Schizotypy		-.03*(.02)*	0.97	[.93, 1.01]		.00*(.02)*	0.99	[.97, 1.03]		-.03*(.02)*	0.98	[.93, 1.02]

Note. $p < .01$, **, $p < .05$, *, [t] refers to trending toward significance ($p < .10$, $> .05$). For the factor variable of 'intention', intentional TUT is dummy coded as 1, and unintentional as 0 (baseline). For self-focus, other-focussed was the reference category. For close others, non-close others was the reference category. For prospection, retrospection was the reference category.

9.3.6 Hypothesis 2: Problem Solving Content in Social Task-Unrelated Thought

A series of multi-level logistic models were then conducted to investigate problem-solving differences in social TUT episodes. Poerio and Smallwood (2016) argue that one function of TUTs may be to assist an individual with problem-solving in their social world. As such an analysis was performed on the subgroup of social TUT episodes (*N* = 2044) which were concerned with a social issue in the individual's life. In particular, the differences in the likelihood of approach content in TUTs (with avoid as the baseline) and the likelihood of thinking about a solution to a social dilemma (with no solution as a baseline) were examined. For the subset of episodes where participants reported a solution to their TUT episode (*N* = 854), an analysis was performed to observe whether there were differences in associations between intention, schizotypy, and trait loneliness with thinking of or anticipating a positive resolution (with negative resolutions the baseline). All results are illustrated in Table 30.

Across all three models, intentional TUTs were associated with greater approach-based content. Trait loneliness did not predict differences in approach-avoidance content, and neither did disorganised nor cognitive-perceptual schizotypy. Interpersonal schizotypy however did predict less approach-based content compared to avoidance. Intentional TUTs also predicted a greater likelihood to think of a solution to problems during a TUT, but the schizotypal factors and trait loneliness did not predict differences in this variable for any model. Intentional TUTs were also more likely to have a positive outcome compared to unintentional TUTs, whereas greater trait loneliness predicted less positive outcomes when problem-solving during TUTs for all models except interpersonal.

Table 30

Associations in Approach-Based Content, Problem Resolutions, and Positive Outcomes in the Content of Social TUTs

Dependent Variables	Approach-Based[a]				Solution[b]				Positive Outcome[c]			
	ICC	B *(SE)*	*Odds Ratio*	CI	ICC	B *(SE)*	*Odds Ratio*	CI	ICC	B *(SE)*	*Odds Ratio*	CI
Cognitive-Perceptual Schizotypy, Full Model	.17				.20				.23			
Intention		.65*(.12)***	1.92	[1.51, 2.42]		.56*(.11)***	1.76	[1.41, 2.20]		.75*(.12)***	2.12	[1.68, 2.69]
ULS-8		-.01*(.02)*	1.00	[.96, 1.03]		-.02*(.02)*	0.98	[.94, 1.01]		-.05*(.02)***	0.95	[.91, .99]
Cognitive-Perceptual		-.01 *(.01)*	0.99	[.97, 1.02]		.02*(.01)*	1.02	[.99, 1.04]		-.01*(.01)*	1.01	[.98, 1.04]
Interpersonal Schizotypy, Full Model	.17				.20				.23			
Intention		.63*(.12)***	1.88	[1.49, 2.38]		.55*(.11)***	1.73	[1.39, 2.16]		.74*(.12)****	2.09	[1.65, 2.64]
ULS-8		.02*(.02)*	1.02	[.98, 1.06]		.00*(.02)*	1.00	[.95, 1.04]		-.02*(.02)*	0.98	[.93, 1.02]
Interpersonal		-.03*(.01)**	0.97	[.95, .99]		-.02*(.01)*	0.99	[.96, 1.01]		-.02*(.01)*	0.98	[.95, 1.01]
Disorganised Schizotypy, Full Model	.17				.20				.23			
Intention		.65*(.12)***	1.92	[1.51, 2.43]		.56*(.11)***	1.75	[1.40, 2.19]		.75*(.12)***	2.12	[1.68, 2.68]
ULS-8		-.01*(.02)*	0.99	[.96, 1.03]		-.02*(.02)*	0.98	[.94, 1.02]		-.05*(.02)**	0.95	[.92, .99]
Disorganised		.00*(.02)*	1.00	[.96, 1.04]		.01*(.02)*	1.01	[.96, 1.05]		.00*(.03)*	1.00	[.96,1.05]

Note. *p* < .01, **, *p* <.05, *. For the factor variable of ‘intention’, intentional TUT is dummy coded as 1, and unintentional as 0 (baseline). For approach-based, avoidance based is the reference category. For solution, no solution is the reference category. For positive outcome, negative outcomes is the reference category.

9.3.7 Hypothesis 3: Socio-Emotional Regulation

Previous research has indicated a regulatory function of TUTs to manage emotions. To investigate individual differences in socio-emotional outcomes a series of linear multi-level models were run to observe differences in emotional states after TUTs (Table 31). The decision to use state loneliness and positivity prior to a TUT episode was made, rather than trait loneliness scores for these models because the main interest was in the in-the-moment self-regulatory functioning. Valence of the episode was also included as a predictor as the content-regulation hypothesis predicts that the valence of the episode should influence post-TUT mood. State loneliness or positivity and valence of the episode were both modelled as Level 1 predictors and were centred within clusters. However, the trait-level schizotypy were still included in the models as a stable trait (i.e. does not have a state measure).

Post-TUT positivity was predicted by intentional TUTs and valence of the episode, with more positive and intentional episodes predicting more positive mood following TUT. Pre-TUT positivity also had a small but significant predictive relationship with post-TUT positivity. Findings indicated that intentional TUTs predicted less post-TUT loneliness. In addition, more positively valenced episodes did predict less loneliness post-TUT. Again, pre-TUT loneliness had a small but significant positive relationship with post-TUT loneliness. The schizotypal factors were not significant predictors for either loneliness or positivity. The effect size for models predicting positive mood were large, indicating 45% of variance was explained by the covariates included in the models, and the loneliness models had medium effect sizes with 26% of variance being explained by the model covariates.

Table 31

Associations of Post-TUT Positivity and Loneliness with Intention and Valence of the Episode and Schizotypy and Trait Loneliness as Estimated by Linear Multi-Level Models

Dependent Variables	**Positivity**				**Loneliness**			
	ICC	f^2	**B *(SE)***	**CI**	***ICC***	f^2	**B *(SE)***	**CI**
Cognitive-Perceptual Schizotypy, Full Model	.10	.45			.10	.26		
Intention			.17*(.05)***	[.07, .26]			-.10*(.04)**	[-.18, -.02]
T_1 State			.01*(.00)***	[.01, .02]			.01*(.00)***	[.01, .02]
Valence			.49*(.02)***	[.46, .53]			-.27*(.01)***	[-.30, -.24]
Cognitive-Perceptual			.00*(.00)*	[.00, .01]			.00*(.01)*	[-.01, .01]
Interpersonal Schizotypy, Full Model	.10	.46			.10	.26		
Intention			.15*(.05)***	[.06, .24]			-.09*(.04)**	[-.17, -.01]
T1 State			.01*(.00)***	[.01, .02]			.01*(.00)***	[.01,.02]
Valence			.49*(.02)***	[.46, .53]			-.27*(.01)***	[-.30, -.24]
Interpersonal			-.01*(.00)*	[-.02, -.01]			.01*(.01)*	[.00, .02]
Disorganised Schizotypy, Full Model	.10	.45			.10	.26		
Intention			.16*(.05)***	[.07, .26]			-.10*(.04)**	[-.18, -.02]
T1 State			.01*(.00)***	[.01, .02]			.01*(.00)***	[.01, .02]
Valence			.49*(.02)***	[.46, .53]			-.27*(.02)***	[-.30, -.24]
Disorganised			.00*(.01)*	[.00, .01]			.00*(.01)*	[-.01, .01]

9.3.8 Post-Hoc Analysis

The trait-level correlations demonstrated that schizotypy was associated with MW-S scores, whereas trait loneliness correlated with neither MW-D nor MW-S. A logistic multi-level model was run to investigate if there was a similar pattern in state-level social TUT measures. That is, whether or not individuals with higher schizotypy also tended to engage in more unintentional social TUTs, and if trait loneliness was associated with neither intentional nor unintentional TUT was examined (Table 32). The dependent variable in this model was intentional social TUTs, with unintentional social TUTs coded as the reference category.

Partially consistent with trait-level rates of TUT, this analysis found that greater interpersonal schizotypy was associated with less intentional daily social TUTs, although there was no association with cognitive-perceptual or disorganised factors. Interestingly intentional social TUTs were associated with greater trait loneliness in the interpersonal model, indicating that when interpersonal symptoms are controlled for, loneliness does have a positive association with intentional social TUTs.

Table 32

Associations of Schizotypy and Trait Loneliness with Intentional and Unintentional Social TUTs, Estimated with Multi-Level Logistic Modelling

Intentional TUT	**ICC**	**B *(SE)***	**Odds Ratio**	**CI**
Cognitive-Perceptual Full-Model	.26			
UCLA-8		.01*(.02)*	1.01	[.97, 1.05]
Cognitive-Perceptual		.00*(.01)*	1.00	[.97, 1.03]
Interpersonal Full-Model	.26			
UCLA-8		.05*(.02)**	1.05	[1.01, 1.10]
Interpersonal		-.04*(.02)***	0.96	[.93, .99]
Disorganised Full-Model	.26			
UCLA-8		.01*(.02)*	1.01	[.97, 1.06]
Disorganised		-.02*(.03)*	0.98	[.93, 1.03]

Note. SE refers to standard error, CI refers to confidence intervals. In this model intentional TUT is the DV, with unintentional TUT the reference category.

9.4 Discussion

This study makes a novel contribution to the literature by investigating the content and outcomes of socially oriented intentional and unintentional TUTs in daily life. Importantly, TUTs were sampled during a lockdown period in response to COVID-19, and so this study also offers a window into the nature and function of off-task thoughts during a time of unprecedented social isolation for participants. These findings extend on ongoing efforts to delineate the determinants of off-task thoughts in relation to the benefits or costs for individuals (Mooneyham & Schooler, 2013) by investigating their socio-emotional outcomes, as well as efforts to understand the links between mind wandering and social cognition through investigating the content of social TUTs (Poerio & Smallwood, 2016). By separating intentional and unintentional TUTs this study aimed to investigate whether arguments that intention is an important dimension upon which TUT content and outcomes vary could be supported.

Based on past findings related to social daydreaming, as well as the growing documentation of heterogeneity within TUTs, it was predicted that intentional social TUTs would feature more constructive content and socio-emotional outcomes compared to unintentional TUTs. In addition, consistent with past clinical and subclinical associations of trait-level spontaneous mind wandering, it was predicted that greater MW-S scores (and in post-hoc analyses that daily self-reported unintentional TUTs) would be associated with greater schizotypy and loneliness, and that in turn these personality and dispositional traits would be associated with less functional daily TUT content and socio-emotional outcomes.

9.4.1 The Content and Emotional Outcomes of Intentional and Unintentional Task-Unrelated Thoughts

Consistent with the current concerns (McVay & Kane, 2010; Watkins, 2008) and content-regulation hypotheses (Smallwood & Andrews-Hanna, 2013), the content of TUTs in the current study reflected socially relevant goals, with 73.83% of social TUT episodes involving interpersonal dilemmas in participants' social worlds. This supports the possibility that TUTs offer opportunities for consolidating, planning, or rehearsing interpersonal interactions (Baird et al., 2011; Poerio & Smallwood, 2016; Stawarczyk et al., 2013). Evidence from the current study further suggests that the functionality of TUTs may differ based on their intention. In all the models except those predicting whether content featured 'close others', intentionality of TUTs was a significant predictor of constructive content and outcomes with these models having moderate-to-strong effect sizes. Results demonstrated that intentional TUTs, relative to unintentional episodes, predicted more positive, realistic, constrained, self-focussed, and prospective content. In addition, when thinking of an interpersonal problem these TUTs were also more likely to be approach-based and involve thinking of a positive solution. There were also differences in the socio-emotional regulatory outcomes of intentional and unintentional TUTs. Results found that intentional social TUTs, relative to unintentional TUTs, predicted greater self-reported positivity and less loneliness following the episode.

Together these results align with studies finding that the outcomes of mind wandering are dependent on the specific content of the episode, with certain variables (e.g. positive or interesting content) being associated with increases in mood (Franklin et al., 2013; Poerio et al., 2015). Also, that intentional TUTs had more constructive content in the current study aligns with past findings that these TUTs tend to be more functional than spontaneous episodes. Specifically, intentional TUTs have been linked to more prospective and less vague content when compared to unintentional TUTs in the laboratory (Seli et al., 2017), which was also found in the current results, and intentional TUTs are more likely to involve self-reflection (Vannucci & Chiorri, 2018), or involve planning, and controlled thought processes (Golchert et al., 2017). In contrast, unintentional TUTs have been associated with executive failure (Robison & Unsworth, 2018) and subclinical depression and anxiety (Seli et al., 2019b) consistent with the relatively less constrained, less positive and/or less prospective content that these TUTs demonstrated in the current study.

The content of self-reported social TUTs in the current work indicates that these transient cognitions may provide an opportunity for planning, rehearsing, or synthesising social information. This contrasts with the intrusive, fantastical, and freely-moving nature of unintentional TUTs which may impair goal-oriented activities and negatively impact upon wellbeing (Robison & Unsworth, 2018; Seli et al., 2017a). These results provide insight into some of the factors which influence whether TUTs are beneficial or harmful, with one important moderating factor ostensibly being whether or not they are engaged intentionally. While no current theory of mind wandering explicitly integrates a distinction between deliberate and spontaneous episodes, these results stand as further evidence for the necessity of future work to consider the heterogeneity in off-task thought. The family-resemblances framework (Seli et al., 2018a) argues that 'mind wandering' refers to a variety of thought types which have overlapping and nonoverlapping features. However, the current work is only an initial step toward understanding the nature of social TUTs at a general level. For example, while prospective thought tends to be linked to more constructive processes such as future-planning, it may also take the form of future worries. As such, efforts are still needed to more precisely understand the nature of these off-task thoughts.

Moreover, trait- and state-level frequencies of spontaneous and deliberate mind wandering had separable associations with schizotypy and loneliness. Higher trait loneliness was associated with higher rates of state-level intentional social TUTs when interpersonal schizotypy symptoms were controlled for, but there was no relation with the trait-level MW-D measurement. This was not consistent with the prediction that loneliness would be associated with more spontaneous TUT episodes. Comparatively, higher schizotypy scores were correlated with higher MW-S scores, and disorganised schizotypy in particular was predictive of greater MW-S scores. Interestingly, interpersonal schizotypy predicted more unintentional social TUTs at the state-level, whereas disorganised schizotypy did not. This could reflect differences in the type of spontaneous mind wandering that interpersonal and disorganised schizotypy experience. The MW-S and MW-D measure general mind wandering, not TUTs or social mind wandering specifically. Individuals with greater disorganised schizotypy traits may experience more general spontaneous mind wandering experiences, whereas those with greater interpersonal schizotypy traits may experience more spontaneous mind wandering involving social thought content. This makes sense given interpersonal schizotypy in particular features symptoms of social anxiety and social anhedonia, which may be reflected in TUT content. This could also suggest that those with higher trait loneliness experience more deliberate social TUTs in daily life, but not necessarily more deliberate general mind wandering.

The relationship between intentional social TUTs and loneliness in the interpersonal schizotypy model may reflect deliberate attempts by certain individuals to engage in TUTs in an effort to compensate for the perceived discrepancies in one's social life and alleviate feelings of loneliness (Hawkley & Cacioppo, 2010; Poerio et al., 2015). Poerio et al. (2015) suggest that imagination can provide substitution for social interactions when it is not immediately available. Perhaps lonelier individuals are thus engaging in TUTs intentionally as a means to alleviate loneliness. This could be particularly influenced by the fact that this data was collected during pandemic regulations limiting social connection, which could increase attempts to rely on mind wandering in order to counter negative mood states.

Nonetheless, depending on the content of these episodes, TUTs can either act as a protective factor against poorer mental health outcomes such as loneliness, or can enhance and exacerbate such symptoms (Mar et al., 2012, Poerio et al., 2016). For example, positively valenced episodes were associated with greater positivity and less loneliness after TUTs, consistent with evidence that imagined events can evoke the feelings that would arise if the event occurred in reality (Westerman et al., 1996). It may be that lonelier individuals in this study are attempting to engage in TUTs to alleviate loneliness but due to cognitive biases are experiencing greater negative content instead.

Also to consider, when comparing the TUTs before and after lockdown began for 17 participants in the supplemental materials [Appendix D], during lockdown relative to the 3 days prior to lockdown, people reported more future-focussed thoughts and more thoughts about close others. In addition approach-based TUTs decreased, and avoidance-based TUTs increased. All other variables did not differ in frequency before and after lockdown initiated. Given the small sample of data these supplemental analyses were based on, it is important to be mindful when interpreting these results. However, it would make sense for participants to experience more prospective thoughts and thoughts of close others during a lockdown. Participants may be spending time planning post-lockdown social activities, or find themselves worrying about what their social worlds will look like in the near future. In addition, they may think of their close others more often as they were not able to physically be with many of those people at this time. As such, the lack of significant difference between intentional and unintentional TUTs for close others could be due to general increases in thoughts of close others making these types of TUTs act more similarly to each other. The increase in avoidance-based coping may reflect the impact of isolation and loneliness on participants cognitions, leading them to want to limit and avoid any negative emotions or consequences.

While loneliness did not increase pre- and during lockdown for these participants during their time in the study, the nature of their loneliness may have changed as loneliness has been argued to be a multidimensional construct. A unidimensional short-form measure of loneliness was used here and so this was not something that could necessarily be explored further. Generally, these results highlight that some of the associations observed during lockdown may differ to what may normally occur in one's daily life when such restrictive measures are not in place. Furthermore, loneliness during the days prior and during initial lockdown may not differ from each other, however this level of loneliness would likely differ to general levels individual's experience outside of the pandemic context. There are a number of studies which support that people felt lonelier during the pandemic than they had prior (Isaac et al., 2021; Lupton & Lewis, 2023). As such, these results may be reflecting social TUT content and emotional outcomes during periods of heightened stress or loneliness.

9.4.2 Loneliness and Schizotypy

Schizotypy and loneliness scores demonstrated associations with certain content variables and socio-emotional outcomes that suggested TUTs reflected less constructive functioning in individuals as predicted. To note however, estimates and effect sizes for these variables tended to be weaker than other covariates across the models. Trait loneliness predicted less positive, less fantastical and more prospective TUT episodes, that more often involved close others. While future-thinking and thoughts about close others are linked to better wellbeing (Mar et al., 2012; Poerio et al., 2016), that TUTs for lonelier individuals were also less positive suggests an important deviation in their phenomenology. Again, lonelier individuals are perhaps deliberately engaging in TUTs about (close) others in an attempt to alleviate loneliness. Yet certain content of these thoughts in the current sample are consistent with negative expectations that could motivate withdrawal (Hawkley & Cacioppo, 2010).

For example, while lonelier individuals showed tendencies to engage in more prospective thought, these may have been in the form of anxieties and worries about future interactions and events. The more constrained and less positive nature of TUTs also implies a more rigid worry-based style of thought. While the level of future-based worry in TUTs was not assessed here, an avenue for future research could be to investigate differences between constructive and unconstructive prospection in mind wandering. Promisingly, however, positive social TUTs were observed to decrease feelings of state loneliness and increase feelings of positivity, similarly observed in other research (Poerio et al., 2015; 2016), and thus provides a possible avenue for future interventions.

Schizotypy also demonstrated unique associations with a number of outcomes and this depended on the particular schizotypal factor in question. First, cognitive-perceptual and interpersonal schizotypy were both associated with greater fantasy-based content, reinforcing a number observations that schizotypy is associated with fantasy-proneness and magical thinking (Merckelback et al., 2022; Raine, 1991; Welhaf, 2020). Interpersonal schizotypy had a small but significant association with less self-focussed and approach-based TUTs. Self-focus in mind wandering has been linked to a maintenance of sense of self and identity (Song & Wang, 2012), and so a lower rate of self-focussed TUTs in interpersonal schizotypy may reflect an impaired self-concept in schizotypal individuals. Although impairments in self-concept are usually linked to cognitive-perceptual schizotypy, there is evidence that the interpersonal factor can also reflect a disrupted sense of self (Kállai et al., 2019). Zhang et al. (2022) found mind wandering was one mediator of lower wellbeing in individuals with schizotypy, and the results from the current study offer insights into the nature of daily TUTs for such individuals which may go some way in signposting a pathway of this effect.

As schizotypy is a multidimensional construct it is perhaps unsurprising that the associations with TUT content differed between the three factors used here. In particular, interpersonal schizotypy tended to predict more differences in TUTs. The criteria for interpersonal schizotypy includes social anhedonia and anxiety, and general withdrawal which might shed light on some of the subtle differences in the social TUT phenomenology observed (Raine, 1991). The fanciful, other-focussed, avoidance-based, and unintentional nature of the social TUTs associated with this factor may indicate an under-preparedness for, or a lack of understanding of, social interactions that is reflected in TUT content. Social cognition functions to allow individuals to plan, rehearse, and prepare for interactions in their lives (Fiske & Taylor, 1991; Poerio & Smallwood, 2016), and positively valenced imagined interactions tend to be more similar to actual communication (Zagacki et al., 1992). If those with higher interpersonal schizotypy engage in social TUTs that tend to be fantastical and focussed on avoiding negative outcomes to social problems, then a sense of under-preparedness for actual social interactions could result. This could reinforce a distressing mismatch between the individual's internal and realised world, aligning with the idea that higher schizotypal individuals are compromised in a module for representing relationships between internal mental states and reality (Langdon & Coltheart, 1999). Additionally, individuals can miss out on the benefits of problem-focussed coping attempts, including better self-regulation, efficacy, and the facilitation of concrete plans for action by engaging in more avoidance-based coping (Taylor et al., 1998).

However, again that these measures were completed during a lockdown period may also mean that traits such as loneliness were atypically heightened across many participants. If this were the case, then this could mean that the associations between trait-level loneliness and trait- and state- mind wandering measures are reflecting what occurs during contexts where individuals are especially isolated and feeling lonely rather than what may be more typical associations for these individuals. For example, Zabelina et al. (2021) found that lonelier individuals who engage in more imagined interactions exhibited more anxiety. In the current study trait loneliness was associated with more intentional social TUTs, and state loneliness predicted more loneliness after a TUT. Perhaps then the current results are reflecting that when individuals experience prolonged heightened loneliness then they begin to deliberately engage in TUTs which unfortunately then maintain and exacerbate their loneliness to an extent. This may be because loneliness can cause cognitive biases which influence the thoughts people experience (Hawkley

& Cacioppo, 2010). Moreover, perhaps lonely individuals are engaging in social TUTs and becoming lonely in response to these as the current restrictive measures in place meant many of these TUTs represented out of reach interactions. This issue will be discussed further in the limitations and future directions.

9.4.3 Limitations and Future Directions

Limitations of the current study include the central yet unavoidable issue that this data collection took place over a time of national social isolation regulations in response to the COVID-19 pandemic. As such, this data was collected when the student participants were in a unique position of not having access to their usual social circle and routines. These restrictions are likely to influence the type of social cognitions engaged, as individuals attempted to cope with increased social isolation via a greater reliance on reflecting on social interactions rather than engaging in them. As such it will be important for continued efforts to investigate social TUTs in daily life in order to better understand whether the associations documented in the current study are consistent outside of lockdown contexts. Promisingly however, a number of findings from the current study align with findings in the literature. This includes that valence of TUTs influences the impact of TUT on mood (Poerio et al., 2015), and that intentional TUTs tend to show more prospective and constrained thoughts (Seli et al., 2017b).

There is also some evidence that imagined interactions, which are similar in concept to TUTs, do not necessarily show changes during lockdown (Sealy, 2021). Indeed, while lockdown significantly limited in-person interactions, the self-report data of the current study whereby participants identified the task during which they experienced the TUT demonstrated that individuals still reported engaging in a number of social interactions including; online class tutorials and work meetings, game nights with housemates, online zoom parties with friends, and outdoor exercise with friends. Mckeown et al. (2021) reported that both virtual and in-person interactions increased social thought during COVID-19 lockdowns in the UK, and as such it may be that as participants seemed to still be engaging and interacting with others in the current study their social TUTs may not be entirely different to what they might experience outside of lockdown contexts. It is still likely however that for a number of individuals loneliness was influenced by the unique context of this study, and that the nature of social TUTs engaged are subsequently affected.

A second limitation is that this study focussed on the content of daily social TUTs, and did not link it to follow-through on the actions imagined. It would be useful to observe whether the types of problem-solving resolutions and interactions imagined in TUTs translated into real-life interactions and resolutions. In addition, the frequency and nature of TUTs can change depending on the level of difficulty of the task being completed. Future work could then also try to measure the difficulty of tasks during which daily TUTs occur to observe whether how difficult an individual reports their current task to be then influences the content of their TUTs. Although to note, it is not entirely possible to be able to objectively assess the difficulty and performance of self-reported tasks in daily life.

Recent work has also begun to measure variables such as intention using continuous scales. A mixture of categorical and continuous variable assessments were employed here, based on how prior work has measured particular variables and on the analytical goals of the current study. The question formats were also varied in order to reduce likelihood that participants would simply mindlessly respond to a series of scales or checkboxes. By integrating different types of question formats in an attempt to increase attentive responding. Yet, it is important to acknowledge that more work is needed to understand how best to measure constructs of interest.

Future work could also investigate whether and how trait and state measures of constructs such as loneliness may differ from each other in their predictions of TUT content. Here the trait measure was used in most of the models as the aim was to investigate how durable dispositions influence thought content. This was motivated by the content-regulation hypothesis which suggests that individual differences in disposition and personality will influence how people regulate and experience their off-task thoughts. While state loneliness is also measured in the current study, the focus was on trait-loneliness in order to better understand assumptions of the content-regulation hypothesis and to limit the amount of models being reported given these were already large in number. The exception to this was the socio-emotional regulation models as these models aimed to investigate how TUTs can impact concurrent mood.

Nonetheless, multi-level models which use state measures of loneliness are reported in the supplemental materials of Appendix D for the interested reader to compare (see Tables 51 to 53). While there may be interesting differences between content associated with longer-lasting lonely dispositions (trait loneliness) and content associated with momentary fluctuations of loneliness (state loneliness), the models in Appendix D mostly support state loneliness being either a similar predictor of certain content to trait loneliness (albeit with smaller coefficients), or not having a predictive association with certain content where trait loneliness does. This again supports that durable dispositions seem to influence the regulation of social TUT content, however these models do not preclude that moods and states also have influences.

Finally, this study used TUTs that occurred any time before the probe and not just immediately prior – this was to ensure that there were enough social TUT samples to analyse effectively but also did not want to probe excessively as a greater response load could encourage participant attrition. Retrospective reports on short-lived cognitions can be problematic, because as time lapses between the TUT and the self-report to the prompts, information can be misremembered and forgotten. To increase confidence in the current results, analyses are provided in the supplemental materials [Appendix D] using only TUTs reported to occur < 10 minutes prior to the prompt. These analyses were consistent with the ones reported here using the full TUT samples, with the only difference being that some associations were no longer significant due to the reduced sample size. However the coefficients were still in the same direction and often of a similar magnitude, with significance trending. To ensure accurate recall of TUT episodes, future work could increase the number of prompts a participant receives each day and only allow responses for TUTs occurring closer to the prompt. Despite these limitations the findings of the current study stand as a basis on which to further develop and broaden theory, and benchmark empirical investigations that consider the relationships between individual differences associated with social functioning and related TUT activity.

9.4.4 Conclusion

This study aimed to explore the role of TUTs as a possible form of social cognition by investigating whether the intention of a socially-oriented TUT episode, or the personality traits of the individual (i.e., trait schizotypy and loneliness) were associated with differences in content and outcomes. Consistent with predictions drawn from past work, intentional TUTs were associated with more constructive content and outcomes perhaps reflecting a role for these thoughts to support socio-emotional regulation and assist in navigating interactions. In addition, there were differences in the social TUTs of those scoring higher on interpersonal schizotypy and loneliness although the effects for these variables were weaker. Individuals scoring higher on these traits demonstrated less constructive TUT content, which may impair pursuits of social goals and maintain deficits in socio-emotional functioning. These results extend on broader theory and research regarding the cognitions of lonely and schizotypal individuals, and dissociations between types of TUT as well as other types of mind wandering, by highlighting that consideration of the intentionality of social TUTs facilitates the unveiling of the phenomenology of daily social cognitions.

Chapter 10: General Discussion

10.1 Preamble

The family-resemblances framework for mind wandering provides guidance to the interpretation of results from this body of work, and the similarities and differences in findings both within the studies of this thesis, and between this thesis and the literature more generally. According to the family-resemblances framework, mind wandering is an umbrella term referring to a number of cognitions which have both overlapping and non-overlapping features (Seli et al., 2018a; 2018b). Thoughts which have fallen under the category of mind wandering include unconstrained thoughts, daydreams, task-free thoughts, prospective thoughts, ruminative thoughts, and for the focus of the current thesis, task-unrelated thoughts (TUTs). As such, when drawing comparisons between the findings of the current work and other literature it is important to note that what is discussed and concluded here refers mostly to TUTs. While there may be overlap or similarities in patterns of associations among other candidate mind wandering forms with the variables of interest in this thesis, it should not be assumed that they will be identical. This thesis discussion will also demonstrate that different theories of mind wandering are useful for accounting for specific experiences of TUT mechanisms and/or outcomes in different contexts.

In addition, the current body of work has examined different types of TUTs in order to investigate their unique relationships to other factors. Specifically, a differentiation between intentional (or deliberate) and unintentional (or spontaneous) TUTs has been the focus. While there is debate about what is meant by 'intentional' TUTs [see Section 5.3] and whether the mind can wander intentionally (e.g. Murray & Krasich, 2022), this thesis assumes that there are times where individuals allow themselves to engage in off-task thoughts despite having an external task to attend to. As such, this thesis defines 'task-unrelated' as being unrelated to an ongoing (usually external) task which one is trying to complete in the present moment. Indeed, in many mind wandering frameworks it is assumed that individuals have a hierarchy of goals and intentional TUTs may represent a mismatch between external task goals and other internal goals. Unintentional TUTs in contrast, may represent a failure in goal-maintenance for an external task which then allows thoughts unrelated to that task (but possibly still related to some other personal goal) into consciousness. To conclude, the current work is concerned with the form of mind wandering that occurs during external task completion, either intentionally or unintentionally and attempts to outline the mechanisms which underpin the occurrence of these thoughts, as well as differences in their phenomenological experiences in daily life.

10.2 Overview

The studies comprising this thesis were designed as a means to contribute to, and extend on, the observed differences between intentional and unintentional TUTs across a range of domains. Past work has generally found evidence to support that unintentional off-task thoughts result from failures in executive attention, as they increase in frequency in difficult task contexts (Forrin et al., 2021; Seli et al., 2016b), and have inverse associations with variables such as WMC and attention control (Robison & Unsworth, 2018). In addition, unintentional 'mind wandering' has shown trait-level associations with clinical and subclinical symptoms of obsessive-compulsive (Seli et al., 2017a) and attention-deficit/hyperactivity disorders (Seli et al., 2015a) which are often in turn associated with impaired executive function. In contrast, measures of intentional TUTs and 'mind wandering' more generally are associated with motivation (Seli et al., 2016a) and mindfulness (Ju & Lien, 2018; Seli et al., 2016a), indicating a stronger relationship with self-regulatory mechanisms rather than cognitive variables specifically.

If it is the case that there are theoretically and/or practically significant differences between intentional and unintentional TUTs across a wide range of contexts, as the current literature suggests, then this would support arguments that both TUT and general mind wandering literature should acknowledge these different types of self-generated thoughts explicitly in theory. The current aim was therefore to further document evidence that intention is a significant dimension upon which TUTs vary, and so should be explicitly integrated into theories and predictions of off-task thought. Only through amassing evidence which confirms and extends the findings of past work can the argument for the integration of intention be strengthened. Three studies were undertaken which measured intention of TUTs across diverse types of domains (environmental influence in the form of task context, cognitive ability in the form of executive processes, and personality and social cognition in everyday life). In doing so, the scope of the utility of differentiating between these types of thought is highlighted. Chapter 10 summarises the aims and key findings from this thesis, and contextualises results in light of past theory and current aims.

10.3 Summary of Aims

The aims of this thesis were as follows;

i) To investigate differences in intentional and unintentional TUT rates during different task contexts, namely during a SART and *n*-back task (which benchmark task ease and difficulty) (Study 1).

ii) To investigate whether working memory, subjective task appraisals, and motivation had differential associations with intentional and unintentional TUTs across different tasks (Study 1).

iii) To investigate how different types of executive mechanisms (i.e., maintenance and disengagement processes) relate to intentional and unintentional TUT rates (Study 2).

iv) To investigate the content and phenomenology of intentional and unintentional TUTs in daily life in relation to social cognitions (Study 3).

v) To investigate whether intentional and unintentional social TUTs differ in relation to their socio-emotional regulatory outcomes and personality associations (Study 3).

The pursuit of these aims has extended current knowledge in relation to the mechanisms and functions of intentional and unintentional TUTs, and the theoretical and practical utility of differentiating between them. This thesis has highlighted a number of otherwise ambiguous findings which may be better understood by identifying the level of intention of a TUT episode.

10.4 Key Findings

There are a number of novel findings from this thesis, as well as findings that strengthen evidence for observed associations in past TUT literature (see Figures 16 and 17 for a schematic summary of key findings). Study 1 comprised two experiments investigating the role of task type and difficulty (i.e., sustained attention versus working memory updating tasks) and cognitive (i.e., WMC) and subjective (i.e., task evaluation and participant motivation) variables in determining intentional and unintentional TUT rates. In the first experiment, the SART was chosen to represent the 'easy' end of the task-difficulty spectrum, relative to a *3*-back task which was selected as a 'difficult' task. This was consistent with categorisations of a SART as a 'relatively simple' task in a meta-analysis by Randall et al. (2014), as well as arguments by the '*mindlessness*' hypothesis that these tasks can seem under-stimulating due to their monotony (although see Thomson et a., 2015 for an overview of diverging perspectives). A *1*-back was chosen as the intermediate task, as it is less monotonous than the SART but only requires a low-level of updating of the contents of working memory. The *3*-back is generally agreed to be a high-load/difficult task which taps into both attention and working memory updating. As was predicted, intentional TUTs increased during the SART, which was also regarded as the easiest and a less interesting task by participants. Intentional TUT rates were also associated with motivation and perceived difficulty, indicating a role for self-regulating off-task thought through top-down motivational mechanisms. In contrast, the *3*-back seemed to encourage more unintentional TUTs, which were associated with both WMC and motivation. This task was also rated as being the most difficult task of the three, supporting the argument that spontaneous TUTs can result from executive failure due to overload of cognitive resources.

Figure 16

Summary of Thesis Findings for Intentional TUTs

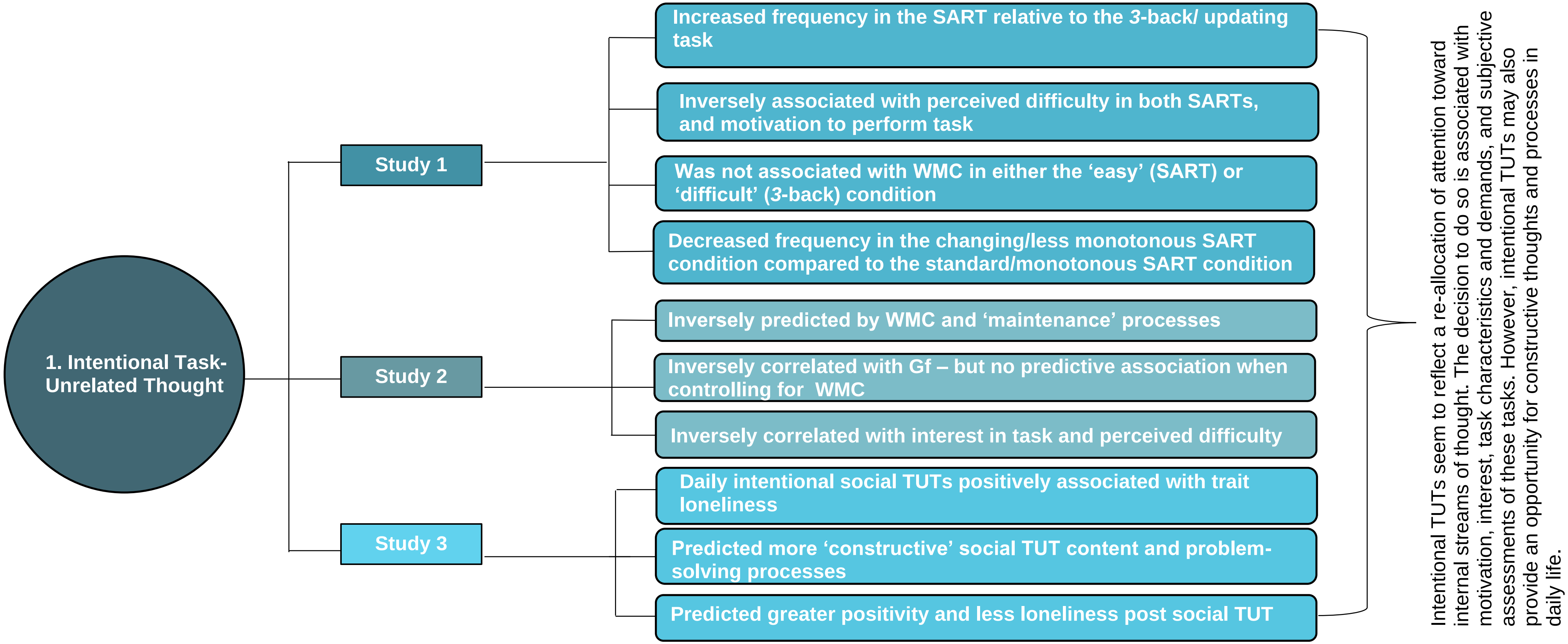
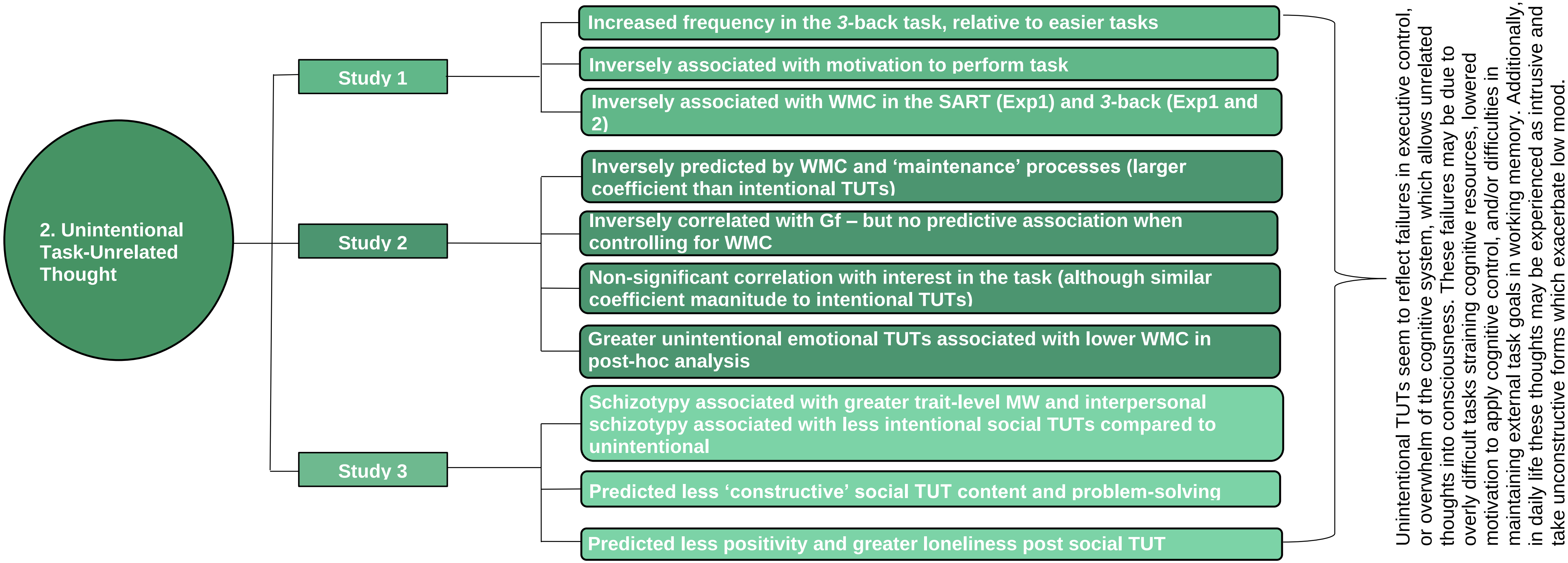


Figure 17

Summary of Thesis Findings for Unintentional TUT



The second experiment of Study 1 investigated the possibility that the monotony of the SART was the key feature which made intentional TUTs more common in that task. Monotony may lead to perceptions of a task being easy or simple (regardless of whether or not the task is actually easy for the participant to perform), as well as increasing boredom which encourages disengagement of attention from the task (Ralph et al., 2016). Consequently, in the follow-up experiment a modified changing-target SART was utilised, where the target changed identity after each block. This made the changing-target SART more similar to the *1*-back in some respects, as rather than tracking the same target over the duration of the task, participants had to maintain a level of attention in order to notice the changing identity of the target. The basic demands of the task however, were still very similar to the standard SART. As predicted, intentional TUTs were less frequent, and motivation and interest were greater. This pattern indicated that participants limited their intentional TUTs possibly due to the joint influence of i) the lower task monotony and associated greater engagement in the task, and ii) the requirement to stay attentive in order to track the changes in target identity and perform the task correctly. Indeed, participants perceived the task to be more difficult than the standard SART despite equivalent or better performance, indicating the task may have increased arousal and modulated engagement in intentional TUTs to meet the expected/perceived task demands.

Study 1 was able to demonstrate the separable influence of i) subjective appraisal variables, ii) cognitive ability, and iii) task type and difficulty on the frequency of intentional and unintentional TUT rates in two commonly used task paradigms in the literature. These differences shed light on the inconsistencies of the TUT-task difficulty relationships in the wider literature. That TUTs both increase and decrease as task difficulty increases need not be contradictory. Instead, these findings further support claims of Seli et al. (2016b; 2018c) that by measuring intention this may demonstrate that, depending on level of difficulty, motivation, and interest, increases in TUTs may reflect changing influences on intentional and unintentional TUT rates. For example, Ju and Lien (2018) demonstrated that measuring cognitive and non-cognitive abilities and how they associate with intentional and unintentional TUTs in different task contexts can reveal greater understanding of what drives these TUTs. Furthermore, Study 1 also confirmed that a curvilinear task difficulty – TUT association can occur when difficulty is benchmarked by different task paradigms, extending on both the works of Seli et al. (2018c) and Martínez-Pérez et al. (2021), as well as the observations of a curvilinear association within a given task paradigm (Xu & Metcalfe, 2016; Randall et al., 2019).

Study 2 focussed on the relationship between TUTs and different executive functions, using both the recent framework proposed by Shipstead et al. (2016) and the SEM method employed by Martin et al. (2020). The aim was to differentiate between the executive attentional mechanisms of maintenance and disengagement as measured by working memory and fluid intelligence tasks respectively. In the literature TUTs have been associated with attention/executive control generally, with only a small number of studies aiming to further investigate the contributions of specific factors of executive control (e.g. Kam & Handy, 2014). Results indicated that, in contrast to Study 1, *both* intentional and unintentional TUTs were inversely associated with WMC, although unintentional TUTs did reveal greater variance explained by this path. Furthermore, only intentional TUTs were associated with perceived difficulty indicating that the more difficult an individual perceived the task, the less they deliberately mind wandered. Fluid intelligence was also inversely correlated with both intentional and unintentional TUTs, however in the predictive models WMC alone had a significant predictive relationship; a novel finding that the correlation between fluid intelligence and TUTs, in the context of this SART, was driven by the shared variance with WMC. In addition, this finding supports the argument that it is the maintenance of goals in working memory which is responsible for avoiding TUTs, rather than the ability to disengage from such thoughts once they occur (at least in the context of a standard SART).

Both Studies 1 and 2 investigated TUTs during performance on a laboratory task to better understand how cognitive and task-based variables interact with TUT propensity. However, it is also important to understand the phenomenological experience and outcomes of intentional and unintentional TUTs in daily life. That is, it is important to determine whether differences in TUT by intentionality extend outside the laboratory as well, and to identify if and when TUTs are potentially helpful or harmful to individuals. Investigating the nature of TUTs in daily life may facilitate a clearer picture of the different functions they can have. In particular, it has been suggested that forms of mind wandering may be beneficial for social function. Study 3 used ESM to investigate the possibility that TUTs can be a form of social cognition, as well as to further document any differences between types of TUTs. Results supported the existence of reliable differences in associations between intentional and unintentional TUTs with both the content of social TUTs, as well as subsequent emotional outcomes. In fact, effect sizes for the intention of TUTs indicated this variable was a stronger predictor than the personality factors included in this study, further highlighting the importance of this dimension in understanding these thoughts and roles in conscious experience.

Specifically, results from Study 3 demonstrated a trait-level positive association of both overall schizotypy and the disorganised factor with spontaneous *general* mind wandering (i.e., *MW-S*), and more frequent daily unintentional social TUTs were associated with interpersonal schizotypy. Interestingly however, loneliness scores were associated with greater daily intentional social TUTs when interpersonal symptoms were controlled. The content of state-level daily social TUT rates also revealed interesting content differences depending on their intention, with intentional social TUTs reported as being more positive, realistic, constrained, self-focussed, and prospective in nature relative to unintentional social TUTs. When social TUTs involved thinking of an interpersonal issue in an individual's life, intentional episodes were more likely to be approach-based, involve a solution to the issue, and predict a positive outcome. Finally, intentional social TUT episodes predicted greater in in-the-moment feelings of positivity and lower levels of loneliness. This pattern of results supports ideas that not all TUTs are harmful, and that depending on factors such as content and intention they can facilitate goal attainment and wellbeing (Smallwood & Andrews-Hanna, 2013). Moreover, that loneliness is related to more frequent intentional TUTs may also indicate that for some populations, the potentially constructive processes of intentional TUTs may be impaired or atypical in nature, resulting in TUT episodes that do not offer feasible solution paths. To note, this study occurred during initial lockdown measures undertaken in response to the COVID-19 pandemic in Australia. This is important as the context may have impacted the measures, and the lockdown context may have acted as an ecological induction of loneliness. In Section 9.4 there is a discussion regarding how these measures may or may not be impacted by their environment.

10.5 Correlates of Intentional and Unintentional Task-Unrelated Thoughts

Across each study of this thesis, there were dynamic and significant differences in intentional and unintentional TUTs and their associations, often depending on the task context and the content of the thought. In addition, cognitive ability and subjective appraisals of participants also differed in their relation to each thought type. These results may go some way in explaining why inconsistent and seemingly contradictory findings are frequently documented in the literature, particularly when TUTs are only measured as a singular construct. To note, while the central aim of this thesis is to demonstrate the critical role of intention as a dimension to be explicitly included and considered in TUT theory, this is not to argue that intention is the only important dimension. Increasingly, research is identifying other important dimensions to consider in understanding the determinants and outcomes of off-task thought. Some additional factors that were important in this thesis are discussed below, but research has also identified the role of constraint (O'Neill et al., 2021; Smith et al., 2022) and emotional valence and mood (Banks et al., 2016; Banks & Welhaf, 2022) as influential variables.

10.5.1 Cognitive Ability (Study 1 and 2)

Study 1 and 2 replicated past work which has found an association between unintentional TUTs and cognitive ability (Robison & Unsworth, 2018; Soemer & Schiefele, 2020; Ju & Lien, 2018; Wong et al., 2022). Working memory capacity had an inverse association with unintentional TUT rates in both studies, and across three SEMs in Study 2 it was indicated that this association is driven by the ability to maintain task-related goals in mind and limit the ability for spontaneous thoughts to enter consciousness, rather than processes related to disengaging from these thoughts when they do occur (at least in the context of a standard SART) (Shipstead et al., 2016; McVay & Kane, 2010). However, in Study 1 the association between unintentional TUTs and WMC occurred during the SART of Experiment 1 but not Experiment 2. This inconsistency is also found in the literature, where some authors have failed to find an association in the SART (McVay & Kane, 2012; Smeekens & Kane, 2016). McVay and Kane (2012) argue that this may be due to differences within tasks, such as the duration of the SART. In addition, Experiment 2 only used one measure of WMC to limit attrition and fatigue of completing the task battery online. This may have also compromised the ability to observe a SART-WMC association.

An unexpected finding of Study 2 was the inverse association between intentional TUTs and cognitive ability (specifically WMC and fluid intelligence), in the context of a SART. While contrary to prediction, and the results of both experiments in Study 1, such an association is not unprecedented. Other studies have also found that *both* intentional and unintentional TUTs are inversely associated with cognitive ability (Soemer & Schiefele, 2020; Unsworth & McMillan, 2016), or surprisingly that only intentional (and not unintentional) TUTs are associated with cognitive ability (Banks & Welhaf, 2022). It may be that in certain task contexts there is greater strain on cognition which requires the use of cognitive ability to avoid not only unintentional TUTs from occurring, but also from allowing intentional TUTs to occur. Indeed, in Study 1 participants rated the SART's level of difficulty at a mean of 1.90 and 2.38 out of 5 in Experiments 1 and 2 respectively, whereas in Study 2 participants gave it a more moderate difficulty rating of 3.32. Concomitantly, interest in the task was numerically lower in Study 2 than Study 1. This possibility aligns with conceptions of deliberate mind wandering reflecting an intentional choice to 'loosen' cognitive control which then allows TUTs to enter consciousness. Some tasks contexts may challenge the ability or will to maintain control (Arango-Muñoz and Bermúdez, 2021).

In Study 2, the SART may have been more difficult and less interesting for participants as they completed it after a large battery of tasks in a single online session. In Experiments 1 and 2 of Study 1 breaks were provided between sessions in the laboratory to limit fatigue. The remote nature of Study 2 meant that participants were able to decide for themselves when or whether to have a break (although both the study instructions and between-task screens did encourage this). The timeout data from these break screens suggest a large number of participants did not engage in these breaks, perhaps in order to complete the testing session more quickly. This prolonged use of executive resources and attention to complete the tasks may have placed a larger load on cognition, and resulted in difficulties for those with lower resources to limit either type of TUT as cognitive control is a motivated act (Botnivick & Braver, 2015), and is linked to self-regulatory ability (Inzlicht et al., 2021). If participants are fatigued, lower motivation to avoid engaging in deliberate TUTs might result, again consistent with ideas that deliberate TUTs reflect intentional weakening of control. Clearly, future work must be done to better grasp the volatile association between intentional TUTs and cognitive ability. Overall, the evidence from Studies 1 and 2 suggest that working memory and maintenance abilities are important for limiting unintentional TUTs, and in some circumstances intentional TUTs.

10.5.2 Objective Difficulty and Subjective Appraisals (Study 1 and 2)

Study 1 demonstrated that when task difficulty is benchmarked by different paradigms which place separable demands on cognitive and attentional processes, a curvilinear association can arise. This is consistent with efforts by both Seli et al., (2018c) and Martínez-Pérez et al. (2021) to investigate how different attentional and working memory demands of tasks can influence TUTs. In comparing difficulty across separate tasks the documentation of a broader influence of difficulty on TUTs is enabled, assisting the comparison of studies using diverse paradigms. Indeed, Ju and Lien (2018) demonstrated that depending on task context, different cognitive (i.e., WMC) and non-cognitive (i.e., mindfulness) mechanisms will underpin the regulation of intentional and unintentional TUTs. Therefore, observing TUTs in a single task context, or measuring TUTs in multiple tasks and collapsing them together as 'overall TUT' rates can mask the nuances of associations TUTs share with the tasks in which they occur. Furthermore, Study 1 demonstrated non-linear associations with between-task benchmarks of ease and difficulty, strengthening the finding that TUTs can increase with both ease and difficulty but that they do so for different reasons. For example, TUT increases in easy tasks are likely increasing due to the influence of intentional TUT rates which are underpinned by factors such as motivation, interest, and at times, evaluations of task difficulty. In contrast, unintentional TUTs may drive increases in overly challenging contexts as they reflect increases in executive failures resulting from an overloaded cognitive system.

While differences in objective and subjective appraisals of a task are often not considered in TUT research, there have been recent efforts to integrate subjective assessment of difficulty in the context of, for example, reading comprehension tasks (Forrin et al, 2021; Kahmann et al., 2022). Study 1 of the current thesis aimed to investigate influences of difficulty perceptions in standard laboratory tasks. Results demonstrated that perceived difficulty was uniquely inversely associated with intentional TUT rates, in the SART but not the *3*-back. Study 2 also confirmed an association between intentional (but not unintentional) TUTs and perceived difficulty. These findings provide evidence that in addition to objective task demands, participant perceptions of task demands appear to be influential in determining TUT rates, but that these perceptions might not influence all TUTs in all contexts. This is important to consider, as while participant perceptions of task difficulty do often align with the objective demands of the task itself, these variables are not always identical in specific contexts (e.g. Forrin et al., 2018; 2021).

There was possible evidence to suggest a disassociation of objective and subjective difficulty in Experiment 2 of Study 1, in the two versions of a SART (standard and a changing-target version) that were employed to investigate how monotony and under-stimulation are associated with TUTs during a sustained attention task. Modification of the SART was based on findings that unchanging stimuli encourage attentional lapses (Ralph et al., 2016) as well as the evidence that compliant demands from a task, rather than task difficulty itself, inhibit intentional (but not unintentional) TUTs (Subhani et al., 2019). Modifying the SART to have a changing target between blocks resulted in participants viewing the changing-target SART as more difficult than its standard form and greater participant responsiveness (as per performance measure differences), despite the underlying requirements of both tasks being similar. Objective performance measures on the SART and changing-target SART confirmed that participants performed equal or better on the changing-target SART despite perceiving it as more difficult. This implies that a determinant of intentional TUT rates involves the subjective evaluations that participants make of the task. This is understandable as both task evaluations and the decision to engage in a TUT are top-down processes that will influence each other as participants self-regulate their attention and make decisions on how to disperse attentional resources (Kurzban et al., 2013).

However, it is important to acknowledge that it may also be the case that the changing-target SART *was* more difficult as it required keeping a new target in mind between each block despite the blocks being relatively short and participants being given about 7.5 seconds to adjust to the new target. In addition, both tasks had equivalent false alarms with only the pattern of false alarms being different (see Appendix B, Figures 20 and 21). Nonetheless, there may still have been difficulties in tracking target identities and the better performance may simply reflect engagement through greater arousal and interest in the task.

If this is the case, and the task was more difficult but participants also performed better and engaged in fewer intentional TUTs, this may indicate that when tasks are less monotonous people will modulate their intentional TUTs to ‘keep up’ with expected task demands. Indeed, participants perceived the SART as easier than the *1*-back and also engaged in more TUTs during it despite making a high number of false alarm errors. This highlights that task features can influence how participants perceive a task – that monotony can be mistaken for ease even if the task still poses a level of challenge. When the target identity changed in the modified task participants may have registered this as an increase in cognitive difficulty and become more aroused and alert during this task to meet expected demands. This again indicates that there are complicated task by participant interactions which have an influence on TUT rates, in particular on intentional TUT engagement.

That perceived difficulty was associated with TUTs during both SARTs but not the *3*-back further underpins dissociations in perceived difficulty and its relationship to TUTs. There seem to be contexts where perceived difficulty does not influence TUT rates, perhaps because there is less variation in perceptions of difficulty for those tasks or perhaps because there are other variables which more strongly relate to decisions to disengage in those tasks. Importantly then, task difficulty may also have a multidimensional nature – it is not only influenced by the response demands and memory or executive resource components of a task. Other factors such as boredom may also come into play – having to focus and sustain attention on something that is under-stimulating, unengaging, and boring, is inherently difficult even if performance of the task itself is not. Perceived difficulty/ease appears to relate to the idea of 'what makes task engagement easier' rather than only how a participant performs. In some cases then an increase in cognitive load will help with stimulation, whereas in others an increase in cognitive load pushes resources over the edge.

While a direct examination of different task contexts occurred in Study 1, across all three studies in this thesis the dependent nature of TUTs on the different contexts in which they occurred (e.g., different tasks, and in laboratory versus ecological settings) are demonstrable. Broad-ranging contextual impacts are important as studying TUTs in one context (e.g. in the laboratory, and/or in very difficult cognitive tasks) may lead to limited conclusions (i.e., that TUTs are harmful and should generally be avoided). It seems the nature of these thoughts is inextricably linked to the context in which they occur.

Furthermore, comparing the associations of TUTs in the standard SART between Study 1 and Study 2 reveals that even within a single type of task there may be certain boundaries and characteristics that change the associations observed and performance in the task. It may be that differences in features of the same task (e.g. the length of the task, the ratio of targets to non-targets, and perhaps even whether the task is performed in the laboratory versus at home and/or the length of the overall testing session) can also influence the difficulty level of performing the task. The influence of task difficulty (both objective and subjective) on TUT rates has led to proposals of a curvilinear association whereby tasks considered very easy or very difficult will both lead to greater rates of mind wandering (Randall et al., 2014, Xu & Metcalfe, 2016). This aligns with resource allocation principles [further discussed in Section 10.6.4], arguing that underload in easy tasks can lead to mind wandering just as overload in difficult tasks will also encourage off-task thoughts. While this curvilinear mind wandering – task difficulty association has been observed mostly within task paradigms (Xu & Metcalfe, 2016), this argument also explains between-task differences (Seli et al., 2018c). Further still, the mechanisms leading to this curvilinear association are not only cognitive in nature, but also related to self-regulatory processes that participants engage in when completing tasks that they perceive to either exceed or be well within their ability.

10.5.3 Motivational Processes (Study 1 and 2)

Study 1 and 2 found that participant task interest and motivation particularly influenced intentional TUT rates. Note that motivation was not measured in Study 2, but that interest is often linked to motivational processes (i.e., people will likely motivate themselves to attend to a task that they find interesting). The link between intentional TUTs and motivational processes is unsurprising in light of both previous research (Robison & Unsworth, 2018; Seli et al., 2016a; Seli et al., 2019a) as well as the reasonable assumption that the decision to deliberately engage in off-task thoughts is likely to be somewhat dependent on how motivated and interested the individual is to complete the external task. If an individual experiences a low level of motivation or finds the task to be uninteresting or inducing boredom, they may engage in mind wandering to alleviate this state, or because they have determined that they have other topics or matters which are of more value to expend cognitive resources on (e.g., Danckert et al., 2018; Kurzban et al., 2013; Thomson et al., 2015). For example, perhaps a student has an assignment due the next day and they do not perceive an external monotonous sustained attention task to be interesting or engaging enough to maintain their attention. In such a circumstance the student may decide to plan, for or perhaps worry about their assignment instead of focussing on the task. There are models of attention which argue that individuals make choices about how to allocate resources based on a type of cost-benefit analysis of the task and personal resources (Kurzban et al., 2013).

Interestingly however, there was an association between unintentional TUTs and motivational processes. In Study 1 both Experiments 1 and 2 observed that greater motivation was associated with fewer unintentional TUTs and in Study 2 the correlation of intentional and unintentional TUTs with subjective interest ratings did not statistically differ. While this is not the first study to observe associations between motivation and unintentional TUTs (e.g., see Robison & Unsworth, 2018), Smith et al. (2022) highlight that such an association may be due to participants confounding constraint and intention, as discussed in Section 7.9. Better control of this problem could be achieved by providing advice to participants about the difference between constraint and intentionality prior to the engagement with research. Equivalent strength of association of TUTs with subjective interest in Study 2 aside, it is also possible that as cognitive control is a motivated act (i.e., having a greater cognitive ability alone will not inhibit mind wandering if an individual is not motivated to actually apply cognitive control), the association observed in Study 1 may be reflecting the necessity to apply control to limit unintentional TUTs. That is, more motivated individuals will be more willing to apply attentional control to limit spontaneous thoughts whereas less motivated individuals may be more likely to allow such thoughts to enter consciousness.

Understanding the association between TUTs and motivation can further help in accounting for different associations in the literature. Indeed, Study 1 found comparably higher intentional TUT rates in the SART than previous literature, however this sample of participants also showed much lower motivation to perform on the task than has been previously observed (e.g., Robison & Unsworth, 2018). By measuring the motivation of a sample, comparison of different associations and patterns of thought content among studies can be made meaningfully. The influential role of motivational processes also has implications for theories of mind wandering which perhaps overly rely on cognitive ability as a singular predictor and determinant of TUTs.

10.5.4 Wellbeing and Social Function (Study 2 and 3)

Findings from this thesis support there being different associations between social and emotional processes, as well as personality traits (i.e., loneliness and schizotypy), with intentional and unintentional TUTs. Post-hoc analyses from Study 2 suggested that people with greater WMC experienced fewer unintentional emotional and prospective TUTs during a SART, but did not differ in their experience of intentional emotional or prospective TUTs. Study 3 investigated potential functions of TUTs and demonstrated that intentional *social* TUTs were more likely to be positive in valence and also more likely to result in greater feelings of positivity and reduced feelings of loneliness. Together, these results indicate that there are important valence and intention effects which have separate underpinning mechanisms and outcomes. These differences in emotional TUTs also align with arguments made by the content-regulation hypothesis, that the content of TUTs can implicate different mechanisms in their occurrence, and differences in subsequent outcomes of psychological wellbeing (Smallwood & Andrews-Hanna, 2013). Further still, Study 3 found personality to be an additional factor associated with the type of TUT content one may experience. This may be because personality is related to how individuals regulate and experience thoughts (Hoyle & Davisson, 2021).

In light of findings from Study 2, it is possible that maintenance abilities assist in limiting the 'stickiness' of emotional and prospective TUTs – that people with greater WMC are better equipped to block unintentional emotional TUTs from entering the working memory space (Banks & Welhaf 2022). This aligns with findings that WMC is associated with emotional regulation abilities (Schmeichel et al., 2008), and findings of impaired executive functions in a number of disorders marked by presence of distressing thoughts, which are often experienced as uncontrollable (Semkovska et al., 2019). Indeed, spontaneous mind wandering at the trait-level has been associated with clinical disorders and subclinical traits (Seli et al., 2015a; 2019b), including in the current thesis where it was associated with schizotypy (Study 3). This implies that it is uniquely the experience of unintentional TUTs through executive failures which may maintain, exacerbate, or be exacerbated by, poorer wellbeing or atypical functioning. Intentional TUTs contrast in this regard with unintentional TUTs, as Study 2 did not observe any association with WMC, and Study 3 highlighted that in daily life intentional TUTs seem to have a more constructive or functional role. The latter may assist in problem-solving and greater emotional regulation, as their content is often approach-focussed and positive in nature. However, when controlling for interpersonal schizotypal symptoms, loneliness was associated with greater intentional daily social TUTs perhaps demonstrating some important caveats for whom these benefits of intentional processes are experienced.

These findings have practical importance as they support the ability for TUTs to be functional in certain circumstances. Indeed, one debate in the literature is whether TUTs are helpful or harmful (e.g. Mooneyham & Schooler, 2013). The results within the current thesis highlight that if TUTs are spoken of homogenously, one may come to a very limited conclusion in this regard. The answer is more graded, as some TUTs appear to increase loneliness or maintain unrealistic representations of the world – particularly unintentional TUTs. However others, such as intentional TUTs, may provide opportunities for consolidating, planning, and rehearsing events and producing feelings of positivity. Yet the evidence that lonelier individuals had a small but significant tendency to engage in more intentional social TUTs further indicates that while intentional TUTs may generally be constructive, for some individuals the attempt to capitalise on these TUTs may be undermined by tendencies to engage in distorted thinking which then becomes captured by the TUTs. Notably this aligns with some models of loneliness (e.g., Cacioppo & Hawkley, 2009). A rival explanation of this result however, points to the broader context of pandemic response and lockdown, that could distort the pattern of TUTs engaged against settings where social interaction is more accessible.

In addition, these findings demonstrate that studying TUTs in the laboratory setting alone, whereby external task performance is likely to suffer when TUTs occur can lead to narrow conclusions. In this context the experience of TUTs will be more likely to have negative outcomes. In daily life, the use of TUTs for personal benefits and goal processes may be more readily observable (e.g., Poerio et al., 2016). These findings also highlight that individual differences in personality and disposition have important implications for the phenomenology of these offline thoughts.

10.6 Practical Implications of Thesis Findings

An important implication of these dissociations then is that interventions aimed at reducing mind wandering in workplace, clinical, or educational contexts will need to first understand the type of TUT they are aiming to decrease. The reduction of intentional TUTs is more likely to be responsive to interventions aimed at increasing motivation, improving self-regulation, and through changing features of task environments to be more interesting and engaging. In contrast, efforts to target unintentional mind wandering may be more challenging. These interventions might centre more on focussing on the demands of to-be-completed tasks on cognitive systems rather than on improving individual abilities. This is because to date, literature on training WMC has ambiguous findings – albeit with trends that there is a lack of efficacy (Shipstead et al., 2012). This indicates individuals will not be successful in trying to train their attentional control to avoid unintentional TUTs. Instead, unintentional TUTs will likely be better avoided by reducing demand on attention and environmental or contextual triggers of TUTs where possible to limit the opportunity for cognitive failures due to an over-stimulated or fatigued system.

The links between TUTs, social function (including loneliness and schizotypy) and emotional thought content regulation, have important implications for wellbeing. Not all TUTs are detrimental to wellbeing, and so perhaps the goal should not be to limit TUTs in every context but instead to improve the regulation of TUT content. Additionally, certain clinical and subclinical presentations may be maintained and exacerbated by negative thought content (Joorman, 2019), which may feel at least in part uncontrollable, as it seems to be associated with the capacity for the working memory system to block or inhibit negative thoughts from entering consciousness. Interventions aimed at changing the goal hierarchy may be important in limiting these TUTs, as competing goals become less effective at hijacking attention. In this way, capitalising on positive and constructive TUT content may become more possible. Moreover, TUTs which are *intentional* and which have positive content have the capacity to increase positivity and decrease in-the-moment loneliness. They also seem to feature problem-solving content which may be important to navigating social interactions (Poerio & Smallwood, 2016). This highlights a potential avenue for helping to regulate emotions and improve socio-emotional wellbeing.

10.7 Theoretical Implications of Thesis Findings

The family-resemblances framework argues that different theories of mind wandering need not be in competition with each other. Instead, these different accounts are explaining particular types of mind wandering in particular contexts. Below, the ability of different theories to account for certain aspects or patterns of TUTs within the results of the present thesis are discussed. This thesis aligns with arguments of the family-resemblances framework that integrating theories will allow for greater explanatory power of this heterogeneous construct.

10.7.1 Executive Resource Theory

Smallwood and Schooler (2006) proposed an executive resource account of mind wandering, which posits that mind wandering reflects the recruitment of executive resources for the maintenance of off-task thought. This perspective is able to account – to an extent – for the findings in the present thesis, particularly in relation to intentional TUTs. In Study 1 intentional TUT episodes were more common in the SART, which was also rated as the least difficult task. Further still, the rate of intentional TUT was inversely associated with perceived difficulty and these tasks were rated as less interesting by participants. Together this suggests that in the SART, participants were deliberately engaging in TUTs perhaps because they believed the task was simple enough to be completed without requiring substantial attentional resources, or perhaps because participants found the task monotonous and boring and so decided to engage in TUTs to alleviate boredom. Participants were able to reduce intentional TUTs when the task was perceived to be more difficult (e.g. in the changing-target SART compared to the standard SART) perhaps because they perceived there were no longer sufficient resources to maintain both task-goals and TUTs. These explanations are consistent with the idea that the same pool of resources is distributed toward task completion and off-task thought.

Social TUTs in daily life (Study 3) also featured patterns consistent with the recruitment of executive resource and goal processing. In particular, deliberate social TUT episodes were associated with constrained thought, prospection, and constructive features such as approach-based and solution-focussed thoughts. These features align with processes such as planning, problem-solving, and emotional regulation, all of which are usually regarded as requiring a level of controlled attention and effort (Cristofori et al., 2019). Poerio and Smallwood (2016) further argue that social TUTs are a form of social cognition which can facilitate adaptation of individuals to their interpersonal worlds. In this way intentional social TUT episodes may involve the use of controlled processes in order to facilitate the achievement of certain social goals.

Evidence for this link has been found in work by Poerio et al. (2015; 2016) and is also supported by findings in this thesis. Study 3 found over 70% of social mind wandering episodes reported by participants involved thoughts about a social issue or dilemma they were experiencing. People also engaged in problem-solving thoughts regarding this social issue, and would generate solutions to these problems. Finally, when these TUTs were intentionally engaged they were associated with greater feelings of positivity and reduced loneliness in-the-moment, suggesting a socio-emotional regulative function. Altogether, the results from intentional social TUTs are less consistent with TUTs simply reflecting spontaneous executive failures and more consistent with a functional and constructive role of mind wandering.

While this perspective can account for a number of associations of intentional TUTs in the current work, it cannot account for the inverse association between WMC and intentional and unintentional TUTs in the SART (Study 2). Presumably, participants with greater executive resources should engage in TUTs more often as they have the capacity to do so compared to lower WMC individuals who may need to allocate greater attention to task completion. In addition, that unintentional TUTs were so frequent in the *3*-back despite this task being greater in difficulty is also not necessarily consistent with the executive resource perspective. In a task which places great demands on attention and working memory updating, participants should reduce TUTs to allow greater focus on task completion. Indeed, supplemental materials of Appendix A (Table 33) demonstrate that both intentional and unintentional TUTs in the *3*-back predicted poorer performance on the preceding trial.

10.7.2 Current Concerns x Executive Failure Hypothesis

The *current concerns x executive failure* hypothesis states that TUTs are the result of a joint influence of cued current concerns and failures in executive control of attention which allow the concerns to enter the working memory space (McVay & Kane, 2010). Current concerns refer to any ongoing worries or goals of an individual, which can be internally or externally cued to consciousness. The pattern of results for unintentional TUT rates across each study in this thesis are consistent with arguments from this perspective. This is unsurprising given the executive failure perspective has often been considered best suited for accounting for unintentional instances of TUTs (Banks & Welhaf, 2022; Robison & Unsworth, 2018). Unintentional TUTs were more common in difficult task contexts (Study 1) and inversely associated with WMC and maintenance processes (Studies 1 and 2), consistent with the possibility that these thoughts are entering consciousness due to failures in the executive control system. In addition, the content and socio-emotional functions of these thoughts did reflect ongoing goals and issues individuals were facing (i.e., *current* concerns) and were also less well associated with constructive outcomes (Study 3). This indicates a level of uncontrollability over the nature of these thoughts, again consistent with a lack of executive control.

While the *current concerns x executive failure* hypothesis readily accounts for the pattern of unintentional TUTs observed, it cannot account for deliberate episodes in a straightforward and meaningful way. First, at a conceptual level intentional episodes by definition imply a level of control over, or allocation of resources toward, self-generated thoughts rather than a failure in attention control. However, Arango-Muñoz and Bermúdez (2021) offer that perhaps intentional TUTs reflect not the intentional engagement of a thought but the intentional omission of cognitive control, which then allows TUTs into the working memory space. Yet, this is still not entirely consistent with an executive failure perspective as the individual is intending to release control, rather than intending to maintain control but experiencing a control failure. Alternatively, intentional TUTs may reflect the deliberate engagement in a thought rather than a release of control, but again this could not be considered a failure in attentional control. It seems then that intentional TUTs are not able to be fully accounted for by an executive failure perspective as it currently stands.

The association between WMC and intentional TUTs observed in Study 2 may align better with this framework as it would indicate that greater attentional control ability protects against the occurrence of both intentional and unintentional TUTs. Likewise, under the intentional omission framework

(Arango-Muñoz & Bermúdez, 2021) if intentional TUTs reflect omissions of executive control, then perhaps individuals with greater WMC choose to lapse control less often in certain task contexts as they would be more equipped to meet the demands of the task. Yet the idea that release of cognitive control underpins intentional TUTs introduces another question regarding at what point in a TUT's ignition intention is considered characteristic of the thought. That is, if someone chooses to release control they are not necessarily choosing to experience a TUT but merely deciding to withdraw attention from a task. If intention is seen as a characteristic of the mechanism causing the TUT (i.e., released cognitive control) then perhaps this could be considered an *intentional* TUT. However, if intention must be a feature of the engagement of the TUT itself then perhaps these TUTs are still considered as unintentional as they were not necessarily the aim of the participant when releasing cognitive control. These possibilities again highlight the need for greater clarity on the terms and constructs which are used in this literature.

The executive failure perspective can also offer insight to the unintentional TUT – task difficulty association as under this framework mind wandering decreases as tasks become more difficult (to a point). When a task becomes exceedingly difficult (such as a *3*-back) then this may result in an increase in spontaneous TUTs as the cognitive system becomes overwhelmed and thus vulnerable to more off-task thoughts entering consciousness (Adam & Vogel, 2017). Furthermore, in easy task contexts perhaps participants reduce executive control or effort in inhibiting TUTs which allows them to enter consciousness more frequently. Although again, this cannot necessarily account for why *intentional* TUTs are occurring in these tasks. It could be –following Arango-Muñoz and Bermúdez's (2021) view– that in easier tasks participants choose to ease control over their focus of attention and so allow mind wandering into consciousness. However, arguably the intentional goal of omitting executive control to allow mind wandering to occur is not a *failure* of executive control as the individual has chosen to relax attentional control. It is also likely that in easier tasks participants choose to think of other – perhaps more interesting – goals to ease boredom or frustration.

An important step in future research will be to understand what is meant by 'intentional' mind wandering as this will have significant implications for theory. Indeed as outlined in Chapter 5 there are ongoing questions regarding the conceptual validity of intentional and unintentional TUTs (Murray & Krasich, 2022). There are questions of whether the mind can truly wander intentionally, and proposals that if intentional TUTs involve the purposeful engagement in thought regarding an alternative goal then is this truly "task-unrelated", or does the new goal not become the new "task" (thus making the thought task-related)? Arango-Muñoz and Bermúdez's (2021) surrealist concept of releasing control offers an alternative possibility to this question. This possibility is further supported by the fact that TUTs are often spoken of as reflecting the 'default' state of the mind (Christoff et al., 2016), and cognitive control is required to inhibit such TUTs to allow focus on the task (McVay & Kane, 2010). People may choose to relax such control, and this could be what is reflected in intentional TUT episodes.

Additionally, people have goal hierarchies whereby a number of goals can compete for attention or be triggered to attention by external or internal cues (Klinger, 1999; Smallwood & Schooler, 2006; McVay & Kane, 2010). Intentional TUTs may then reflect moments of goal competition whereby individuals switch focus toward another goal either because it is more interesting, they are not motivated to complete the external task goal, or for other reasons. As such, these intentional TUTs would be task-unrelated in terms of their relatedness to the 'original' or 'intended' task goal despite representing thoughts which are task-related in terms of an alternative, personally salient goal. In light of these ongoing debates it should be reiterated that in the current thesis 'task-unrelated' was defined as being unrelated to the external experimenter- (Studies 1 and 2) and individual- (Study 3) defined to-be-completed task, and intentional TUTs are those moments whereby participants chose not to engage with the task (either by intentionally engaging a stream of thought or intentionally relaxing cognitive control). This thesis contends that it is important to study these moments of intentional off-task thinking, and their cognitive and contextual correlates to better unravel how and if they differ from spontaneous episodes of TUT.

The executive failure hypothesis does account for a number of observed associations with unintentional TUTs and may be able to explain some of the intentional TUT findings. However, that these types of thought have also exhibited differences which are not formally accounted for by this framework demonstrates that this theory provides a useful but limited account for mind wandering phenomena. Both the executive resource and executive failure hypotheses emphasise the role of cognitive ability and capacity in determining the occurrence and/or maintenance of TUTs. It is clear from the studies in this thesis, as well as evidence from the wider literature, that cognitive ability and attentional control do play an important role. Yet, to focus on these factors alone is turning out to be overly simplistic, as highlighted by the separable determinants and associations of intentional and unintentional episodes across the three studies presented here. For theory to be successful in predicting and accounting for off-task thoughts, it needs to be able to integrate multiple factors outside of cognitive ability, which can lead to, inhibit, or alter the manifestation of TUT episodes.

10.7.3 Context and Content Regulation

The context-regulation hypothesis proposes that the context in which mind wandering is being measured and observed will determine both how frequently it occurs, and the associations that it has with cognitive ability. This theory reconciles some of the claims of the executive resource and executive failure hypotheses by identifying that the context in which mind wandering takes place will change its associations. In this way, conflicting findings in the literature need not be seen as contradictory but rather as representing important contextual boundaries which influence off-task thought. This argument follows findings of a non-linear relationship between task difficulty and mind wandering frequency observed in within-task paradigms in the literature (Randall et al. 2019; Xu & Metcalfe 2016) as well as in between-task paradigms (Seli et al., 2018c).

That mind wandering increases in both easy and difficult tasks is not necessarily inconsistent but instead reflects an interaction between the context of the task, different types of TUTs (e.g., intentional and unintentional), and their underpinning mechanisms. In easier tasks intentional TUTs are more common and this may reflect motivation, interest, boredom, or the perception that one can both engage in TUTs and perform the task without impairment (whether or not this is the actual case). Likewise difficult task contexts encourage more unintentional TUTs, which may be due to more difficulty maintaining attentional control due to the overwhelm of the cognitive system. These ideas are consistent with the argument that TUTs reflect re-allocation of attention at certain times (i.e., executive resource hypothesis) and failures in attention at other times (i.e., executive failure hypothesis).

Furthermore, in the context of laboratory tasks, TUTs are often inherently determined to be detrimental as they reduce the cognitive resources allocated to external task completion. However, as demonstrated in Study 1 and 2 intentional TUTs may serve a function for boredom/interest-regulation (as it occurred in a monotonous task determined to be less interesting and more simple compared to other tasks). In addition, the results from Study 3 support a functional and constructive role of social TUTs in daily life. Accordingly, mind wandering is not fundamentally helpful or harmful – its outcomes and impacts depend on the context of the episode. Echoing the sentiment of Smallwood and Andrews-Hanna (2013), to have a satisfactory understanding of mind wandering phenomena, a balanced perspective that does not attempt to reduce the many forms of mind wandering to a single construct must be achieved.

Insistence on a reduced position will inevitably lead to theories which fail to make fruitful and reliable predictions and explanations.

Similarly, the content-regulation hypothesis argues that the influence mind wandering will have on psychological wellbeing and functioning depends on the content of the episode. The characteristics of mind wandering content varies considerably between individuals, with factors such as mood, personality, and psychopathology having significant capacity to influence content. Some forms of thought content can exacerbate psychological distress, whereas other forms may be constructive. This is exemplified in Study 3 whereby interpersonal schizotypy and loneliness were both associated with more frequent maladaptive content in mind wandering. In contrast intentional mind wandering features constructive content and predicted enhanced wellbeing following the episode. Furthermore, in Study 2 neither fluid intelligence nor updating ability (which may reflect disengagement processes - Shipstead et al., 2016; Martin et al., 2020), predicted intentional or unintentional mind wandering during a SART when shared variance with WMC was taken into account. However, in a series of linear regressions the unique variance from the WMC factor did significantly predict fewer unintentional *emotional* TUTs during the SART (i.e., both positively and negatively valenced episodes combined). This again highlights that mind wandering is not a singular phenomenon, and along with the intention of an episode, the content of the episode also has important implications for interpretation of its role.

10.7.4 Resource Allocation and Self-Regulation

While traditional perspectives often fail to differentiate between intentional and unintentional mind wandering, and also tend to focus too narrowly on cognitive mechanisms at the expense of other determinants such as motivation and self-regulation, there are emerging frameworks which have shown the capacity to integrate a more nuanced understanding of these mind wandering phenomena. In addition to the context and content regulation hypotheses, resource allocation frameworks can also explicitly consider the task characteristics (including difficulty) as well as cognitive and non-cognitive processes when determining and accounting for mind wandering across various contexts (Randall et al., 2019; 2022; Thomson et al., 2013). These explanations do so by describing two types of attentional resource allocation; controlled processing refers to any process that requires conscious cognitive control to execute; automatic processing refers to processes which require very little attention because the stimulus-response pattern is well-learnt (Thomson et al., 2015).

In relation to TUTs, controlled processes, such as those required to complete tasks with a higher cognitive load (for example, working memory updating tasks), may reduce all mind wandering to allow more attentional resources to focus on task demands. As such the results observed in Study 1 may reflect more controlled processing needed to ‘keep up’ with the relevant stimuli and update working memory contents in the *3*-back task compared to the more repetitive SART. Indeed, when the target-identity was changed in the modified SART this also showed a reduction in intentional TUTs, perhaps reflecting the application of more controlled attention to meet perceived demands. In contrast, over time people may begin to automatically respond to monotonous tasks which then result in the use of excess cognitive resources for intentional off-task thought. This repetitive and monotonous response might also be more likely to be perceived as reflecting simple, easy, and/or unengaging tasks (as evidenced in the SART of Studies 1 and 2) and participants may feel under-loaded or under-stimulated. Intentionally engaging in TUTs can alleviate a bored or frustrated mood state or allow the opportunity to attend to more personally salient matters. Monotony and/or time-on-task may also result in unintentional TUTs as executive control can wane and allow more TUTs into consciousness. In contrast, exceedingly difficult tasks may overwhelm the cognitive system and increase the chance for cognitive lapses in attention, which can be experienced as unintentional mind wandering.

The results from this thesis align with assumptions of resource allocation arguments that both motivational and self-regulatory processes can influence and be influenced by perceptions of task difficulty and cognitive load. Motivation generally influences the intensity and persistence of human behaviours (Campbell & Pritchard, 1976) and can also determine, to an extent, self-regulatory processes during a task. Through this combined influence, motivation ultimately determines how one will distribute attentional resources in the pursuit of personal goals and interests (Kanfer et al., 1996). Therefore, when participants are cognitively underloaded they can become demotivated to focus on the given task, and as an attempt to regulate feelings of boredom can change the focus of their thoughts. Likewise, if a task is overly challenging individuals might become frustrated or doubt their ability to complete the task and lose motivation, and again they may mind wander as a result of these changes to resource allocation. Indeed, Ju and Lien (2018) argued that self-regulatory processes will have differential roles to play in the regulation of intentional and unintentional TUTs, depending on the task being performed. Lastly, curvilinear associations of mind wandering with levels of within-task difficulty further demonstrate that the causes and consequences of TUTs will not be the same in all tasks (Xu & Metcalfe, 2026; Randall et al., 2019).

In the context of personality and mood considered in Studies 2 and 3, personality influences how people regulate emotions and interpret and process information. The interaction between personality traits and current concerns in one's daily life can therefore direct attentional resources to attend to such concerns. One mechanism through which this may occur is people's "offline" thoughts about their social worlds and daily life interactions (Poerio & Smallwood, 2016). Mind wandering may be a mechanism for attempting to regulate emotions by processing past, and preparing for future, interactions. Importantly, this may be a beneficial pursuit when intentionally engaged and when an individual has adaptive self-regulatory tendencies. But if the individual has a maladaptive view of their world (e.g. they are a lonelier individual) or if they are more susceptible to unintentional mind wandering (e.g. those with higher schizotypal traits) this may have negative outcomes. Likewise, emotions and cognitions often interact with each other and indeed people with greater executive ability are also often better able to regulate their emotions. This is reflected in the current thesis, through the inverse association between people with higher WMC and the experience of spontaneous emotional TUTs when trying to complete an external task, consistent with prior work (Banks & Welhaf, 2022).

Recent efforts have further investigated resource allocation explanations for mind wandering. Robison and Brewer (2022) extended on a model of attentional regulation known as the *adaptive gain theory* (Aston-Jones & Cohen, 2005). These researchers argue that one possible mechanism of variability in WMC may be individual differences in the ability to maintain a moderate level of arousal – that is avoiding both under- and over-stimulation. This is what is more or less argued in U-shaped hypotheses of mind wandering – whereby to limit mind wandering and maintain focus an individual needs to avoid being overwhelmed and underwhelmed by task demands. To investigate this, they measured attention control, fluid intelligence, WMC, and employed pupillometry (which is argued to reflect arousal levels). These authors found, consistent with correlations from Study 2, an inverse association between overall TUTs and all three cognitive factors. While they did not find an association between pupil diameter variability and WMC, they did find an association with TUTs. This further supports how the regulation/allocation of attention and arousal influences the experience of TUTs. They did not differentiate between intentional and unintentional TUTs however, and so in light of the argument of this thesis, it is apparent that further work needs to investigate an arousal regulation explanation that integrates both spontaneous and deliberate TUTs.

10.8 Limitations

While the findings of this thesis go some way in further justifying the necessity of the explicit inclusion of intention as a dimension in predictive theories of mind wandering, the studies included here are not without limitations. One relatively unavoidable methodological decision that had to be made was to change data collection using remote rather than in situ laboratory methods. This decision was necessary in order to comply with COVID-19 stay-at-home orders and social distancing requirements. This limited experimenter control over the types of environmental distractions that may have occurred and so influenced mind wandering measurements, task types, and numbers of tasks. In stating this, there is some evidence to suggest that mind wandering during experimental tasks completed in participants' homes does not necessarily result in increases in mind wandering rates (Diede et al., 2022) and online cognitive data has been found to have equal reliability to laboratory data for a range of experimental tasks (Crump et al., 2013). In addition, while Study 3 would always be collected outside the laboratory, collecting daily life social cognition during a period when individuals were experiencing extreme disruption and change in their social interactions likely would have shaped the general context and possibly the content of mind wandering episodes to some degree, and therefore the pattern of associations observed.

Another limitation to consider is the ongoing debate regarding the reliability of self-reported measures in general, but in particular of self-reported mind wandering rates. As discussed in Section 2.6, the probe-caught method of measuring mind wandering has shown reliability and validity in a range of circumstances. Indeed, as many mind wandering probes simply require participants to report either being on-task or not the opportunity for variations in probe interpretation or level of self-disclosure are limited. It may be difficult for participants to answer more detailed probes such as those used in Study 3, and to overcome possible issues with this, participants were also asked to provide a short summary of the mind wandering episode to be compared to the probed responses for consistency. However, researchers can have unconscious biases or differences in interpretations which will also influence the measurement. In addition, Kane et al. (2021) recently highlighted uncertainties regarding validity of self-reports of *intention* in mind wandering. Thus, ongoing efforts to verify probe-caught mind wandering reports will be essential. To date however, there are no reliable objective alternative measures of intention of TUT episodes.

As regards the construct validity of intention measures, Kane et al. (2021) found evidence to suggest that intentional probes had lower confidence ratings from participants when compared to other probes and found nominal evidence for differences in associations of TUTs when they were measured by intentionality probes versus content and depth probes. If it is to be accepted that participants can judge whether they are mind wandering, on-task, or experiencing task-related interference, then there is also reason to believe they can judge whether they intended to mind wander or not (Seli et al., 2015b; 2015c). However, considering the evidence of Kane et al. (2021) perhaps future measures should incorporate confidence ratings to better understand how participants are engaging with probes and to guide the interpretation of observed associations between variables. The use of forced-choice prompts in the current thesis is also important to note, whereby participants had to categorise their thoughts into pre-defined options, rather than using a continuous scale method for rating their thought content. Research is beginning to use continuous scales for measuring the intentionality of TUTs in acknowledgement that intention may be a graded construct (Kane et al., 2021). The use of continuous scales in future work may therefore further allow for greater nuance in understanding the nature of TUTs.

This thesis also shares the concern outlined by Kane et al. (2021) that as mind wandering theory currently stands, it does not specify the role of intention or make strong enough or precise enough arguments about what associations and disassociations these TUTs should have, if any. This lack of precision makes judgements of construct validity difficult, as results and measured outcomes cannot be evaluated against theoretically-based predictions. Somewhat promisingly, many of the findings from the current thesis *are* consistent with results from past literature and were also consistent across studies, including associations with motivation and WMC. Yet work is still needed to integrate intention into theory, and evidence needs to be accumulated which can allow for sound appraisals of the consistency and reliability of intentional and unintentional TUT associations. The current work stands as a contribution to these efforts, but evidence still needs to be amassed to increase confidence in the validity, predictions, and explanations of these cognitive phenomena.

The measurement of variables such as motivation and interest in this thesis relied on a single-item self-report which was completed after the task in question. While this is consistent with methods from past literature (Seli et al., 2015b; Seli et al., 2017a; Unsworth & McMillan 2013), single-item measurements may also be unreliable in a number of ways. For example, having multiple items can make it easier to control for response styles such as acquiescence and extreme responses. Some variables are also too complex to accurately measure with a single item. While concerns about single-item report are well-founded, motivational and affective constructs have been successfully measured with single-items in contexts such as education (Gogol et al., 2014) and addiction (Kotz et al., 2013). Future research comparing mind wandering associations when using single and multi-item measures of certain constructs, such as motivation, can provide further adjudication of whether single-items can be reliably used in this area of work. Conversely, more detailed multi-item measurements of constructs will rely on clearer explication so that they adequately sample those attributes that interact with mechanisms of mind wandering.

Finally, Study 1 indicated that perceived and objective difficulty may have separable influences on TUT frequency in different task contexts. However, this argument can only be made tentatively as there are difficulties in drawing unambiguous interpretations about objective/subjective difficulty. This is especially the case as, in a multi-factorial system, there are a number of variables which can influence how difficult a task is considered to be (Seli et al., 2018c) There is also disagreement and variability in how best to define difficulty (i.e., is it the cognitive load? the complexity of the task? the response demand? the type of processes involved?). As such, a greater understanding of how perceived and objective difficulty functions to determine TUTs in different contexts will be necessary. Study 1 suggests the possibility that these processes may be separable in some task contexts.

10.9 Future Directions

To begin, while correlations between performance measures and TUTs were included in the appendices this thesis did not focus on examining the effects of TUTs on performance in tasks. To get a fuller picture of not only the mechanisms of TUTs in laboratory tasks but also their consequences and outcomes, future studies can incorporate direct comparisons of intentional and unintentional TUTs on performance. This will further inform whether i) all forms of TUTs are equally harmful to performance of cognitive tasks, and ii) all types of tasks are interrupted by TUTs. For example, Kam and Handy (2014) found TUTs did not disrupt performance on task switching but did disrupt updating and inhibition, and Wong et al. (2022) found that those with greater task switching performance ability also actually report greater trait-level spontaneous TUTs. This suggests that just as we cannot generalise the associations of TUTs with cognitive and motivational abilities across all task contexts, it also cannot be assumed that their impact on performance would be the same. A comparison of how TUTs relate to or impact performance on different tasks can further inform the types of mechanisms which are implicated in the production and/or prevention of these thoughts. That is, if TUTs are impairing performance on some types of tasks but not others this may reveal the types of processes which are compromised by off-task thoughts and therefore which may be involved in their occurrence.

Similarly, in Study 3 the difficulty of tasks participants were performing was not assessed, nor whether episodes of TUTs impacted performance on these tasks. While it is difficult to objectively evaluate performance on tasks individuals are completing in their daily lives, future initiatives to understand TUTs in ecological settings could incorporate scales of perceived difficulty and self-evaluations of performance on the task. Other than in the education and driving literatures, there is still a significant lack of research investigating the impact of mind wandering on real-world tasks. This may be due to the complications in attempting to objectively assess variables such as task difficulty in the tasks people complete in their daily lives. However efforts to do so can inform whether TUTs in daily life impact tasks being completed or whether – due to the greater freedom of task selection and completion in daily life compared to laboratories – they are engaged in a more flexible manner which avoids task disruptions.

On this note, Study 3 found that social TUTs often reflect ongoing dilemmas in individual's social lives as well as efforts to deal with these dilemmas. This aligns with the content-regulation hypothesis for mind wandering, which was developed specifically as a clinical framework for understanding the impact that mind wandering content can have on well-being. Future work should aim to close the gap of understanding between how individuals think about social interactions and what transpires in actual interactions. For example, individuals could be asked to provide an example of a feasible interpersonal issue or dilemma they are facing in their lives. A daily diary study could then assess how frequently they find themselves thinking of this issue in the form of intentional and unintentional TUTs. After a window of time, participants may then be asked whether i) they resolved the dilemma, and ii) the resolution involved actions thought of during the TUT episodes. This would provide initial insights into whether actions thought up during TUTs translate into (or are at least related to) approaches used in daily life.

Finally, it is clear that there are important task boundary conditions which are influencing mind wandering and its association with other variables of interest. One possibility is that processing used for TUTs might reflect processing used in the task. It would be interesting to compare the SART with the modified SART (update of target) to see whether otherwise similar tasks show a difference in relationships to TUTs in terms of maintenance and disengagement processes. Likewise, Study 1 found an inverse association between unintentional TUTs and motivation, and found that intentional TUT was not associated with WMC. However, Study 2 found no association between unintentional TUTs and motivation, and found that intentional TUT was inversely associated with WMC (as well as unintentional mind wandering). Both sets of findings are consistent with results documented in the literature, indicating that such relationships are not spurious but reflect aspects of tasks and testing conditions which can alter the mind wandering – executive control relationship. A systematic comparison of TUTs during the same tasks differing along a number of dimensions (e.g. duration of task, target non-target ratios) and other factors related to the participant (e.g., perceptions of task difficulty, motivation, level of fatigue) may assist in understanding how the same task can show diverging associations depending on certain task characteristics and boundary conditions. Investigating the interactions between motivation, cognitive ability, and TUTs would further assist in understanding difficult findings in the literature. One potential method could be a factorial design examining how high and low motivation and high and low WMC influence TUT frequency. If, as is argued, cognitive control requires motivation to be applied, it could be predicted that high WMC low motivation participants would experience similar TUT frequencies to low WMC participants.

More generally, an important recommendation for future directions is to review mind wandering theory as it currently stands and explicitly integrate intention into the accounts that propose mechanisms underpinning mind wandering. In each study, observations supported the claim that intentional and unintentional mind wandering exhibit separable associations with a number of factors. In order to more fully account for and predict mind wandering in different contexts, theories must consider which *type* of mind wandering they are predicting and how each type of mind wandering interacts with the context of the task, the nature of the setting and disposition of the participant. Theories which only explicitly mention cognitive ability and refer to mind wandering as a singular phenomenon (i.e., traditional executive failure and executive resource theories) will not capture the nuance of the different types of thought which fall under the umbrella of 'mind wandering'. It should be acknowledged that these early theories have provided informative frameworks for explaining the potential relationship(s) between cognitive ability and off-task thought thus far, but future theory will need to integrate more than cognitive ability to make to meaningfully expand explanatory power for this ubiquitous cognitive activity. Indeed, work is already being done with resource allocation frameworks, as well as the context and content regulation hypotheses, as attempts to integrate multiple factors in the occurrence and consequences of mind wandering.

As mentioned in Sections 5.5, 10.7.2, and 10.8 there is conceptual debate regarding how 'intentional' mind wandering should be defined, and indeed whether any such form of mind wandering really exists. While it is not within the scope of this thesis to explore the different philosophical debates on off-task thought, clearly in order to make sense of the associations intentional mind wandering has with motivation and cognition (among other variables), it will be important to understand what researchers define intentional mind wandering as. Specifically, whether intentional mind wandering reflects the deliberate decision to engage in off-task thought, or the deliberate decision to withdraw cognitive control and allow off-task thought into cognition. While at first glance these differences may seem small, they have clear implications for the mechanisms proposed to underpin this type of mind wandering. This may be particularly important in understanding the variable associations between intentional TUTs and executive control measures (e.g. WMC) in both Study 2 and the literature more widely (Soemer & Schiefele 2020; Banks & Welhaf, 2022). Perhaps this association reflects the tendency of lower WMC individuals to disengage from cognitive control and allows distraction to enter consciousness during an ongoing external task. An understanding of the factors and task boundary conditions which influence the presence (and/or absence) of this association will be necessary to further understanding what underpins the occurrence of intentional TUT.

10.10 Conclusions

This thesis aimed to investigate the differences in contextual, cognitive, and dispositional correlations of intentional and unintentional TUTs across a range of domains. The rationale for investigating differences broadly across contexts was to demonstrate the widespread implications of this dimension of off-task thoughts. In doing so, this thesis highlights the need for theory to integrate different mechanisms and explanations readily and explicitly for mind wandering as a set of phenomena rather than attempt to explain it as a unitary construct, echoing the calls made by others (Seli et al., 2015b). This thesis established differences in spontaneous and deliberate off-task thought on measures of task difficulty evaluations, WMC, maintenance and disengagement processes, interest, and motivation, schizotypy, and loneliness, and content and outlook. The pattern of results here further suggest that there are important mechanistic similarities but also distinctions underpinning the engagement in each type of thought.

Consistent with findings in the literature, this thesis found that greater intentional mind wandering was associated with less interest in, and motivation toward, the external task (Seli et al., 2015b; O'Neill et al., 2021; Smith et al., 2022). A WMC-intentional mind wandering association was observed in some, but not all, task contexts (consistent with variable findings in the literature as well, e.g. Banks & Welhaf, 2022; Soemer & Schiefele, 2020). Intentional TUTs were influenced by top-down regulatory processes association with task evaluation, such as subjective task difficulty appraisals. Unintentional TUTs were consistently associated with WMC, and reductions in certain forms of unintentional TUTs during a sustained attention task (i.e., unintentional *emotional* and unintentional *prospective* mind wandering) were associated with greater updating ability. Unintentional *social* TUTs at the state level and spontaneous mind wandering at the trait level was also associated with greater schizotypal traits. Important differences were observed in the socio-functional outcomes of each type of thought, with intentional TUTs exhibiting more constructive pro-social content and unintentional TUTs demonstrating less constructive content. Congruent with this, intentional social TUTs were associated with greater post-TUT positivity and less loneliness when compared to unintentional social TUTs.

There are clear implications of the current work. Most evidently, theory will need to continue adapting to accommodate a wide range of factors which can influence and lead to mind wandering. These theories will also need to explicitly make mention of whether the mind wandering they are trying to predict is intentional or unintentional in nature, as each form of off-task thought has unique cognitive, contextual, and dispositional associations as well as unique outcomes. While traditional theories such as the executive resource and executive control hypotheses have been influential and indeed are still useful in accounting for some of the cognitive mechanisms which can influence mind wandering susceptibility, particularly during a range of laboratory tasks, theory must also account for other non-cognitive variables which can influence self-generated cognitions and may be of more influence under conditions of greater ecological validity. Consistent with arguments from the family-resemblances framework, the current thesis demonstrates that different theories of mind wandering seem to be accounting for specific types of mind wandering in specific contexts. Further still, not all mind wandering is a detrimental pursuit, with some forms of social mind wandering during daily life demonstrating a possible functional and adaptive role for individuals. Emerging theories which continue to explore and integrate new variables into their explanations will be necessary to fully capture the nuance of these complex mind wandering phenomena. Ultimately, the empirical evidence of this body of work asserts that the role of intention should be more integral to theorising on mind wandering, as reiterated and expanded upon by the dynamic associations these types of TUTs demonstrated with key variables of interest in the literature.

References

Adam, K.C.S., & Vogel, E.K. (2017). Confident failures: Lapses of working memory reveal a metacognitive blind spot. *Attention, Perception, & Psychophysics, 79*(5), pp. 1506-1523. DOI: 10.3758/s13414-017-1331-8

Agnoli, S., Vanucci, M., Pelagatti, C., & Corazza, G.E. (2018). Exploring the link between mind wandering, mindfulness, and creativity: A multidimensional approach. *Creativity Research Journal, 30*(1), 41-53. DOI: https://doi.org/10.1080/10400419.2018.1411423

Andrillon,T., Windt, J., Silk, T., Drummond, S.P.A., Bellgrove, M.A., & Tsuchiya, N. (2019). Does the mind wander when the brain takes a break? Local sleep in wakefulness, attentional lapses and mind-wandering. *Frontiers in Neuroscience, 13*(3). DOI: 10.3389/fnins.2019.00949

Antrobus, J.S. (1968). Information theory and stimulus-independent thought. *British Journal of Psychology, 59*(4), 423-430.

Arabaci, G., & Parris, B.A. (2018). Probe-caught spontaneous and deliberate mind wandering in relation to self-reported inattentive, hyperactive and impulsive traits in adults. *Scientific Reports, 8*(4113). DOI: https://doi.org/10.1038/s41598-018-22390-x

Arango-Muñoz, S., & Bermúdez, J.P. (2021). Intentional mind-wandering as intentional omission: The surrealist method. *Synthese, 199,* pp.7727-7748. DOI: https://doi.org/10.1007/s11229-021-03135-2

Aston-Jones, G., & Cohen, J.D. (2005). An interpretive theory of locus-coeruleus – norepinephrine function: Adaptive gain and optimal performance. *Annual Reviews in Neuroscience, 28,* pp.403-450. DOI: 10.1146/annurev.neuro.28.061604.135709

Atkinson, R.C., & Shiffrin, R.M. (1968). Human memory: A proposed system and its control processes. *Psychology of Learning and Motivation, 2*, pp. 89-195. DOI: https://doi.org/10.1016/S0079-7421(08)60422-3

Au, J., Sheehan, E., Tsai, N., Duncan, G.J., Buschkuehl, M., & Jaeggi, S.M. (2015). Improving fluid intelligence with training on working memory: A meta-analysis. *Psychonomic Bulletin & Review, 22*(2), 366-377. DOI: 10.3758/s13423-014-0699-x

Badcock, J.C., & Dragović, M. (2006). Schizotypal personality in mature adults. *Personality and Individual Differences, 40*(1), pp.77-85. DOI: https://doi.org/10.1016/j.paid.2005.06.015

Badcock, J.C., Barkus, E., Cohen, A.S., Bucks, R. & Badcock, D.R. (2016). Loneliness and schizotypy are distinct constructs, separate from general psychopathology. *Frontiers in Psychology, 7.* DOI: 10.3389/fpsyg.2016.01018

Baddeley, A.D. & Hitch, G. (1974). Working memory. *Psychology of Learning and Motivation, 8*, pp. 47-89. DOI: https://doi.org/10.1016/S0079-7421(08)60452-1

Baddeley, A.D., (1996). Exploring the central executive. *Quarterly Journal of Experimental Psychology, 49* (1). DOI: https://doi.org/10.1080/713755608

Baddeley, A.D & Logie, R.H. (1999). Working memory: the multiple component model. In: A. Miyake, and P. Shah (Eds.), *Models of Working Memory.* Cambridge University Press.

Baddeley, A.D. (2000). The episodic buffer: A new component of working memory? *Trends in Cognitive Science, 4* (11), pp.417-423. DOI: 10.1016/s1364-6613(00)01538-2.

Baddeley, A.D. (2007). *Working memory, thought, and action.* Oxford University Press. DOI: https://doi.org/10.1093/acprof:oso/9780198528012.001.0001

Baddeley, A.D. (2012). Working memory: theories, models, and controversies. *Annual Review of Psychology, 63*, pp.1-29. DOI: 10.1146/annurev-psych-120710-100422

Baird, B., Smallwood, J., & Schooler, J.W. (2011). Back to the future: autobiographical planning and the functionality of mind-wandering. *Consciousness & Cognition, 20*(4), pp.1604-1611. DOI: 10.1016/j.concog.2011.08.007

Baird, B., Smallwood, J., Mrazek, M.D., Kam, J.W.Y., Franklin, M.S., & Schooler, J.W. (2012). Inspired by distraction: mind wandering facilitates creative incubation. *Psychological science, 23* (10), pp.1117-1122. DOI: 10.1177/0956797612446024

Banks, J.B., Welhaf, M.S., Hood, A.V.B., Boals, A., & Tartar, J.L. (2016). Examining the role of emotional valence of mind wandering: All mind wandering is not equal. *Consciousness & Cognition, 43*, 167-176. DOI: 10.1016/j.concog.2016.06.003

Banks, J.B., & Welhaf, M.S. (2022). Individual differences in dimensions of mind wandering: The mediating role of emotional valence and intentionality. *Psychological Research, 86*(5), pp.1495-1517. DOI: 10.1007/s00426-021-01579-2

Bargh, J.A., & Pietromonaco, P. (1982). Automatic information processing and social perception: The influence of trait information presented outside of conscious awareness on impression formation. *Journal of Personality and Social Psychology, 43*(3), 437-449.

Bargh, J.A. (1997). The automaticity of everyday life. In R.S. Wyer, Jr. (Ed.), *The automatic of everyday life: Advances in social cognition,* (Vol. 10). Lawrence Erlbaum Associates.

Barron, E., Riby, L.M., Greer, J., & Smallwood, J. (2011). Absorbed in thought: the effect of mind wandering on the processing of relevant and irrelevant events. *Psychological Science, 22* (5), pp.596-601. DOI: 10.1177/0956797611404083

Barrouillet, P. (1996). Transitive inferences from set-inclusion relations and working memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 22*(6), 1408-1422. DOI: https://doi.org/10.1037/0278-7393.22.6.1408

Berner, E.S. (2011). Mind wandering and medical errors. *Medical Education, 45*(11), pp. 1068-1069. DOI: https://doi.org/10.1111/j.1365-2923.2011.04072.x

Bopp, K.L., & Verhaeghen, P. (2020). Aging and *n*-back performance: A meta-analysis. *Journals of Gerontology: Series B, 75*(2), 229-240. DOI: 10.1093/geronb/gby024

Botvinick, M. & Braver, T. (2015). Motivation and cognitive control: from behaviour to neural mechanism. *Annual Review of Psychology, 66,* pp.83-113. DOI: 10.1146/annurev-psych-010814-015044

Bozhilova, N.S., Michelini, G., Kuntsi, J., & Asherson, P. (2018). Mind wandering perspective on attention-deficit/hyperactivity disorder. *Neuroscience and Biobehavioural Reviews, 92,* pp.464-476. DOI: 10.1016/j.neubiorev.2018.07.010

Brown, T.A. (2006). *Confirmatory factor analysis for applied research.* Guilford Press.

Brown, L.H., Silvia, P.J., Myin-Germeys, I., Lewandowski, K.E, & Kwapil, T.R. (2008). The relationship of social anxiety and social anhedonia to psychometrically identified schizotypy. *Journal of Social and Clinical Psychology, 27,* 127-149. DOI: https://doi.org/10.1521/jscp.2008.27.2.127

Burdett, B., Charlton, S., & Starkey, N. (2019). Mind wandering during everyday driving: An on-road study. *Accident, Analysis, and Prevention, 122,* pp. 76-84. DOI: 10.1016/j.aap.2018.10.001

Cacioppo, J.T., & Hawkley, L.C. (2009). Perceived social isolation and cognition. *Trends in Cognitive Science, 13*(10), 447-454. DOI: 10.1016/j.tics.2009.06.005

Callard, F., Smallwood, J., Golchert, J., & Margulies, D.S. (2013). The era of the wandering mind? Twenty-first century research on self-generated mental activity. *Frontiers in Psychology, 4.* DOI: 10.3389/fpsyg.2013.00891

Calvillo, D.P. (2014). Individual differences in susceptibility to misinformation effects and hindsight bias. *The Journal of General Psychology, 14*(4), pp.393-407. DOI: https://doi.org/10.1080/00221309.2014.954917

Campbell, J.P., & Pritchard, R.D. (1976). Motivation theory in industrial and organizational psychology. In M. Dunnette (Ed.), *Handbook of industrial and organizational psychology*. Rand McNally.

Campbell, D.J. (1988). Task complexity: A review and analysis. *The Academy of Management Review, 13*(1), 40-52. DOI: https://doi.org/10.2307/258353

Carriere, J.S.A., Seli, P., & Smilek, D. (2013). Wandering in both mind and body: Individual differences in mind wandering and inattention predict fidgeting. *Canadian Journal of Experimental Psychology, 67,* pp. 19-31. DOI: doi:10.1037/a0031438

Casner, S.M., & Schooler, J.W. (2015). Vigilance impossible: Diligence, distraction, and daydreaming all lead to failures in a practical monitoring task. *Consciousness & Cognition, 35,* pp.33-41. DOI: https://doi.org/10.1016/j.concog.2015.04.019

Cattell, R.B. (1963). Theory of fluid and crystallised intelligence: A critical experiment. *Journal of Educational Psychology, 54*(1), pp.1-22. DOI: https://doi.org/10.1037/h0046743

Chau, A.K.C., Zhu, C., & So, S.H.W. (2019). Loneliness and the psychosis continuum: a meta analysis on positive psychotic experiences and a meta-analysis on negative psychotic experiences. *International Review of Psychiatry, 31*(5-6), 471-490. DOI: 10.1080/09540261.2019.1636005

Chiappe, D.L., & Chiappe, P. (2007). The role of working memory in metaphor production and comprehension. *Journal of Memory and Language, 56*(2), pp.172-188. DOI: https://doi.org/10.1016/j.jml.2006.11.006

Christoff, K., Gordon, A.M., Smallwood, J., Smith, R., & Schooler, J. (2009). Experience sampling during fMRI reveals default network and executive system contributions to mind wandering. *Proceedings of the National Academy of Sciences, 106*(21), 8719-8724. DOI: 10.1073/pnas.0900234106

Christoff, K., Irving, Z.C., Fox, K.C.R., Spreng, N.R., Andrews-Hanna, J.R. (2016). Mind-wandering as spontaneous thought: A dynamic framework. *Nature Reviews Neuroscience, 17,* pp.718-731. DOI: https://doi.org/10.1038/nrn.2016.113

Conway, A.R.A., & Engle, R.W. (1994). Working memory and retrieval: A resource-dependent inhibition model. *Journal of Experimental Psychology: General, 123*(4), 354-373. DOI: https://doi.org/10.1037/0096-3445.123.4.354

Conway, A.R., & Engle, R.W. (1996). Individual differences in working memory capacity: more evidence for a general capacity theory. *Memory, 4*(6), pp.577-590. DOI: 10.1080/741940997

Conway, A.R., Kane, M.J., Bunting, M.F., Hambrick, D.Z., Wilhelm, O., & Engle, R.W. (2005). Working memory span tasks: A methodological review and users guide. *Psychonomic Bulletin & Review, 12, 5*, 796-86. https://doi.org/10.3758/BF03196772

Cowan, N. (1988). Evolving conceptions of memory storage, selective attention, and their mutual constraints within the human processing system. *Psychological Bulletin, 104,* pp.163-181. DOI: 10.1037/0033-2909.104.2.163

Cowan, N. (1995). *Attention and memory: an integrated framework.* Oxford University Press.

Cowan, N. (1999). An embedded-processes model of working memory. In A. Miyake & P. Shah (Eds.), *Models of Working Memory: Mechanisms of Active Maintenance and Executive Control*. Cambridge University Press.

Cristofori, I., Cohen-Zimmerman, S., & Grafman, J. (2019). Executive functions. *Handbook of Clinical Neurology, 163,* pp.197-219. DOI: https://doi.org/10.1016/b978-0-12-804281-6.00011-2

Crump, M.J.C., McDonnell, J.V., & Gureckis, T.M. (2013). Evaluating Amazon's Mechanical Turk as a tool for experimental behavioural research. *PLoS ONE, 8*(3). DOI: https://doi.org/10.1371/journal.pone.0057410

Danckert, J., Hammerschmidt, T., Marty-Dugas, J., Smilek, D. (2018). Boredom: Under-aroused and restless. *Consciousness & Cognition, 61,* pp. 24-37. DOI: 10.1016/j.concog.2018.03.014

Dane, R. (2018). Where is my mind? Theorizing mind wandering and its performance-related consequences in organizations. *The Academy of Management Review, 43*(2), 179-197. DOI: https://doi.org/10.5465/amr.2015.0196

Daneman, M., & Carpenter, P.A. (1980). Individual differences in working memory and reading. *Journal of Verbal Learning and Verbal Behavior, 19* (4), 450-466. DOI: https://doi.org/10.1016/S0022-5371(80)90312-6

Daneman, M. & Tardif, T. (1987). Working memory and reading skill re-examined. In Coltheart (Ed.), *Attention and performance 12: The psychology of reading* . Lawrence Erlbaum Associates, Inc.

Diede, N.T., Gyurkovics, M., Nicosia, J., Diede, A., & Bugg, J.M. (2022). The effect of context on mind wandering in younger and older adults. *Consciousness & Cognition, 97.* DOI: https://doi.org/10.1016/j.concog.2021.103256

Dubey, S., Dubey, M.J., Ghosh, R., Mitchell, A.J., Chatterjee, S., Das, S., Pandit, A., Ray, B.K., Das, G., & Benito-León, J. (2022). The cognitive basis of psychosocial impact in COVID-19 pandemic. Does it encircle the default mode network of the brain? A pragmatic proposal. *Medical Research Archives, 10*(3). DOI: 10.18103/mra.v10i3.2707

Dweck, C.S., & Leggett, E.L. (1988). A social-cognitive approach to motivation and personality. *Psychological Review, 95*(2), 256-273. DOI: https://doi.org/10.1037/0033-295X.95.2.256

Ecker, U.K.H., Lewandowsky, S., & Oberauer, K. (2014). Removal of information from working memory: A specific updating process. *Journal of Memory and Language, 74*, 77-90. DOI: 10.1016/j.jml.2013.09.003

Ekstrom, R.B., French, J.W., Harman, H., & Derman, D. (1976). *Manual for kit of factor-referenced tests.* Educational Testing Service.

Engle, R., Kane, M.J., & Tuholski, S.W. (1999). Individual differences in working memory capacity and what they tell us about controlled attention, general fluid intelligence, and functions of the prefrontal cortex. In A. Miyake & P. Shah (Eds.), *Models of working memory: Mechanisms of active maintenance and executive control.* Cambridge University Press.

Engle, R.W. (2002). Working memory capacity as executive attention. *Current Directions in Psychological Science, 11* (1). DOI: https://doi.org/10.1111/1467-8721.00160

Engle, R.W., & Kane, M.J. (2004). Executive attention, working memory capacity, and a two-factor theory of cognitive control. In B.H. Ross (Ed.), *The psychology of learning and motivation: Advances in research and theory,* Vol. 44, pp.145-199. Elsevier Science.

Engle, R.W. (2018). Working memory and executive attention: A revisit. *Perspectives in Psychological Science, 13*(2), 190-193. DOI: 10.1177/1745691617720478

Feng, S., D'Mello, S., & Graesser, A.C. (2013). Mind wandering while reading easy and difficult texts. *Psychonomic Bulletin & Review, 20,* pp.586-592. DOI: https://doi.org/10.3758/s13423-012-0367-y

Fiske, S.T., & Taylor, S.E. (1991). *Social Cognition* (2nd ed.). McGraw-Hill Book Company.

Franklin, M.S., Mrazek, M.D., Anderson, C.L., Smallwood, J., Kingstone, A., & Schooler, J.W. (2013). The silver lining of a mind in the clouds: interesting musings are associated with positive mood while mind-wandering. *Frontiers in Psychology, 4*(583). DOI: 10.3389/fpsyg.2013.00583

Forrin, N.D., Risko, E.F., & Smilek, D. (2018). In the eye of the beholder: Evaluative context modulates mind-wandering. *Acta Psychologica, 185,* pp.172-179. DOI: 10.1016/j.actpsy.2018.02.005

Forrin, N.D., Mills, C., D'Mello, S.K., Risko, E.F., Smilek, D., & Seli, P. (2021). Tl;dr: Longer sections of text increase rates of unintentional mind-wandering. *Journal of Experimental Education, 89*(2). DOI: https://doi.org/10.1080/00220973.2020.1751578

Forster, S., & Lavie, N. (2009). Harnessing the wandering mind: the role of perceptual load. *Cognition, 111*(3), 345-355. DOI: https://doi.org/10.1016/j.cognition.2009.02.006

Foulsham, T., Farley, J., & Kingstone, A. (2013). Mind wandering in sentence reading: decoupling the link between mind and eye. *Canadian Journal of Experimental Psychology, 67* (1), pp.51-59. DOI: 10.1037/a0030217.

Fox, K.C., Spreng, R.N., Ellamil, M., Andrews-Hanna, J.R., & Christoff, K. (2015). The wandering brain: meta-analysis of functional neuroimagining studies of mind-wandering and related spontaneous thought processes. *Neuroimage, 111,* 611-621. DOI: 10.1016/j.neuroimage.2015.02.039

Franklin, M.S, Broadway, J.M, Mrazek, M.D., Smallwood, J., & Schooler, J.W. (2013). Window to the wandering mind: pupillometry of spontaneous thought while reading. *Quarterly Journal of Experimental Psychology, 66* (12), DOI: https://doi.org/10.1080/17470218.2013.858170

Friedman, N.P., & Miyake, A. (2004). The reading span test and its predictive power for reading comprehension ability. *Journal of Memory and Language, 51*(1), 136-158. DOI: https://doi.org/10.1016/j.jml.2004.03.008

Frith, E., Kane, M.J., Welhaf, M.S., Christensen, A.P., Silvia, P.J., & Beaty, R.E. (2021). Keeping creativity under control: Contributions of attention control and fluid intelligence to divergent thinking. *Creativity Research Journal, 33*(2), pp. 138-137. DOI: https://doi.org/10.1080/10400419.2020.1855906

Geden, M. & Feng, J. (2015). Simulated driving environment impacts mind wandering. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 59*(1). DOI: https://doi.org/10.1177/1541931215591240

Giambra, L.M., (1989). Task-unrelated thought frequency as a function of age: A laboratory study. *Psychology and Aging, 4* (2), pp.136-143. DOI: https://doi.org/10.1037/0882-7974.4.2.136

Giambra, L.M. (1995). A laboratory method for investigating influences on switching attention to task-unrelated imagery and thought. *Consciousness & Cognition, 4*(1), 1-21. DOI: 10.1006/ccog.1995.1001

Gil-Jardiné, Née, M., Lagarde, E., Schooler, J., Contrand, B., Orriols, L., & Galera, C. (2017). The distracted mind on the wheel: Overall propensity to mind wandering is associated with road crash responsibility. *PLoS ONE.* DOI: https://doi.org/10.1371/journal.pone.0181327

Gilhooly, K.J. (2004). Working memory and reasoning. In J.P. Leighton & R.J. Sternberg (Eds.), *The nature of reasoning.* Cambridge University Press.

Gogol, K., Brunner, M., Goetz, T., Martin, R., Ugen, S., Keller, U., Fischbach, A., Preckel, F. (2014). "My questionnaire is too long!" The assessments of motivational-affective constructs with three-item and single-item measures. *Contemporary Educational Psychology, 39*(3), pp.188-205. DOI: https://doi.org/10.1016/j.cedpsych.2014.04.002

Golchert, J., Smallwood, J., Jefferies, E., Seli, P., Huntenburg, J.M., Liem, F., Lauckner, M.E., Oligschäger, S., Bernhardt, B.C., Villringer, A., & Margulies, D.S. (2017). Individual variation in intentionality in the mind-wandering state is reflected in the integration of the default-mode, fronto-parietal, and limbic networks. *Neuroimage, 146,* pp.226-235. DOI: 10.1016/j.neuroimage.2016.11.025

Gollwitzer, P.M. (1999). Implementation intentions: Strong effects of simple plans. *American Psychologist, 54*(7), 493-503. DOI: https://doi.org/10.1037/0003-066X.54.7.493

Goulding, S. M., McClure-Tone, E. B., & Compton, M. T. (2009). Associations between multiple dimensions of schizotypy and sociodemographic variables in a non-psychiatric sample of young adults. The Journal of Nervous and Mental Disease, 197(10), 786-789. DOI: 10.1097/NMD.0b013e3181b975e6

Gouraud, J., Delorme, A., & Berberian, B. (2018). Dynamic of mind wandering within automated environments. *Conference: Association for Scientific Study of Consciousness.*

Greer, T., & Dunlap, W.P. (1997). Analysis of variance with ipsative measures. *Psychological Methods, 2*(2), 200-207. https://doi.org/10.1037/1082-989X.2.2.200

Harrison, T.L., Shipstead, Z., & Engle, R.W. (2015). Why is working memory capacity related to matrix reasoning tasks? *Memory & Cognition, 43,* 389-396. DOI: 10.3758/s13421-014-0473-3

Hayes, A.F., & Coutts, J.J. (2020). Use omega rather than Cronbach's alpha for estimating reliability. But… *Communication Methods and Measures, 14*(1), pp.1-24. DOI: https://doi.org/10.1080/19312458.2020.1718629

Hays, R.D., & DiMatteo, M.R. (1987). A short-form measure of loneliness. *Journal of Personality Assessment, 51*(1), 69-81. DOI: https://doi.org/10.1207/s15327752jpa5101_6

Hawkley, L.C., & Cacioppo, J.T. (2010). Loneliness matters: A theoretical and empirical review of consequences and mechanisms. *Annals of Behavioral Medicine, 40*(2). DOI: 10.1007/s12160-010-9210-8

Henry, J.D., Bailey, P.E., & Rendell, P.G. (2008). Empathy, social functioning and schizotypy. *Psychiatry Research, 160*(1), pp.15-22. DOI: 10.1016/j.psychres.2007.04.014

Hicks, K.L., Foster, J.L., & Engle, R. (2016). Measuring working memory capacity on the web with the online working memory lab (the OWL). *Journal of Applied Research in Memory and Cognition, 5*(4), 478-489.

Ho, N.S.P., Poerio, G., Konu, D., Turnbull, A., Sormaz, M., Leech, R., Bernhardt, B., Jefferies, E., & Smallwood, J. (2020). Facing up to the wandering mind: Patterns of off-task laboratory thought are associated with stronger neural recruitment of right fusiform cortex while processing facial stimuli. *NeuroImage, 214.*

Hoffman, F., Banzhaf, C., Kanske, P., Bermpohl, F., & Singer, T. (2016). Where the depressed mind wanders: Self-generated thought patterns as assessed through experience sampling as a state marker of depression. *Journal of Affective Disorders, 198,* pp.127-134. DOI: 10.1016/j.jad.2016.03.005

Holtzer, R., Shuman, M., Mahoney, J.R., Lipton, R., & Verghese, J. (2011). Cognitive fatigue defined in the context of attention networks. *Neuropsychology, Development, and Cognition. Section B, Aging, Neuropsychology, and Cognition, 18*(1), pp.108-128. DOI: 10.1080/13825585.2010.517826

Horn, J.L., & Cattell, R.B. (1966). Refinement and test of the theory of fluid and crystallised intelligences. *Journal of Educational Psychology, 57.* DOI:

Hoyle, R.H., & Davisson, E.K. (2021). Self-regulation and personality. In O.P. John & R.W. Robins

(Eds.), *Handbook of personality: Theory and research* (pp. 608-624). The Guildford Press.

Hox, J. (2002). *Multilevel analysis techniques and applications*. Lawrence Erlbaum Associates Publishers.

Ilkowska, M., & Engle, R.W. (2010). Working memory capacity and self-regulation. In R.H. Hoyle (Ed.), *Handbook of personality and self-regulation* (pp. 265-290). Wiley-Blackwell. DOI: https://doi.org/10.1002/9781444318111.ch12

Inzlicht, M., Werner, K.M., Briskin, J.L., & Roberts, B.W. (2021). Integrating models of self-regulation. *Annual Review of Psychology, 72,* pp.319-345. DOI: https://doi.org/10.1146/annurev-psych-061020-105721

Irving, Z.C. (2016). Mind-wandering is unguided attention: accounting for the "purposeful" wanderer. *Philosophical Studies, 173,* pp.547-571. DOI: https://doi.org/10.1007/s11098-015-0506-1

Irving, Z.C., Glasser, A., Gopnik, A., Pinter, V., & Sripada, C. (2020). What does "mind-wandering" mean to the folk? An empirical investigation. *Cognitive Science: A Multidisciplinary Journal, 44* (10). DOI: https://doi.org/10.1111/cogs.12908

Isaac, V., Cheng, T., Townsin, L., Assareh, H., Li, A., & McLachlan, C.S. (2021). Happiness and worry about developing loneliness: A cross-sectional analysis of rural, regional, and urban Australian communities. *Environmental Research and Public Health, 18*(8), pp.9501. DOI: https://doi.org/10.3390/ijerph18189501

Isacescu, J., Struk., A.A., & Danckert, J. (2017). Cognitive and affective predictors of boredom proneness. *Cognition and Emotion, 31*(8), 1741-1748. DOI: 10.1080/02699931.2016.1259995

Jaeggi, S.M., Buschkuehl, M., Jonides, J., & Perrig, W.J. (2009). Improving fluid intelligence with training on working memory. *PNAS, 105*(19), 6829-6833. DOI: https://doi.org/10.1073/pnas.080126810

James, W. (1890). *The principles of psychology, Vol 1.* Henry Holt and Co.

Jonides, J., & Smith, E.E. (1997). The architecture of working memory. In M.D. Rugg (Ed.), *Cognitive neuroscience* (pp. 243-276). The MIT Press.

Jonkman, L.M., Markus, C.R., Franklin, M.S., & van Dalfsen, J.H. (2017). Mind wandering during attention performance: Effects of ADHD-inattention symptomatology, negative mood, ruminative response style and working memory capacity. *PLoS One, 12* (7). DOI: 10.1371/journal.pone.0181213

Joorman, J., Levens, S.M., & Gotlib, I.H. (2011). Sticky thoughts: Depression and rumination are associated with difficulties manipulating emotional material in working memory. *Psychological Science, 22*(8). DOI: https://doi.org/10.1177/0956797611415539

Joorman, J. (2019). Is the glass half empty or half full and does it even matter? Cognition, emotion, and psychopathology. *Cognition & Emotion, 33*(1), pp.133-138. DOI: https://doi.org/10.1080/02699931.2018.1502656

Ju, Y.J., & Lien, Y.W. (2018). Who is prone to wander and when? Examining an integrative effect of working memory capacity and mindfulness trait on mind wandering under different task loads. *Consciousness & Cognition, 63,* pp.1-10. DOI: https://doi.org/10.1016/j.concog.2018.06.006

Kahmann, R., Ozuer, Y., Zedelius, C.M., & Bikleveld, E. (2022). Mind wandering increases linearly with text difficulty. *Psychological Research, 86,* pp. 284-293. DOI: https://doi.org/10.1007/s00426-021-01483-9

Kahneman, D. (1973). *Attention and Effort.* Prentice-Hall.

Kállai, J., Rózsa, S., Hupuczi, E., Hargitai,R., Birkás, B., Hartung, I., Martin, L., Herold, R., & Simon, M. (2019). Cognitive fusion and affective isolation: Blurred self-concept and empathy deficits in schizotypy. *Psychiatry research, 271,* 178-186. DOI: 10.1016/j.psychres.2018.11.045

Kam, J.W.Y., Dao, E., Farley, J., Fitzpatrick, K., Smallwood, J., Schooler, J.W,. & Handy, T.C. (2011). Slow fluctuations in attentional control of sensory cortex. *Journal of Cognitive Neuroscience, 23,* 460-470. DOI: 10.1162/jocn.2010.21443

Kam, J.W.Y., & Handy, T.C. (2014). Differential recruitment of executive resources during mind wandering. *Consciousness and Cognition: An International Journal, 26,* pp.51-63. DOI: https://doi.org/10.1016/j.concog.2014.03.002

Kane, M.J., Bleckley, M.K., Conway, A.R.A, & Engle, R.W. (2001). A controlled-attention view of working-memory capacity. *Journal of Experimental Psychology: General, 130* (2), 169-183. DOI: https://doi.org/10.1037/0096-3445.130.2.169

Kane, M.J., & Engle, R.W. (2003). Working-memory capacity and the control of attention: The contributions of goal neglect, response competition, and task set to Stroop interference. *Journal of Experimental Psychology: General, 132* (1), 47-70. DOI: https://doi.org/10.1037/0096-3445.132.1.47

Kane, M.J., Hambrick, D.Z., & Conway, A.R.A (2005). Working memory capacity and fluid intelligence are strongly related constructs: Comment on Ackerman, Beier, & Boyle (2005). *Psychological Bulletin, 131*(1), 66-71. DOI: https://doi.org/10.1037/0033-2909.131.1.66

Kane, M.J., Brown, L.H., McVay, J.C., Silvia, P.J., Myin-Germeys, I., & Kwapil, T.R. (2007a). For whom the mind wanders, and when: an experience-sampling study of working memory and executive control in daily life. *Psychological Sciences*, *18*(7), 614-621. DOI: 10.1111/j.1467-9280.2007.01948.x

Kane, M.J., Conway, A.R.A, Miura, T.K., & Colflesh, G.J.H. (2007b). Working memory, attention control, and the n-back task: A question of construct validity. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 33*, pp. 615-622. DOI: 10.1037/0278-7393.33.3.615

Kane, M.J., Conway, A.R.A, Hambrick, D.Z., & Engle, R.W. (2008). Variation in working memory capacity as variation in executive attention and control. In Andrew Conway and others (Eds). *Variation in Working Memory.* Oxford Academic.

Kane, M.J., & McVay, J.C. (2012). What mind wandering reveals about executive-control abilities and failures. *Current Directions in Psychological Science, 21* (5), pp.348-354. DOI: https://doi.org/10.1177/0963721412454875

Kane, M.J., Meier, M.E., Smeekens, B.A., Gross, G.M., Chun, C.A., Silvia, P.J., Kwapil, T.R. (2016). Individual differences in executive control of attention, memory, and thought, and their associations with schizotypy. *Journal of Experimental Psychology: General, 145*(8), 1017-1048. DOI: 10.1037/xge0000184

Kane, M.J., Gross, G.M., Chun, C.A.,, Smeekens, B.A., Meier, M.E., Silvia, P.J., & Kwapil, T.R. (2017). For whom the mind wanders, and when, varies across laboratory and daily-life settings. *Psychological Sciences, 28* (9), pp.1271-1289. DOI: 10.1177/0956797617706086

Kane, M.J., Smeekens, B.A., Meier, M.E., Welhaf,, M.S., & Phillips, N.E. (2021). Testing the construct validity of competing measurement approaches to probed mind-wandering reports. *Behavior Research Methods, 53,* pp.2372-2411. DOI: https://doi.org/10.3758/s13428-021-01557-x

Kanfer, R. & Ackerman, P.L. (1989). Motivation and cognitive abilities: An integrative/aptitude-treatment interaction approach to skill acquisition. *Journal of Applied Psychology, 74*(4), pp. 657-690. DOI: https://doi.org/10.1037/0021-9010.74.4.657

Kanfer, R., Ackerman, P.L., & Heggestad, E.D. (1996). Motivational skills & self-regulation for learning: A trait perspective. *Learning and Individual Differences, 8*(3), pp. 185-209. DOI: https://doi.org/10.1016/S1041-6080(96)90014-X

Kanske, P., Sharifi, M., Smallwood, J., Dziobek, I., & Singer, T. (2017). Where the narcissistic mind wanders: Increased self-related thoughts are more positive and future oriented. *Journal of Personality Disorders, 31*(4), pp.553-566. DOI: 10.1521/pedi_2016_30_263

Kawagoe, T., Onoda, K., & Yamaguchi, S. (2020). The association of motivation with mind wandering in trait and state levels. *PLoS ONE, 15*(8). DOI: https://doi.org/10.1371/journal.pone.0237461

Kellogg, R.T., Turner, C.E., Whiteford, A.P., & Mertens, A. (2016). The role of working memory in planning and generating written sentences. *Journal of Writing Research, 7* (3), 397-416. DOI: https://doi.org/10.17239/jowr-2016.07.03.04

Khaksari, K., Condy, E., Millerhagen, J., Anderson, A.A., Dashtestani, H., & Gandjbakhche, A.H., (2019). Effects of performance and task duration on mental workload during working memory task. *Photonics*, *6*(94). https://doi.org/10.3390/photonics6030094

Killingsworth, M.A., & Gilbert, D..T (2010). A wandering mind is an unhappy mind. *Science, 330* (6006). DOI: 10.1126/science.1192439

Klinger, E. (1971). *Structure and functions of fantasy.* Wiley-Interscience.

Klinger, E. (1999). Thought flow: Properties and mechanisms underlying shifts in content. In JA. Singer P. Salovey (Eds.). *At play in the fields of consciousness: Essays in honor of Jerome L. Singer.* Erlbaum.

Klinger, E. (2009). Daydreaming and fantasizing: Thought flow and motivation. In K.D. Markman, W.M.P. Klein, & J.A. Suhr (Eds.), *Handbook of imagination and mental stimulation*. Psychology Press.

Kline, R.B. (2016). *Principles and practices of structural equation modelling* (4th ed.). Guilford Press.

Korovkin, S., Vladimirov, I., Christopolskaya, A., & Savinova, A. (2018). How working memory provides representational change during insight problem solving. *Frontiers in Psychology, 8.* DOI: https://doi.org/10.3389/fpsyg.2018.01864

Kotz, D., Brown, J., & West, R. (2013). Predictive validity of the Motivation to Stop Scale (MTSS): A single-item measure of motivation to stop smoking. *Drug and Alcohol Dependence, 128*(1-2), pp.15-19. DOI: https://doi.org/10.1016/j.drugalcdep.2012.07.012

Kruger, T.B., Dixon, M.J., Graydon, C., Stange, M., Larche, C.J., Smith, S.D., & Smilek, D. (2020). Using deliberate mind-wandering to escape negative mood states: Implications for gambling to escape. *Journal of Behavioral Addictions, 9*(3), pp.723-733. DOI: 10.1556/2006.2020.00067

Kurzban, R., Duckworth, A., Kable., J.W., Myers, J. (2013). An opportunity cost model of subjective effort and task performance. *Behavioral Brain Science, 36*(6), pp. 661-679. DOI: 10.1017/S0140525X12003196

Langdon, R., & Coltheart, M. (1999). Mentalising, schizotypy, and schizophrenia. *Cognition, 71*(1), 43-71. DOI: 10.1016/s0010-0277(99)00018-9

Le, T., Cowan,T., Schwartz, E.K., Elvevåg, B., Holmlund, T.B., Foltz, P.W., Barkus, E., & Cohen,A.S. (2019). The importance of loneliness in psychotic-like symptoms: Data from three studies. *Psychiatry Research, 282.* DOI: https://doi.org/10.1016/j.psychres.2019.112625

Leding, J.K. (2011). Working memory predicts the rejection of false memories. *Memory, 20*(3), pp.217-223. DOI: https://doi.org/10.1080/09658211.2011.653373

Leszczynski, M., Chaieb, L., Reber, T.P., Derner, M., Axmacher, N., Fell, J. (2017). Mind wandering simultaneously prolongs reactions and promotes incubation. *Scientific Reports, 7.* DOI: https://doi.org/10.1038/s41598-017-10616-3

Levinson, D.B., Smallwood, J., & Davidson, R.J. (2012). The persistence of thought: Evidence for a role of working memory in the maintenance of the task-unrelated thinking. *Psychological Science 23*(4), 375-380. DOI: 10.1177/0956797611431465

Lewis-Peacock, J.A., Kessler, Y., & Oberauer, K. (2018). The removal of information from working memory. *Annals of the New York Academy of Sciences.* DOI: doi: 10.1111/nyas.13714

Linck, J.A., & Weiss, D.J. (2015). Can working memory and inhibitory control predict second language learning in the classroom. *SAGE Open.* DOI: https://doi.org/10.1177/2158244015607352

Linz, R., Pauly, R., Smallwood, J., & Engert, V. (2021). Mind-wandering content differentially translates from lab to daily life and relates to subjective stress experience. *Psychological Research, 85,* pp.649-659. DOI: https://doi.org/10.1007/s00426-019-01275-2

Long, J.S. (1997). *Regression models for categorical and limited dependent variables.* Sage.

Lorah, J. (2018). Effect size measures for multilevel models: Definition, interpretation, and TIMSS example. *Large-scale Assessments in Education, 6*(8). DOI: https://doi.org/10.1186/s40536018-0061-2

Lupton, D., & Lewis, S. (2023). Australians' experiences of COVID-19 during the early months of the crisis: A qualitative interview study. *Frontiers in Public Health, 23*(11). DOI: 10.3389/fpubh.2023.1092322

Malkovsky, E., Merrifield, C., Goldberg, Y., & Danckert, J. (2012). Exploring the relationship between boredom and sustained attention. *Experimental Brain Research, 221,* 59-67. DOI: 10.1007/s00221-012-3147-z

Mancas, M., Ferrera, V.P., Riche, N., & Taylor, J.G. (2016). *From human attention to computational attention: A multidisciplinary approach.* Springer Publishing Company, Incorporated.

Manly, T., Robertson, I.H., Galloway, M., & Hawkins, K. (1999). The absent mind: Further investigations of sustained attention to response. *Neuropsychologia, 37*(6), 661-670. DOI: https://doi.org/10.1016/S0028-3932(98)00127-4

Mar, R.A., Mason, M.F., & Litvack, A. (2012). How daydreaming relates to life satisfaction, loneliness, and social support: The importance of gender and daydream content. *Consciousness & Cognition, 21*(1), 401-407. DOI: https://doi.org/10.1016/j.concog.2011.08.001

Mars, R.B., Neubert, F.X., Noonan, M.P., Sallet, J., Toni, I., & Rushworth, M.F.S. (2012). On the relationship between the "default mode network" and the "social brain". *Frontiers in Human Neuroscience, 6*(189). DOI: 10.3389/fnhum.2012.00189

Marchetti, I., Koster, E.H.W., Klinger, E., & Alloy, L.B. (2016). Spontaneous thought and vulnerability to mood disorders: The dark side of the wandering mind. *Clinical Psychological Science, 4*(5), pp. 835-857. DOI: 10.1177/2167702615622383

Martin, J.D., Shipstead, Z., Harrison, T.L., Redick, T.S., Bunting, M., & Engle, R.W. (2020). The role of maintenance and disengagement in predicting reading comprehension and vocabulary learning. *Journal of Experimental Psychology: Learning, Memory, & Cognition, 46*(1), pp.140-154. DOI: https://doi.org/10.1037/xlm0000705

Martin, L., Mills, L., D'Mello, S.K., & Risko, E.F. (2018). Re-watching lectures as a study strategy and its effect on mind wandering. *Experimental Psychology, 65*(5), 297-305. DOI: https://doi.org/10.1027/1618-3169/a000412

Martin, R.C., Yan, H., & Schnur, T.T. (2014). Working memory and planning during sentence production. *Acta Psychologica, 152,* pp.120-132. DOI: 10.1016/j.actpsy.2014.08.006

Martínez-Pérez, V., Baños, D., Andreu, A., Tortajada, M., Palmero, L.B., Campoy, G., & Fuentes, L.J. (2021). Propensity to intentional and unintentional mind-wandering differs in arousal and executive vigilance tasks. *PLoS ONE, 16*(10). DOI: 10.1371/journal.pone.0258734

Mason, M.F., Norton, M.I., Van Horn, J.D., Wegner, D.M., Grafton, S.T., & Macrae, C.N. (2007). Wandering minds: The default network and stimulus-independent thought. *Science, 315*(5810), 393-395. DOI: 10.1126/science.1131295

Mathöt, S., Schreji, D., & Theeuwes, J. (2012). OpenSsesame: An open-source graphical experiments builder for the social sciences. *Behavioral Research Methods, 44*(2), pp.314-324. DOI: 10.3758/s13428-011-0168-7

Mckeown, B., Poerio, G.L., Strawson, W.H., Martinon, L.M., Riby, L.M., Jefferies, E., McCall, C., & Smallwood, J. (2021). The impact of social isolation and changes in work patterns on ongoing thought during the first COVID-19 lockdown in the United Kingdom. *PNAS, 118*(4), DOI: https://doi.org/10.1073/pnas.2102565118

McVay, J.C., & Kane, M.J. (2009). Conducting the train of thought: Working memory capacity, goal neglect, and mind wandering in an executive-control task. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 35* (1), pp.196-204. DOI: https://doi.org/10.1037/a0014104

McVay, J.C., & Kane, M.J. (2010). Does mind wandering reflect executive function or executive failure? Comment on Smallwood and Schooler (2006) and Watkins (2008). *Psychological Bulletin, 136* (2), pp.188-197. DOI: https://doi.org/10.1037/a0018298

McVay, J.C., & Kane, M.J. (2012). Why does working memory capacity predict variation in reading comprehension? On the influence of mind wandering and executive attention. *Journal of Experimental Psychology: General, 141* (2), pp.302-320. DOI: https://doi.org/10.1037/a0025250

McVay, J.C., Unsworth, N., McMillan, B.D., & Kane, M.J. (2013). Working memory capacity does not always support future-oriented mind-wandering. *Canadian Journal of Experimental Psychology, 67*(1), pp.41-50. DOI: 10.1037/a0031252

McVay, J.C., & Kane, M.J. (2013). Dispatching the wandering mind? Toward a laboratory method for cuing "spontaneous" off-task thought. *Frontiers in Psychology, 4*(570). DOI: https://doi.org/10.3389/fpsyg.2013.00570

Meier, M.E. (2019). Is there a positive association between working memory capacity and mind wandering in a low-demand breathing task? A preregistered replication of a study by Levinson, Smallwood, and Davidson (2012). *Psychological Science*, *30*(5), pp. 789-797. DOI: 10.1177/0956797619837942

Melby-Lervåg, M., Redick, T.S., & Hulme, C. (2016). Working memory training does not improve performance on measures of intelligence or other measures of "far transfer": Evidence from a meta-analytic review. *Perspectives on Psychological Science, 11*(4). DOI: https://doi.org/10.1177/174569161663561

Merckelbach, H., Otgaar, H., & Lynn, S.J. (2022). Empirical research on fantasy proneness and its correlates 2000-2018: A meta-analysis. *Psychology of Consciousness: Theory, Research, and Practice, 9*(1), pp.2-26. DOI: https://doi.org/10.1037/cns0000272

Mesghina, A., Wong, J.T., Davis, E.L., Lerner, B.S., Jackson-Green, B.J., & Richland, L.E. (2021). Distressed to distracted: Examining undergraduate learning and stress regulation during the COVID-19 pandemic. *AERA Open, 7*(2), pp.1-20. DOI: https://doi.org/10.1177/23328584211065721

Mildner, J.N., & Tamir, D.I. (2021). The people around you are inside your head: Social context shapes spontaneous thought. *Journal of Experimental Psychology: General*, *150*(11), 2375-2386. DOI: https://doi.org/10.1037/xge0001057

Miller, G.A. (2003). The cognitive revolution: A historical perspective. *Trends in Cognitive Sciences, 7* (3), 141-144. DOI: https://doi.org/10.1016/S1364-6613(03)00029-9

Miller, A.B., & Lenzenweger, M.F. (2012). Schizotypy, social cognition, and interpersonal sensitivity. *Personality Disorders, 3*(4), pp.379-392. DOI: 10.1037/a0027955

Minor, K.S., Hardin, K.L., Beaudette, D.M., Waters, L.C., White, A.L., Gonzenbach, V., & Robbins, M.L. (2020). Social functioning in schizotypy: How affect influences social behavior in daily life. *Journal of Clinical Psychology, 76*(12), p.2212-2221. DOI: 10.1002/jclp.23010

Mittner, M., Boekel, W., Tucker, A.M., Turner, B.M., Heathcote, A., & Forstmann, B.U. (2014). When the brain takes a break: A model-based analysis of mind wandering. *Journal of Neuroscience*, *34*(49), 16286-16295. DOI: https://doi.org/10.1523/JNEUROSCI.2062-14.2014

Miyake, A., Friedman, N.P., Emerson, M.J., Witzki, A.H., Howerter, A., & Wager, T.D. (2000). The unity and diversity of executive functions and their contributions to complex "Frontal Lobe" tasks: a latent variable analysis. *Cognitive Psychology*, *41* (1), pp.49-100. DOI: 10.1006/cogp.1999.0734.

Miyake, A. & Friedman, N.P. (2012). The nature and organization of individual differences in executive functions: Four general conclusions. *Current Directions in Psychology, 21* (1), pp.8-14. DOI: 10.1177/0963721411429458

Monsell, S. (2003). Task switching. *Trends in Cognitive Science, 7*(3), 134-140. DOI: 10.1016/s1364-6613(03)00028-7

Mooneyham, B.W., & Schooler, J.W. (2013). The costs and benefits of mind-wandering: A review. *Canadian Journal of Experimental Psychology, 67* (1), pp.11-18. DOI: https://doi.org/10.1037/a0031569

Morrison, S.C., Brown, L.A., & Cohen, A.S. (2013). A multidimensional assessment of social cognition in psychometrically defined schizotypy. *Psychiatry Research, 210,* pp. 1014-1019. DOI: 10.1016/j.psychres.2013.08.020

Murray, S., Krasich, K., Schooler, J.W., & Seli, P. (2020). What's in a task? Complications in the study of the task-unrelated-thought variety of mind wandering. *Perspectives on Psychological Science, 15* (3). DOI: https://doi.org/10.1177/1745691619897966

Murray, S., & Krasich, K. (2022). Can the mind wander intentionally? *Mind & Language, 47*(3), pp. 432-443. DOI: https://doi.org/10.1111/mila.12332

Neigel, A.R., Claypoole, V.L., & Szalma, J.L. (2019). Effects of state motivation in overload and underload vigilance task scenarios. *Acta Psychologica, 197*, 106-114. DOI: https://doi.org/10.1016/j.actpsy.2019.05.007

Nisbett, R.E., & Wilson, T.D. (1977). Telling more than we can know: Verbal reports on mental processes. *Psychological Review, 84* (3), 231-259. DOI: https://doi.org/10.1037/0033-295X.84.3.231

Norman, D.A., & Bobrow, D.G. (1975). On data-limited and resource-limited processes. *Cognitive Psychology, 7*(1), pp.44-64. DOI: https://doi.org/10.1016/0010-0285(75)90004-3

Nouwens, S., Groen, M.A., Kleemans, T. & Verhoeven, L. (2021). How executive functions contribute to reading comprehension. *British Journal of Educational Psychology, 91* (1), 169-192. DOI: https://doi.org/10.1111/bjep.12355

O'Neill, K., Smith, A.P., Smilek, D., & Seli, P. (2021). Dissociating the freely-moving thought dimension of mind-wandering from the intentionality and task-unrelated thought dimensions. *Psychological Research, 85*(7), 2599-2609. doi: 10.1007/s00426-020-01419-9

Peplau, L.A., & Perlman, D. (1982). Perspectives on loneliness. In L.A. Peplau & D. Perlman (Eds.), *Loneliness*. Wiley.

Piccoli, T. Valente, G., Linden, D.E.J., Re, M., Esposito, F., Sack, A.T., & Di Salle, F. (2015). The default mode network and the working memory network are not anti-correlated during all phases of a working memory task. *PLoS ONE, 10*(4). DOI: 10.1371/journal.pone.0123354

Pluck, G. (2019). Preliminary evidence of a free-to-use, brief assessment of adult intelligence for research purposes: The matrix matching test. *Psychological Report, 122*(2), pp.709-730. DOI: 10.1177/0033294118762589

Poerio, G.L., Totterdell, P., Emerson, L.M., & Miles, E. (2015). Love is the triumph of the imagination: Daydreams about significant others are associated with increased happiness, love and connection. *Consciousness & Cognition, 33,* 135-144.

Poerio, G.L., & Smallwood, J. (2016). Daydreaming to navigate the social world: What we know, what we don't know, and why it matters. *Social and Personality Psychology Compass, 10* (11), pp.605-618. DOI: https://doi.org/10.1111/spc3.12288

Poerio, G.L., Totterdell, P., Emerson, L.M., & Miles, E. (2016). Social daydreaming and adjustment: An experience-sampling study of socio-emotional adaptation during a life transition. *Frontiers in Psychology, 7,* DOI: https://doi.org/10.3389/fpsyg.2016.00013

Polich, J. (1986). P300 development from auditory stimuli. *Psychophysiology, 23*(5), pp. 590-597. DOI: https://doi.org/10.1111/j.1469-8986.1986.tb00677.x

Polner, B., Faiola, E., Urquijo, M.F., Meyhöfer, I., Steffens, M., Rónai, L., Koutsouleris, N., & Ettinger, U. (2021). The network structure of schizotypy in the general population. *European Archives of Psychiatry and Neuroscience, 271,* pp.635-645. DOI: https://doi.org/10.1007/s00406-019-01078-x

Posner, M.U., & Peterson, S.E. (1990). The attention system of the human brain. *Annual Review of Neuroscience, 13,* 25-42. DOI: https://doi.org/10.1146/annurev.ne.13.030190.000325

Raichle, M.E., MacLeod, A.M., Snyder, A.Z., Powers, W.J., Gusnard, D.A., & Shulman, G.L. (2001). A default mode of brain function. *PNAS, 98*(2), 676-682. DOI: https://doi.org/10.1073/pnas.98.2.676

Raine, A. (1991). The SPQ: A scale for the assessment of schizotypal personality based on DSM-III-R criteria. *Schizophrenia Bulletin, 17*(4), 555-564. DOI:https://doi.org/10.1093/schbul/17.4.555

Ralph, B.C., Onderwater, K., Thomson, D.R., & Smilek, D. (2016). Disrupting monotony while increasing demand: Benefits of rest and intervening tasks on vigilance. *Psychological Research, 81,* pp.432-444. DOI: 10.1007/s00426-016-0752-7

Randall, J.G., Oswald, F.L., & Beier, M.E. (2014). Mind-wandering, cognition, and performance: A theory-driven meta-analysis of attention regulation. *Psychological Bulletin, 140* (6), pp.1411-1431. DOI: 0.1037/a0037428

Randall, J.G., Beier, M.E., & Villado, A.J. (2019). Multiple routes to mind wandering: Predicting mind wandering with resource theories. *Consciousness & Cognition, 67*, 26-43. DOI: 10.1016/j.concog.2018.11.006

Randall, J.S., Hanson, M.W., Nassrelgrgawi, A.S. (2022). Staying focused when nobody is watching: Self-regulatory strategies to reduce mind wandering during self-directed learning. *Applied Psychology, 71*(4), 1428-1464. DOI: https://doi.org/10.1111/apps.12366

Redick, T.S., Heitz, R.P., & Engle, T.W. (2007). Working memory capacity and inhibition: Cognitive and social consequences. In D.S. Gorfein & C.M. MacLeod (Eds.), *Inhibition in cognition* (pp. 125-142. American Psychological Association. DOI: https://doi.org/10.1037/11587-007

Redick, T.S., Broadway, J.M., Meier, M.E., Kuriakose, P.S., Unsworth, N., Kane, M.J., & Engle, R.W. (2012). Measuring working memory capacity with automated complex span tasks. *European Journal of Psychological Assessment, 28*(3), 164-171. DOI: DOI: 10.1027/1015-5759/a000123

Reichle, E.D., Reineberg, A.E., & Schooler, J.W. (2010). Eye movements during mindless reading. *Psychological Science, 21*(9), pp. 1300-1310. DOI: https://doi.org/10.1177/0956797610378686.

Ren, X., Schweizer, K., Wang, T., Chu, P., & Gong, Q. (2017). On the relationship between executive functions of working memory and components derived from fluid intelligence measures. *Acta Psychologica, 180,* pp.79-87. DOI: https://doi.org/10.1016/j.actpsy.2017.09.002

Robertson, I.H., Manly, T., Andrade, J., Baddeley, B.T., Yiend, J. (1997). ‘Oops!’: Performance correlates of everyday attentional failures in traumatic brain injured and normal subjects. *Neuropsychologia, 35* (6), pp.747-758. DOI: 10.1016/s0028-3932(97)00015-8.

Robertson, I.H., & O’Connell, R. (2010). Vigilant attention. In A.C. Nobre & J.T. Coull (Eds.) *Attention and Time,* 79-88. Oxford University Press.

Robison, M.K., & Unsworth, N. (2015). Working memory offers resistance to mind-wandering and external distraction in a context-specific manner. *Applied Cognitive Psychology, 29*(5), pp. 680-

690. DOI: https://doi.org/10.1002/acp.3150

Robison, M.K., & Unsworth, N. (2017). Working memory capacity and mind-wandering during low demand cognitive tasks. *Consciousness & Cognition, 52*, pp. 47-54. DOI: 10.1016/j.concog.2017.04.012

Robison, M.K., Gath, K.I., & Unsworth, N. (2017). The neurotic wandering mind: An individual differences investigation of neuroticism, mind-wandering, and executive control. *The Quarterly Journal of Experimental Psychology, 70*(4), pp.649-663. DOI: 10.1080/17470218.2016.1145706

Robison, M.K., & Unsworth, N. (2018). Cognitive and contextual correlates of spontaneous and deliberate mind-wandering. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 44*(1), 85-98. DOI: 10.1037/xlm0000444.

Robison, M.K., Miller, A.L., & Unsworth, N. (2019). Examining the effects of probe frequency, response options, and framing within the thought-probe method. *Behavior Research Methods, 51,* pp.398-408. DOI: https://doi.org/10.3758/s13428-019-01212-6

Robison, M.K., Miller, A.L., & Unsworth, N. (2020). A multi-faceted approach to understanding individual differences in mind-wandering. *Cognition, 198.* DOI: 10.1016/j.cognition.2019.104078

Robison, M.K., & Brewer, G.A. (2022). Individual differences in working memory capacity, attention control, fluid intelligence, and pupillary measures of arousal. *Journal of Experimental Psychology: Learning, Memory, & Cognition, 48*(9), pp. 1296-1310. DOI: https://doi.org/10.1037/xlm0001125

Rosen, V.M., & Engle, R.W. (1997). The role of working memory capacity in retrieval. *Journal of Experimental Psychology: General, 126*(3), 211-227. DOI: https://doi.org/10.1037/0096-3445.126.3.211

Rummel, J., & Boywitt, C.D. (2014). Controlling the stream of thought: Working memory capacity predicts adjustment of mind-wandering to situational demands. *Psychonomic Bulletin Review, 21*(5), 1309-1315. DOI: 10.3758/s13423-013-0580-3

Saggino, A., Perfetti, B., Spitoni, G., & Galati, G. (2006). Fluid intelligence and executive functions: New perspectives. In L. V Wsley (Ed.), *Intelligence: New Research*. Nova Science Publishers.

Schmeichel, B.J., Volokhov, R.N., & Demaree, H.A. (2008). Working memory capacity and the self-regulation of emotional expression and experience. *Journal of Personality and Social Psychology, 95*(6), pp.1526-1540. DOI: https://doi.org/10.1037/a0013345

Schubert, A.L., Frischkorn, G.T., & Rummel, J. (2020). The validity of the online thought-probing procedure of mind wandering is not threatened by variations of probe rate and probe framing. *Psychological Research, 84*(7), pp.1846-1856. DOI: 10.1007/s00426-019-01194-2

Sealy, M.K. (2021). Communication in the time of COVID-19: An examination of imagined interactions and communication apprehension during the COVID-19 pandemic. *Imagination, Cognition, and Personality, 41*(2), 158-186. DOI: https://doi.org/10.1177/02762366211021076

Segerstrom, S.C., Stanton, A.L., Alden, L.E., & Shortridge, B.E. (2003). A multidimensional structure for repetitive thought: What's on your mind, and how, and how much? *Journal of Personality and Social Psychology, 85*(5), pp. 909-921. DOI: 10.1037/0022-3514.85.5.909.

Seli, P., Smallwood, J., Cheyne, J.A., & Smilek, D. (2015a). On the relation of mind wandering and ADHD symptomatology. *Theoretical Review, 22,* pp. 629-636. DOI: https://doi.org/10.3758/s13423-014-0793-0

Seli, P., Cheyne, J.A., Xu, M., Purdon, C., & Smilek, D. (2015b). Motivation, intentionality, and mind wandering: Implications for assessments of task-unrelated thought. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 41*(5), pp.1417-1425. DOI: https://doi.org/10.1037/xlm0000116

Seli, P., Carriere, J.S.A., & Smilek, D. (2015c). Not all mind wandering is created equal: Dissociating deliberate from spontaneous mind wandering. *Psychological Research, 79*(5), 750-758. DOI: DOI: 10.1007/s00426-014-0617-x

Seli, P., Risko, E.F., Smilek, D., & Schacter, D.L. (2016a). Mind-wandering with and without intention. *Trends in Cognitive Science, 20* (8), pp. 605-617. DOI: 10.1016/j.tics.2016.05.010

Seli, P., Risko, E.F., & Smilek, D. (2016b). On the necessity of distinguishing between unintentional and intentional mind wandering. *Psychological Science, 27* (5). DOI: https://doi.org/10.1177/0956797616634068

Seli, P., Risko, E.F., & Smilek, D. (2016c). Assessing the associations among trait and state levels of deliberate and spontaneous mind wandering. *Consciousness & Cognition: An International Journal, 41*, pp.50-56. DOI: https://doi.org/10.1016/j.concog.2016.02.002

Seli, P., Risko, E.F., Purdon, C., & Smilek, D. (2017a). Intrusive thoughts: Linking spontaneous mind wandering and OCD symptomatology. *Psychological Research, 81*(2), pp. 392-398. DOI: 10.1007/s00426-016-0756-3

Seli, P., Ralph, B.C.W., Konishi, M., Smilek, D., & Schacter, D.L. (2017b). What did you have in mind? Examining the content of intentional and unintentional types of mind wandering. *Consciousness & Cognition, 51*, pp. 149-156. DOI: 10.1016/j.concog.2017.03.007

Seli, P., Kane, M.J., Smallwood, J., Schacter, D.L., Maillet, D., Schooler, J.W., & Smilek, D. (2018a). Mind-wandering as a natural kind: A family-resemblances view. *Trends in Cognitive Science, 22* (6), pp.479-490. DOI: doi: 10.1016/j.tics.2018.03.010.

Seli, P., Kane, M.J., Metzinger, T., Smallwood, J., Schacter, D.L., Maillet, D., Schooler, J.W., & Smilek, D. (2018b). The family-resemblances framework for mind-wandering remains well clad. *Trends in Cognitive Sciences, 22*(11), pp.959-961. DOI: https://doi.org/10.1016/j.tics.2018.07.007

Seli, P., Konishi, M., Risko, E.F., & Smilek., D. (2018c). The role of task difficulty in theoretical accounts of mind wandering. *Consciousness & Cognition, 65*, pp.255-262. DOI: 10.1016/j.concog.2018.08.005

Seli, P., Carriere, J. S., Wammes, J. D., Risko, E. F., Schacter, D. L., & Smilek, D. (2018d). On the clock: Evidence for the rapid and strategic modulation of mind wandering. Psychological science, 29(8), 1247-1256.

Seli, P., Schacter, D.L., Risko, E.F., & Smilek, D. (2019a). Increasing participant motivation reduces rates of intentional and unintentional mind wandering. *Psychological Research, 83* (5), pp. 1057-1069.

Seli, P., Beaty, R.E., Marty-Dugas, J., & Smilek, D. (2019b). Depression, anxiety, and stress and the distinction between intentional and unintentional mind wandering. *Psychology of Consciousness: Theory, Research, and Practice, 6*(2), pp. 163-170. DOI: https://doi.org/10.1037/cns0000182

Semkovska, M., Quinlivan, L., O'Grady, T., Johnson, R., Collins, A., O'Connor, J., Knittle, H., Ahern, E., & Gload, T. (2019). Cognitive function following a major depressive episode: A systematic review and meta-analysis. *The Lancet Psychiatry, 6*(10), pp.851-861. DOI: https://doi.org/10.1016/S2215-0366(19)30291-3

Shin, M., Linke, A., & Kemps, E. (2020). Moderate amounts of media multitasking are associated with optimal task performance and minimal mind wandering. *Computers in Human Behavior, 111*. DOI: https://doi.org/10.1016/j.chb.2020.106422

Shipstead, Z., Redick, T.S., & Engle, R.W. (2012). Is working memory training effective? *Psychological Bulletin, 138*(4), pp. 628-654. DOI: https://psycnet.apa.org/doi/10.1037/a0027473

Shipstead, Z., Harrison, T.L., & Engle, R.W. (2016). Working memory capacity and fluid intelligence: maintenance and disengagement. *Perspectives on Psychological Science, 11* (6), pp. 771-799. DOI: 10.1177/1745691616650647

Shrimpton, D., McGann, D., & Riby, L.M. (2017). Daydream believer: Rumination, self-reflection and the temporal focus of mind wandering content. *European Journal of Psychology, 13*(4), pp.794-809. DOI: 10.5964/ejop.v13i4.1425

Skinner, B.F. (1953). *Science and human behaviour.* Macmillan.

Smallwood, J., & Schooler, J.W. (2006). The restless mind. *Psychological Bulletin, 132* (6), pp.946-958. DOI: https://doi.org/10.1037/0033-2909.132.6.946

Smallwood, J., McSpadden, M., & Schooler, J.W. (2008). When attention matters: The curious incident of the wandering mind. *Memory & Cognition, 36,* pp.1144-1150. DOI: https://doi.org/10.3758/MC.36.6.1144

Smallwood, J., Fitzgerald, A., Miles, L.K., & Phillips, L.H. (2009). Shifting moods, wandering minds: Negative moods lead the mind to wander. *Emotion, 9*(2), pp. 271-276. DOI: 10.1037/a0014855

Smallwood, J., & O'Connor, R.C. (2011). Imprisoned by the past: Unhappy moods lead to retrospective bias to mind wandering. *Cognition and Emotion, 25*(8), pp.1481-1490. DOI: https://doi.org/10.1080/02699931.2010.545263

Smallwood, J., Brown, K., Baird, B., & Schooler, J.W. (2012). Cooperation between the default mode network and the fronto-parietal network in the production of an internal train of thought. *Brain Research, 142B,* pp. 60-70. DOI:. doi:10.1016/j.brainres.2011.03.072

Smallwood, J. (2013). Distinguishing how from why the mind wanders: a process-occurrence framework for self-generated mental activity. *Psychological Bulletin, 139*(3), pp. 519-535. DOI: 10.1037/a0030010

Smallwood, J. & Andrews-Hanna, J. (2013). Not all minds that wander are lost: the importance of a balanced perspective on the mind-wandering state. *Frontiers in Psychology,4,* DOI: 10.3389/fpsyg.2013.00441

Smallwood, J., & Schooler, J.W. (2015). The science of mind wandering: Empirically navigating the stream of consciousness. *Annual Review of Psychology, 66*, 487-518. DOI: 10.1146/annurev-psych-010814-015331

Smeekens, B.A. & Kane, M.J. (2016). Working memory capacity, mind wandering, and creative cognition: An individual-differences investigation into the benefits of controlled versus spontaneous thought. *Psychology of Aesthetics, Creativity, and the Arts, 10*(4), pp. 389-415. DOI: https://doi.org/10.1037/aca0000046

Smilek, D., Carriere, J.S.A, & Cheyne, J.A. (2010). Out of mind, out of sight: Eye blinking as indicator and embodiment of mind wandering. *Psychological Science, 21* (6), pp.786-789. DOI: https://doi.org/10.1177/0956797610368063

Smith, A.C., Brosowsky, B., Ralph, B.C.W, Smilek, D., & Seli. (2022). Re-examining the effect of motivation on intentional and unintentional task-unrelated thought: Accounting for thought constraint produces novel results. *Psychological Research, 86,* pp. 87-97. DOI: https://doi.org/10.1007/s00426-021-01487-5

Soemer, A., & Schiefele, U. (2020). Working memory capacity and (in)voluntary mind wandering. *Psychonomic Bulletin & Review, 27,* pp.758-767. DOI: https://doi.org/10.3758/s13423-020-01737-4

Song, X., & Wang, X. (2012). Mind wandering in Chinese daily lives – an experience sampling study. *PLoS ONE, 7*(9). DOI: https://doi.org/10.1371/journal.pone.0044423

Sperry, R.W. (1993). The impact and promise of the cognitive revolution. *American Psychologist, 48* (8), 878-885. DOI: https://doi.org/10.1037/0003-066X.48.8.878

Spreng, R.N., Shoemaker, L., & Turner, G.R. (2017). Executive functions and neurocognitive aging (pp. 169-196). In E. Goldberg (Ed.), *Executive functions in Health and Disease.* Academic Press.

Spunt, R.P., & Lieberman, M.D. (2013). The busy social brain: Evidence for automaticity and control in the neural systems supporting social cognition and action understanding. *Psychological Science, 24*(1), 80-86. DOI: 10.1177/0956797612450884

Stawarczyk, D., Majerus, S., Maj, M., Van der Linden, M., & D'Argembeau, A. (2011). Mind-wandering: phenomenology and function as assessed with a novel experience sampling method. *Acta Psychologica, 136* (3), pp370-381. DOI: 10.1016/j.actpsy.2011.01.002

Stawarczyk, D., Cassol, H., & D'Argembeau, A. (2013). Phenomenology of future-oriented mind wandering episodes. *Frontiers in Psychology, 4*(425). DOI: doi: 10.3389/fpsyg.2013.00425.

Stinson, J., Wolfe, R., & Spaulding, W. (2022). Social connectedness in schizotypy: The role of cognitive and affective empathy. *Behavioral Sciences, 12*(8). DOI: https://doi.org/10.3390/bs12080253

Subhani, B.R., Amos-Oluwole, O.I., Claxton, H.L., Holmes, D.C., Westling, C.E.I., & Witchel, H.J. (2019). Compliant activity rather than difficulty accelerates thought probe responsiveness and inhibits deliberate mind wandering. *Behaviour & Information Technology, 38 (10).* DOI: https://doi.org/10.1080/0144929X.2019.1655095

Szpunar, K.K., Moulton, S.T., & Schacter, D.L. (2013). Mind wandering and education: from the classroom to online learning. *Review in Psychology*, *4*(495). DOI: https://doi.org/10.3389/fpsyg.2013.00495

Taatgen, N.A., Marieke, K.V.V., Daamen, J., Katidoti, I., Huijser, S., & Borst, J.P. (2021). The resource-availability model of distraction and mind-wandering. *Cognitive Systems Research, 68,* pp.84-104. DOI: https://doi.org/10.1016/j.cogsys.2021.03.001

Taylor, S.E., Pham, L.B., Rivkin, I.D, & Armor, D.A. (1998). Harnessing the imagination: Mental simulation, self-regulation, and coping. *American Psychologist*, *53*(4), 429-439. DOI: https://doi.org/10.1037/0003-066X.53.4.429

Teasdale, J.D., Proctor, L., Lloyd, CA., & Baddeley, A.D. (1993). Working memory and stimulus-independent thought: Effects of memory load and presentation rate. *European Journal of Cognitive Psychology, 5* (4), DOI: 10.1080/09541449308520128

Teasdale, J.D., Dritschel, B.H., Taylor, M.J., Proctor, L., Lloyd, C.A., Nimmo-Smith, I., & Baddeley, A.D. (1995). Stimulus-independent thought depends on central executive resources. *Memory & Cognition*, *23*, pp.551-559. DOI: https://doi.org/10.3758/BF03197257

Thomson, D.R., Besner, D., & Smilek, D. (2013). In pursuit of off-task thought: Mind wandering performance trade-offs while reading aloud and color naming. *Frontiers in Psychology, 4*(360). DOI: https://doi.org/10.3389/fpsyg.2013.00360

Thomson, D.R., Besner, D., & Smilek, D. (2015). A resource-control account of sustained attention: Evidence from mind-wandering and vigilance paradigms. *Perspectives on Psychological Science, 10*(1). DOI: https://doi.org/10.1177/1745691614556681

Thurstone, L.L. (1938). *Primary mental abilities.* University of Chicago Press.

Turnbull, A., Poerio, G., Ho, N., Martinon, L., Riby, L., Lin, F., Jefferies, E., & Smallwood, J. (2021). Age-related changes in ongoing thought relate to external context and individual cognition. *Consciousness & Cognition, 96.*

Turner, M.L., & Engle, R.W. (1989). Is working memory capacity task dependent? *Journal of Memory and Language, 28*(2), 127-154. DOI: https://doi.org/10.1016/0749-596X(89)90040-5

Unsworth, N., Fukuda, K., Awh, E., & Vogel, E.K. (2005). Working memory and fluid intelligence: Capacity, attention control, and secondary memory retrieval. *Cognitive Psychology, 71,* 1-26. DOI: 10.1016/j.cogpsych.2014.01.003

Unsworth, N., & Engle, R.W. (2007). The nature of individual differences in working memory capacity: Active maintenance and disengagement in primary memory and controlled search from secondary memory. *Psychological Review, 114*(1), pp.104-132.
DOI: 10.1037/0033-295X.114.1.104

Unsworth, N., Redick, T.S., Heitz, R.P., Broadway, J.M., & Engle, R.W. (2009). Complex working memory span tasks and higher-order cognition: A latent-variable analysis of the relationship between processing and storage. *Memory, 17*(6), pp.635-654.
DOI: 10.1080/09658210902998047

Unsworth, N., & McMillan, B.D. (2013). Mind wandering and reading comprehension: Examining the roles of working memory capacity, interest, motivation, and topic experience. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 39*(3), pp. 832-842.
DOI: https://doi.org/10.1037/a0029669

Unsworth, N., & McMillan, B.D. (2014). Similarities and differences between mind-wandering and external distraction: A latent variable analysis of lapses of attention and their relation to cognitive abilities. *Acta Psychologica, 150,* pp.14-25. DOI; 10.1016/j.actpsy.2014.04.001

Unsworth, N., & Robison, M.K. (2016). The influence of lapses of attention on working memory capacity. *Memory & Cognition, 44*(2), pp. 188-196. DOI: 10.3758/s13421-015-0560-0

Van Vugt, M.K., & Broers, N. (2016). Self-reported stickiness of mind-wandering affects task performance. *Frontiers in Psychology, 7.* DOI: 10.3389/fpsyg.2016.00732

Vannucci, M., & Chiorri, C. (2018). Individual differences in self-consciousness and mind wandering: Further evidence for a dissociation between spontaneous and deliberate mind wandering. *Personality and Individual Differences, 121, pp.* 57-61. DOI: https://doi.org/10.1016/j.paid.2017.09.022

Varao-Sousa, T.L., & Kingstone, A. (2019). Are mind wandering rates an artefact of the probe-caught method? Using self-caught mind wandering in the classroom to test, and reject, this possibility. *Behavior and Research Methods, 51*, 235-242. DOI: https://doi.org/10.3758/s13428-018-1073-0

Vinski, M.T., & Watter, S. (2012). Priming honesty reduces subjective bias in self-report measures of mind wanering. *Consciousness & Cognition, 21* (1), pp.451-455. DOI: 10.1016/j.concog.2011.11.001

Warm, J.S., Parasuraman, R., Matthews, G. (2008). Vigilance requires hard mental work and is stressful. *Human Factors, 50*(3), pp.433-441. DOI: https://doi.org/10.1518/001872008X312152

Was, C.A., Hollis, R.B., & Dunlosky, J. (2019). Do students understand the detrimental effects of mind wandering during online learning? *Computers & Education, 135,* pp. 113-122. DOI: https://doi.org/10.1016/j.compedu.2019.02.020

Watkins, E.R. (2008). Constructive and unconstructive repetitive thought. *Psychological Bulletin, 134*(2), pp.163-206. DOI: 10.1037/0033-2909.134.2.163

Watkins, E.R. (2010). Level of construal, mind wandering, and repetitive thought: Reply to McVay and Kane (2010). *Psychological Bulletin, 136*(2), pp.198-201. DOI: https://doi.org/10.1037/a0018563

Watson, J.B. (1913). Psychology as the behaviourist views it. *Psychological Review, 20* (2), 158-177. DOI: https://doi.org/10.1037/h0074428

Wegner, D.M. (1994). Ironic processes of mental control. *Psychological Review, 101* (1), pp.34-52. DOI: 10.1037/0033-295x.101.1.34.

Welhaf, M.S., Smeekens, B.A., Gazzia, N.C., Perkins, J.B., Silvia, P.J., Meier, M.E., Kwapil, T.R., & Kane, M.J. (2020). An exploratory analysis of individual differences in mind wandering content and consistency. *Psychology of Consciousness: Theory, Research, and Practice, 7*(2), 103-125. DOI: https://doi.org/10.1037/cns0000180

Weinstein, Y. (2018). Mind-wandering, how do I measure thee with probes? Let me count the ways. *Behavioural Research Methods, 50* (2), pp.642-661. DOI: 10.3758/s13428-017-0891-9.

Weissman, D.H., Roberts, K.C., Visscher, K.M., & Woldorff, M.G. (2006). The neural bases of momentary lapses in attention. *Nature Neuroscience, 9*, pp.971-978. DOI: https://doi.org/10.1038/nn1727

Westerman, R., Spies, K., Stahl, G., & Hesse, F.W. (1996). Relative effectiveness and validity of mood induction procedures: a meta-analysis. *European Journal of Social Psychology, 26*(4), 557-580. DOI:

Wiemers, E.A., & Redick, T.S. (2019). The influence of thought probes on performance: Does the mind wander more if you ask it? *Psychonomic Bulletin & Review, 26* (1), pp.367-373. DOI: https://doi.org/10.3758/s13423-018-1529-3

Wong, Y.S., Willoughby, A.R., & Machado, L. (2022). Spontaneous mind-wandering tendencies linked to cognitive flexibility in young adults. *Consciousness & Cognition, 102.* DOI: 10.1016/j.concog.2022.103335

Wuthrich, V.M., & Bates, T.C. (2006). Confirmatory factor analysis of the three-factor structure of the schizotypal personality questionnaire and Chapman schizotypy scales. *Journal of Personality Assessment, 87*(3), pp.292-304. DOI: 10.1207/s15327752jpa8703_10

Xie, X., Bratec, S.M., Schmid-Mühlbauer, G., & Meng, C., Doll, A., Wohlschlaeger, A., Finke, K., Förstl, H., Zimmer, C., Pekrun, R., Schilbach, L., Reidl, V., & Sorg, C. (2016). How do you make me feel better? Social cognitive emotion regulation and the default mode network. *NeuroImage, 134.* DOI: 10.1016/j.neuroimage.2016.04.015

Xu, J. & Metcalfe, J. (2016). Studying in the region of proximal learning reduces mind wandering. *Memory & Cognition, 44,* pp. 681-695. DOI: https://doi.org/10.3758/s13421-016-0589-8

Yanko, M.R & Spalek, T.M. (2014). Driving with the wandering mind: the effect that mind-wandering has on driving performance. *Human Factors and Ergonomics Society, 56* (2). DOI: https://doi.org/10.1177/0018720813495280

Yee, D.M., & Braver, T.S. (2018). Interactions of motivation and cognitive control. *Current Opinions in Behavioural Science, 19,* 83-90. 10.1016/j.cobeha.2017.11.009

Yntema, D.B., & Trask, F.P. (1963). Recall as a search process. *Journal of Verbal Learning and Verbal Behavior, 2*(1), pp.65-74. DOI: https://doi.org/10.1016/S0022-5371(63)80069-9

Zabelina, D.L., Clay, J.Z., & Upshaw, J.D. (2021). The association between imagination and anxiety in the times of the COVID-19 pandemic. *Creativity Research Journal, 33*(3), 264-274. DOI: https://doi.org/10.1080/10400419.2020.1871549

Zagacki, K.S., Edwards, R., & Honeycutt, J.M. (1992). The role of mental imagery and emotion in imagined interaction. *Communication Quarterly, 40*(1), 1992. DOI: https://doi.org/10.1080/01463379209369820

Zhang, Q., Jia, L.X., Cui, J.F,. Wang, Q., Ye, J.Y., Shi, H.S., Wang, Y., & Chan, R.C.K. (2022). The relationship between schizotypal traits and satisfaction with life among Chinese young adults: The mediating effect of trait anxiety and mind wandering. *PsyCh Journal, 11*(3), 310-316. DOI: 10.1002/pchj.531

Zhou, X., & Lei, X. (2018). Wandering minds with wandering brain networks. *Neuroscience Bulletin, 34*(6), 1017-1028. DOI: 10.1007/s12264-018-0278-7

Zhao, G., Li, S., Zhang, Q., Guo, X., Xie, F., Yan, S., Liu, H., Chong, Y., Ding, Y., & Li, X. (2023). The relationship between schizotypal personality features and mind wandering among college students during COVID-19 pandemic: A moderator of depression. *Frontiers in Psychology, 13:*994082. DOI: https://doi.org/10.3389/fpsyt.2022.994082

Appendices

Appendix A: Supplemental Material for Study 1, Experiment 1

Experiment 1: Checking the reliability of the prompts

Further Analyses on 3-back Probe Responses and Performance

Despite reporting high rates of TUT in the *3*-back tasks, participants performed well on this task. As such, to confirm reliability of the probe responses a multi-level hierarchical logistic regression was used to investigate whether the off-task probes (external distraction, intentional and unintentional TUT, and stimulus-independent task unrelated thought) predicted prior performance compared to on-task probes. Probe-responses were nested within participants, and the outcome predictor was correct responses. The model suggested that reported probe outcomes were a significant predictor of prior performance, $F(4, 3965) = 14.94$, $p < .001$. Relative to thought probes identified as on-task, as indicated in Table 33 all other probe outcomes predicted lapses in performance.

Table 33

Predictive Value of Probe Responses

Probe	Coefficient	*t*	*p*
Intentional (1)	-1.178	-4.311	<.001
Unintentional (2)	-1.290	-7.028	<.001
SITRT (3)	-1.247	-5.470	<.001
External Distraction (4)	-1.327	-4.559	<.001
On-task (5)	0	0	0

Note: all prompts above are predicting correct performance compared to an on-task probe.

Repeated Measures ANOVA for Alertness, Motivation, and Pleasantness Across Tasks

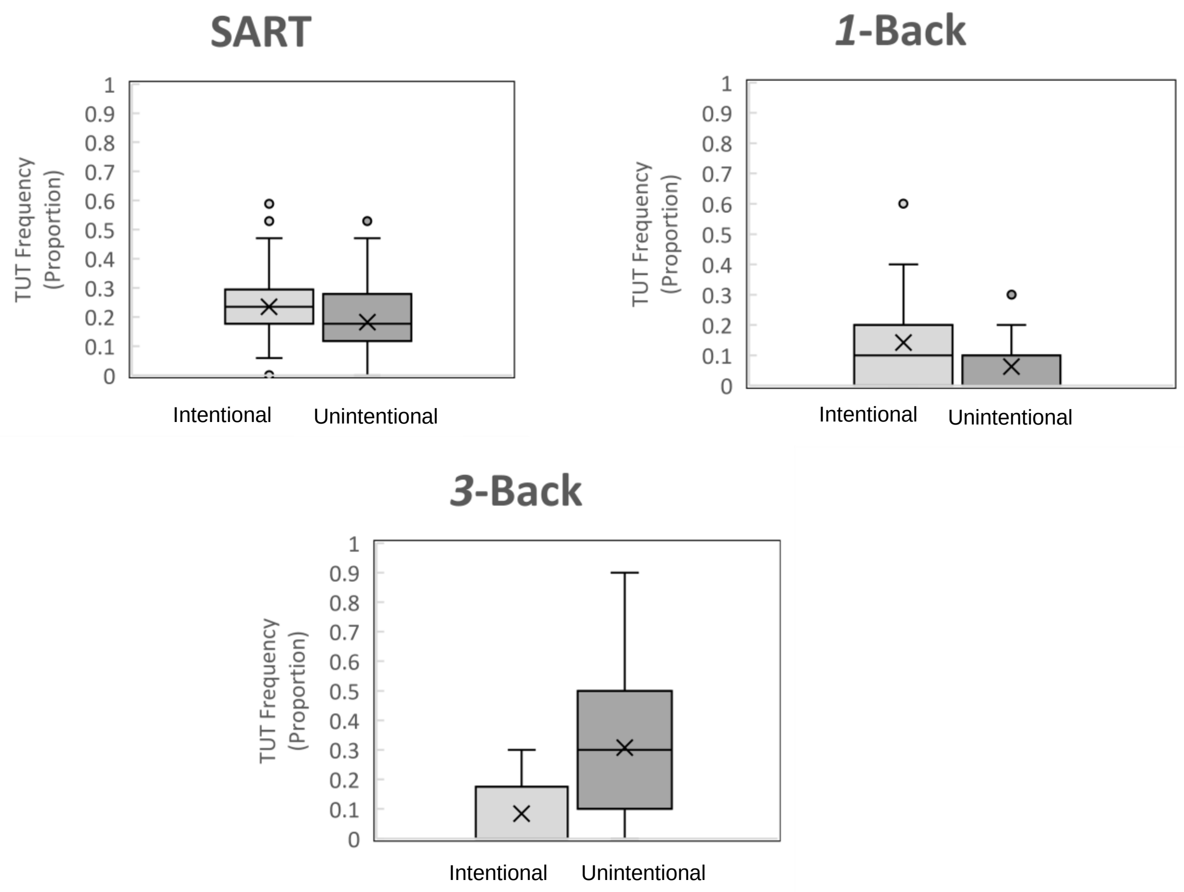
Participants reported the SART as easiest but also performed the worst on this task in terms of *d'*. As such, to again check reliability of the probes, an analysis of self-rated alertness on the three tasks was conducted. A repeated measures ANOVA revealed differences in alertness between tasks, $F = 35.81$, $p < .001$, $MSE = .54$, $\eta_p^2 = .27$. A follow-up quadratic contrast was significant, $F\ (1, 99) = 49.20$, $p < .001$, $\eta_p^2 = .33$. Comparisons confirmed that participants were less alert in the SART compared to the 1-back (Cohen's $d_{av} = -.97$, $p < .001$, [CI = -1.16, -.61]), but also less alert in the SART compared to the 3-back ($p < .001$, Cohen's $d_{av} = -.45$, [CI = -.65, -.18]). This suggests that the poorer performance in the SART may be related to lower alertness during the task despite participants perceiving the task as easy.

Furthermore, participants also differed in their motivation between tasks, $F\ (2, 198) = 50.02$, $p < .001$, $MSE = 16.22$, $n_p^2 = .34$. Follow-up Bonferroni tests showed that motivation was lower in the SART than the *1*-back, ($p < .001$, [CI = -.93, -.54], Cohen's $d_{av} = -1.07$), but equivalent in the *3*-back. Motivation was also greater in the *1*-back than the *3*-back, $p < .001$ [CI = .47, .85], Cohen's $d_{av} = .93$. Lastly, there were also differences in the rating of pleasantness of the tasks, $F\ (2, 198) = 9.47$, $MSE = 6.46$, $p < .001$, $n_p^2 = .09$. Follow-up Bonferroni comparisons indicated that the SART was less pleasant than the *1*-back, $p < .001$ [CI = .-73, -.17], Cohen's $d_{av} = -.53$, but equivalent to the *3*-back. The *1*-back was also more pleasant than the *3*-back [CI = .16, .70], Cohen's $d_{av} = .51$. Motivation and pleasantness may be lower in the SART due to its monotony, and the *3*-back due to its difficulty, relative to the *1*-back task.

Experiment 1: Distribution of prompt responses

Figure 18

Box-and-Whiskers Distribution Plots of Intentional and Unintentional TUTs in each Task



Experiment 1: Effect size calculation

Effect Size Calculation

In Study 1 d_{av} was reported for all effect sizes and this was calculated using the formula:

$$d_{av} = \frac{\bar{X}_1 - \bar{X}_2}{S_{av}}$$

Where

$$S_{av} = \sqrt{(S_1^2 + S_2^2)/2}$$

Experiment 1: Checking for task order effects

Tasks were counterbalanced in Experiment 1, with 6 possible combinations outlined in Table 34 with sample sizes for each. Participants were placed into a task order based on recruitment order. Data was collected from 112 participants but due to *N* = 12 participants being removed from analyses, sample sizes are unequal.

Table 34

Order of Tasks and Sample Size

Order	**Sample size (*N*)**
1. SART, *1*-back, *3*-back	17
2. *3*-back, *1*-back, SART	19
3. *1*-back, SART, *3*-back	18
4. SART, *3*-back, *1*-back	16
5. *3*-back, SART, *1*-back	16
6. *1*-back, *3*-back, SART	14

ANOVAs were performed on all main findings to investigate if task order had an influence, using the first 14 participants of each order group. First the effect of task order on difficulty ratings was investigated, and found no task type x task order interaction, *F* (10, 188) = 0.833, *p* = .60, η_p^2 = .04. There was also no main effect of order on difficulty ratings, *F* (5, 94) = .53, *p* = .76, η_p^2 = .03. Likewise, there was no task order x task type interaction on interest ratings, *F* (10, 188) = 1.10, *p* = .36, η_p^2= .06. There was also no main effect of task order on interest ratings, *F* (5, 94) = .96, *p* .45, *p* = .05.

Next no effect of task order was confirmed for TUT effects. Task type and order of the task did not have an interactive effect on overall TUT rates, *F* (10, 188) = 1.50, *MSE*= .01, *p* = .14, η_p^2= .07. There was no intention x order interaction, *F* (5, 94) = 90, *MSE* = .02, *p* = .48, η_p^2= .05, nor an intention x task x order interaction, *F* (10, 188) = .61, *MSE* = .02, *p* = .80, η_p^2= .03. Order also did not exhibit a main effect on TUTs, *F* = (1,94) = .78, *p* = .57, *ETA* = .04.

Experiment 1: Correlations with performance measures in Study 1, Experiment 1

Table 35

Correlations of Thought Probe Responses in the SART with Performance Measures and WMC

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. WMC	1									
2. TRT	.31**	1								
3. Intentional	.00	-.42**	1							
4. Unintentional	-.36**	-.51**	.07	1						
5. Overall TUT	-.24*	-.64**	.75**	.72**	1					
6. SITRT	-.10	-.47**	-.30**	-.08	-.26**	1				
7. ED	-.08	-.30**	-.16	-.21*	-.25*	.16	1			
8. Accuracy	.02	.01	-.01	-.10	-.07	.08	.01	1		
9. False Alarms	.16	.24*	-.04	-.18	-.15	-.19	.02	-.01	1	
10. *d'*	.16	.21*	-.03	-.19*	-.15	-.14	.03	.45**	.88**	1

Note. * is significant at .05. ** is significant at .01. Intentional refers to intentional TUTs, unintentional refers to unintentional TUTs. Overall TUTs are intentional and unintentional TUTs collapsed together.

Table 36

Correlations of Thought Probe Responses in the 1-Back with Performance Measures and WMC

		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1.	WMC	1									
2.	TRT	.18	1								
3.	Intentional	-.12	-.63**	1							
4.	Unintentional	-.04	-.21*	.02	1						
5.	Overall TUT	-.12	-.64**	.83**	.57**	1					
6.	SITRT	-.12	-.46**	-.11	-.22*	-.21*	1				
7.	ED	-.03	-.52**	.33**	-.01	.26**	-.23*	1			
8.	Accuracy	.23*	.02	.06	.08	.09	-.13	.03	1		
9.	False Alarms	-.10	-.08	-.07	-.04	-.08	.15	.05	-.71**	1	
10.	*d'*	.25*	.05	.07	.02	.07	-.19*	.08	.65**	-.72**	1

Note. * is significant at .05. ** is significant at .01. Intentional refers to intentional TUTs, unintentional refers to unintentional TUTs. Overall TUTs are intentional and unintentional TUTs collapsed together.

Table 37

Correlations of Thought Probe Responses in the 3-Back with Performance Measures and WMC

		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1.	WMC	1									
2.	TRT	.25*	1								
3.	Intentional	-.01	-.30**	1							
4.	Unintentional	-.20*	-.69**	.04	1						
5.	Overall TUT	-.19	-.77**	.38**	.91**	1					
6.	SITRT	-.13	-.41**	-.09	-.12	-.15	1				
7.	ED	.00	-.17	.03	-.13	-.10	-.18	1			
8.	Accuracy	.19*	.40**	-.22*	-.30*	-.37**	-.00	-.18	1		
9.	False Alarms	-.10	-.28**	.29**	.15	.27**	.04	.16	-.59**	1	
10.	*d'*	.25*	.44**	-.26**	-.29**	-.38**	.00	-.26**	.71**	-.76**	1

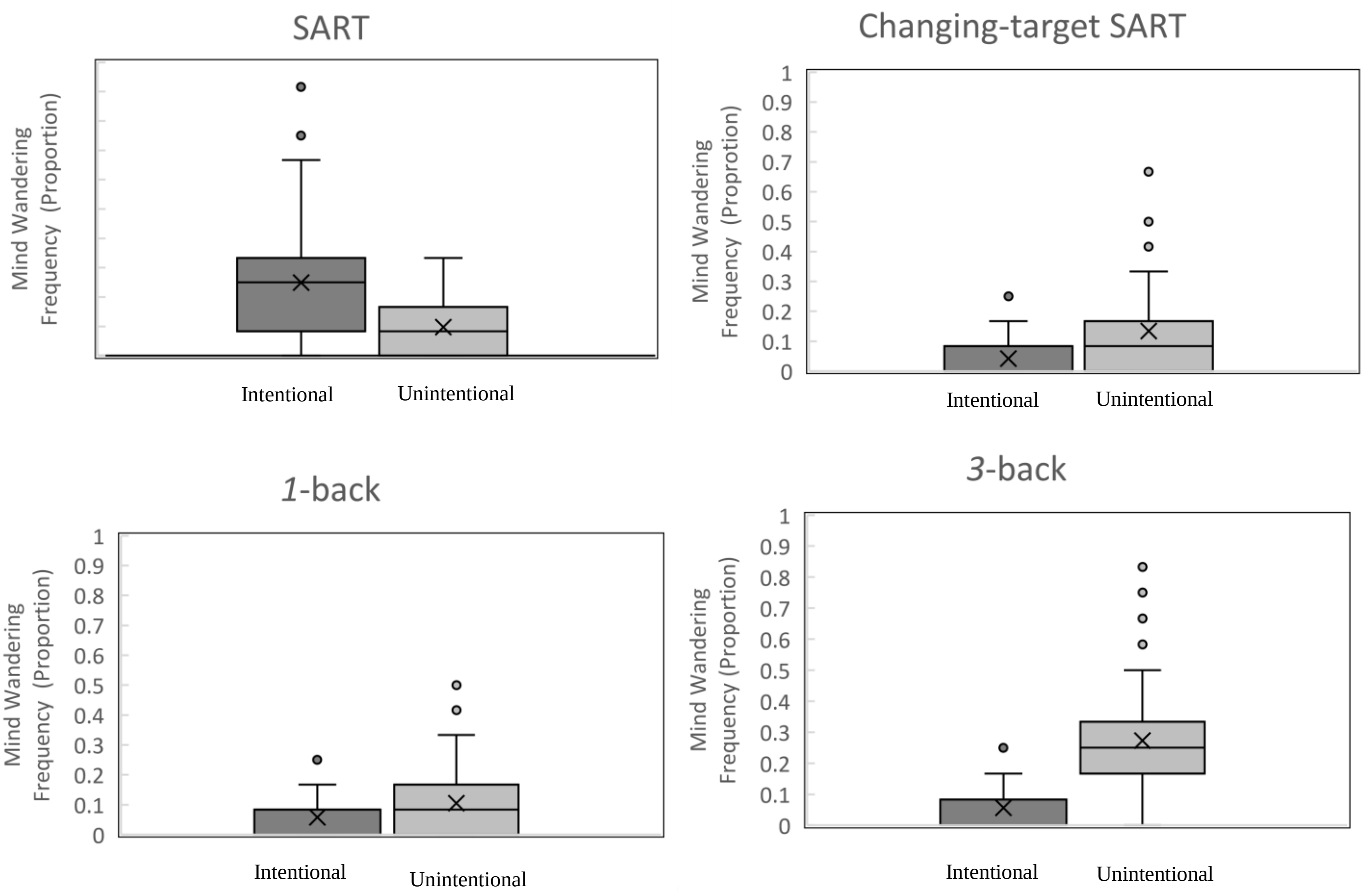
Note. * is significant at .05. ** is significant at .01. Intentional refers to intentional TUTs, unintentional refers to unintentional TUTs. Overall TUTs are intentional and unintentional TUTs collapsed together.

Appendix B: Supplemental Material for Study 1, Experiment 2

Experiment 2: Distribution of probe responses across tasks.

Figure 19

Box-and-Whiskers Distribution Plots of Intentional and Unintentional TUTs in each Task



Experiment 2: Checking false alarms in each version of the SART

Analysis of False Alarms in the Standard SART and Changing-Target SART

There was no significant difference between the rate of false alarms in either SART condition. It was hypothesised that false alarms would be more common after target-identity changes in the changing-target SART due to updating processes, whereas they would be more common in the second half of the standard SART consistent with alertness, attention, and motivation lessening over time. To test these ideas, first a 5 (block) x 2 (half) repeated measures ANOVA was run on the changing-target SART false alarms to investigate whether false alarms were more common within the first half of each block, after target change. The first block of the changing-target SART was omitted as there is no target-identity change until the second block. The dependent variable was the proportion of overall false alarms that occurred within each block and half. For example, if a participant had 23 false alarms overall, and 3 of these occurred within the first half of block one this would equate to a proportion of .13.

A main effect of half was observed $F(1, 102) = 86.27$ $MSE = .01$, $p = <.01$, $\eta_p^2 = .46$, such that more false alarms occurred within the first half ($M = .59$, $SD = .16$) of each block compared to the second half ($M = .37$, $SD = .14$). In addition, there was a main effect of block $F(4, 408) = 3.51$, $MSE = .01$, $p = .008$, $\eta_p^2 = .03$. However using a Bonferroni corrected α, none of the follow-up pairwise comparisons revealed significant differences. The half x block interaction was also non-significant, $F(4, 408) = 1.45$, $MSE = .01$), $p = .22$, $\eta_p^2 = .01$. Altogether, results indicate that more errors occurred during the first half of each block, after target identity change, as is consistent with the hypothesis (see Figure 20).

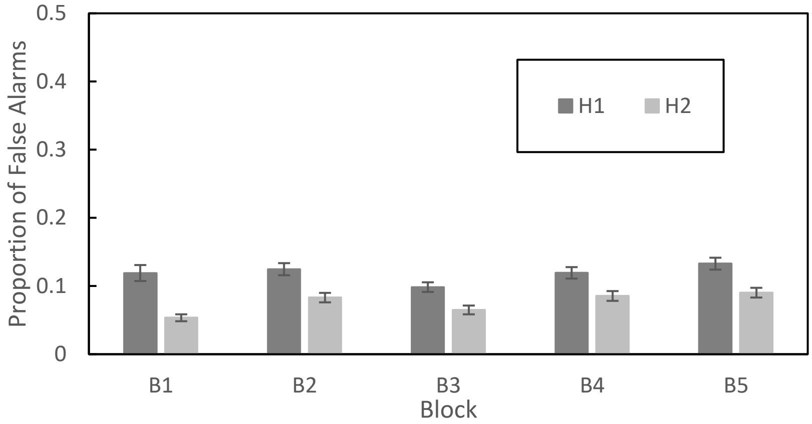
Repeated Measures ANOVA for Alertness, Motivation, and Pleasantness Across Tasks

For completeness, here the differences between alertness, motivation, and pleasantness are reported. A repeated measures ANOVA on self-rated alertness found a significant difference between the tasks, $F(3, 306) = 29.15$, $MSE = .54$, $p <.001$, $n_p^2 = .22$. Follow-up comparisons indicated that alertness was lower in the SART than the changing-target SART, $p < .001$, [CI = -.70, -.13]), Cohen's $d_{av} = -.53$, the *1*-back, $p = <.01$, CI = -.69, -.10], Cohen's $d_{av} = -.50$, and the *3*-back, $p <.001$, CI = -1.18, -.72], Cohen's $d_{av} = -1.38$. Alertness was not different in the changing-target SART and the *1*-back, but it was lower in the changing-target SART compared to the *3*-back, $p <.001$, [-.83, -.28], Cohen's $d_{av} = -.68$. The *1*-back also had lower self-rated alertness compared to the *3*-back, $p <.001$,-.79, -.28], Cohen's $d_{av} = -.70$.

Motivation did not differ between tasks surprisingly, F (3, 306) = .43, MSE = .57, p = .74, n_p^2 = .00. While ratings of pleasantness did differ, F (3, 306) = 3.58, MSE = .74, p = .01, n_p^2 = .03, after Bonferroni corrections were applied (.05/6 = .008) none of the follow-up contrasts were significant.

Figure 20

False Alarm Errors in the First and Second Half of the Last Five Changing-Target SART Blocks

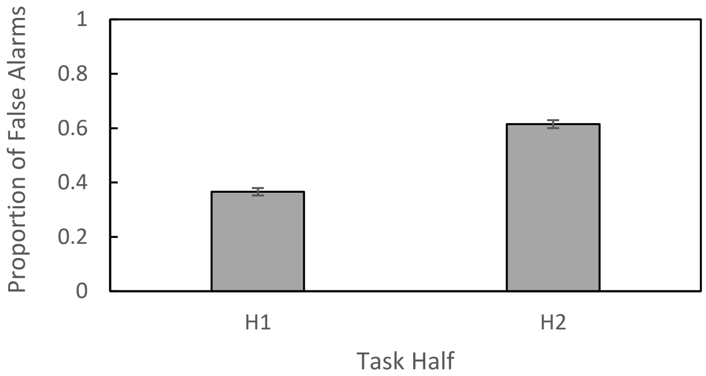


Note. *Standard error bars represent +/- 1 standard deviation. H1 = first half of the block, H2 = second half of the block.*

Next a paired samples *t*-test was run on the number of false alarms in the first and second half of the standard SART test whether more false alarms would occur toward the end of the task compared to the start. As predicted, there was a significant difference between each half, t (102) = -9.952, p <.001, *Cohen's d* = .25, with more false alarms occurring in the second half of the task as demonstrated in Figure 21. Mean false alarm proportions for the first and second half of the standard SART are demonstrated in Figure 21.

Figure 21

Proportion of False Alarms in the First and Second Half of the Standard SART



Note. *Error bars represent +/- 1 standard error.*

Experiment 2: Checking for task order effects

As in Experiment 1, a breakdown is provided of sample sizes for each of the 8 possible order combination used in this experiment in Table 38. Exclusion of participants resulted in uneven sample sizes.

Table 38

Order of Tasks and Sample Size

Order		**Sample size (*N*)**
1.	SART, Changing-target SART, *1*-Back, *3*-Back	13
2.	*3*-Back, *1*-Back, Changing-target SART, SART	13
3.	*3*-back, Changing-target SART, *1*-back, SART	13
4.	*1*-back, Changing-target SART, *3*-back, SART	13
5.	*Changing-target SART, SART,* 3-*back*, 1-*back*	15
6.	SART, *1*-back, Changing-target SART, *3*-back	12
7.	Changing-target SART, *3*-back, SART, *1*-back	13
8.	*1*-back, *3*-back, SART, Changing-target SART	11

Again, due to unequal sample sizes ANOVAs were performed using the first 11 participants from each task order group to investigate whether task order had an effect. To anticipate the following results, there were no main effects or interactions of task order for interest, difficulty, overall TUT rates, or intentional and unintentional TUT rates suggesting that task order did not influence results reported in the main text. There was no task type x task order interactive effect on interest ratings, F (21, 285) = 1.32, p = .16, η_p^2= .09. There was also no main effect of task order, F(7, 95) = 1.22, p = .30, η_p^2= .08. There was no task type x task order interactive effect of perceptions of difficulty, F(21, 285) = .88, p = .62, η_p^2= .06, and no main effect of task order, F (7, 95) = 1.45, p = .19, η_p^2= .10. In regards to TUTs, there was no task type x task order effect on overall TUT propensity, F (21, 285) = 1.41, p = .11, η_p^2= .09. There was no task type x intention interaction either, F(7, 95) = .87, p = .54, η_p^2= .06, nor a task type x intention x task order interaction, F(21, 285) = 1.19, p = .26, η_p^2= .08. Finally, there was no main effect of task order on TUTs, F (7, 95) = .79, p = .57, η_p^2= .06.

Experiment 2: Correlations between probes and performance measures

Table 39

Correlations of Thought Probe Responses in the SART with Performance Measures and WMC

		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1.	WMC	1									
2.	TRT	.15	1								
3.	Intentional	.06	-.53**	1							
4.	Unintentional	.03	-.28	.04	1						
5.	Overall TUT	.06	-.59	.91**	.44**	1					
6.	SITRT	-.19*	-.42**	-.30**	-.11	-.31**	1				
7.	ED	-.11	-.21*	-.21*	-.12	-.24*	-.12	1			
8.	Accuracy	.03	.17	-.28**	.04	-.24*	.15	-.12	1		
9.	False Alarms	-.13	-.22*	-.08	.21*	.01	.24*	.03	.07	1	
10.	*d'*	.19	.29**	-.08	-.09	-.11	-.11	-.18	.40**	-.76**	1

Note. * is significant at .05. ** is significant at .01. Intentional refers to intentional TUTs, unintentional refers to unintentional TUTs. Overall TUTs are intentional and unintentional TUTs collapsed together.

Table 40

Correlations of Thought Probe Responses in the Changing-Target SART with Performance Measures and WMC

		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1.	WMC	1									
2.	TRT	.40**	1								
3.	Intentional	-.11	-.30**	1							
4.	Unintentional	-.23*	-.48*	.06	1						
5.	Overall TUT	-.25*	-.54**	.47**	.91**	1					
6.	SITRT	-.28**	-.67**	-.06**	-.05	.07	1				
7.	ED	-.07	-.32**	.09	-.15	-.09	-.09	1			
8.	Accuracy	.19	.21*	-.07	-.23*	-.24*	-.03	-.09	1		
9.	False Alarms	-.08	-.20*	.00	.03	.02	.12	.21*	-.34**	1	
10.	*d'*	.06	.14	.01	-.06	-.05	-.05	-.15	.66**	-.80**	1

Note. * is significant at .05. ** is significant at .01. Intentional refers to intentional TUTs, unintentional refers to unintentional TUTs. Overall TUTs are intentional and unintentional TUTs collapsed together.

Table 41

Correlations of Thought Probe Responses in the 1-Back with Performance Measures and WMC

		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1.	WMC	1									
2.	TRT	.08	1								
3.	Intentional	-.16	-.34**	1							
4.	Unintentional	-.21*	-.42**	-.17	1						
5.	Overall TUT	-.29**	-.58**	.45**	.80**	1					
6.	SITRT	-.08	-.59**	.09	.07	.11	1				
7.	ED	.19	-.66**	.09	-.06	-.01	.08	1			
8.	Accuracy	.27**	-.02	-.20*	-.06	-.18	.10	.11	1		
9.	False Alarms	-.18	-.04	.14	.05	.14	-.11	.03	-.19	1	
10.	*d'*	.30**	.11	-.19	-.08	-.18	-.04	.01	.37	-.58	1

Note. * is significant at .05. ** is significant at .01. Intentional refers to intentional TUTs, unintentional refers to unintentional TUTs. Overall TUTs are intentional and unintentional TUTs collapsed together.

Table 42

Correlations of Thought Probe Responses in the 3-Back with Performance Measures and WMC

		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1.	WMC	1									
2.	TRT	.20*	1								
3.	Intentional	-.04	-32**	1							
4.	Unintentional	-.24**	-.58**	.07	1						
5.	Overall TUT	-.23*	-.64**	.44**	.93**	1					
6.	SITRT	.01	-.54**	-.05	-.07	-.08	1				
7.	ED	-.05	-.40**	.06	-.14	-.11	-.01	1			
8.	Accuracy	.14	.23*	-.20*	-.18	-.23*	.02	-.15	1		
9.	False Alarms	.01	-.12	.07	-.03	.00	.10	.12	-.44**	1	
10.	*d'*	.18	.26**	-.17	-.11	-.16	-.02	-.25*	.60**	-.53**	1

Note. * is significant at .05. ** is significant at .01. Intentional refers to intentional TUTs, unintentional refers to unintentional TUTs. Overall TUTs are intentional and unintentional TUTs collapsed together.

Appendix C: Supplemental Material for Study 2

Table 43

Correlations of Thought Probe Responses in the SART with Performance Measures and WMC

		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1.	WMC	1									
2.	TRT	.09	1								
3.	Intentional	-.16**	-.20**	1							
4.	Unintentional	-.23**	-.34**	.24**	1						
5.	Overall TUT	-.26**	-.35**	.69**	.87**	1					
6.	SITRT	.08	-.71**	-.20**	-.16**	-.22**	1				
7.	ED	.02	-.39**	-.15**	-.16**	-.19**	.05	1			
8.	Accuracy	.15**	.14**	-.13**	-.04	-.10**	-.04	-.10*	1		
9.	False Alarms	-.07	-.22**	.08	.13**	.14**	.12*	.07	-.29**	1	
10.	*d'*	.18**	.22**	-.12*	-.13**	-.15**	-.10*	-.10*	.73**	-.78**	1

Table 44

Correlations between Manifest Variables

		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
1.	RSPAN	1												
2.	OSPAN	.73**	1											
3.	SYMMSPAN	.61**	.61**	1										
4.	MMT	.49**	.46**	.52**	1									
5.	LST	.44**	.47**	.52**	.62**	1								
6.	NST	.44**	.43**	.52**	.64**	.63**	1							
7.	N-Back	.41**	.43**	.50**	.46**	.45**	.43**	1						
8.	KTT	.44**	.44**	.49**	.48**	.44**	.48**	.59**	1					
9.	RST	.43**	.45**	.46**	.44**	.47**	.43**	.57**	.60**	1				
10.	INT1	-.15**	-.16**	-.11**	-.09[a]	-.05	-.12*	-.08[a]	-.11*	-.03	1			
11.	INT2	-.10*	-.12*	-.10*	-.07	-.04	-.10*	-.06	-.07	-.04	.41*	1		
12.	UN1	-.19**	-.17**	-.12*	-.09[a]	-.04	-.08[a]	-.06	-.11*	-.09[a]	.12*	.21**	1	
13.	UN2	-.23**	-.19**	-.16**	-.10*	-.11*	-.12*	-.08	-.12*	-.09[a]	.22*	.15**	.50**	1

Note. RSPAN = reading span task. OSPAN = operation span task. SYMMSPAN = Symmetry span task. MMT = Matrix matching task. LST = Letter sets task. NST = Number series task. KTT = Keep track task. RST = Running span task. INT1 = Intentional TUTs Parcel 1. INT2 = Intentional TUTs Parcel 2. UN1 = Unintentional TUTs Parcel 1. UN2 = Unintentional TUTs Parcel 2. ** reflects significance at <.001. * reflects significance at <.05. [a] indicates trending significance between > .01 < .09

Table 45

Descriptive Statistics for Performance on the SART

Accuracy	*d'*	RT	Hits	False Alarms
.88 *(.10)*	1.63 *(1.18)*	350.43 *(83.79)*	.94 *(.11)*	.61 *(.22)*

Note. Mean performance is provided with standard deviations in parentheses.

Appendix D: Supplemental Material for Study 3

Study 3: Comparison of Pre-Lockdown and During Lockdown TUTs for Participants

The first 21 participants had their experience-sampling TUT data collected pre- and during initial lockdown measures in response to COVID-19 in Australia. Of these 21 participants, 17 participants were included in the multi-level models. In contrast, the remainder of the participants completed all 7 days of their experience-sampling prompts during lockdown. Here a series of *t*-tests are reported comparing the responses to prompts prior to and during lockdown for these 17 participants for each content variable, to observe whether it may be safe to use this data in the analyses. *T*-tests were used as the sample size would be too small for multi-level modelling to be appropriate. For categorical probes the responses were converted to proportions such that if, for example, a participant responded to 10 prompts prior to lockdown and reported prospective TUTs on 3 of these prompts, then their score for this variable would be .3 (i.e., 3/10). For continuous prompts (that is valence, freely-moving thought, fantasy, and loneliness), these were averaged.

To note, while these participants began their data collection 3 days prior to lockdown, this time was still marked by large reduction in social interaction and movement and so it is reasonable to believe pre-lockdown and during-lockdown TUTs would be safe to collapse together. Indeed a limited number of variables showed differences; more prospective thought during lockdown, less approach-based and more avoidance-based thought during lockdown, and more thoughts about close others during lockdown. Promisingly as well, loneliness did not change pre- and post-lockdown consistent with the idea that despite lockdown note being officially in place that individuals were perhaps already beginning to reduce interactions with others. Altogether, this supports that perhaps the few days before and after lockdown are closer in context than one might assume.

Table 46

Comparison of Pre and During Lockdown Content (N = 17) (df = 16)

Variable	**Pre-Lockdown M *(SD)***	**During Lockdown M *(SD)***	***t***	***p***	***Cohen's d***
Prospection	.50 *(.18)*	.60 *(.16)*	-2.87	.01 *	-.24
Retrospection	.18 *(.14)*	.15 *(.10)*	1.02	.32	.09
Valence	4.79 *(.93)*	4.51 *(.93)*	1.20	.25	.29
Fantasy	3.11 *(.79)*	3.05 *(.69)*	.351	.73	.07
Freely-Moving Thought	4.06 *(.70)*	3.92 *(.80)*	.74	.47	.17
Approach-based coping	.33 *(.25)*	.22 *(.22)*	3.20	.01*	.23
Avoidance-based coping	.14 *(.12)*	.24 *(.20)*	-2.68	.02*	-.25
Resolution	.37 *(.30)*	.27 *(.28)*	1.97	.07	.19
Self-Focus	.50 *(.24)*	.47 *(.30)*	.59	.56	.58
Close others	.50 *(.24)*	.62 *(.20)*	-2.60	.02*	-.26
Intentional	.34 *(.25)*	.29 *(.23)*	.87	.40	.10
Loneliness	29.50 *(18.59)*	32.18 *(16.68)*	1.38	.19	-.64

* indicates significance at < .05.

Multi-Level Linear and Logistic Models Using TUTs Occurring <10 Minutes Prior to the Probe

These multi-level models involved re-running the analyses from Study 3 but using only the 25.59% of TUTs (N = 711) that were reported as occurring <10 minutes prior to the prompt. These models are consistent with those reported in Chapter 9, with the only difference being that certain variables no longer meet significance criterion as a result of the greatly reduced TUT report sample size. Also note that the linear models predicting social TUT content, reported in Table 47 and 50, terminated iteration without reaching convergence likely also due to the changes in sample sizes of TUTs, and so should be interpreted with caution.

First an overview of these prompt responses will be provided. Of these 711 TUTs, 53.73% were prospective, 19.27% were retrospective, and 27.00% were non-temporal. Self-focus occurred in 49.37% of TUTs with the remainder being other-focussed. Close others featured in 54.15% of TUTs, with non-close others occurring in the remaining TUTs, and 41.35% were intentionally initiated with 58.65% reported as being unintentional.

Finally, 75.39% of the social TUTs involved thoughts about a problem or dilemma in the individuals social world and 36.15% of these were approach-oriented. Of these 75.39% TUTs, 33.19% involved also thinking of a way to resolve these issues.

Linear Multi-Level Models for Social TUT Content

To begin, models were run to investigate whether the valence, fantasy, and free-movement of these TUTs were consistent with those reported in Chapter 9 using the full sample. As shown in Table 47, the models for all three variables are consistent with what was found using the full sample. The only deviation is that loneliness no longer reaches significance for predicting freely-moving thought however the coefficient is still the same magnitude and in the same direction. Convergence could not be achieved in these models so they should be interpreted cautiously, however these results align with the models reported in Chapter 9 and those models did converge before terminating iterations.

Table 47

Linear Regressions for Content of the Social TUT Episodes Occurring Less than 10 Minutes Prior to the Prompt

Dependent Variables	Valence				Fantasy				Freely Moving Thought			
	ICC	f^2	**B *(SE)***	**CI**	***ICC***	f^2	**B *(SE)***	**CI**	***ICC***	f^2	**B *(SE)***	**CI**
Cognitive-Perceptual Schizotypy, Full Model	.20	.19			.20	.20			.45	.46		
Intentional			.27*(.13)**	[.02, .52]			-.51*(.12)***	[-.74, -.28]			-.35*(.16)**	[-.66, -.04]
Trait Loneliness (ULS-8)			-.05*(.02)**	[-.09, -.01]			.01*(.02)*	[-.02, .05]			-.05*(.03)*	[-.11, .01]
Cognitive-Perceptual			.00*(.01)*	[-.02, .02]			.02*(.01)**	[.01, .05]			.00*(.02)*	[-.04, .04]
Interpersonal Schizotypy, Full Model	.20	.19			.20	.20			.45	.46		
Intentional			.27*(.13)**	[.02, .52]			-.50*(.12)***	[-.73, -.27]			-.35*(.16)**	[-.66, -.04]
Trait Loneliness (ULS-8)			-.05*(.02)**	[-.10, -.01]			.00*(.02)*	[-.04, .05]			-.05*(.04)*	[-.13, .02]
Interpersonal			.00*(.01)*	[-.02, .03]			.02*(.01)*^{t}	[.00,.05]			.00*(.02)*	[-.04, .05]
Disorganised Schizotypy, Full Model	.20	.19			.20	.20			.45	.46		
Intentional			.27*(.13)**	[.02, .52]			-.52*(.12)***	[-.75, -.28]			-.35*(.16)*	[-.66, -.04]
Trait Loneliness (ULS-8)			-.05*(.02)**	[-.09, -.01]			.02*(.02)*	[-.02, .06]			-.05*(.03)*	[-.11, .01]
Disorganised			.01*(.02)*	[-.04, .05]			.02*(.02)*	[-.03, .06]			-.01*(.04)*	[-.08, .07]

Note. *p* < .01, **, *p* <.05, *, ^{t} trending toward significance (*p* < .10, > .05). For the factor variable of 'intention', intentional TUTs are dummy coded as 1, and unintentional as 0 (baseline).

Logistic Multi-Level Models for Social TUT Content

Next, models were used to investigate whether the categorical content differed in these models from the full-sample models in the thesis. These multi-level models analysed associations with self-focus, close others, and temporality. In the self-focus model other focused was used as the reference category. For the close others model, non-close others was used as the reference category, and for temporality prospective thought was investigated relative to retrospective thought as the reference category. The associations of these models demonstrated in Table 48 are again consistent with the full sample-size models included in Chapter 9. The only difference was that loneliness no longer met significance for predicting greater thoughts about close others, however this association was trending toward significance ($p < .10$).

Table 48

Logistic Regressions for Content of the Social TUT Episodes Occurring Less than 10 Minutes Prior to the Prompt

Dependent Variables	Self-Focussed				Close Others				Prospection			
	ICC	B *(SE)*	*Odds Ratio*	CI	ICC	B *(SE)*	*Odds Ratio*	CI	ICC	B *(SE)*	*Odds Ratio*	CI
Cognitive-Perceptual Schizotypy, Full Model	.20				.10				.21			
Intention		.64*(.18)***	1.89	[1.33, 2.70]		-.19*(.16)*	0.83	[.60, 1.14]		.48*(.24)**	1.61	[1.02, 2.56]
Trait Loneliness (ULS-8)		-.07*(.03)**	0.93	[.89, .98]		.04*(.02)*[t]	1.04	[1.00, 1.08]		.11*(.03)***	1.11	[1.05, 1.18]
Cognitive-Perceptual Schizotypy		.01 *(.02)*	1.01	[.98, 1.04]		-.01*(.01)*	0.99	[.96, 1.01]		-.01*(.02)*	0.99	[.95, 1.02]
Interpersonal Schizotypy, Full Model	.20				.10				.21			
Intention		.61*(.18)***	1.84	[1.29, 2.63]		-.19*(.17)*	0.83	[.60, 1.15]		.46*(24)**	1.59	[1.01, 2.53]
Trait Loneliness (ULS-8)		-.03*(.03)*	0.97	[.91, 1.02]		.03*(.02)*[t]	1.03	[.99, 1.08]		.12*(.03)***	1.13	[1.05, 1.21]
Interpersonal Schizotypy		-.04*(.02)**	0.96	[.93, .99]		.00*(.01)*	1.00	[.97, 1.03]		-.02*(.02)*	0.98	[.94, 1.02]
Disorganised Schizotypy, Full Model	.20				.10				.21			
Intention		.64*(.18)***	1.90	[1.33, 2.70]		-.19*(.17)*	0.83	[.60, 1.15]		.48*(.24)**	1.62	[1.02, 2.57]
Trait Loneliness (ULS-8)		-.06*(.03)**	0.94	[.89, .99]		.03*(.02)*[t]	1.03	[.99, 1.07]		.11*(.03)***	1.12	[1.05, 1.19]
Disorganised Schizotypy		-.02*(.03)*	0.98	[.93, 1.04]		.00*(.02)*	1.00	[.96, 1.05]		-.03*(.04)*	0.97	[.90, 1.04]

Note. *p* < .01, **, *p* <.05, *, [t] refers to trending toward significance (*p* < .10, > .05). For the factor variable of 'intention', intentional mind wandering is dummy coded as 1, and unintentional as 0 (reference). [a] the reference category is other-focussed. [b] the reference category is non-close others. [c] the reference category is retrospection.

Logistic Multi-Level Models Predicting Problem-Solving Content

Table 49 depicts the results of multi-level logistic models predicting problem-solving content reported during social TUTs. These associations are also consistent with that of Chapter 9. These models compared approach-based content to the reference category of avoidance-based content, compared thinking of a solution to a problem to the reference category of no solution, and finally predicted a positive resolution to the dilemma being imagined compared to a negative resolution.

Table 49

Logistic Regressions for Problem-Solving Content of the Social TUT Episodes Occurring Less than 10 Minutes Prior to the Prompt

Dependent Variables	Approach-Based[a]				Solution[b]				Positive Resolution[c]			
	ICC	B *(SE)*	*Odds Ratio*	CI	ICC	B *(SE)*	*Odds Ratio*	CI	ICC	B *(SE)*	*Odds Ratio*	CI
Cognitive-Perceptual Schizotypy, Full Model	.14				.23				.21			
Intention		.79*(.20)***	2.22	[1.50, 3.27]		.63*(.21)**	1.88	[1.24, 2.86]		.81*(.35)***	2.25	[1.13, 4.49]
ULS-8		.01*(.26)*	1.01	[.96, 1.06]		-.02*(.03)*	0.98	[.93, 1.04]		-.10*(.04)**	0.90	[.83, .98]
Cognitive-Perceptual		-.01*(.02)*	*0*.99	[.96, 1.02]		.00*(.02)*	1.00	[.97, 1.04]		.02*(.02)*	1.02	[.97, 1.07]
Interpersonal Schizotypy, Full Model	.14				.23				.21			
Intention		.75*(.20)***	2.12	[1.43, 3.14]		.62*(.21)**	1.86	[1.23, 2.82]		.82*(.35)***	2.26	[1.13, 4.55]
ULS-8		.04*(.03)*	1.04	[.98, 1.10]		-.01*(.03)*	1.00	[.93, 1.07]		-.11*(.05)**	0.90	[.81, .99]
Interpersonal		-.04*(.02)**	0.96	[.93, .99]		-.01*(.02)*	0.99	[.95, 1.03]		.01*(.27)*	1.01	[.96, 1.07]
Disorganised Schizotypy, Full Model	.14				.23				.21			
Intention		.80*(.20)***	2.22	[1.5, 3.28]		.63*(.21)**	1.88	[1.24, 2.85]		.82*(.35)**	2.26	[1.14, 4.51]
ULS-8		.00*(.03)*	1.00	[.95, 1.05]		-.01*(.03)*	0.99	[.93, 1.05]		-.11*(.05)**	0.90	[.82, .98]
Disorganised		.02*(.03)*	1.02	[.96, 1.08]		-.01*(.03)*	0.99	[.93, 1.06]		.04*(.05)*	1.04	[.95, 1.15]

Note. *p* < .01, **, *p* <.05, *, [t] refers to trending toward significance (*p* < .10, > .05). For the factor variable of 'intention', intentional TUT is dummy coded as 1, and unintentional as 0 (reference).[a] the reference category is avoidance. [b] the reference category is no solution occurring during TUT. [c] the reference category is a negative solution.

Linear Multi-Level Models Predicting Socio-Emotional Regulation

Finally, results in Table 50 demonstrates that the socio-emotional outcomes of TUTs using only the episodes occurring within 10 minutes of the prompt have consistent results to the full-sample models reported in Chapter 9. The only difference between the two sets of models is that the T1 mood state for positivity no longer meets significance in predicting post-TUT positivity. However, intention and valence still have significant associations. Also note that these models did not reach convergence before terminating iterations, however the corresponding full-sample analyses in the thesis did converge.

Table 50

Linear Multi-Level Models Predicting the Socio-Emotional Outcomes of TUTs Occurring Less than 10 Minutes Prior to the Prompt

Dependent Variables	**Positivity**				**Loneliness**			
	ICC	f^2	**B *(SE)***	**CI**	***ICC***	f^2	**B *(SE)***	**CI**
Cognitive-Perceptual Schizotypy, Full Model	.10	.45			.10	.17		
Intention			.19*(.10)**	[.01, .37]			-.16*(.08)**	[-.32, -.01]
T_1 State			.01*(.00)*	[.00, .01]			.01*(.00)***	[.01, .02]
Valence			.57*(.04)****	[.50, .64]			-.27*(.03)****	[-.33, -.22]
Cognitive-Perceptual			-.01*(.01)*	[-.02, .01]			.00*(.01)*	[-.01, .01]
Interpersonal Schizotypy, Full Model	.10	.46			.10	.18		
Intention			.17*(.10)**	[.02, .36]			-.14*(.08)*^{t}	[-.30, .02]
T1 State			.01*(.00)*	[.00, .01]			.01*(.00)***	[.01, .02]
Valence			.57*(.04)****	[.50, .64]			-.27*(.03)****	[-.33, -.22]
Interpersonal			-.01*(.01)*^{t}	[-.02, .01]			.01*(.01)*	[.00, -.02]
Disorganised Schizotypy, Full Model	.10	.46			.10	.17		
Intention			.19*(.09)**	[.01, .38]			-.16*(.08)**	[-.32, -.01]
T1 State			.01*(.00)*	[.00, .01]			.01*(.00)***	[.01, .02]
Valence			.57*(.04)****	[.49, .64]			-.27*(.03)****	[-.33, -.22]
Disorganised			-.01*(.01)*	[-.04, .01]			.01*(.01)*	[-.01, .03]

Note. *p* < .01, **, *p* <.05, *, ^{t} refers to trending toward significance (*p* < .10, > .05). For the factor variable of ‘intention’, intentional TUT is dummy coded as 1, and unintentional as 0 (reference).

Multi-Level Linear and Logistic Models Using State Loneliness as a Predictor

Chapter 9 focused on trait loneliness scores to investigate how durable personality and dispositional traits influence the profiles of social TUTs. However, this study also has access to state-level measures as participants self-rated their loneliness prior to the TUT occurring. While it was not a goal of the study to compare state and trait measures, this section reports models that replace the Level 1 trait measure with Level 2 state measures for the interested reader to compare.

Table 51 demonstrates the predictive association of intention, state loneliness and factors of schizotypy on the valence, fantasy, and freely-moving nature of social TUTs. Unlike trait loneliness, state variations in loneliness did not predict the freely-moving nature of thought. As such while individuals who have durable experiences of loneliness (i.e., trait level loneliness) tended to experience more constrained TUTs this variable was unrelated to variations in states of loneliness. State loneliness and trait loneliness both predicted less positive TUT episodes, and neither state nor trait loneliness were associated with level of fantasy in a social TUT episode.

Table 51

Linear Multi-Level Models for Intention, State Loneliness, and Factors of Schizotypy Predicting Content

Dependent Variables	Valence				Fantasy				Freely Moving Thought			
	ICC	f^2	**B *(SE)***	**CI**	***ICC***	f^2	**B *(SE)***	**CI**	***ICC***	f^2	**B *(SE)***	**CI**
Cognitive-Perceptual Schizotypy, Full Model	.15	.05			.21	.02			.30	.43		
Intentional			.26 *(.06)***	[.14, .38]			-.35 *(.06)***	[-.46, -.23]			-.28 *(.07)***	[-.43, -.14]
State Loneliness			-.01 *(.00)***	[-.02, -.01]			.00 *(.00)*	[-.01, .00]			.00 *(.03)*	[-.06, .07]
Cognitive-Perceptual			.00 *(.00)*	[-.01, .01]			.02 *(.00)***	[.01, .03]			.01 *(.01)*	[-.01, .02]
Interpersonal Schizotypy, Full Model	.15	.05			.21	.02			.30	.43		
Intentional			.24 *(.06)***	[.12, .36]			-.31 *(.06)***	[-.43, -.20]			-.28 *(.07)***	[-.43, -.14]
State Loneliness			-.01 *(.00)***	[-.02, -.01]			.00 *(.00)*	[-.01, .00]			.00 *(.03)*	[-.06, .07]
Interpersonal			-.01 *(.00)***	[-.02, -.01]			.02 *(.00)***	[.01, .03]			-.01 *(.01)*	[-.02, .01]
Disorganised Schizotypy, Full Model	.15	.05			.21	.02			.30	.43		
Intentional			.26 *(.06)* **	[.14, .38]			-.31 *(.06)***	[-.43, -.18]			-.28 *(.07)***	[-.43, -.14]
State Loneliness			-.01 *(.00)* **	[-.02, -.01]			.00 *(.02)*	[-.04, .04]			.00 *(.03)*	[-.06, .07]
Disorganised			.00 *(.01)*	[-.02, .01]			.01 *(.01)*	[-.01, .03]			-.02 *(.01)*	[-.04, .01]

Note. $p < .01$, **, $p <.05$, *, [t] trending toward significance ($p < .10$, > .05). For the factor variable of 'intention', intentional TUTs are dummy coded as 1, and unintentional as 0 (baseline).

Next logistic multi-level models were used to investigate the association of state loneliness with self-focus (compared to other focus as the reference category), close others (compared to non-close others as the reference category), and temporal content (i.e., prospective compared to retrospective as the reference category).

As demonstrated in Table 52 state loneliness was a much weaker predictor of TUT content when compared to the trait loneliness models in Chapter 9. State loneliness did not have any association with self-focus in TUTs unlike the trait measure which predicted less self-focus. State loneliness also had a smaller effect size or odds ratio for predicting close others in TUT content compared to trait loneliness (an OR of 1.01 versus 1.05). State loneliness also only reached significance for predicting prospection in thought for the cognitive-perceptual model, state loneliness marginally predicted *less* prospection in this model whereas trait-level loneliness tended to predict more prospective content.

Table 52

Logistic Multi-Level Models with Intention, State Loneliness, and Factors of Schizotypy Predicting Content

Dependent Variables	Self-Focussed [a]				Close Others[b]				Prospection[c]			
	ICC	B *(SE)*	***Odds Ratio***	CI	ICC	B *(SE)*	***Odds Ratio***	CI	ICC	B *(SE)*	***Odds Ratio***	CI
Cognitive-Perceptual Schizotypy, Full Model	.21				.13				.18			
Intention		.51 *(.08)***	1.67	[1.43, 1.95]		-.08 *(.08)*	0.92	[.79, 1.07]		.15 *(.10)*	1.16	[.95, 1.43]
State Loneliness		.00 *(.00)*	1.00	[1.00, 1.01]		.01 *(.00)***	1.01	[1.00, 1.01]		-.01 *(.00)* *	0.99	[.98, 99]
Cognitive-Perceptual		-.01 *(.01)*	0.99	[.98, 1.00]		-.01 *(.01)*	0.99	[.98, 1.00]		-.01 *(.01)*	0.99	[.98, 1.01]
Interpersonal Schizotypy, Full Model	.21				.13				.18			
Intention		.45 *(.08)***	1.58	[1.35, 1.84]		-.07 *(.08)*	0.93	[.80, 1.09]		.15 *(.10)*	1.16	[.94, 1.42]
State Loneliness		.00 *(.00)*	1.00	[1.00, 1.01]		.01 *(.00)***	1.01	[1.00, 1.01]		-.01 *(.00)*	0.99	[.99, 1.00]
Interpersonal		-.04 *(.01)***	0.96	[.95, .97]		.01 *(.00).*	1.01	[1.00, 1.02]		-.00 *(.01)*	1.00	[.98, 1.01]
Disorganised Schizotypy, Full Model	.21				.13				.18			
Intention		.51 *(.08)*	1.66	[1.42, 1.94]		-.08 *(.08)*	0.93	[.79, 1.08]		.15 *(.10)*	1.16	[.94, 1.42]
State Loneliness		.00 *(.00)*	1.00	[1.00, 1.01]		.01 *(.00)***	1.01	[1.00, 1.01]		-.01 *(.00)*	0.99	[.99, 1.00]
Disorganised		-.04 *(.01)***	0.96	[.94, .98]		.01 *(.01)*	1.01	[1.00, 1.03]		-.01 *(.01)*	0.99	[.97, 1.01]

Note. *p* < .01, **, *p* <.05, *, [t] refers to trending toward significance (*p* < .10, > .05). For the factor variable of 'intention', intentional mind wandering is dummy coded as 1, and unintentional as 0 (reference). [a] the reference category is other-focussed. [b] the reference category is non-close others. [c] the reference category is retrospection.

The final set of models in Table 53 replace trait loneliness measures with state loneliness in predicting problem-solving content. Results are similar to trait loneliness models, with loneliness not having a predictive association with approach-based content compared to avoidance-based content, nor having a predictive relationship with thinking of a solution to interpersonal issues. Unlike the trait models, state loneliness also did not predict less likelihood of thinking of a positive solution or perceiving a positive outcome to one's social dilemmas compared to a negative solution. However trait-level loneliness did predict less likelihood of thinking of a positive solution.

To summarise these models, trait and state loneliness do not seem to have identical predictive associations with TUT content. Indeed, trait-level loneliness seems to be more predictive of differences in the content and problem-solving nature of socially-oriented off-task thoughts. This aligns with the content-regulation hypothesis which indicates that trait-level differences in an individual's disposition will have an influence on their cognitive profiles and how they learn to regulate their thought content.

Table 53

Logistic Multi-Level Models with Intention, State Loneliness, and Schizotypal Factors Predicting Problem-Solving Content

Dependent Variables	Approach-Based[a]				Solution[b]				Positive Solution[c]			
	ICC	B *(SE)*	*Odds Ratio*	CI	ICC	B *(SE)*	*Odds Ratio*	CI	ICC	B *(SE)*	*Odds Ratio*	CI
Cognitive-Perceptual Schizotypy, Full Model	.17				.20				.23			
Intention		.64 *(.13)***	1.89	[1.46, 2.46]		.65 *(.09)***	1.92	[1.61,2.30]		.71 *(.17)***	2.03	[1.47, 2.81]
State Loneliness		-.01 *(.00)*	0.99	[.99, 1.00]		-.01 *(.00)*	0.99	[.99, 1.00]		-.01 *(.00)*	0.99	[.99, 1.00]
Cognitive-Perceptual		-.03 *(.01)***	0.97	[.96, .99]		.01 *(.01)*	1.01	[1.00, 1.02]		-.02 *(.02)*	0.98	[.96, 1.00]
Interpersonal Schizotypy, Full Model	.17				.20				.23			
Intention		.56 *(.14)***	1.75	[1.34, 2.28]		.61 *(.09)***	1.83	[1.53, 2.20]		.65 *(.17)***	1.91	[1.38, 2.66]
State Loneliness		-.01 *(.00)*	0.99	[.99, 1.00]		-.01 *(.00)*	0.99	[.99, 1.00]		-.01 *(.00)*	0.99	[.98, 1.00]
Interpersonal		-.04 *(.01)***	0.96	[.95, .98]		-.02 *(.01)***	0.98	[.97,.99]		-.04 *(.01)***	0.96	[.94, .98]
Disorganised Schizotypy, Full Model	.17				.20				.23			
Intention		.62 *(.13)***	1.86	[1.43, 2.42]		.65 *(.09)***	1.92	[1.61, 2.30]		.71 *(.17)***	2.03	[1.47, 2.81]
State Loneliness		-.01 *(.00)*	0.99	[.99, 1.00]		-.01 *(.00)*	0.99	[.99, 1.00]		-.01 *(.00)*	0.99	[.99, 1.00]
Disorganised		-.04 *(.02)***	0.96	[.93, .99]		.01 *(.01)*	1.01	[1.00, 1.02]		-.03 *(.02)*	0.97	[.93, 1.01]

Note. $p < .01$, **, $p < .05$, *, [t] refers to trending toward significance ($p < .10$, > .05). For the factor variable of 'intention', intentional TUT is dummy coded as 1, and unintentional as 0 (reference).[a] the reference category is avoidance. [b] the reference category is no resolution occurring during TUT. [c] the reference category is a negative resolution.

Experience-Sampling Questionnaire

Below is a layout of the questions used in the experience-sampling of social TUTs, including their scales.

PART A: General information.

1) How long ago was your most recent social mind-wandering experience? Please select from the options below.
    a. Within 10 minutes prior to the prompt
    b. 10-20 minutes ago
    c. 20-40 minutes ago
    d. 40+ minutes ago
2) Please provide a brief description of the activity/task you were completing when this mind wandering episode occurred in the textbox below.

PART B: Content variables.

3) How would you characterise the temporality of this mind wandering episode? Please select from the options below.
    a. This episode was mostly prospective in nature (i.e., future-focussed).
    b. This episode was mostly retrospective in nature (i.e., past-focussed).
    c. The temporality of this episode was mostly neutral.
4) Would you characterise this episode as being self-focussed or other-focussed? Please select from the options below.
    a. Mostly self-focussed.
    b. Mostly other-focussed.
5) i) Did this episode involve a close other or a non-close other? Please select from the options below.
    a. Close other.
    b. Non-close other.

    ii) Please categorise the person/s involved using the boxes below. Note you can select more than one category.

    a) Partner/Significant Other
    b) Family member

c) Friend

d) Work colleague

e) Acquaintance

f) Imagined person/Made up person

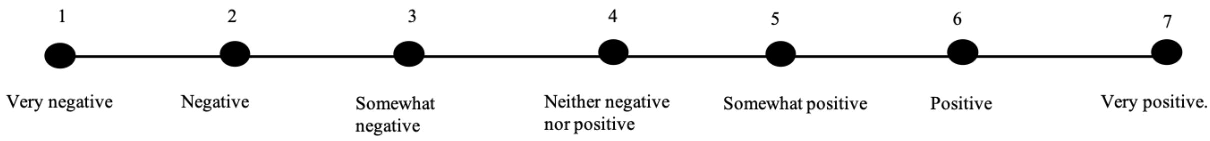
g) Other

6) Was this mind wandering episode intentionally or unintentionally engaged? Please select from the options below.

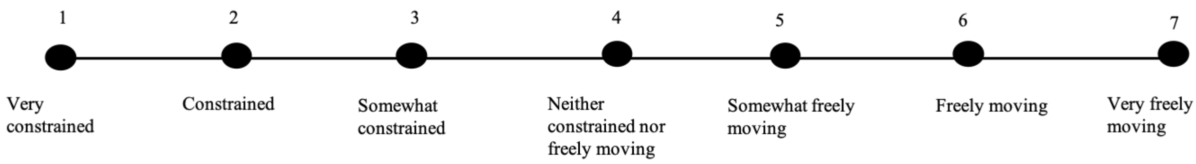
a. Intentional

b. Unintentional

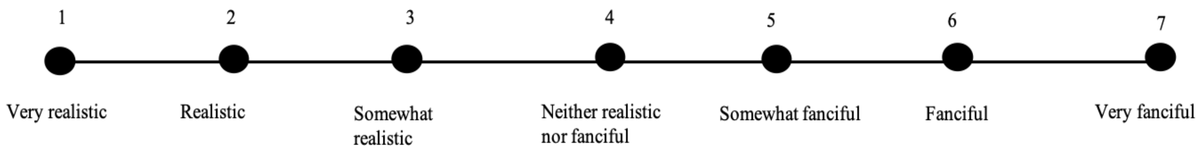
7) Using the slider on the scale below, please indicate the emotional valence of the mind wandering episode.



8) Using the slider on the scale below please indicate how constrained you felt the episode to be.



9) Using the slider on the scale below please indicate how realistic you felt the episode was.



PART C: Problem-solving content.

10) i) Did this mind wandering episode involve thinking about a problem or dilemma you are experiencing in your social life? (e.g., a disagreement with someone, a decision to make, an upcoming interaction or event you are nervous or uncertain about, or any other dilemma). Please select from the options below.

a. Yes

b. No

ii) <<*If 'Yes' is selected for question 10 then this follow-up question is provided*>>. Which of the following options would you select to characterise your thoughts about this problem?

a. Approach-based – this thought involved thinking of ways to seek a positive resolution and outcome to the dilemma.

b. Avoidance-based – this thought involved thinking of ways to avoid discomfort or negative emotions.

c. This thought was passive – it did not involve trying to resolve the dilemma in any way. Instead it involved simply thinking about the dilemma.

iii) <<*If 'Yes' is selected for question '10 i'), then this follow-up question is provided after question 10 ii* >>. Did this mind wandering episode involve thinking of a potential solution to the problem? Please select from the options provided.

a. Yes

b. No

iv)<<*if 'Yes' is selected for question '10 iii', then this follow-up question is provided*>>. Was this imagined potential solution positive (characterised by a satisfactory solution) or negative (characterised by a unsatisfactory solution or an expectation that the dilemma may become worse)?

a. Positive solution.

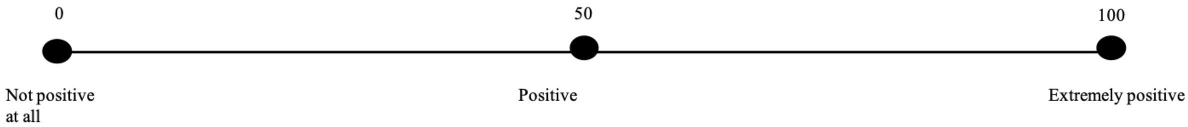
b. Negative solution.

PART D: Description of mind wandering episode.

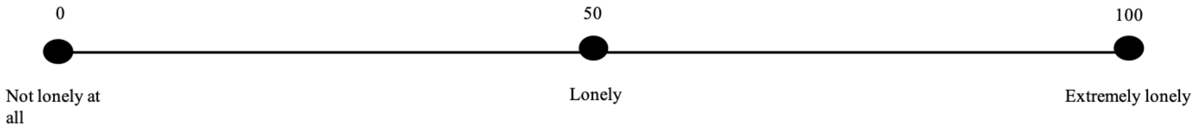
11) Please provide a brief (1-2 sentence) description of the mind wandering episode in the text box below.

PART E) Socio-emotional regulation.

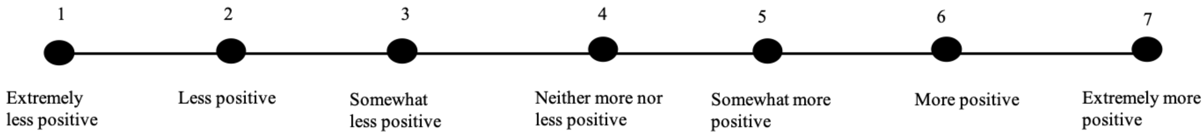
12) Using the slider on the scale below, please indicate how positive you were feeling *just prior* to the mind wandering episode.



13) Using the slider on the scale below, please indicate how lonely you were feeling *just prior* to the mind wandering episode.



14) Compared to your mood before the mind wandering episode, please indicate how positive you were feeling *just after* the mind wandering episode using the slider on the scale below.



15) Compared to your mood before the mind wandering episode, please indicate how comparatively lonely you were feeling *just after* the mind wandering episode using the slider on the scale below.