

Rumination and Cognitive Inhibition

Submitted by Henrietta Whitley Roberts to the University of Exeter
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ABSTRACT

The focus of the thesis is the investigation of the causal nature of the established association between rumination and that ability to resolve interference from task-irrelevant information, and prepotent responses. Rumination is a term used to refer to both unhelpful dwelling on negative moods and depressive symptoms (e.g., Nolen-Hoeksema, 1991), and repetitive intrusive thoughts around the theme of unresolved personal goals (Martin & Tesser, 1996).

It has been proposed that rumination occupies working memory resources, thereby depleting cognitive control capabilities necessary for the performance of concurrent effortful tasks (Hartlage, Alloy, Vasquez, & Dykman, 1993; Hertel, 2004; Watkins & Brown, 2002). This model constitutes one possible account of the considerable data demonstrating an association between depressive rumination and deficits on tasks invoking inhibitory processes (Joormann, Yoon, & Gotlib, 2007).

An inhibition construct is invoked to account for the empirical observation of interference; however there are few instances where inhibition is unambiguously driving interference (MacLeod, 2007). Moreover, there is evidence that inhibition is not a unitary construct (Friedman & Miyake, 2004).

Five experiments manipulated rumination on depressive symptoms and on personal goals in dysphoric and unselected samples in order to test Watkins and Brown's (2002) hypothesis that state rumination impairs interference control capabilities. The causal impact of state rumination was examined on interference control tasks that implicate different inhibitory sub-types: resistance to proactive interference from positive and negative material (Studies One, Two, and Five), and prepotent response inhibition on a go/no-go paradigm (Studies Three and Four).

No evidence was found to support the prediction that state rumination about depressed mood (Studies One and Two) or on-going personal goal discrepancies (Study Five) causes difficulties resolving interference from irrelevant emotional material relative to non-ruminative control conditions in both dysphoric (Studies One and Two) and unselected (Study Five) samples.

No evidence was found to support the prediction that state rumination about personal goal discrepancies impairs prepotent response inhibition relative to non-ruminative control conditions (Studies Three and Four). There was some tentative evidence to suggest that ruminating on personal goal discrepancies increased efficiency in holding a single goal active in working memory without reinforcement (Study Four).

The implications of these findings for existing models of the causal nature of the relationship between rumination and interference control processes is discussed (Chapter Nine). It is concluded that models proposing a causal impact of state rumination on available working memory capacity are insufficient to fully account for the established association between the trait tendency to ruminate and increased susceptibility to interference from irrelevant material.

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TABLE OF CONTENTS

Abstract	1
Acknowledgements	3
Table of Contents	5
List of Tables	11
List of Figures	13
Thesis Declaration	14
Notes on thesis structure	15
CHAPTER ONE: Overview	17
CHAPTER TWO: Literature Review	21
2.1 Abstract	21
2.2 Introduction	23
2.2.1 Measuring and conceptualising rumination	24
2.2.2 Operationalisations of inhibition and interference control	26
2.2.3 Theoretical accounts relating rumination and interference control	28
2.2.3.1 Impaired interference control as cause of rumination	29
2.2.3.2 Impaired interference control as consequence of rumination	32
2.2.3.3 Impaired interference control as both cause and consequence of rumination	35
2.2.3.4 Impaired interference control and rumination as consequences of depression and/or anxiety	36
2.3 Literature search	37
2.4 Evidence of an association between rumination and interference control processes	51
2.4.1 Modified Sternberg task as index of interference control	51
2.4.2 Working memory manipulation task as index of interference control	52
2.4.3 Backward inhibition as index of interference control	53
2.4.4 Directed forgetting as index of interference control	57
2.4.5 Retrieval-induced forgetting as index of interference control	61
2.4.6 Comparing letter naming and modified Stroop tasks	62
2.4.7 Negative priming as index of interference control	64
2.4.8 Recency probes task as index of interference control	68
2.4.9 Mixed antisaccade task as index of interference control	70
2.4.10 Garner task as index of interference control	72
2.4.11 Wisconsin Card Sorting Task as index of interference control	73
2.4.12 Refresh task as index of interference control	74
2.4.13 Prose distraction task as index of interference control	77
2.4.14 Emotional go/no-go task as index of interference control	78
2.4.15 Change detection task as index of interference control	80
2.4.16 Summary of correlational studies	81
2.5 Evidence relevant to the <i>impaired-interference-control-as-cause-of-rumination</i> hypothesis	82
2.6 Evidence relevant to the <i>impaired-interference-control-as-consequence-of-rumination</i> hypothesis	86

2.6.1	Inclusion-exclusion test as index of interference control	88
2.6.2	Stroop task as index of interference control	90
2.6.3	Random number generation as index of interference control	91
2.6.4	The role of cognitive load	94
2.6.5	The role of mood state	97
2.6.6	The role of motivation	98
2.7	Evidence relevant to the third factor (non-causal) hypothesis of relationship between rumination and cognitive control	99
2.8	Future challenges	99
2.8.1	Nature of causality	99
2.8.2	A two-level model of state and trait rumination	100
2.8.3	Taxonomies	104
2.8.4	Role of valence of task stimuli	104
2.8.5	The role of mood state	105
2.9	Clinical implications	106
2.10	Conclusions	107
	CHAPTER THREE: Thesis Hypotheses	111
	CHAPTER FOUR: Study One	115
4.1	Introduction	115
4.1.1	Hypotheses	118
4.2	Method	119
4.2.1	Participants	119
4.2.2	Materials	120
4.2.3	Design	124
4.2.4	Procedure	124
4.2.5	Data analysis	125
4.3	Results	126
4.3.1	Participant characteristics	126
4.3.2	Effects of rumination and distraction inductions on self-reported affect	127
4.3.3	Duration of the effects of the inductions through the cognitive task	129
4.3.4	Effects of rumination versus distraction on correct responses	131
4.3.5	Decision latencies to relevant probes	132
4.3.6	Effects of the rumination and distraction inductions on decision latencies to irrelevant probes	133
4.3.7	Decision latencies to irrelevant probes in each block of the task	136
4.4	Discussion	137
	CHAPTER FIVE: Study Two	141
5.1	Introduction	141
5.1.1	Hypotheses	142
5.2	Method	144
5.2.1	Participants	144
5.2.2	Materials	145
5.2.3	Design	145
5.2.4	Procedure	146
5.3	Results	147
5.3.1	Participant characteristics	147

5.3.2	Effects of rumination and distraction inductions on self-reported affect	148
5.3.3	Effects of rumination versus distraction on correct responses	152
5.3.4	Decision latencies to relevant probes	153
5.3.5	Effects of the rumination and distraction inductions on decision latencies to irrelevant probes	153
5.4	Discussion	155
CHAPTER SIX: Study Three		159
6.1	Preface	159
6.2	Abstract	163
6.3	Introduction	165
6.4	Method	169
6.4.1	Participants	169
6.4.2	Measures and Materials	170
6.4.3	Design and Procedure	173
6.5	Results	174
6.5.1	Participant characteristics	174
6.5.2	Effects of goal manipulation on mood and self-focus	174
6.5.3	State rumination during the modified SART	175
6.5.4	Trait rumination and state rumination during the modified SART	177
6.5.5	Errors of commission and correct go-trial RTs during the modified SART	179
6.5.6	Mood and self-focus during the modified SART	181
6.6	Discussion	181
6.6.1	Conclusion	185
6.7	Appendix A: Rumination, working memory capacity and SART performance	186
6.7.1	Introduction	186
6.7.2	Method	187
6.7.2.1	Additional measures	187
6.7.3	Results	188
6.7.3.1	WMC and self-reported rumination during the modified SART	188
6.7.3.2	WMC and errors of commission and RTs during the modified SART	189
6.7.3.3	Intraindividual reaction time variability	191
6.7.4	Discussion	193
6.7.5	Overall summary	195
CHAPTER SEVEN: Study Four		197
7.1	Introduction	197
7.1.1	Hypotheses	201
7.2	Method	202
7.2.1	Participants	202
7.2.2	Design and Materials	202
7.2.3	Procedure	203
7.3	Results	204
7.3.1	Participant characteristics	204
7.3.2	Effects of goal manipulation on mood and self-focus	205
7.3.3	Mood and self-focus during the modified SART	207

7.3.4	State rumination during the modified SART	208
7.3.5	Trait rumination and state rumination during the modified SART	210
7.3.6	Errors of commission and correct go-trial RTs during the modified SART	211
7.3.7	Intraindividual reaction time variability	213
7.3.8	Trait and state rumination and decision latencies and error rates during the modified SART	214
7.3.9	Interactions of goal condition, state rumination, and sadness during the modified SART	216
7.4	Discussion	218
7.4.1	Rumination and interference control on the modified SART	219
7.4.2	Integration of RST and control theory	221
7.4.3	State rumination and sadness and tension during the modified SART	221
7.4.4	Replication of the preliminary validation of an online measure of state rumination	223
7.4.5	Summary	224
CHAPTER EIGHT: Study Five		227
8.1	Introduction	227
8.1.1	Hypotheses	230
8.2	Method	231
8.2.1	Participants	231
8.2.2	Measures and Materials	231
8.2.3	Design and Procedure	233
8.3	Results	233
8.3.1	Participant characteristics	233
8.3.2	Effects of goal manipulation on mood and self-focus	235
8.3.3	Mood and self-focus during the modified Sternberg task	237
8.3.4	State rumination during the modified Sternberg task	237
8.3.5	Trait rumination and state rumination during the modified Sternberg task	239
8.3.6	Error rates on the modified Sternberg task	240
8.3.7	Decision latencies to relevant probes	241
8.3.8	Decision latencies to irrelevant probes	241
8.4	Discussion	243
CHAPTER NINE: General Discussion		247
9.1	Summary of thesis findings	247
9.2	Discussion of thesis findings	253
9.3	Limitations of current studies	258
9.4	Implications of thesis findings for <i>impaired-interference-control-as-consequence-of-rumination</i> hypothesis	261
9.5	Implications of thesis findings for <i>impaired-interference-control-as-cause-of-rumination</i> hypothesis	264
9.6	Implications for a third factor (non-causal) model of rumination and cognitive control	264
9.7	Methodological challenges and implications	266
9.8	Implications for theoretical models of rumination	268
9.9	Future research directions	273
9.10	Final summary	281

REFERENCES	283
APPENDIX ONE: Stimuli for the modified Sternberg task	312
APPENDIX TWO: Stimuli for the modified SART task	315
APPENDIX THREE: Goal manipulation protocol	321
APPENDIX FOUR: Mean percentages of each thought type to the thought probes	325
APPENDIX FIVE: Trait brooding and reflection analyses	327

LIST OF TABLES

CHAPTER TWO

Table 2.1	Studies examining the relationship between rumination and interference control processes	39
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CHAPTER FOUR

Table 4.1	Experimental conditions of the modified Sternberg paradigm	126
Table 4.2	Characteristics of participants (means with standard deviations in parentheses)	127
Table 4.3	Decision latencies (in ms) to positive and negative intrusion probes (means with standard deviations in parentheses)	135

CHAPTER FIVE

Table 5.1	Characteristics of participants (means with standard deviations in parentheses)	148
Table 5.2	Decision latencies (in ms) to positive and negative intrusion probes (means with standard deviations in parentheses)	155

CHAPTER SIX

Table 6.1	Hierarchical linear regression estimating state rumination during the modified SART	178
Table 6.2	% Errors of commission and mean RTs (in ms) for correct go-trials (standard deviations in parentheses)	180
Table 6.3	Hierarchical linear regression estimating state rumination during the SART	189
Table 6.4	Hierarchical linear regression estimating errors of commission	190
Table 6.5	Hierarchical linear regression estimating RTs for correct go-trials	191
Table 6.6	Hierarchical linear regression estimating RT variability	193

CHAPTER SEVEN

Table 7.1	Mean depressive symptoms, trait rumination, and ratings of sadness, tension and self-focus (standard deviations in parentheses)	207
Table 7.2	Hierarchical linear regression estimating state rumination during the modified SART	210
Table 7.3	% Errors of commission and mean RTs (in ms) for correct go-trials (standard deviations in parentheses)	212
Table 7.4	Hierarchical linear regression estimating RTs for correct go-trials	215
Table 7.5	Hierarchical linear regression estimating errors of commission	216

CHAPTER EIGHT

Table 8.1	Mean depressive symptoms, trait rumination, and ratings of sadness, tension, and self-focus (standard deviations in parentheses)	235
Table 8.2	Hierarchical linear regression estimating state rumination during the modified Sternberg task	240
Table 8.3	Mean decision latencies to positive and negative intrusion	

	probes (standard deviations in parentheses)	242
CHAPTER NINE		
Table 9.1	Summary of thesis findings	248

LIST OF FIGURES

CHAPTER FOUR		
Figure 4.1	Schematic of the modified Sternberg task	117
Figure 4.2	Mean mood ratings as a function of mood group, rumination manipulation, and time	130
Figure 4.3	Mean self-focus ratings as a function of mood group, rumination manipulation, and time	131
CHAPTER FIVE		
Figure 5.1	Mean mood ratings as a function of mood group, rumination manipulation, and time	151
Figure 5.2	Mean self-focus ratings as a function of mood group, rumination manipulation, and time	152
CHAPTER SIX		
Figure 6.1	Mean goal-related ruminative thoughts as a function of time	177
Figure 6.2	Simple slopes for state rumination one standard deviation above and below the mean RRS score	179
CHAPTER SEVEN		
Figure 7.1	Mean goal-related ruminative thoughts as a function of time	209
Figure 7.2	Simple slopes for state rumination one standard deviation above and below the mean RRS score	211
CHAPTER EIGHT		
Figure 8.1	Mean goal-related ruminative thoughts as a function of time	239

Thesis declaration

The research reported in this thesis was carried out at the University of Exeter between October 2008 and December 2012, and was supervised by Professors Edward Watkins and Andy Wills.

This dissertation has not been submitted, in whole or in part, for any other degree, diploma or qualification at any university. Chapters Two and Six are articles that have been submitted to scientific journals. Chapter Two was submitted to *Psychological Bulletin*, by Henrietta Roberts, Edward R. Watkins and Andy J. Wills. I conducted the literature review, wrote the first draft and prepared the table. My coauthors have edited the manuscript. Chapter Six was submitted by Henrietta Roberts, Edward R. Watkins and Andy J. Wills to *Journal of Behavior Therapy and Experimental Psychiatry*. I collected the data, carried out all analyses, wrote the first draft and prepared the figures and tables. My co-authors have edited the manuscript.

Henrietta Roberts

January 2013.

Notes on thesis structure

Chapters Two and Six are presented in the form of manuscripts submitted for publication. Chapter Two was submitted to *Psychological Bulletin* and is now under revision to submit to *Clinical Psychology Review*; Chapter Six was submitted to *Journal of Behavior Therapy and Experimental Psychiatry* and is currently under revision to resubmit to the same journal. The main text in each chapter is presented as a replication of the manuscript as required by the School of Psychology's guidelines for the inclusion of papers in the thesis. A preface is provided at the beginning of Chapter Six which summarises the contribution of the manuscript to the aims of the thesis, and an appendix details additional analyses conducted and provides an overall summary of the findings of the study and its contribution to the hypotheses examined in the thesis. Some adjustments have been made to these papers to integrate them into the thesis: a) a global numbering system has been applied to the entire thesis; b) figures and tables have been presented in appropriate places within the manuscripts and their numbering has been altered to reflect their integration into the thesis (e.g., Table 1 in Chapter Two becomes Table 2.1); c) where relevant the dates of citations have been updated to reflect changes to publication status.

CHAPTER ONE: *Overview*

Rumination is recognised as an important vulnerability factor for depression (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008; Watkins, 2008). There is growing evidence that the trait tendency to ruminate on depressed moods is associated with impairments on cognitive tasks that measure interference and have been argued to implicate inhibition (e.g., Joormann, Yoon, & Gotlib, 2007).

The term inhibition refers to a theoretical construct reflecting the dampening or stopping of a particular process or response and there is considerable debate regarding the extent to which inhibition can be unambiguously invoked to explain the empirical observation of interference on any given task (e.g., MacLeod, Dodd, Sheard, Wilson, & Bibi, 2003). Throughout the thesis where the theoretical construct of inhibition is invoked by a particular theory, this term (“inhibition”) is used, whereas for empirical results not unambiguously implicating inhibition I refer to interference control.

Interference control is defined as the ability to apply executive control processes to protect the contents of working memory from disruption from task-irrelevant internal representations and external stimuli. There is evidence that inhibition is not a unitary construct (e.g., Friedman & Miyake, 2004). A limitation to existing research examining rumination and interference control is that studies in this area frequently do not specify the sub-type of interference control that is assumed to be implicated in the cognitive task used to examine interference.

The vast majority of studies examining the relationship between rumination and interference control processes have adopted a correlational design; as a consequence, the causal nature of this relationship remains ambiguous. A number of theorists have proposed that deficits in resolving interference from task-irrelevant material cause

depressed individuals to be at increased vulnerability to both the onset and maintenance of ruminative thought (e.g., Joormann, 2005). An alternative account proposes that individuals high in trait rumination have a habitual tendency to state rumination (that is not caused by interference control deficits), and that state rumination occupies working memory capacity, causing deficits on concurrent cognitive tasks (e.g., Watkins & Brown, 2002). A third hypothesis is that the causal relationship between rumination and interference control is bi-directional, such that interference control deficits increase vulnerability to rumination, which in turn occupies working memory capacity, thereby exacerbating pre-existing difficulties in resolving interference. Finally, the association between rumination and interference control deficits could be driven by a third factor, such as depressed mood, which causes both increased ruminative tendencies and interference control deficits.

Clarifying the causal nature of the association between rumination and interference control is of both theoretical and clinical importance given the substantial deleterious outcomes that have been associated with rumination (Watkins, 2008). If impaired interference control causes increased vulnerability to rumination (an *impaired-interference-control-as-cause-of-rumination* hypothesis), this indicates the potential value of interventions aimed at improving interference control (e.g., Verbruggen, Adams, & Chambers, 2012) in targeting ruminative response tendencies and thereby reducing vulnerability to depressive episodes. Alternatively, if rumination causes impairments in interference control (an *impaired-interference-control-as-consequence-of-rumination* hypothesis) then this indicates the potential significance of clinical interventions that specifically target rumination (e.g., Watkins, Mullan, Wingrove, Rimes, Steiner, Bathurst, Eastman, & Scott, 2011) in reducing depressive deficits in interference control.

Thesis outline and objectives

The overarching aim of the thesis is to systematically examine the causal nature of the established association between rumination and interference control through using different methods to manipulate rumination and then measure subsequent interference control using tasks that clearly implicate the different proposed sub-types of the construct of inhibition (e.g., Friedman & Miyake, 2004). The five studies reported in the thesis manipulated rumination on depressive symptoms and on unresolved personal goals in dysphoric and unselected samples in order to test the hypothesis that rumination impairs (i) resistance to proactive interference from positive and negative material, and (ii) prepotent response inhibition.

The thesis structure is as follows: Chapter Two systematically reviews the extant literature regarding the association between rumination and interference control, contrasting the different theoretical accounts and proposes a two level model of the association between rumination and interference control. Chapter Three briefly summarises the thesis hypotheses and the empirical research reported in the thesis.

Chapters Four to Eight report a series of empirical studies which systematically examine the prediction that induced rumination impairs interference control processes relative to a non-ruminative control condition. Chapter Four (Study One) examines the effects of rumination and distraction inductions (Nolen-Hoeksema & Morrow, 1993) on resistance to proactive interference in dysphoric and non-dysphoric individuals. The modified Sternberg task (Oberauer, 2001) was selected as a relatively clear index of resistance to proactive interference. Chapter Five (Study Two) sought to overcome limitations to Study One through modifications to the methodology adopted. Chapter Five therefore examines the same predictions as Chapter Four. Chapter Six reports the development and validation of a direct measure of state rumination on personal goal

discrepancies in order to more directly assess the potential causal impact of state rumination on interference control. Chapter Six additionally reports a preliminary examination of the impact of state rumination on prepotent response inhibition in an unselected sample. The Sustained Attention to Response Task (SART; Robertson, Manly, Andrade, Baddeley, & Yiend, 1997) was selected to assess prepotent response inhibition. Chapter Seven sought to clarify the findings reported in Chapter Six regarding the impact of rumination on prepotent response inhibition through a modification to the cognitive task designed to address variability in speed accuracy trade-offs. Consequently, Chapter Seven examines the same predictions as Chapter Six in a larger sample. Chapter Eight examines the impact of rumination on resistance to proactive interference using the more powerful and ecologically valid rumination manipulation reported in Chapters Six and Seven and directly measuring the extent of state rumination. As in Studies One and Two, the modified Sternberg task was selected to measure resistance to proactive interference, therefore examining the extent of convergence across two rumination manipulations regarding the consequences of state rumination for the same index of interference control. Finally, Chapter Nine is a general discussion of the thesis and provides an overall conclusion regarding the hypotheses examined.

CHAPTER TWO: *Literature Review*

Rumination and Deficits of Interference Control.

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2.1 *Abstract*

Inhibitory processes have been identified as a potential mechanism underpinning rumination and it has been proposed that deficits in the ability to control the contents of working memory may drive depressive difficulties in disengaging from ruminative content (e.g., Joormann, 2005). An inhibition construct is invoked to account for the empirical observation of interference; however there are few instances where inhibition is unambiguously driving interference. There is robust evidence of a relationship between trait rumination and measures of the ability to resolve interference, and there has recently been a rapid expansion of research in this field. This review considers the key theoretical models regarding rumination and interference resolution. We systematically review existing evidence regarding rumination and interference control, contrasting the different causal hypotheses that have been proposed and examining which theoretical models best account for the existing data. We conclude there is strong evidence that trait rumination is related to interference control; in some cases

rumination is associated with deficits to interference resolution, whereas other studies demonstrate an association between high trait rumination and benefits to performance on tasks requiring interference control. Possible accounts of these findings are discussed, and a two-level model of rumination and interference control is proposed. We conclude that state rumination plays a causal role in deficits to interference control. The reverse direction of causality has yet to be systematically tested. The clinical implications of these findings are considered and future work to develop a more specified model of rumination is proposed.

Keywords:

Rumination; depression; interference control; working memory

2.2 Introduction

Depressive rumination is defined as “repetitively focusing on the fact that one is depressed; on one’s symptoms of depression; and on the causes, meaning and consequences of depressive symptoms” (Nolen-Hoeksema, 1991, p. 569) and has been identified as a key process in the onset and maintenance of depression. There is extensive evidence that rumination maintains and exacerbates depressive symptoms (Morrow & Nolen-Hoeksema, 1990; Nolen-Hoeksema, 2000; Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008; Watkins, 2008), is a vulnerability factor for the onset of depression (Nolen-Hoeksema, 1991), and in contrast to strategies that help regulation and recovery from negative mood (Rusting & DeHart, 2000), rumination perpetuates low mood. Therefore, understanding the cognitive mechanisms that drive persistent rumination is of value in improving recovery from dysphoric moods and reducing vulnerability to depression.

Recent investigations have examined how the cognitive deficits and biases observed in depressed individuals are associated with the tendency to ruminate in response to sadness (e.g., Gotlib & Joormann, 2010; Joormann, Yoon, & Zetsche, 2007). In a recent review of cognitive control and depression, Joormann et al. (2007) highlighted evidence that trait rumination was associated with poor performance on tasks presumed to index cognitive control. They therefore proposed that individual differences in cognitive control may be critical to “differentiating people who recover easily from negative affect from those who initiate a vicious cycle of increasingly negative ruminative thinking” (p. 136). The key aspect of cognitive control, in so far as it relates to rumination, was considered by Joormann to be the ability to control the contents of working memory; Joormann et al. (2007) indicated the need for a detailed

investigation of the relationship between rumination and the ability to redirect attention, and to disengage from negative material. Following this recommendation, the current article critically reviews the extant literature on rumination and cognitive control processes, incorporating numerous experimental studies added to this literature since the Joormann et al., (2007) review. As noted by Joormann and colleagues (Joormann et al., 2007; Joormann & Gotlib, 2010), the construct validity of a number of the paradigms in which researchers have invoked the theoretical construct of inhibition has been questioned (e.g., MacLeod, Dodd, Sheard, Wilson & Bibi, 2003; MacLeod, 2007, Mayr & Bucher, 2007). Indeed, a particular methodological issue within the field is that researchers investigating inhibition frequently invoke this both as a phenomenon to be explained, and as the explanation for the theoretical construct in question. Moreover, there has been a rapid expansion in studies in this field (at least 22 published studies since 2007). Thus, a critical examination of existing evidence and theory is timely. The current review outlines the main definitions of rumination and inhibition and operationalizations of rumination and of inhibition within tasks implicating interference control processes, considers the main classes of theory about the relationship between rumination and interference control, and then systematically reviews existing evidence of an association between ruminative response tendencies and measures of interference control. For the first time, this literature is reviewed to examine which of the main competing theoretical accounts best accommodate all of the available data.

2.2.1 Measuring and Conceptualizing Rumination

Response Styles Theory (RST; Nolen-Hoeksema, 1991) conceptualises depressive rumination as a stable, trait-like style of responding to depressed mood

involving persistent focus on one's negative emotional state and the inhibition of behaviours that threaten to distract from this focus. Rumination is typically assessed on the Ruminative Responses Scale of the Response Styles Questionnaire (RSQ; Nolen-Hoeksema & Morrow, 1991), which is the measure of trait rumination adopted by the majority of research examining rumination and interference control. The RRS is a 22-item scale that asks participants to report the frequency with which they ruminate in response to sad or depressed moods (e.g., "analyse recent events to try and understand why you are depressed"). Treynor, Gonzalez and Nolen-Hoeksema (2003) identified two distinct components within the RRS – *brooding* and *reflection*. Brooding is conceptualised as negative and evaluative focus on the self, and is proposed to be maladaptive; reflection is conceptualised as a purposeful focus on problem solving aimed at alleviating symptoms of depression and is argued to be adaptive. According to RST (Nolen-Hoeksema, 1991) ruminative responses are habitual and automatic, typically developing during childhood. This conceptualisation implies that stopping ongoing rumination would involve effortful suppression or disengagement from these cognitions, a process that could be interpreted as resisting a prepotent tendency to ruminate in response to sadness (Joormann, 2005).

A number of other important models of rumination have been proposed (e.g., Carver & Scheier, 1982; Martin & Tesser, 1996; Pyszczynski & Greenberg, 1987; Watkins, 2008; 2011). Goal-oriented theories of rumination propose that detection of a discrepancy between one's current status and anticipated progress towards a goal instigates ruminative thoughts, which continue until either the discrepancy is resolved (by meeting the goal) or the individual disengages from the goal (Martin & Tesser, 1996). Thus, individuals prone to the repeated and prolonged unconstructive rumination that is implicated in depression are hypothesized to experience difficulties disengaging

from unattainable and abandoned goals (e.g., van Randenborgh, Huffmeier, LeMoult, & Joormann, 2010). Attention-narrowing models of depression-related memory difficulties (see Hartlage, Alloy, Vasquez & Dykman, 1993 for a review) propose that depressed individuals may prioritise ruminative thoughts at the expense of other tasks. The majority of research examining the relationship between rumination and interference control has adopted Nolen-Hoeksema's (1991) formulation of rumination.

2.2.2 Operationalizations of inhibition and interference control

Interference is the empirical result whereby the processing of content that is not relevant to the current task slows down the processing of task-relevant material, resulting in decrements in performance. Inhibition is one theoretical mechanism by which interference might be explained. MacLeod (2007) proposed that the theoretical construct of inhibition is best conceptualized as “the stopping or overriding of a mental process, in whole or in part, with or without intention” (p.5). In a number of tasks that are regarded as classic demonstrations of an inhibition construct, alternative accounts of the interference observed are also possible (e.g., Neill & Mathis, 1998; MacLeod et al., 2003; MacLeod, 2007). For example, negative priming is a form of interference revealed by the slowing of response to a stimulus that has recently been ignored. It has been argued by some that negative priming reflects the time cost associated with overcoming inhibition of previously ignored material that has subsequently become relevant. However, alternative accounts propose that negative priming does not reflect inhibition and is attributable to memory processes. As discussed in greater detail in section 2.4.6 the question of whether negative priming is best described as an inhibitory phenomenon is an on-going debate (see e.g. May, Kane, & Hasher, 1995; Tipper, 2001,

Mayr & Buchner, 2007). In the remainder of this article, we use the term *interference control* where the theoretical construct of inhibition is not unambiguously the underlying phenomenon driving the empirical result of interference. For example, the magnitude of negative priming in an individual is less controversially described as an index of their ability to control interference, than as an index of their ability to *inhibit* previously relevant information.

A number of researchers have argued that the inhibition construct is not a unitary ability but that instead it fractionates into multiple components (e.g., Friedman & Miyake, 2004; Hasher & Zacks, 1988; Nigg, 2000). These fractionations have three broad components: (a) resistance to distraction (including the blocking of irrelevant information from access to working memory, WM); (b) resistance to proactive interference (i.e., the ability to resist interference from information that was previously relevant to the task but has since become irrelevant); and (c) inhibiting prepotent responses. A number of researchers (e.g., Aron, 2007; Bissett, Nee, & Jonides, 2009) have argued that whilst there is evidence to suggest that inhibition is implicated in withholding prepotent behavioural responses, it is not clear that inhibition plays a role in other types of interference control, such as resistance to proactive interference.

The fractionation of interference control processes is supported by both individual difference (e.g. Friedman & Miyake, 2004) and neuroscience (e.g. Nee & Jonides, 2008; Bissett, Nee & Jonides, 2009) research. Nevertheless, interference control processes are widely acknowledged to be a difficult set of constructs to measure for a number of reasons. First, measures of interference control processes frequently do not correlate with other measures purported to tap the same process (Friedman & Miyake, 2004; Kramer, Humphrey, Larish, Logan, & Strayer, 1994). Second, there is a severe task impurity problem, such that the relative proportion of variance that can be

attributed to the proposed ability to resist interference is likely to be relatively small in relation to that attributable to the error variance and idiosyncratic task requirements (e.g., Shilling, Chetwynd & Rabbitt, 2002). For example, one of the most frequently used executive tasks, the Wisconsin Card Sorting Task (WCST), is known to involve visual processing, numeric ability, working memory, rule induction, motivation, set shifting, and feedback processing (Strauss, Sherman & Spreen, 2006). Consequently, there are many ways in which performance on such measures may be compromised, leading to difficulties in establishing what task failure signifies. This problem can be circumvented to some degree through the use of multiple tasks to assess interference control (Friedman & Miyake, 2004; Miyake, Emerson et al., 2000), as the idiosyncratic components of the tasks will be less critical to the pattern of performance across these measures.

2.2.3 Theoretical accounts relating rumination and interference control

There are four possible accounts of the relationship between rumination and interference control deficits. First, impaired interference control causes increased rumination. Second, on-going rumination causes impaired interference control. Third, there is a bi-directional relationship between rumination and interference control. Fourth, the association between rumination and interference control deficits is secondary to a third factor, such as depression, which causes both increased rumination and impaired interference control. These contrasting proposed accounts of rumination and interference control processes have distinct implications for clinical understanding and interventions for depression, and each causal model predicts different approaches to reducing cognitive interference and rumination in depression.

2.2.3.1 *Impaired interference control as a cause of rumination*

The most elaborated account of an impaired interference control-as-cause of rumination hypothesis has been developed by Linville (1996) and Joormann (2005). Linville (1996) proposes two possibilities: (1) that ruminative thoughts may access consciousness because they are goal-related (i.e., in the absence of interference control difficulties), and (2) that stress and depression might deplete inhibitory capabilities, resulting in rumination. Linville (1996) adopted Martin and Tesser's (1996) goal-directed conceptualisation of rumination, arguing that under normal inhibitory function, ruminative thoughts that are irrelevant to one's current task may occur in circumstances where the focus of such thoughts is a highly prioritised goal. Linville's argument that negative mood plays a causal role in depleting inhibitory capabilities can be related to Hasher and Zack's (1979) proposal that depression and arousal selectively impair effortful processing, through reducing total cognitive capacity and thereby depleting resources available for cognitively demanding acts of attentional control. Linville further argues that inhibition is not perfect, and task-irrelevant thinking (i.e., mind-wandering) is not in itself problematic, however, efficient inhibitory processes are required to prevent the continued activation and processing of such thoughts at the expense of attending to one's current task.

Linville (1996) operationalized inhibition as “an automatic cognitive gatekeeper, hindering access to consciousness of marginally relevant or irrelevant external information and internal thoughts” (p. 122). Linville proposes a number of mechanisms by which weakened inhibitory attentional processes might cause intrusive ruminative thoughts to occur. Firstly, difficulties in preventing ruminative thoughts accessing working memory as a consequence of poor inhibitory control might result in concurrent

and inefficient processing of both one's current task and the focus of ruminative thinking. Second, inefficient inhibitory control might result in proactive interference of thoughts pertaining to a concern that has subsequently become irrelevant due to a change in goals. Third, depleted inhibitory control could allow proactive interference from rejected interpretations and unsuccessful attempts at goal-pursuit.

An important issue for Linville's (1996) model is determining what constitutes goal-irrelevant content. People hold multiple goals, which are of varying salience and importance at any moment; thus information may be inhibited because it pertains to an on-going and relevant goal that is not currently active. Further, there may be multiple goals that are activated by any particular task, such that the processing of task-relevant material may initiate task-irrelevant thoughts pertaining to other goals that can be related to, but are distinct from, the task at hand. Thus, rumination is conceptualised as a process driven by both motivational components and weakened inhibitory attentional control, implying that a full account of the circumstances in which rumination is predicted to occur requires the specification of both cognitive and motivational components.

Joormann's (Gotlib & Joormann, 2010; Joormann, 2005; Joormann et al., 2007; Joormann, 2010; Joormann & D'Avanzato, 2010) model of cognitive control mechanisms in depression proposes that deficits in the ability to control the contents of working memory cause depressed individuals to experience difficulties blocking or removing irrelevant negative content from working memory, which in turn fosters rumination. Joormann (2005) specifies a number of mechanisms by which weakened inhibitory control is proposed to result in greater rumination and poorer performance on tasks requiring the ability to control the contents of working memory, and implicates all three subtypes of interference control in this relationship. First, Joormann proposes that

depressed individuals have a specific deficit in preventing irrelevant negative material from accessing working memory (i.e., resistance to distraction), which once activated is not easily discarded from working memory (i.e., resistance to proactive interference), resulting in rumination and persistent negative mood. Joormann proposes that these difficulties in inhibition lead to greater processing of negative content and rehearsal into long term memory. Second, Joormann proposes that poor inhibition causes depressed individuals to experience difficulties overcoming a depression-related prepotent tendency to ruminate and argued that inhibition of such responses (prepotent response inhibition) is required in order to redirect attention to the current task.

Koster and colleagues (Koster, De Lissnyder, Derakshan, & De Raedt, 2011) propose a reciprocal relationship between depression, attentional control, and rumination, whereby depression is characterised by impaired attentional control in the presence of negative information. Impaired attentional disengagement from negative material is in turn proposed to contribute to the vulnerability to persistent and repetitive rumination. Finally, persistent rumination is hypothesised to exacerbate negative mood, thereby further narrowing attentional focus and exacerbating biases in the allocation of attentional resources such that mood congruent emotional material is preferentially processed and depletes available attentional resources.

Koster et al. define attentional control as “the ability to selectively attend to task-relevant information and to inhibit distraction by task-irrelevant material” (p. 139), and argue that this implicates inhibition, set-shifting, and the monitoring and updating working memory contents. Koster et al.’s model predicts that both generalised attentional control deficits and valence-specific attentional biases play a causal role in the tendency to persistently ruminate about negative moods and negative self-relevant cognitions (i.e., trait rumination).

In support of this model, as well as the studies reviewed in detail in sections 2.4-2.6 indicating an association between poor interference control and rumination, there are studies indicating an association between rumination and attentional bias. There is evidence that trait depressive rumination is correlated with an attentional bias towards sad faces (Joormann, Dkane, & Gotlib, 2006), and negative words (Donaldson, Lam, & Mathews, 2007), and that in negative moods, induced rumination reduces attentional biases to positive material (Morrison & O'Connor, 2008). Thus, there is evidence consistent with Koster et al.'s proposal that negative moods and rumination are associated with biases in the allocation of attentional resources whereby negative emotional material is preferentially processed.

2.2.3.2 Impaired interference control as a consequence of rumination

A number of theoretical accounts (Andrews & Thomson, 2009; Beevers, 2005; Ellis & Ashbrook, 1988; Hertel, 1997, 1998, 2004; Hester & Garavan, 2005; Jermann, van der Linden, Adam, & Cheschi, 2005; Jones, Seigle, Muelly, Haggerty, & Ghinassi, 2010; Levens, Muhtadie, & Gotlib, 2009; Philippot & Brutoux, 2008; von Hecker & Sedak, 1999; Watkins & Brown, 2002) share the hypothesis that ruminative thoughts occupy attentional resources, thereby reducing available working memory capacity or executive control capabilities and impairing performance on concurrent tasks that require effortful processing. Thus, an alternative model of the relationship between rumination and interference control processes is that ongoing rumination causally influences interference resolution processes. The different theoretical accounts that share this hypothesis posit a series of related but distinct predictions regarding the relationship between state rumination and cognitive control.

The cognitive exhaustion model of depression (Kofta & Sedak, 1998; von Hecker & Sedak, 1999) proposes that impairments on some cognitive control tasks in depression can be explained in terms of perceived uncontrollability. Specifically, the model proposes that “uncontrollability, and in particular ruminating thoughts about uncontrollable conditions, lead to a depletion of those cognitive resources that support generative and flexible, constructive thinking” (von Hecker & Sedak, 1999, p. 835). The model thus predicts that rumination-related impairments will be evident on tasks that require flexible shifting between different task goals. This prediction is shared by Altamirano, Miyake, & Whitmer (2010) who propose that trait rumination reflects a stable tendency to maintain focus on a particular goal once it is activated. Altamirano et al. (2010) argue that individuals high in rumination demonstrate impairments on cognitive tasks that require the ability to flexibly shift between different task goals. Altamirano et al. further propose that trait rumination confers a benefit for performance of cognitive tasks that require the ability to maintain a single goal and resist distraction from this.

Beevers (2005) dual process model of cognitive vulnerability to depression proposes that cognitive capacity is occupied by mood-congruent and ruminative thinking in depression, and that depressed individuals are impaired in their ability to correct automatic negative cognitive biases because they have insufficient cognitive resources available as a consequence of ongoing negative thinking. Resource allocation models of depression (Ellis & Ashbrook, 1988; Levens et al., 2009) posit that depressed individuals prioritise the allocation of attentional resources to the processing of depressive content and ruminative thoughts. As a consequence, cognitive capacity available for processing information relevant to concurrent effortful tasks is reduced. Hartlage et al (1993) argue that whilst the automatic initiation of processing negative

self-referent content does not occupy cognitive capacity, the negative thoughts that such processing generates does interfere with concurrent cognitive functioning. Beevers (2005) dual process model and the resource allocation models (Hartlage et al., 1993) share the prediction that ruminative thoughts result in impairments that are specific to cognitive tasks that are attentionally demanding, and the degree of impairment is predicted to be determined by the effortfulness of the task (e.g., Hartlage et al., 1993).

Hertel (1997) proposes that the initiation of rumination occurs automatically, but resultant ruminative thoughts occupy cognitive capacity and have consequences for resources available for effortful processing. Hertel (Hertel & Rude, 1991; Hertel, 1997, 1998, 2004) further proposes that constrained situations (for example, memory tasks that require participants to verbally rehearse the test material during the learning phase) eliminate the opportunity to ruminate, and that deficient attentional control, habits of attending to ruminative thoughts, and difficulties initiating task-focused cognitive strategies are responsible for depressed individuals' impaired performance on unconstrained tasks (i.e., impaired interference resolution as a consequence of ongoing rumination). Rumination involves repeated thinking about personally important events, and, as such it will utilise a certain degree of cognitive processing resources (Hertel, 2004). Hertel (1997) posits that depressive memory impairments are greatest on unconstrained tasks that permit task-irrelevant ruminative thought, thus task performance is predicted to be improved under more structured (e.g., Hertel & Rude, 1991) or attentionally demanding (e.g., Krames & MacDonald, 1985) conditions.

Common to all these models is the proposal that state rumination occupies cognitive resources and would be predicted to interfere with controlled processing in service of a concurrent cognitive task that places demands on executive control processes. Thus, a parsimonious account of the relationship between rumination and

cognitive control would be that since rumination occupies working memory capacity, it impairs performance on tasks sensitive to working memory load (Hester & Garavan, 2005).

2.2.3.3 Impaired interference control as both cause and consequence of rumination

A third possible account of the relationship (e.g., De Raedt & Koster, 2010; Hartlage et al., 1993; Hertel, 1997, 2004; Jones et al., 2010; Joormann, 2005; Joormann et al., 2007; Levens et al., 2009) is that impaired interference resolution is both a cause and a consequence of rumination. Depleted interference control resources may interfere with the capacity to override ruminative response tendencies. Once initiated, rumination may exact a cognitive load effect, further depleting inhibitory resources available for other tasks (Levens et al., 2009).

For example, Hertel (2004) proposes that depressed individuals have habits of ruminating and argued that “Deficient cognitive control sets the stage for habits to emerge. At the same time, thoughts that habitually occupy attention leave little mental room for thoughts about anything else” (p. 195). A number of factors have been proposed to increase the susceptibility to the development of pathological habits (Uhart & Wand, 2009; Schwabe, Dickinson & Wolfe, 2011; Schwabe & Wolfe, 2011). Schwabe et al. (2011) propose that under conditions of stress, habitual behaviours are favoured over goal-driven ones, that the transition from initially goal-driven and voluntary responses (e.g., voluntary alcohol consumption) may be accelerated by the bias to habitual responding following chronic stress, and that reduced cognitive control and greater stress reactivity might increase the predisposition to develop a pathological habit.

Early stressful experiences such as abuse and neglect have been identified as important vulnerability factors in the development of pathological rumination (Conway, Mendelson, Giannopoulos, Csank, & Holm, 2004). Thus, one possible account of the relationship between interference control processes and rumination is that reduced interference resolution increases susceptibility to negative impacts of early stressors, thereby increasing vulnerability to developing pathological habits of rumination. Ongoing rumination in response to a stressor then occupies cognitive capacity resulting in impaired performance on a concurrent task requiring interference resolution. Hertel's (2004) model thus conceptualises the relationship between rumination and cognitive control as reciprocal. Such a proposal implies that the relationship between rumination and interference resolution may be bi-directional and have a synergistic effect on cognitive capacity.

2.2.3.4 Impaired interference control and rumination as consequences of depression and/or anxiety

Depressive symptoms such as negative affect or loss of motivation, may cause both rumination and impaired interference control (e.g., Frings, Wentura, & Holtz, 2007; Hartlage et al., 1993; Jones et al., 2010; Joormann & D'Avanzato, 2010; Joormann, 2010). Thus, it is possible that rumination and interference control processes are not causally related, and that both observations are a consequence of depression. Further, symptoms of depression and anxiety are highly co-morbid. It is thus possible that anxiety regarding ongoing and unresolved concerns both causes rumination, and, consistent with Attentional Control Theory (Eysenck, Derakshan, Santos & Calvo, 2007, Derakshan & Eysenck, 2009), also impairs processing efficiency resulting in worsened performance on interference control measures.

2.3 Literature Search

To establish whether (a) there is a robust association between rumination and impaired interference control; (b) examine which subtype of interference control is most associated with rumination (resistance to distraction, resistance to proactive interference, or prepotent response inhibition); and (c) examine the different accounts of this putative relationship, a comprehensive and systematic review of the extant literature is required. To this end, a computerised search using keyword terms was conducted to identify relevant publications. The search (using wild cards such as *ruminat** for rumination, ruminative, ruminate, ruminator) included the following keyword terms intended to identify studies examining rumination: *rumination, depression, dysphoria, self-focus, repetitive thought, perseverative, worry*, which were combined with each of the following keyword terms to identify studies examining interference control: *inhibition, inhibitory, interference, prepotent, cognition, cognitive, executive, attention, working memory, memory*, entered into ISI Web of Knowledge and PsycINFO from the beginning of the database through to April 2012. In addition, the reference lists of the identified publications, as well as key review articles and chapters (e.g., Joormann, 2005; Hertel, 2004) were reviewed for relevant literature. Table 2.1 summarises the studies identified and reports their design, the cognitive task used, and the main findings. Studies included examined rumination and interference control processes in adult samples. To our knowledge, this is the first review reporting a systematic literature search to examine this field in depth.

Three main types of studies were identified: (a) correlational studies relating individual differences in trait rumination to interference control processes, (b)

prospective studies that related individual differences in trait rumination to interference control processes longitudinally, and (c) experimental studies that manipulated state rumination and measured subsequent interference control. First, the review examines the correlational studies to establish whether the finding of an association between rumination and interference control is robust when recent critiques of the paradigms used are incorporated and to determine which operationalization of interference control is most associated with trait rumination. Typically, such correlational data cannot discriminate between the four potential accounts of the relationship between interference control and rumination. Thus, second, we will review those studies, principally experimental studies, that are relevant to evidence for and against each distinct account.

Establishing the construct validity of the paradigms that have been adopted by these studies is critical to developing a clear synthesis of the evidence relating rumination and interference control. Given the debate concerning operationalizations of interference control noted earlier, it is important to review the validity of the paradigms adopted. The studies are organized by experimental paradigm, and each paradigm is reviewed and critically evaluated in terms of whether on conservative criteria it can be considered to index interference control. As the construct validity of several of the paradigms used to investigate the association between trait rumination and interference control is debatable, studies utilising more valid and less debatable measures of interference control are considered first and given greater weight in synthesizing the findings of the review.

Table 2.1 *Studies examining the relationship between rumination and interference control processes*

✓ = relatively clear index of interference control processes ? = a number of possible interpretations of the task

Authors	Design	Sample	Task	Materials	Construct validity	Main finding
<i>Experimental Studies</i>						
Hertel (1998)	Manipulated rumination and then measured interference control	BDI ≥ 9 & ≤ 6	Fragment completion test of memory for studied word pairs, dissociating controlled and automatic retrieval.	Neutral words	✓	Impairments resisting proactive interference observed in both rumination conditions, but not in distraction condition.
Philippot & Brutoux (2008)	Manipulated rumination and then measured interference control	BDI ≥ 18 & ≤ 10	Stroop task	Neutral words	✓	Impaired prepotent response inhibition observed for dysphoric participants in rumination condition, compared to those in distraction condition, and to non-dysphoric participants.
Watkins & Brown (2002)	Manipulated rumination and then measured interference control	MDD & controls (not depressed in past 5 years)	Random Number Generation	Neutral	?	Depressed participants in rumination condition showed a greater tendency towards stereotyped counting responses than all others. Depressed participants in distraction condition did not differ from non-depressed controls.

Authors	Design	Sample	Task	Materials	Construct validity	Main finding
<i>Experimental Studies</i>						
Whitmer & Gotlib (2012)	Manipulated rumination and then measured interference control	MDD & controls	Task switching paradigm.	Neutral	✓	Induced rumination caused greater switch costs relative to distraction for depressed participants but not for controls. No effects of depression status or rumination condition on preparation effect. High trait rumination was associated with reduced backward inhibition cost.
Wong & Moulds (2009)	Manipulated rumination and then measured interference control	BDI ≥ 12 & ≤ 5	Directed forgetting paradigm	Positive, negative, and neutral words.	?	The rumination manipulations differentially effected self-reported self-focus, but not mood. Dysphoric participants in the rumination and distraction conditions did not differ in directed forgetting for positive, negative, or neutral words. All dysphoric participants exhibited standard directed forgetting effects.

Authors	Design	Sample	Task	Materials	Construct validity	Main finding
<i>Correlational Studies</i>						
Altamirano, Miyake, & Whitmer (2010)	Related individual differences in trait rumination to cognitive measures of goal flexibility and goal maintenance	Healthy students	Letter-naming task and modified Stroop paradigm	Letters and numbers (letter naming task) and neutral words (modified Stroop).	✓	Trait rumination was positively associated with postcue errors on the letter naming task (interpreted as a measure of goal flexibility), and was negatively associated with incongruent trial errors on the Stroop (interpreted as goal maintenance).
Berman et al (2011)	Related individual differences in trait rumination to interference control	MDD and healthy controls	Directed forgetting paradigm	Positive and negative words	✓	Individual differences in trait rumination were positively correlated with slower rejection of the negative words from the to-be-forgotten list.
Bernblum & Mor (2010)	Compared high and low trait brooders using quartile split	Healthy students	Memory refreshing task (Johnson et al., 2006)	Neutral and emotional words	?	Based on a quartile split high trait brooders demonstrated greater interference from emotional words.

Authors	Design	Sample	Task	Materials	Construct validity	Main finding
<i>Correlational Studies</i>						
Cheun Yee Lo, Lau, Cheung, & Allen (2012)	Used hierarchical linear modelling to examine the relationship between trait rumination, induced sad mood, and switch costs	Healthy students	Mental counting task	Neutral and emotional words (positive and negative)	✓	There was no relationship between switch costs and rumination, mood condition, or the interaction of the two
Daches, Mor, Winquist, & Gilboa-Schechtman (2010)	Related individual differences in brooding, to interference control	Healthy students	Modified Garner task	Neutral words, and non-emotional self-referentially	?	Brooding was positively associated with Garner interference
Davis & Nolen-Hoeksema (2000)	Compared high and low trait ruminators using predetermined criteria on RSQ	RRS-SF item "often" or "always" & RRS-SF items "often" or "always"	Wisconsin Card Sorting Task (flexibility measure) and backward digit span (working memory measure) and Colours subtest (task switching measure)	Neutral	?	High RRS scorers made more perseverative errors than low RRS scorers. No group differences in WMC or task-switching.

Authors	Design	Sample	Task	Materials	Construct validity	Main finding
<i>Correlational Studies</i>						
De Lissnyder, Derakshan, & De Raedt, & Koster (2011)	Compared high and low trait ruminators using a median split (RRS <45.5 & RRS >45.5) – dysphoric participants were not distributed evenly over two	BDI-II- NL <14 & BDI-II- NL ≥14	Mixed antisaccade task	Neutral	✓	No interaction of dysphoria status with the anti-saccade benefit, the increase in error rates from single to mixed blocks was greater for non-dysphorics than dysphorics. No interaction of rumination with the anti-saccade benefit. High trait ruminators exhibited slower anti-saccade latencies than low ruminators overall, and the groups did not differ on pro-saccade latencies.
De Lissnyder, Koster, Derakshan & De Raedt (2010)	Examined correlation between individual differences in trait rumination and interference control and compared high and low trait ruminators using a median split (RRS <45.5 & RRS >45.5) – dysphoric participants were not distributed evenly over two rumination groups	BDI-II- NL <14 & BDI-II- NL ≥14	Affective shift task (modified task switching paradigm)	Happy and angry faces	✓	High ruminators were impaired at resolving interference from irrelevant negative material. Depressive brooding was predictive of faster RTs on n-2 repetitions of negative material, BDI-II, RRS and reflective pondering were not. High ruminators had a greater shift-cost than low ruminators. Depressive brooding was predictive of set-shift costs, BDI-II, RRS and reflective pondering were not.

Authors	Design	Sample	Task	Materials	Construct validity	Main finding
<i>Correlational Studies</i>						
De Lissnyder, Koster & De Raedt (2011)	Compared high and low trait ruminators using a median split (RSS) – dysphoric participants were not affected by RRS over two rumination groups	BDI-II-NL < 14 & BDI-II-NL ≥ 14	Internal Shift Task (IST)	Neutral and angry faces	✓	High trait ruminators had larger switch costs when classifying faces according to emotionality (emotional condition) relative to making gender classifications (neutral conditions). High ruminators had larger switch costs in the emotional condition than low trait ruminators
Goeleven, De Raedt, & Baert, & Koster (2006)	Examined correlation between individual differences in trait rumination and interference control	MDD, formerly MDD (2+ episodes) & controls (never disordered)	Negative Affective Priming Task	Happy and sad faces	?	Depression-related performance deficits for negative material were not related to trait rumination
Hertel & Gerstle (2003)	Examined correlation between individual differences in trait rumination and interference control and compared high and low trait ruminators operationalized as the higher and lower scorer on the RSQ in each cell of their counterbalancing design	BDI ≥ 6 & ≥ 9	Adapted think/no-think paradigm	Positive and negative words	✓	RRS was negatively correlated with intrusion effect size – participants higher in trait rumination recalled more suppressed targets. Based on a median split analysis high RSS scorers forgot fewer suppressed targets than low RSS scorers.

Authors	Design	Sample	Task	Materials	Construct validity	Main finding
<i>Correlational Studies</i>						
Joormann (2006)	Examined correlation between individual differences in trait rumination and interference control and compared high and low trait ruminators on the 21-item RSQ-R and RSQ-reflection operationalized using a median split	Healthy students	Negative Affective Priming task	Positive and negative words	?	High ruminators on both RSQ-R and on RSQ-reflection did not show negative priming effect for emotional words (both positive and negative). RSQ-R and RSQ-reflection were significantly negatively correlated with the negative bias score. A regression model identified CES-D (symptoms of depression) and RSQ-R as significant predictors of negative bias score.
Joormann & Gotlib (2008)	Related individual differences in trait rumination to interference control	MDD & controls (never disordered)	Modified Sternberg task	Positive and negative words	✓	Rumination was correlated with depression-related impairments resisting proactive interference from negative words.
Joormann & Gotlib (2010)	Related individual differences in trait rumination to interference control	MDD, RMD (1+ episode, currently remitted), & controls (no hx Axis I disorder)	Negative Affective Priming task	Positive, negative and neutral words	?	Depressed participants exhibited a reduced negative priming effect for negative material, and this was associated with greater trait rumination (RRS) and trait brooding. MDD participants exhibited an increased negative priming effect for positive material, and this was positively associated with trait reflection.

Authors	Design	Sample	Task	Materials	Construct validity	Main finding
<i>Correlational Studies</i>						
Joormann, Levens & Gotlib (2011)	Related individual differences in trait rumination to interference control	MDD and never depressed controls	Working memory manipulation task	Positive, negative, and neutral words	✓	MDD had bigger sorting costs (RT backwards trials – RT forwards trials) than controls. MDDs had bigger sorting costs for negative than positive or neutral trials. For MDDs only RRS scores significantly predicted sorting costs for negative words.
Joormann, Nee, Berman, Jonides, & Gotlib (2010)	Related individual differences in trait rumination to interference control	MDD & controls (no hx Axis I disorder)	Ignore/ Suppress task	Positive and negative words (study 1); letters (study 2)	✓	Expt 1: emotional words. MDD took longer to respond to match probes than CTL. MDD had greater interference effects (RT forget probes – RT control probes) for negative words than CTL. Rumination (RRS) was correlated with depression-related impairments resisting proactive interference from negative words. Expt 2: 4 or 8 letters (high and low WM load). Trend towards more errors in MDD than CTL group during ignore phase under low load. In both ignore and suppress phase under low WM load MDD participants were slower to respond to match probes than CTL participants, but the groups did not differ under high WM load. No correlation between RRS and interference effects (RT forget probes – RT control probes).

Authors	Design	Sample	Task	Materials	Construct validity	Main finding
<i>Correlational Studies</i>						
Joormann & Tran (2009)	Compared high and low trait ruminators using median split	Healthy students	Directed forgetting task	Positive and negative words	?	No group differences in recall of negative words; high RRS group recalled more positive words. Low RRS group recalled fewer words under forget than remember instructions; high RRS group did not differ in recall of words under forget compared to remember instructions. Groups did not differ in frequency of positive intrusions (“recall” of words never presented); high RRS groups had more negative intrusions than low RRS group.
Lau, Christensen, Hawley, Gemar, & Segal (2007)	Related individual differences in trait rumination to interference control	MDD, non-depressed anxious, and controls (no hx Axis I disorder)	Prose distraction task and stop signal task	Positive, negative and neutral words	?	MDD were slower to read stories containing negative distractors than those containing positive or neutral distractors. CTL faster to read stories containing negative distractors than those containing neutral or positive distractors. RSQ-R correlated with negative interference index (RT negative distractors – RT neutral distractors in MDD group. No impairments observed on stop signal task.
Levens, Muhtadie, & Gotlib (2009)	Related individual differences in trait brooding to interference control	MDD & controls (never disordered)	Dual-task recency probes task	Neutral words	?	MDD had significantly greater interference in the condition combining within-task and cross-task interference and rerouting. Interference levels between groups were equivalent for all other conditions. Trait brooding was associated with greater cross-task interference under dual task conditions

Authors	Design	Sample	Task	Materials	Construct validity	Main finding
<i>Correlational Studies</i>						
Stout & Rokke (2010)	Related individual differences in trait rumination to cognitive control	Healthy students	Change-detection task	Coloured squares	?	Measures of working memory capacity and resistance to distraction interacted to predict individual differences in trait rumination
Whitmer & Banich (2007)	Related individual differences in trait rumination to interference control	Expt 1: Students high & low in trait rumination (top & bottom 10% scores on RRS from sample of 776 Expt 2: unselected students	Task-switching paradigm	Neutral	✓	Expt 1: RRS was positively associated with set-switching costs, as was brooding, there was a trend towards an association with reflection. RRS was predictive of inhibition after control for depression and worry. RRS was negatively associated with set inhibition, brooding and reflection were both negatively correlated with set inhibition. Expt 2: RRS predicted set inhibition, as did brooding, but reflection did not. RRS and brooding did not predict switch costs but reflection did.
Whitmer & Banich (2010)	Related individual differences in trait rumination to interference control	Students	Retrieval induced forgetting paradigm	Neutral words	?	Rumination was positively correlated with greater recall of unpractised words during the final test phase.

Authors	Design	Sample	Task	Materials	Construct validity	Main finding
<i>Correlational Studies</i>						
Vanderhasselt, Kuhn, & De Raedt (2011)	Related individual differences in trait rumination to interference control and compared high and low trait ruminators based on a median split.	Healthy students	Emotional go/no-go task	Sad and happy faces	?	Depressive brooding was not correlated with no-go trial accuracy for either sad or happy faces, or with the difference between no-go accuracy for happy and sad no-go trials. No correlation between brooding and accuracy rates for low trait brooders, but a significant correlation between brooding and the difference in accuracy for happy and sad no-go trials in the high brooders
Von Hippel, Vasey, Gonda, & Stern (2008)	Related individual differences in trait rumination to the association between depression and interference control (mediation)	Older adults (>65 years) with late (>60 years) and early onset depression	Stroop, paragraph reading and working memory task collapsed into a composite score	Neutral	?	Rumination mediated relationship between executive dysfunction score and depression in individuals with late-onset depression.

Authors	Design	Sample	Task	Materials	Construct validity	Main finding
<i>Longitudinal Studies</i>						
Demeyer, De Lissnyder, Koster, & De Raedt (2012)	Mediation analysis relating interference control and trait rumination to depressive symptoms at one year follow-up	Remitted depressed adults	Internal Shift Task	Neutral and angry faces	Neutral and ✓	Emotional shift scores, trait rumination and depressive symptoms were not related at baseline. Trait rumination mediated the relationship between emotional shift scores and depressive symptoms at follow-up.
De Lissnyder, Koster, Goubert, Onreadt, Vanderhasselt, & De Raedt (2012)	Used multi-level modelling to examine whether emotional shift costs moderated the relationship between self-reported stress and trait rumination at follow-up (6, 7, 8, 9 weeks).	Healthy students	Internal Shift Task	Neutral and angry faces	Neutral and ✓	Baseline emotional switch costs significantly moderated the association between baseline stress and trait brooding at follow-up, such that the association was stronger when individuals showed larger switch costs for emotional material. There was no significant moderating effect of non-emotional switch costs.
Zetsche & Joormann (2011)	Related individual differences in trait rumination to interference control at baseline and 6 month follow-up	Healthy students	Verbal and pictorial negative affective priming and emotional flanker	Positive, negative and neutral nouns and faces	?	Interference on the emotional flanker significantly predicted trait rumination and brooding at baseline, but not at follow-up. Reduced negative affective priming for sad faces at baseline predicted trait rumination at follow-up but not at baseline. The negative priming score for sad words predicted reflection at follow-up.

2.4 Evidence of an association between rumination and interference control processes

2.4.1 Modified Sternberg task as index of interference control

Joormann and Gotlib (2008) used the modified Sternberg paradigm to examine interference control processes in depressed and non-depressed individuals, where half of the non-depressed individuals first underwent a sad mood induction and the other half did not. The modified Sternberg task (Oberauer, 2001) presents participants with two lists of three words simultaneously, which they are instructed to remember. The word lists can be of positive or negative, or mixed (positive and negative) valence. A cue is then presented indicating which list will be relevant for evaluating the probe word. Following the cue, a single probe word is presented and participants are asked to indicate whether this word belongs to the relevant (cued) list. The difference in reaction time (RT) between responses to new words and words which were on the irrelevant list (labelled an intrusion effect) is interpreted as reflecting the strength of residual activation of words from the to-be-ignored list in working memory. This task appears to be a relatively valid index of interference control processes, with no extant account of the observed effect that does not implicate interference control. It matches most closely the resistance to proactive interference operationalization of interference control. Joormann and Gotlib (2008) found that depressed participants took significantly longer to reject a negatively-valenced intrusion probe than either of the non-depressed groups, and that intrusion effects significantly correlated with self-reported rumination (on the RRS) for depressed participants. Joormann and Gotlib (2008) interpret their findings as demonstrating that depressed individuals have difficulties in updating the contents of working memory, and specifically in removing negative irrelevant information.

2.4.2 *Working Memory Manipulation Task as index of interference control*

Joormann, Levens and Gotlib (2011) used a working memory manipulation task to examine interference control processes in depressed and never depressed controls. The working memory manipulation task presented three words one at a time followed by a cue indicating whether the words were to be remembered in the order that they were presented (forward trials) or in reverse order (backward trials). Following a 3000ms delay a probe word consisting of one of the three words was presented and participants were required to respond 1, 2, or 3 to indicate the words position in the list as they had been instructed to remember it. The word sets were all positive, all negative, or all neutral. The difference in RTs between forward and backward trials was operationalized as involving a sorting cost, and argued to reflect difficulties manipulating information in working memory.

Joormann et al. found that depressed participants had significantly greater sorting costs than controls for positive, negative, and neutral words. Moreover, depressed participants' sorting costs were significantly higher for negative words than for either positive or neutral words. Rumination (indexed by the RRS) was found to be predictive of sorting costs for negative words amongst the depressed group, but not for control participants. Joormann et al. interpret these findings as supportive of a depression-related relationship between trait rumination and cognitive inflexibility in manipulating negative material. However, as the backwards condition of the task is more difficult than the forwards condition, it is not possible to rule out alternative accounts of the findings as attributable to overall task difficulty, as opposed to the manipulation of material in working memory. No data regarding the relationship between trait rumination and sorting costs for positive words is reported, consequently it

is unclear if the association between rumination and sorting costs for negative words is reliably different from that for positive words.

2.4.3 *Backward inhibition as index of interference control*

Whitmer and Banich (2007) examined the relationship between self-reported ruminative responses and interference processes using a variant of Mayr and Keele's (2000) task-switching paradigm. In Mayr and Keele's task, participants are presented with four rectangles that can differ on three dimensions (size, motion or orientation). Before each presentation, participants are cued with the relevant dimension with which to identify the rectangle that is discrepant from the other three rectangles. An inhibitory trial is represented by the cue sequence a-b-a (e.g., size-motion-size). It is hypothesised that when a participant switches from one task set to another, the previous set is inhibited in order to facilitate a faster transition to the new one. As a consequence, a switch back to the recently abandoned set immediately following the switch away requires the participant to overcome residual inhibition of the representation of the to-be-returned-to task set, which is reflected in a greater time cost for these trials. The task distinguishes set-switching costs (e.g., the switches in the a-b-c sequence) from backward inhibition (a-b-a) costs. Set-switching costs reflect time taken to reconfigure cognitive processes for the representation of the new task set and are estimated by subtracting reaction times (RTs) on repeat trials (e.g., a-b-b) from RTs on non-inhibitory switch trials (e.g., a-b-c). Backward inhibition costs are estimated by subtracting RTs on set-switching trials (e.g., a-b-c) from RTs on inhibitory trials (e.g., a-b-a; labelled n-2 repetitions). The backward inhibition paradigm has been thoroughly investigated (e.g., Mayr & Keele, 2000; Mayr, 2002; Mayr, 2007) and is generally accepted as one of the clearer indexes of inhibitory control processes. The paradigm is

considered to have successfully addressed alternative accounts such as interpretations based on episodic retrieval (Mayr, 2002; Koch, Gade, Schuch, & Philipp, 2010). In two experiments, Whitmer and Banich (2007) found that scores on the RRS were significantly negatively correlated with backward inhibition, and this relationship remained significant even when depression scores on the Beck Depression Inventory (BDI; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961) were taken into account. However, Whitmer and Banich did not find that rumination affected overall task performance. Moreover, a reduced backward inhibition effect indicates *improved* task performance (faster reaction times). Thus, individuals low in trait rumination appeared to experience greater difficulty overcoming inhibition from the n-2 trial than individuals higher in trait rumination. If individuals high in trait rumination exhibited slower response times on the n-2 trials, this would be consistent with a rumination related performance deficit, however, the reverse pattern of results is observed: it is individuals low in trait rumination who are slower on these trials. Thus, individuals high in trait rumination appear to exert a more appropriate level of cognitive control, thereby facilitating better overall task performance. This data is therefore not consistent with the view that high trait rumination is associated with a deficit in interference control processes.

These findings regarding trait rumination have subsequently been replicated in a recent study examining the relationship between both state and trait rumination and backward inhibition (Whitmer & Gotlib, 2012) (see later section regarding evidence relevant to the impaired-interference-control-as-consequence-of-rumination hypothesis for detailed discussion of this study).

De Lissnyder, Koster, Derakshan, and De Raedt's (2010) Affective Shift Task modified Mayr and Keele's (2000) task switching paradigm such that the stimuli were

happy and angry faces. The study found that individuals reporting elevated levels of depressive symptoms on the BDI-II (Beck, Steer, & Brown, 1996) did not significantly differ from non-dysphoric individuals on the interference control task, either in overall interference control, or valence-specific interference control. Individuals reporting higher ruminative response tendencies on the RRS were faster on a-b-a trials containing negative material (the angry faces) than individuals reporting lower ruminative response tendencies. Additionally trait brooding was negatively correlated with RT on a-b-a trials containing negative materials. Thus, individuals higher in trait rumination are processing the angry faces more efficiently, which is consistent with a valence-specific benefit to task performance for trait ruminators. De Lissnyder et al.'s use of a-b-a reaction time without controlling for a-b-c reaction time in their critical rumination analyses (examining valence-specific effects) means they are not indexing backward inhibition as usually defined (see above) for these analyses and hence it is hard to interpret this result. However, De Lissnyder et al. did find evidence of a positive association between trait brooding and switch costs, which is a clear deficit to task performance. The deficit they found was not valence-specific.

De Lissnyder, Koster and De Raedt (2011) used an Internal Switch Task (IST) to examine the relationship between trait rumination and emotional interference in working memory in dysphoric (classified as BDI-NL ≥ 14 ; BDI-NL is the Dutch translation of the BDI) and non-dysphoric individuals (classified as BDI-NL < 14). The IST presented participants with a series of faces which they were instructed to mentally classify according to either gender (male, female) or emotionality (neutral, angry). The two conditions were presented in separate blocks, with an equal number of blocks for the gender and emotion conditions. Within each block participants were instructed to keep a silent mental count of the number of faces within each category (male vs. female,

or neutral vs. angry). When a face was presented participants were instructed to press a button as fast as they could to indicate that they had updated their mental count for each category, and at the end of each block they typed in the count for each category. Switch trials were defined as trials on which the target trial (n) requires the updating of a different category to that of the preceding trial (n-1), and no-switch trials were trials in which the n and n-1 trials required the updating of the same category. Switch costs were thus calculated as $RT(\text{switch trial}) - RT(\text{no switch trial})$. Median scores for RTs across all trials (correct and incorrect) were used to analyse the interaction between switching and emotionality.

There were no significant differences in accuracy between the two conditions (emotional vs. neutral). However, there were significantly higher error rates in the non-dysphoric group than the dysphoric group. Between group comparisons revealed no dysphoria-related differences in switch costs, and the switch cost was higher in the neutral than the emotional condition for non-dysphoric participants only. Participants categorised as high ruminators based on a median split exhibited a significantly larger switch cost for emotional material than those classified as low ruminators; the groups did not differ in error rates or switch costs for neutral material. Additionally, high ruminators were significantly faster on no-switch emotional trials, than on no-switch neutral trials, whilst low ruminators did not differ in RTs according to emotionality. De Lissnyder et al argue that these findings are indicative of a rumination-related impairment in cognitive control that is specific to the processing of emotional material. However, it is not clear why incorrect trials were included in the analysis of RT data, especially given the group differences in error rates. If there are differential error rates between groups, and RTs for incorrect trials are included in the analysis, then between-group RTs are confounded with error rates. The RT data is intended to provide a

measure of the time taken for a certain cognitive process (which requires a correct response), and so the mean RT for the group with higher error rates is both less accurate as a measure of the underlying process, and likely to be biased in a fast/slow direction as a result of including more incorrect RTs. Thus the inclusion of RT data for both correct and incorrect trials results in the RTs providing a less precise estimate of the time taken to resolve interference when switching between updating two different categories (emotional and neutral). Additionally De Lissnyder et al's examination of the relationship between rumination and task performance was reliant on a median split analysis, and the reliability of this method has been questioned by a number of commentators (e.g., MacCallum, Zhang, Preacher, & Rucker, 2002).

Chuen Yee Lo, Lau, Cheung and Allen (2012) used an internal switching paradigm using neutral and emotional words to examine the relationship between interference control and rumination following sad and neutral mood inductions in an electroencephalographic (EEG) study. Interestingly, this study reported no significant association between interference control and self-reported rumination at a behavioural level, which is not consistent with the findings of De Lissnyder et al. (2011). Chuen Yee Lo et al. examined event related potentials (ERPs) during the task and report that high ruminators deployed more neuronal resources when switching between affective words following a sad mood induction.

2.4.4 Directed forgetting as index of interference control

Four studies (Bermann et al., 2011; Hertel & Gerstle, 2003; Joormann, Nee, Berman, Jonides & Gotlib 2010; Joormann & Tran, 2009) found evidence that trait rumination is related to performance on directed forgetting tasks (Anderson & Spellman, 1995; Anderson & Green, 2001; Nee & Jonides, 2008), in which participants

are instructed to forget a subset of previously studied material. Subsequent recall of both the material that they were instructed to remember, and that which they were told to forget is measured: proactive interference from the to-be-forgotten material is indexed by increased recall of this material and decreased recall of the material to be remembered. MacLeod (1998) reviewed the evidence regarding theoretical accounts of directed forgetting, and concluded that when participants are instructed which material is to be forgotten using a list procedure (as opposed to being cued whether to remember or forget each item before the next item is presented), the paradigm can be regarded as a relatively clear measure of resistance to proactive interference.

Berman et al. (2011) adopted a directed forgetting paradigm (Nee, Jonides, & Berman, 2007) similar to the modified Sternberg task in which participants were presented with two lists of two emotionally valenced words, one of which they were subsequently directed to forget. Participants were asked to indicate whether a single probe word had appeared in the list that they were asked to remember. Interference resolution difficulties were operationalized as incorrectly responding “yes” to a word from the list that they had been instructed to forget (“lure” trials). The experiment found that relative to never depressed controls, depressed individuals had a greater RT difference between negatively valenced “lure” trials and control trials (new words not from either the list to be remembered or the list to be forgotten). For depressed individuals, the difference in RT between negatively valenced lure trials and control trials was positively correlated with trait rumination (as indexed by the RRS). Consistent with the hypothesis that rumination occupies cognitive capacity, the study additionally found a positive correlation between increased trait rumination and lower working memory capacity (as indexed by the Operation span, Unsworth, Heitz, Schrock, & Engle, 2005). Stepwise regressions confirmed that the relationship between

depression status and interference resolution was not driven by individual differences in working memory capacity.

Hertel and Gerstle (2003) adopted a list procedure using positive and negative words, and found evidence that individuals scoring high in trait rumination (as indexed by the RRS) recalled more of the words that they were instructed to forget. However, this data comes from the final phase of the experiment where the instruction was to recall all items, including those each participant was previously asked to forget. Hence, these data show a positive relationship between trait rumination and task performance since high trait ruminators recalled more of the items that they were currently being asked to recall. Evidence for a deficit in interference control could potentially be found in a directed forgetting procedure if high ruminators made more errors during the suppression phase (where the instruction was to forget certain items). Unfortunately, Hertel and Gerstle do not report this data, making their study hard to interpret.

Joormann and Tran (2009) also used a list-procedure directed forgetting paradigm with positive and negative words, and found evidence that individuals scoring high in trait rumination (as indexed by the RRS) recalled more of the words in the final phase than individuals low in trait rumination, and this was not specific to negative material. As with Hertel and Gerstle's data, this evidence is consistent with a rumination-related benefit to task performance. However, Joormann and Tran's analyses are based on a median split procedure, which as noted previously is methodologically problematic. Joormann et al. (2010) used an ignore/suppress task (Nee & Jonides, 2008) to examine directed forgetting of positive and negative words. The ignore/suppress task presents participants with four words simultaneously, and then participants are instructed to remember a subset of these and to ignore the other two words. A single probe word is then presented and participants are required to indicate whether this appeared in the

relevant subset of words. In the second suppress phase of each trial, participants are cued to forget a subset of the memorized words, finally a single probe word is presented which could be a to-be-remembered word, a to-be-ignored word, a to-be-suppressed word, or a new word that they had not seen at all on that trial. Participants are required to indicate whether this was the word that they had been instructed to remember.

Joormann et al. reported no differences between depressed individuals and non-depressed controls in error rates, and both groups were slower to reject to-be-suppressed words than new words. Depressed individuals were slower than non-depressed controls to reject negative, but not positive to-be-suppressed words. Additionally, trait rumination was significantly positively correlated with interference effects (RT (to-be-suppressed words) – RT (new words)) when processing negative words, and this relationship remained significant when statistically controlling for interference effects for positive material.

In a second experiment, Joormann et al. presented letters as the stimuli instead of emotionally valenced words and manipulated task difficulty by varying the number of letters (four versus eight) presented in each trial. There were no group differences for interference resolution on this version of the ignore/suppress task and neither symptoms of depression nor trait rumination was correlated with interference effects. This result supports the interpretation of their first experiment as demonstrating a rumination-related processing bias rather than an overall deficit. Interestingly, depressed participants made more errors and exhibited longer decision latencies than controls under conditions of low task difficulty, but did not differ from controls under the high task difficulty condition. Joormann et al. propose that this finding is consistent with Hertel's (2004) hypothesis that easy tasks permit rumination and consequently easy tasks are more sensitive to depression-related deficits in cognitive control. However, at

odds with this interpretation, there was no correlation between rumination and task performance.

2.4.5 Retrieval-induced forgetting as index of interference control

In a typical retrieval induced forgetting paradigm (Anderson, Bjork & Bjork, 1994), participants are instructed to learn category–exemplar pairs (e.g., fruit–orange; fruit–lemon etc.) from different categories (e.g., fruit, animals). For a subset of these categories participants are then required to practice retrieving some of the pairs (e.g., fruit–orange), but not others (e.g., fruit–lemon). Subsequent recall of the full set of category–exemplar pairs is measured: exemplars that were not practised but are from categories that were practised (e.g., fruit–lemon) are less likely to be recalled than exemplars from categories that were not practised (e.g., animals–lion). Two main accounts of this effect exist. First, practising retrieval leads to the inhibition of non-practiced items with the same cue (i.e., same category label). So, for example, practicing *fruit-orange* inhibits *lemon*. Second, practicing retrieval leads to the increased activation of the practiced items, and retrieval probability is a function of the relative activation of items sharing the same cue. So, retrieving *lemon* to the cue *fruit* becomes harder, not because *lemon* is inhibited, but because *orange* comes to mind more easily. There is on-going debate as to which account is superior (e.g., Jakab & Raaimakers, 2009; Storm & Nestojko, 2010). Thus, both accounts implicate interference control to some extent, but it is premature to conclude that retrieval-induced forgetting demonstrates inhibition.

Whitmer and Banich (2010) used a retrieval-induced forgetting design with neutral words and found that individuals high in trait rumination (indexed by the RRS) were more likely to recall the unpractised words when asked to do so, indicating a task-

performance benefit associated with high trait rumination. There was no relationship between trait rumination and overall memory performance on the task. Hence, this study provides no evidence of an association between rumination and a deficit in interference control. As in a number of previously discussed experiments, high trait ruminators seem to suffer less from the after-effects of interference control than low trait ruminators, and with no cost to their overall performance. It seems hard to characterize such a pattern of results as a deficit.

2.4.6 Comparing letter-naming and modified Stroop tasks

Altamirano et al. (2010) examined the relationship between individual differences in trait rumination, and tasks that they argued measure goal flexibility and goal maintenance. They used a letter-naming task (Duncan, Emslie, Williams, Johnson, & Freer, 1996) to index goal flexibility, and a modified Stroop paradigm to index goal maintenance. The letter naming task presented letter pairs and number pairs in rapid succession, with each trial presenting a total of 15 pairs. Participants were required to attend to the letters, and to read them aloud. A cue (“LEFT” or “RIGHT”) was presented to indicate whether they were to read out the right or left letter from each pair. After 10 pairs of letters and numbers had been presented, a second cue (“+” or “-”) was presented to indicate whether participants should attend to the right or left letter for the remaining 5 pairs. The dependent measure was the proportion of trials for which there were no errors or omissions, and this was scored for both pairs preceding the secondary cue (precue pairs) and pairs following the secondary cue (postcue pairs). The task is argued to require rapid switching between letter naming and cue interpretation. Postcue accuracy was interpreted as an index of the ability to flexibly switch back to letter

naming, following a recent switch away to cue interpretation, and thus argued to reflect goal flexibility.

The modified Stroop task required participants to view colour words (red, blue, green) and to name the actual colour in which the word is presented. On 75% of trials, the colour of the word corresponded with the word meaning (e.g., blue presented in blue), and the remaining 25% of trials were incongruent trials in which the colour of the word differed from its meaning. Thus, participants had to maintain the colour naming goal across trials, in order to be able to inhibit the prepotent response to read the word on the relatively rare incongruent trials. Accuracy on incongruent trials was thus interpreted as an index of goal maintenance.

Altamirano et al. (2010) reported that trait rumination was negatively associated with goal flexibility (postcue accuracy on the letter-naming task) but positively correlated with goal maintenance (accuracy on incongruent trials of the modified Stroop task). The positive correlation between trait rumination and incongruent trial accuracy remained significant when statistically controlling for congruent trial RTs, incongruent trial RTs, and BDI scores. Interestingly, when scores on the 10 item RRS were partialled out, BDI scores were negatively correlated with goal maintenance (incongruent trial accuracy). Altamirano et al. argue that trait rumination and dysphoria have opposing effects on goal maintenance and that in contexts where goal maintenance is required, higher levels of trait rumination confer a benefit. This proposal is potentially in contrast to the hypothesis that on-going state rumination acts as a cognitive load if one assumes that high trait rumination is associated with increased state rumination (the impaired interference control-as-consequence hypothesis). However, in Altamirano et al.'s study the mean RRS score is relatively low, as is the range of scores (10-32). Therefore, it is not clear that the study sampled individuals who are high in pathological

rumination and likely to spontaneously engage in state rumination. Moreover, because state rumination was not assessed, it is not possible to be definitive about the extent of state rumination in this study.

2.4.7 Negative Priming as index of interference control

The negative affective priming paradigm (Joormann, 2004) presents participants with a prime trial and then a probe trial, each consisting of two simultaneously presented stimuli: a target (indicated by a black frame) and a distractor (indicated by a grey frame). Participants must respond to the target by classifying it according its valence (e.g., sad or happy) whilst ignoring the distractor. It has been argued that for trials where the prime distractor matches the probe target (for example, both are classified sad), participants must overcome inhibition of the response “sad” from the prime trial in order to respond correctly to the probe target, resulting in a time cost. Inhibitory accounts of negative priming argue that internal representations of competing distracting stimuli (in this example the words framed in grey) are inhibited to facilitate the selection and processing of a target stimulus (the words framed in black). When the inhibited representations become relevant on the next trial, overcoming inhibition of the previously ignored information results in a time cost relative to baseline conditions.

In contrast, episodic retrieval accounts propose that negative priming does not reflect inhibitory processes, but is attributable to memory processes. Neill and Mathis (1998) proposed that during the processing of the irrelevant stimulus in the prime trial, it is encoded with a memory tag designating its status as not to be responded to. In the probe trial a conflict occurs between the retrieved information regarding this stimulus as not to be responded to and the trial requirement to respond to it; this conflict must be resolved, which results in slower processing, producing a cost (see also Mayr &

Buchner, 2007). Consequently, the magnitude of negative priming is not a clear index of inhibition. In the context of that debate, it seems more appropriate to describe negative priming as involving interference control rather than assuming a specific process of inhibition (although see later comments regarding the work of Goeleven and colleagues).

In a number of studies, Joormann demonstrated an association between trait rumination and reduced negative priming effects for emotional material. Joormann interpreted this evidence as reflecting weakened inhibition of emotional material amongst individuals high in trait rumination, resulting in a reduction in the expected negative priming effect. Joormann (2006) reported evidence that individuals high in trait rumination exhibited a reduced negative priming effect for emotional material. Additionally, trait reflection but not trait brooding was associated with reduced negative affective priming for emotional material. Joormann and Gotlib (2010) found that depressed participants exhibited a reduced negative priming effect for negative material, and that this was associated with trait rumination. Reduced negative priming means better task performance (as negative priming is an RT cost) and hence these results indicate that individuals low in trait rumination experience greater difficulty overcoming interference from the prime trial than individuals higher in trait rumination. Hence, the findings are not straightforwardly consistent with the idea that high trait rumination leads to a deficit in interference control.

Zetsche, D'Avanzato and Joormann (2012) examined the performance of depressed and never depressed individuals on two tasks designed to measure different aspects of interference control. An emotional version of the Eriksen flanker task (Eriksen & Eriksen, 1974) was used to examine interference control when processing emotional material. In the emotional flanker task (EFT), participants are presented with

four words arranged in a square: a single target word which is presented in green, and three distractor words presented in red. Participants are required to ignore the distractor words and to indicate whether the target is positive or negative. When the valence of the distractors differs from the valence of the target (incongruent trials) participants must resolve interference from the irrelevant words in order to correctly respond to the target. Thus interference control is operationalized as decision latencies on incongruent trials minus decision latencies on neutral trials (when the valence of the target and distractors are the same).

The Working Memory Selection Task (WMST) was used to examine interference control in the discarding of no-longer relevant emotional material from memory. The WMST presents participants with six words simultaneously, which they are instructed to remember, all words are either positive or negative. Three of these words are then presented again with the instruction to forget these words. Finally a single cue word is presented, which can be from the to-be-remembered sub-set (relevant probes), the to-be-forgotten subset (suppress probes), or a new word. Participants are required to decide whether the word belongs to the subset of words that they should remember. Individuals take longer to reject suppress probes than new probes, and it is argued that this reflects interference from the residual activation of the suppress probe in memory. Thus, the WMST provides a relatively clear index of the ability to resist interference from information in memory that is no longer relevant to the task demands.

Zetche et al. found that depressed individuals had higher interference scores for negative words than non-depressed individuals on the EFT. No group differences were found on the WMST. Regression analyses revealed that after controlling for depressive symptoms, WMST intrusion scores for negative words significantly predicted trait rumination, such that higher intrusion scores were associated with greater rumination.

This is consistent with the findings of Joormann and Gotlib (2008) and indicative of an association between high trait rumination and difficulties resisting interference from no-longer relevant negative material. No relationship was found between intrusion scores for positive words and trait rumination. Interestingly, in contrast with the findings of Zetsche and Joormann (2011; see 2.5 for detailed discussion of this study), there was no association between EFT interference scores for either negative or positive words and trait rumination.

Goeleven, De Raedt, Baert, and Koster (2006) examined the performance of depressed, formerly depressed, and never depressed individuals on a negative affective priming paradigm, using images of sad, neutral and happy faces. Depressed participants showed a reversed negative priming effect on negative trials. In other words, they were *faster* to respond to recently ignored sad faces than control faces. Non-depressed participants showed a standard negative priming effect. As argued by Metzler and Parkin (2000), the presence of reversed negative priming in a patient group under conditions where a control group shows standard negative priming provides fairly good evidence of a deficit in inhibitory processes. It also appears from the reported mean reaction times that depressed participants were slower overall than non-depressed patients (although no statistical analysis of this difference was presented). One might therefore argue that the results of Goeleven and colleagues provide reasonably good evidence that depression can be associated with a deficit in inhibitory control processes. However, in terms of the central concern of this review (rumination), it is important to note that Goeleven found no significant correlations between the size of the priming effect and RRS score. Hence, Goeleven et al.'s (2006) data do not provide positive evidence for an association between depressive rumination and interference control processes.

2.4.8 *Recency Probes task as index of interference control*

Levens et al. (2009) modified the recency probes task (Monsell, 1978) to be a dual task paradigm in which participants were required to perform the recency probes task and a tracking task concurrently. The recency probes task presents participants with a list of three words to remember followed by a 3000ms delay and then participants are presented with a single probe word and asked to indicate whether this was contained in the target set. The task involves four trial types: non-recent no response (words not contained in the current or recent sets), non-recent yes response (words contained in the current but not other recent sets), recent no response (words contained in recent but not the current set), and recent yes response (words contained in both a recent and the current set). Within-task interference is operationalized as the difference in reaction times to non-recent no trials and recent no trials (D'Esposito, Postle, Jonides, & Smith, 1999). The tracking task presented a category name at the beginning of each block of the recency probes task (e.g., "Things to Save in Case of a Fire"). Stimuli within the block consisted of neutral words and words belonging to the specified category. Participants were required to count the number of words within the target sets (but not the probe words) that belonged to the cued category whilst completing the recency probes task.

Cognitive re-routing was operationalized as RTs on trials in which a category word appeared in the target set. On these trials participants had to reallocate cognitive resources between the primary (recency-probes) task and the secondary (tracking task) in order to update the count of category words. Cross-task interference was operationalized as RTs on trials in which a category word was presented as the probe. On these trials participants must resist the counting response and instead respond yes or

no to the probe (because probe words were not included in the count for the tracking task). Finally, the combination of cross-task and re-routing was operationalized as RTs for trials in which the category words appeared in both the target set and as the probe. On these trials participants had to both reallocate resources between the two tasks (recency-probes and tracking) in order to update the word count whilst processing the target set, and also to resolve interference from the secondary tracking task in order to respond correctly to the probe.

Levens et al. (2009) reported that depressed individuals demonstrated significantly greater interference in the cross-task re-routing condition than healthy controls did, although the numerical trend in the accuracy data was in the opposite direction. Depressed and non-depressed individuals displayed comparable levels of interference in the other three conditions (baseline, cross-task, and re-routing). Further, trait brooding was associated with greater cross-task interference under dual task conditions (the cross-task re-routing condition).

Levens et al. (2009) argued that depressed individuals who were highest in trait brooding demonstrated the greatest difficulties in controlled allocation of cognitive resources in their high interference conditions. Levens et al. proposed that individuals high in trait rumination experience interference from ruminative thoughts when trying to complete other tasks, which generates cross-task interference. Further, high trait ruminators are argued to then need to repeatedly reallocate cognitive resources back to the task at hand and away from brooding rumination. The authors argue that impaired resource allocation amongst high trait brooders might underlie the association between brooding and negative depressive outcomes by interfering with the ability to execute adaptive cognitive processes that might alleviate depressed mood.

The authors adopt Hertel's (2000) argument that because the task is complex and demanding, it would interfere with the ability to engage in rumination whilst completing it. However, they propose that the cross-task rerouting condition constitutes a proxy for the processes that occur during bouts of pathological state brooding in depression in which individuals experience difficulties resolving interference from brooding thoughts and re-routing resources toward more adaptive cognitive operations that would improve negative moods. This conceptualisation is consistent with the phenomenology of pathological rumination and with conceptual models of rumination and depression (e.g., Hartlage et al., 1993; Hertel, 2004; Watkins & Nolen-Hoeksema, submitted). Levens et al. argue that their data is consistent with a bi-directional model of rumination and interference control, whereby depressed individuals experience difficulties disengaging from ruminative thoughts as a consequence of impairments in efficient resource allocation, and thus continued rumination acts as a cognitive load, weakening performance on concurrent executive tasks.

2.4.9 Mixed Antisaccade Task as index of interference control

De Lissnyder, Derakshan, De Raedt and Koster (2011) used the mixed antisaccade task (Ansari, Derakshan & Richards, 2008) to examine the relationship between depressive symptoms, rumination, and interference control processes. The mixed antisaccade task involved two conditions: in blocks of the single condition, participants completed trials of a single task (either anti- or pro- saccade); in blocks of the mixed condition, anti- and pro- saccade trials were presented pseudo-randomly within the same block, thus requiring participants to switch between the two tasks. All trials presented a single fixation cue. In the mixed blocks this indicated response type (antisaccade: a white diamond; prosaccade: a white circle); in the single blocks it was

always a white cross. Following this an oval cue appeared to either the right or left side of the screen and participants were required to direct their gaze as fast as possible either towards (prosaccade) or away from (antisaccade) the cue. There is an established antisaccade switch benefit, whereby when individuals are required to switch between anti and pro saccade trials antisaccade latencies become faster relative to repeat trials without a cost to error rates (Cherkasova, Manoach, Intriligator, & Barton, 2002).

It is proposed that effortful secondary attentional tasks inhibit reflexive responses, resulting in the facilitation of non-dominant responses (Kristjansson, Chen & Nakayama, 2001). The antisaccade switch benefit is thus argued to reflect increased attentional resource allocation on the more effortful switch trials. This interpretation is supported by evidence of an association between measures of attentional control and the anti-saccade benefit, such that individuals highest in attentional control display lower antisaccade benefits (Cherkasova et al., 2002). Cherkasova et al (2002) propose that individuals highest in attentional control need to devote fewer attentional resources to the secondary operation of switching between tasks, resulting in reduced facilitation of the primary operation of executing the anti-saccade. Thus individual differences in the antisaccade benefit are interpreted as a relatively clear measure of attentional control, and one that is not confounded by differences in the difficulty of the primary dependent measure across conditions.

De Lissnyder et al. (2011) classified participants scoring ≥ 14 on the BDI as dysphoric, and those scoring less than 14 as non dysphoric. Participants were classified as high or low trait ruminators based on a median split using scores on the RRS. De Lissnyder et al. reported no interaction of group (dysphoric vs. non-dysphoric) with the anti-saccade benefit, and that the increase in error rates from single to mixed blocks was greater for non-dysphorics than dysphorics. There was no interaction of rumination with

the anti-saccade benefit. High trait ruminators exhibited slower anti-saccade latencies than low ruminators overall, and the groups did not differ on pro-saccade latencies. There was no relationship between rumination and error rates. De Lissnyder et al. argue that the difference in anti-saccade latencies between high and low rumination is indicative of inhibitory deficits in high trait ruminators. However, anti-saccades are more difficult to execute than pro-saccades and thus an alternative account of this finding is that high trait ruminators experienced greater difficulty in executing the more demanding task. It is of note that there was no interaction between rumination and anti-saccade benefit, which is regarded as a relatively robust measure of attentional control. If individuals high in trait rumination have reduced attentional resources then Cherkasova et al.'s findings suggest that one might predict an increased antisaccade benefit relative to low ruminators. In contrast, if high and low ruminators do not differ in overall attentional resources but rather for high ruminators attentional resources are occupied by concurrent rumination, then Kristjansson et al.'s findings suggest that one might predict that high ruminators would exhibit faster antisaccade latencies and higher error rates relative to low ruminators since rumination is acting as an effortful secondary task and thereby reducing reflexive responding. Thus, whilst De Lissnyder et al.'s findings are consistent with an association between rumination and difficulties executing demanding tasks, it is not clear that such difficulties are attributable to interference control processes.

2.4.10 *Garner Task as index of interference control*

Daches, Mor, Winquist, & Gilboa-Schechtman (2010) modified Garner's (1976) Speeded Classification Task, which was originally designed to analyze whether stimulus dimensions were integral or separable. The Garner task presents participants

with stimuli that can vary on two dimensions (e.g., size, brightness). Participants are required to classify the stimuli according to a specified dimension. In baseline conditions, the stimuli vary only on the relevant dimension; in orthogonal conditions, the stimuli vary on both the relevant and the irrelevant dimensions (e.g., when classifying according to size, the stimuli will also vary in brightness). Daches et al. operationalized attentional interference as the difference in RTs between the baseline and orthogonal conditions. However, in this novel paradigm, there was no difference in RTs between the orthogonal and baseline conditions when the encoding phase did not manipulate self-relevance.

Daches et al. modified the task such that stimuli varied according to self-relevance: Prior to completing the Garner task, participants were asked to generate and write down an autobiographical memory for half of the words from each semantic category, with these words constituting the self-relevant stimuli set. Participants were then required to classify each of the stimulus words as belonging to one of the two semantic categories (time, or family; the relevant dimension). The classification task was split into three blocks: in the two neutral blocks, the stimulus words did not vary in self-relevance (the irrelevant dimension), and in the third orthogonal block, half the words were self-relevant, such that self-relevance varied from trial to trial. Daches et al. reported that trait brooding was positively correlated with the difference in RT between their baseline and orthogonal conditions, and interpreted this as reflecting interference from the self-referential material.

2.4.11 *Wisconsin Card Sorting Task as index of interference control*

The Wisconsin Card Sorting Task (WCST; Grant & Berg, 1948) presents participants with four cards displaying a red triangle, two green stars, three yellow

crosses and four blue circles respectively. Additionally, participants work through two packs of 64 cards each displaying similar designs to the stimulus cards but varying in colour, number, and geometric shape. Participants are instructed to match each card in the deck to one of the four stimulus cards and are provided with feedback as to whether each sort is correct. No warning is given when the sorting rule changes. The task measures the extent to which participants persevere with a previously correct sorting rule once the rule is changed, as an index of executive function. Davis and Nolen-Hoeksema (2000) compared the performance of high and low ruminators (as classified by pre-determined criteria for responses on the RRS) on the WCST. Individuals reporting greater ruminative responses made more perseverative errors on the task. The authors propose that this is indicative that rumination may be characterised by particular difficulties with endogenous set switching.

A number of cognitive processes are commonly proposed to be implicated in the WCST including attention, set-shifting, inhibition and working memory. Factor analytic studies and subsequent experimental studies have indicated that attention and executive processes are important to performance (e.g., Greve, Williams, Haas, Littell, & Reinoso, 1996; Miyake, Friedman et al., 2000). Thus, Davis & Nolen-Hoeksema's study provides further support to the proposal that rumination is related to impaired performance on cognitive tasks, but it is not possible to infer whether this relationship is specific to interference control on the basis of their data.

2.4.12 Refresh task as index of interference control

The refresh task (Johnson, Reeder, Raye, & Mitchell, 2002; Johnson, Mitchell, Raye, McGuire, & Sanislow, 2006) presents participants with three words simultaneously on a computer screen, one of which is a negative emotional word and

two of which are neutral words. Participants are instructed to read all three words aloud. The words are then replaced with a blank screen and a probe is then presented in the location of one of the previously displayed words. On half the trials the probe is one of the previously presented words (repeat trials), and on half the trials it is a dot (refresh trials). On repeat trials, participants are instructed to read the word presented and on refresh trials, participants are requested to recall and recite the word that was previously presented in the location of the probe, with the time taken to initiate a response to each probe recorded. For half of each trial type the target word was emotional and for half it was neutral.

It is argued that individuals take longer to refresh a neutral word than an emotional word, due to increased engagement with emotional content and/or difficulties disengaging with this content, with this effect termed “mental rubbernecking” (Johnson et al., 2006). This effect is only observed when the emotional word is task-relevant (i.e., a potential target for refreshing). When the emotional word is never the target for refreshing, mental rubbernecking is no longer observed (Johnson et al., 2006). The mental rubbernecking effect is hypothesised to reflect greater difficulty disengaging from no longer relevant emotional material, relative to neutral material (Johnson et al., 2006).

Bernblum and Mor (2010) reported an interaction between trial type (refresh, repeat), emotionality (emotional, neutral) and individual differences in trait brooding. They used a quartile split to explore the nature of the association between brooding and performance on the refresh task and reported that individuals high in trait brooding were slower to refresh words than individuals low in trait brooding. Consistent with previous research, individuals low in trait brooding were slower to refresh neutral than emotional words when the emotional words were task relevant. However, individuals high in trait

brooding did not differ in the time it took to refresh neutral versus emotional words, and displayed a trend towards an overall slowing of refreshing relative to non-brooders.

However, it is of note that Bernblum and Mor's paradigm differed from Johnson et al.'s because it did not include trials in which all three words were neutral. Thus, whilst their findings indicate differences in the refreshing of neutral and emotional words in the presence of an emotional distractor, they do not directly examine Johnson et al.'s operationalization of mental rubbernecking, which requires a comparison with the time taken to refresh neutral words in the absence of emotional distractors.

Bernblum and Mor proposed two possible accounts for their findings. First, when presented with emotional material, high trait brooders engage in increased processing of this material, which in turn interferes with refreshing both emotional and neutral material. Second, high trait brooders are characterized by refreshing deficits. A second experiment was designed to contrast these accounts by examining the refreshing of neutral words only, but in half the trials one of the non-target words was emotional (but not task relevant since it was never a target for refreshing) and in half the trials all the words were neutral. Individuals high in trait brooding (based on a quartile split) were slower to refresh neutral words when presented alongside an emotional word than when all the words were neutral, but no such differences were observed amongst individuals low in trait brooding. Bernblum and Mor posit that this evidence is supportive of Joormann and Gotlib's (2008) hypothesis that individuals high in trait brooding experience difficulties discarding emotional material from working memory. However, it is of note that in order to more clearly distinguish this observation from the mental rubbernecking effect, a direct comparison of the difference in refreshing latencies between refreshing of neutral words in neutral vs. mixed word lists when the

emotional word was task relevant vs. task irrelevant (in line with Johnson et al.'s design) would be needed.

2.4.13 *Prose distraction task as index of interference control*

Lau, Christensen, Hawley, Gemar, and Segal (2007) examined the performance of depressed, healthy, and non-depressed anxious individuals on two tasks hypothesised to index different types of interference control processes which they termed “cognitive inhibition” and “motor response inhibition”. The task used to examine “cognitive inhibition” was a prose distraction task (PDT) in which participants were presented with a series of thirteen short stories, which they were asked to read aloud. Nine of the stories had emotionally valenced adjectives embedded in them, and three contained no such adjectives (the control stories). These distractor words were printed in italics, and participants were instructed to ignore them (i.e., not read them aloud). The primary dependent variable was reading time for the control stories subtracted from reading time for each of the emotional conditions, thus representing the incremental reading time cost for prose containing distractors. Slowed reading time for stories containing negative distractors relative to those containing positive or neutral distractors was interpreted as reflecting difficulties in the “suppression of [negative] cognitive contents” (p. 1250).

“Motor response inhibition” was examined using the stop-signal task (SST; Logan, Cowan, & Davis, 1984). The SST required participants to indicate with a button press whether a series of presented stimuli were words or non-words. On a minority of trials, a computer-generated tone indicated that participants should not make a response for that trial. The stop-signal task (SST) has been modelled in terms of a race between the parallel processing of the “go” process (i.e., activation of the response) and the “stop” process (i.e., inhibition of the response) (Logan, Cowan, & Davis, 1984). Both

the SST and PDT were modified to include positive and negative self-referent words and neutral words. Lau et al. (2007) found that the depressed group exhibited poorer performance than the non-depressed groups on the PDT when the distracters were negatively valenced words, but not when they were neutral or positive words. This relative impairment was significantly correlated with self-reported ruminative response tendencies on the RRS. In contrast, no group differences were observed on the SST. Lau et al. (2007) thus concluded that rumination is associated specifically with impaired cognitive inhibition, and not with difficulties in motor inhibition. There are a number of possible ways that Lau et al.'s findings might be interpreted. It is possible that the prose distraction task is more difficult than the stop signal task, and consequently that any difference in levels of difficulty provides an alternative explanation for the findings. Additionally, the stop signal task places less demands on the phonological buffer, relative to the prose distraction task, and thus, given the verbal content of rumination, it is possible that rumination acts as a cognitive load on primarily verbal tasks such as the PDT, but not on tasks that require less elaborative verbal processing, such as the SST. This is one of the few studies to examine performance on more than one task implicating inhibitory processes. The results are consistent the suggestion that there is a relationship between rumination and specific subtypes of inhibitory processes, as opposed to a more generalised effect of WM load on cognitive performance. However, alternative accounts positing a verbal working memory load are plausible.

2.4.14 Emotional go/no-go task as index of interference control

Vanderhasselt, Kuhn, and De Raedt (2011) used an emotional go/no-go task comprising two blocks: in block one, participants were instructed to respond to frequent positive faces and withhold responses to infrequent (20%) negative faces (sad no-go); in

block two, participants were instructed to respond to frequent negative faces and withhold responses to infrequent (20%) positive faces (happy no-go). Vanderhasselt et al. argue that in the happy no-go block participants must inhibit negative information in order to withhold their prepotent go response, and make the same argument regarding positive information for the sad no-go block. They interpret the difference in accuracy between the happy no-go and sad no-go blocks (accuracy difference score) as a measure of difficulties in disengaging from negative material relative to positive material. Depressive brooding was not correlated with no-go trial accuracy in either block type, or with the difference between no-go accuracy for happy no-go trials and no-go accuracy for sad no-go trials. No RT data is reported, thus it is not clear whether rumination was related to individual differences in response latencies. Based on a median split analysis in which Vanderhasselt et al. examined the same accuracy correlations in the high and low brooders there were no correlations between brooding and accuracy rates or the accuracy difference score in the low trait brooders. For high ruminators there was also no correlation between brooding and accuracy rates, but there was a significant correlation between brooding and the accuracy difference score. Higher brooding was associated with a smaller difference score amongst high trait brooders, which Vanderhasselt et al. argue reflects more errors among high brooders in disengaging from the negative relative to positive. However, it is of note that there was no overall association between levels of trait rumination and accuracy difference score, and as discussed previously median split analyses are problematic. Additionally, the absence of any reported RT effects makes it difficult to draw any firm conclusions regarding the overall pattern of task performance and how this might be related to rumination.

2.4.15 *Change detection task as index of interference control*

The change detection task (Vogel, Woodman, & Luck, 2001) presents participants with a memory array of squares of different colours following which a second array is presented which is either identical or in which one of the squares is a different colour. Participants are required to indicate whether the new array matches the previously presented one. The number of stimuli presented in each trial is varied and so the change detection task is argued to provide an estimate of the number of visual stimuli that an individual can hold in working memory. Working memory capacity was estimated by multiplying the set size by the difference between the proportion of correct responses when a change occurs and the proportion of incorrect responses when no change occurs.

Stout and Rokke (2010) adapted the task to include an additional condition in which both targets and distractors were presented in the arrays: coloured rectangles which served as distractors were presented with the same number of coloured squares. This second condition (labelled filtering efficiency) was argued to estimate attentional control in selectively attending to the targets and resisting distraction from the irrelevant stimuli. Filtering efficiency (F.E.) was estimated as a ratio comparing capacity for the targets plus distractors condition to capacity for the targets only condition. Participants for the study were undergraduate students sampled on the basis of their scores on the Centre for Epidemiological Studies Depression Scale (CES-D; Radloff, 1977) such that a relatively full range of levels of depressed mood was represented.

Stout and Rokke reported that working memory capacity moderated the relationship between filtering efficiency and trait rumination such that greater FE was predictive of lower levels of trait rumination at low levels of working memory capacity, but not at high working memory capacity (based on simple slopes analysis; Aiken &

West, 1991). A similar pattern of findings was reported for symptoms of depression and anxiety. Stout and Rokke argue that working memory capacity is a limiting factor in predicting symptoms of distress, including rumination, and that individuals with high storage capacity are able to compensate for limitations to filtering efficiency. However, it is of note that the estimate of filtering efficiency is based on working memory capacity, thus filtering efficiency would be predicted to vary with working memory capacity since the two measures are not independent.

Finally, one of the cross-sectional studies relating trait rumination and cognitive control processes examined composite measures of performance across multiple tasks in late onset depression (von Hippel et al., 2008). As a consequence this study provides evidence of an association between rumination and cognitive functioning, but it is not possible to specify which process(es) are implicated in this relationship.

2.4.16 Summary of correlational studies

In summary, there is convergent evidence from a number of measures of interference control that individual differences in trait rumination are related to the capacity to resist interference from material that is not currently relevant. However, a substantial number of the paradigms employed are ambiguous with respect to the specific processes most clearly implicated. Twelve studies are consistent with high trait rumination being associated with deficits in interference control (Bernblum & Mor, 2010; Berman et al., 2011; Daches et al., 2010; Davis & Nolen-Hoeksema, 2000; Demeyer et al., 2012; De Lissnyder, Koster et al., 2011; De Lissnyder et al., 2012; Lau et al., 2007; Levens et al., 2009; Joormann & Gotlib, 2008; Joormann et al., 2011; Stout & Rokke, 2010), four are indicative of trait rumination being associated with both benefits and deficits to interference control processes (Altamirano et al., 2010; De

Lissnyder et al., 2010; Whitmer & Banich, 2007; Zetsche & Joormann, 2011), and six are consistent with trait rumination being associated with the utilization of a level of interference control that is more appropriate to the demands of the task and thus results in benefit to performance (Hertel & Gerstle, 2003; Joormann, 2006; Joormann & Gotlib, 2010; Joormann & Tran, 2009; Whitmer & Banich, 2010; Whitmer & Gotlib, 2012).

2.5 Evidence relevant to the impaired-interference-control-as-cause-of-rumination hypothesis

Despite many commentators implicitly or explicitly postulating the impaired interference control-as-a-cause of rumination hypothesis (e.g., Hertel, 2000; Joormann, 2006; Joormann & Gotlib, 2008; Levens et al., 2009; Whitmer & Banich, 2007; 2010), there is a notable lack of studies that have manipulated interference control and measured subsequent state rumination in response to a relevant potentially rumination-inducing task. Such studies are critical to test the impaired interference control-as-cause of rumination hypothesis by examining whether increases and decreases in interference control result in changes in state rumination. To date, three prospective studies have examined the correlational relationship between interference control processes and trait rumination longitudinally, although it is of note that none of these studies have included a measure of state rumination.

De Lissnyder, Koster, Goubert, Onreadt, Vanderhasselt and De Raedt (2012) used a prospective design to examine whether self-reported stress levels (indexed by the Adverse Events Questionnaire; AEQ) were predictive of subsequent self-reported trait rumination, and whether this relationship was modified by switch costs on the IST. An undergraduate sample completed baseline measures of interference control (indexed by

the IST), symptoms of depression (on the BDI), trait rumination (on the RRS), and stress. Six, seven, eight and nine weeks later the BDI, RRS, and AEQ were administered online and participants completed each with reference to the previous week. Multilevel modelling identified that after controlling for baseline rumination and depressive symptoms, switch costs in the emotional condition of the IST moderated the relationship between subsequent (weeks six-nine) stress and rumination, such that rumination was stronger when individuals showed larger switch costs in the emotional condition. Switch costs for non-emotional material were not a significant moderator. These findings were also significant when depressive brooding was examined, but this was not the case for reflective pondering.

This is one of the few studies that have examined the prediction that deficits in interference control may predict subsequent stress-reactive rumination, and the findings are broadly consistent with an impaired-interference-control-as-cause-of-rumination account. It will thus be important that future studies adopt such designs, and employ a clearer measure of state (as opposed to trait) rumination.

Demeyer, De Lissnyder, Koster and De Raedt (2012) examined the relationship between switch costs on the IST and rumination prospectively at one year follow up using a small sample of remitted depressed patients. Demeyer et al. reported that rumination mediated the relationship between switch costs on the emotional condition of the IST and subsequent depressive symptoms (on the BDI). However, it is not clear from the report whether baseline levels of rumination were controlled for. Additionally, Demeyer et al report that there were no significant associations between depressive symptoms, trait rumination, and performance on the IST at baseline. These findings are at odds with considerable evidence demonstrating both an association between

depression and rumination, and an association between interference control processes and trait rumination.

Zetsche and Joormann (2011) examined the relationship between individual differences in trait rumination and interference control processes using verbal and pictorial negative affective priming tasks and the emotional flanker task. After controlling for depressive symptoms, individual differences in trait rumination were positively correlated with the emotional flanker interference score, but not with negative priming scores for negative material. Zetsche and Joormann additionally reassessed trait rumination and symptoms of depression six months later and reported that, after controlling for symptoms of depression and trait rumination at baseline, reduced negative affective priming for sad faces was predictive of trait rumination and trait reflection, but not trait brooding at follow-up. However, the observation that negative affective priming scores were not predictive of trait rumination at baseline, but were at follow-up, is not straightforwardly consistent with theoretical accounts of rumination and interference control. Additionally, this pattern of results is statistically surprising, given that the retention rate at follow-up was 36%, which raises questions about the generalizability of the findings. Moreover, this data is supportive of a relationship between reduced negative affective priming and trait rumination, but this association is specific to trait reflection as opposed to trait brooding, which is generally conceptualised as the subcomponent associated with persistent psychopathology (Treyner et al., 2003). Additionally, as noted previously, reduced negative affective priming scores are indicative of a relative improvement to task performance, as opposed to a clear deficit.

These three studies are broadly supportive of the proposal that individual differences in interference control are predictive of subsequent rumination. However, all

three studies have measured trait as opposed to state rumination. An impaired-interference-control-as-cause-of-rumination model predicts that impaired interference control results in increased susceptibility to prolonged bouts of state rumination in response to a stressor. Thus prospective studies that directly assess state rumination will be important in order to extend upon these initial findings that are suggestive of a predictive correlational relationship between interference control and subsequent rumination. Additionally, it is of note that two of the three studies did not find an association between the interference control processes argued to be predictive of later rumination, and baseline levels of rumination. These findings are surprising and indicate the need for further investigation and specification of the nature of these associations.

Several other correlational studies have been proposed as supportive of this account relative to other accounts. For example, Whitmer and Banich (2007) hypothesise that inhibitory difficulties play a causal role in rumination. The authors argued that their experiment did not induce rumination or low mood, and that cognitive resources did not appear to be under extra load because inhibitory difficulties were indicated by faster reaction times. However, the correlational design of these studies does not permit a direct test of these hypotheses. Further, the finding that individuals high in trait rumination were faster on the task is consistent with the proposal that under some circumstances, trait rumination confers a benefit to performance on cognitive tasks (Altamirano et al., 2010) since this data indicates that trait rumination is positively associated with performing the task more efficiently.

A number of studies that find a clear deficit in interference control have been proposed to support the impaired interference control-as-cause hypothesis (e.g., Joormann & Gotlib, 2008; Levens et al., 2009) because it is argued that the cognitive tasks employed are too demanding to permit concurrent rumination, and thus the

observed relationship between trait rumination and cognitive interference cannot be due to rumination causing cognitive interference. However, these studies have not directly assessed whether participants are ruminating during or immediately after the task, and as has been noted by a number of commentators (e.g., Hertel, 2000; Levens et al., 2009), pathological ruminators and depressed individuals experience difficulties reallocating resources away from ruminative content to focus on other tasks. Thus, it is not clear on the basis of these correlational studies whether individuals high in trait rumination were focusing their attention primarily on the task, on ruminative content, or repeatedly reallocating attention between the two. Further, many of these cognitive tasks are difficult, long, and repetitive to complete and as such could be experienced as stressful and aversive, and involve perceived performance failure, which in turn might lead to rumination in those individuals who are predisposed to ruminate. Moreover, the correlational design of the study leaves open the possibility that the association between trait rumination and impaired interference control is due to a common third factor.

2.6 Evidence relevant to the impaired-interference-control-as-consequence-of-rumination hypothesis

Several studies (Hertel, 1998; Philippot & Brutoux, 2008; Watkins & Brown, 2002; Whitmer & Gotlib, 2012; Wong & Moulds, 2009) have examined the effects of experimentally manipulating rumination on subsequent performance on cognitive tasks, thereby directly testing the impaired interference control-as-consequence hypothesis. The impaired interference control-as-consequence hypothesis does not predict an effect of rumination that is specific to interference control; it posits that state rumination exacts a cognitive load effect, which would be predicted to have deleterious

consequences for a number of processes and cognitive tasks, including those indexing interference control.

Whitmer and Gotlib (2012) examined the relationships between induced rumination, depression and backward inhibition and set-switching using an adaptation of Mayr and Keele's (2000) paradigm, which additionally examined preparation effect. The preparation effect is the observation of lower switch costs when there is a longer cue stimulus interval (CSI) and is understood to reflect the use of the longer CSI to prepare for the switch. Preparation effect was examined by manipulating the CSI such that for half the trials this was 100ms and for half 900ms. Whitmer and Gotlib found no interaction between group (depressed vs. control), condition (rumination vs. distraction) and preparation effect, indicating that group differences in task performance are unlikely to be attributable to differences in motivation, since all conditions made equivalent use of the longer CSI to prepare for a switch. The authors reported that depressed ruminators exhibited significantly greater switch costs than both depressed individuals in the distraction condition and non-depressed ruminators. This is consistent with evidence that trait rumination is associated with greater switch costs on De Lissnyder et al.'s (2010) Affective Shift Task.

Interestingly, in contrast to correlational evidence of an association between trait rumination and backward inhibition (Whitmer & Banich, 2007, Whitmer & Gotlib, 2012) there were no effects of either group (depressed vs. control) or rumination condition on backward inhibition scores. Thus, while the evidence suggests an association between backward inhibition and trait rumination, the findings regarding induced rumination suggest that this association may not be attributable to a causal effect of depressive rumination on interference control. Furthermore, in contrast to the association between higher trait rumination and better task performance (reduced

backward inhibition effects), this study provides evidence that state rumination results in impaired task performance (higher switch costs). It is of note that the manipulation checks following the rumination and distraction inductions examined mood, but not self-focus. Furthermore, the inductions appeared to differ in effect according to group – in the control group, rumination and distraction conditions did not differ in negative affect, whereas depressed participants reported more negative affect when ruminating than when distracted. Thus it is not possible to rule out an alternative account of the findings as attributable to differences in mood, as opposed to rumination.

2.6.1 Inclusion-exclusion test as index of interference control

Jacoby's (1996) fragment completion task presents participants with a series of word pairs, which they are instructed to remember for a later memory test (learning phase). In the test phase, participants are given word stems to complete. In trials where the instruction "use old" is presented, participants must use the stem as a cue to recall a word from the learning phase and complete the stem with this word. For trials in which the instruction "use new" is presented, participants must also use the stem to cue recall of a word from the learning phase, but must not use the recalled words to complete the stem and instead produce a novel completion. Jacoby (1991, 1998) developed a process dissociation procedure whereby the relative contributions of controlled and automatic processes to the task are estimated. Completions using an old word can be achieved via both controlled retrieval (with a probability of R) and automatic processes (i.e., the word came to mind automatically, which has a probability of A). However when participants are asked to retrieve a new word, production of an old word reflects the success of automatic processes and failure of controlled processes (Jacoby, 1991; 1998).

The estimate of controlled retrieval is thus the proportion of targets correctly used on “use old” trials minus the proportion used erroneously on “use new” trials.

Hertel (1998) compared the performance of dysphoric and non dysphoric students on the fragment completion test of memory for studied word pairs, using Jacoby’s (1991, 1996, 1998) procedure to dissociate controlled and automatic retrieval. Between the rehearsal phase and the fragment completion phase, Hertel (1998) manipulated rumination by allocating participants to one of three conditions: a rumination induction, an unconstrained interval (in which it was hypothesised that dysphoric individuals would be likely to engage in rumination), and a distraction induction. Dysphoria-related impairments in controlled retrieval, relative to the non-dysphoric group, were observed following a rumination induction, or a period of unconstrained thought, but not following a distraction induction. Thus, consistent with the interference control-as-consequence accounts, eliminating the opportunity to ruminate eliminated cognitive control impairments.

However, Hertel’s results indicate that one of the assumptions of this estimation procedure was violated. Dysphoric participants produced more targets (base rate) in the inclusion (“use old” trials) than in the exclusion (“use new” trials) test. Jacoby (1998) argues that the observation of a higher base rate on the inclusion test is indicative of the use of a generate/recognise strategy. This strategy is employed when a completion comes to mind automatically and recognition memory is used to determine whether it is an old or a new word. In this case, A (probability of the word coming to mind automatically) and R (probability of controlled recollection) cannot be assumed to be independent. Hertel reports that this violation makes A, but not R, uninterpretable. However, Jacoby (1998) found that in such cases estimates of R will be larger than

when a direct retrieval strategy is used. Jacoby (1998) proposes that this is because in such cases R reflects recognition memory for words generated as completions.

This difference in base rates cannot explain differences between the rumination and distraction inductions within the dysphoric group (assuming that these conditions do not differ in base rate completions) as this violation would be expected to influence estimates for both conditions equally. However, Hertel does not report whether the rumination and distraction conditions differed in base rate completions. Thus, the findings might be explained either in terms of ability to inhibit the rehearsed response or ability to generate an alternative response. Additionally, the absence of a rumination manipulation check following the inductions limits the extent to which the findings can be reliably attributed to rumination.

2.6.2 *Stroop task as index of interference control*

The Stroop paradigm is one of the most frequently used cognitive tests and is designed to index the ability to resist interference (MacLeod, 2005). However, there are several ways in which Stroop interference has been modelled (see MacLeod, 2005). Accounts that propose a competition between the relatively automatic process of reading and the more effortful cognitive control processes required to name the ink colour are most consistent with the inhibition of a prepotent response operationalization of interference control processes (e.g., Friedman & Miyake, 2004; May & Hasher, 1998). However, Monsell, Taylor and Murphy (2001) report evidence that Stroop interference is a consequence of competition from the task level (i.e., the reading task set), as opposed to being purely a consequence of response competition, which they argue will only occur when lexical access is sufficiently primed. This data is suggestive

of Stroop interference comprising a relatively clear index of interference control, but not necessarily implicating prepotent response inhibition.

Philippot and Brutoux (2008) used a modified Stroop task to examine interference control processes in dysphoric and non-dysphoric female undergraduates following a rumination or distraction induction. The study included conditions designed to examine Stroop interference (participants were asked to name the ink colour of printed congruent and incongruent colour words) and flexibility (participants were presented with colour words printed in different ink colours, some of which were framed; they were asked to read the framed words and to say the ink colour of the unframed words). Dysphoric participants in the rumination condition made significantly more interference errors than any other participant group, and dysphoric participants across both conditions made more flexibility errors than the control group.

Philippot and Brutoux proposed that structural interference between rumination and interference control occurs, suggesting that rumination and interference control may share a common processing stage. Philippot and Brutoux (2008) additionally hypothesised that flexibility (an example of task switching) may be fundamentally impaired in depression because depression occupies cognitive resources that would otherwise be employed for efficient flexible processing. Philippot and Brutoux (2008) thus demonstrate a causal influence of rumination on the efficiency of interference resolution.

2.6.3 Random Number Generation as index of interference control

In the random number generation task, participants are instructed to say the numbers 1 to 9 in a random order 100 times at a rate of one per second, which is paced using a metronome. An alternative version of the task involves pressing keys

corresponding to each number in a random order. The count score is used to assess the tendency to count in series (e.g., 1-2-3) by calculating the sum of the squared length of sequences of two or more numbers that are consecutive. The count score is argued to constitute one of the more sensitive indexes of randomness using the random number generation task and to reflect executive functioning (e.g., Brown, Soliveri, & Jahanshahi, 1998). Random number generation is argued to involve working memory and is frequently interpreted as an index of cognitive control processes (e.g., Baddeley, Emslie, Kolodny & Duncan, 1998), including the ability to inhibit prepotent counting responses, the ability to generate possible responses, the ability to maintain the complete set of response options in mind continually, and to recall those that have recently been used (Towse & Valentine, 1997).

Watkins and Brown (2002) compared the performance of depressed and non-depressed individuals on a random number generation task following rumination and distraction inductions. Depressed patients were impaired on generation of random numbers relative to non-depressed patients in the rumination condition but not in the distraction condition, when the groups did not differ. Thus, the results indicate that the depression-related impairments in cognitive control are maintained by ongoing rumination, and are ameliorated by distraction, which eliminates rumination.

One putative element within random number generation is controlling interference between the tendency to count in a non-random way and the task instructions. However, alternative non-inhibitory accounts of this finding are possible. Thus, Watkins and Brown's finding (2002) provides further evidence that state rumination impairs cognitive control processes, but does not establish that this effect is specific to interference control.

Wong and Moulds (2009) used a directed forgetting paradigm to examine cognitive control amongst dysphoric and non-dysphoric individuals following either rumination or distraction. Wong and Moulds reported that dysphoric participants in the rumination and distraction conditions did not differ in directed forgetting for positive, negative, or neutral words; all dysphoric participants exhibited standard directed forgetting effects. However, Wong and Moulds found that their rumination and distraction inductions differentially influenced change in self-reported self-focus (using the standard VAS scales that have been used in studies with these manipulations – e.g., Watkins, 2004), but not in happiness or sadness. The majority of studies that have used the rumination and distraction inductions have found a reliable differential effect on changes in self-reported mood (e.g., Lavender & Watkins, 2004; Lyubomirsky, Caldwell & Nolen-Hoeksema, 1998; Lyubomirsky, Kasri, & Zehm, 2003; Lyubomirsky & Nolen-Hoeksema, 1995; Nolen-Hoeksema & Morrow, 1993; Watkins & Teasdale, 2001), which is used as a manipulation check for the successful induction of rumination versus distraction. Thus, it is not clear that the rumination manipulations operated in the usual way since on this measure, this study found no evidence of the commonly reported differential effects of the rumination manipulation on mood. One could infer from this that it is not clear that rumination had been reliably induced since rumination is understood to exacerbate dysphoric mood states. Alternatively, one could argue that this study represents a potentially valuable case where self-focus changes independent of mood, and interestingly the study finds no evidence to indicate that rumination impaired interference control.

In summary, three of these studies (Hertel, 1998; Philippot & Brutoux, 2008; Whitmer & Gotlib, 2012) have adopted paradigms which can be regarded as relatively valid measures of interference control. A fourth study (Watkins & Brown, 2002)

adopted a random number generation paradigm, which is argued to involve working memory and is frequently interpreted as an index of cognitive control processes (e.g., Baddeley, Emslie, Kolodny & Duncan, 1998). Thus, there is convergent evidence that is consistent with the proposal that state rumination interferes with concurrent cognitive control resulting in decrements to task performance. However, the effect of induced rumination does not seem to extend to all operationalizations of interference control that are known to be associated with elevated trait rumination. Induced rumination had no significant effect on backward inhibition scores (Whitmer & Gotlib, 2012), in contrast individuals high in trait rumination have been established to exhibit reduced backward inhibition effects and thus improved task performance relative to those lower in trait rumination. On the basis of the existing experimental studies, there is no evidence to suggest that induced rumination impacts on interference control processes in ways that confer a benefit to task performance.

2.6.4 The role of cognitive load

One proposed account of the relationship between rumination and interference control is that state rumination occupies working memory capacity, thus impairing performance on tasks that are sensitive to working memory load (Hester & Garavan, 2005). Consistent with this account, many of the tasks used to assess interference resolution in the studies reviewed above are known to be sensitive to the imposition of concurrent working memory load, or to systematically vary according to working memory span. For example, the Stroop task is sensitive to individual differences in working memory span such that individuals low in working memory capacity make more errors and exhibit larger response latency interference effects (Kane & Engle, 2003). Working memory load eliminates a negative priming effect (Conway et al.,

1999), reduces R (controlled retrieval) whilst leaving A (automatic generation of the word without recollection) relatively invariant on inclusion-exclusion memory tasks such as that used by Hertel (1998) (Jacoby, 1998), and impairs random number generation (Towse & Valentine, 1997). There is also evidence that task switching is sensitive to working memory load (e.g., Hester & Garavan, 2005; see Vandierendonck, Liefoghe, & Verbruggen, 2010 for recent discussion). Indeed, there is no firm evidence to discount working memory span being critical to any of the interference control paradigms that have been related to rumination. The data regarding working memory is thus consistent with the hypothesis that if rumination acts as a working memory load, it should impair performance on interference control paradigms that have been associated with trait rumination. Consistent with this hypothesis, there is evidence suggesting that working memory capacity is restricted during worry amongst individuals reporting high levels of worry (Hayes, Hirsch & Mathews, 2008), which closely parallels rumination (Watkins, 2008). Hayes et al. (2008) examined state worry, whereas to date the majority of studies relating rumination and cognitive control have operationalized rumination at the trait level (e.g., as indexed on the RRS). Curci, Lanciano, Bianco and Cozzoli Poli (in press) report data indicating that individuals low in working memory span demonstrate greater interference to task performance following the processing of emotional material than individuals high in working memory span, and also report greater levels of subsequent rumination. Additionally, depressed individuals exhibit sustained pupil dilation in response to negative stimuli (Siegle, Steinhauer, Carter, Ramel, & Thase, 2003), which has been demonstrated to be a correlate of cognitive load (Steinhauer & Hakerem, 1992).

An impaired-interference-control-as-a-consequence-of-rumination model operationalizes rumination at the state level, which is not independent of the trait

tendency to ruminate. Thus studies that directly manipulate or measure state rumination are critical to empirically evaluating working memory load accounts of the relationship between rumination and interference control.

If the observed relationship between rumination and interference control is the result of working memory load, a negative effect of rumination on performance on all purported interference control measures that are sensitive to load, and indeed on other (non-inhibitory) cognitive tasks that are also sensitive to load would be predicted. Such deficits would be predicted to be specific to controlled, as opposed to automatic, processes (Hartlage et al., 1993), and thus process dissociation procedures would be predicted to be sensitive to the impact of rumination on performance of a concurrent task. Consistent with this hypothesis, there is evidence that reports of task-irrelevant thoughts predict poor performance on memory tasks amongst depressed individuals (e.g., Ellis, Moore, Vamer, & Ottaway, 1997), and that depression interferes with effortful, but not automatic processing (e.g., Hartlage et al., 1993; Jermann et al., 2005).

One methodological complication with examining the proposed role of working memory load is the proposal that the cognitive tasks act as natural distractors from continued rumination during task performance itself (e.g., Davis & Nolen-Hoeksema, 2000). Thus, in experimental studies that manipulate rumination and then examine performance on a cognitive task, it is possible that the task can interfere with continued rumination. However, as described above, studies have demonstrated that experimental manipulations of rumination influence subsequent performance on cognitive tasks, suggesting that this issue is surmountable. Additionally, Hester and Garavan (2005) have proposed that ruminative thought content is particularly salient to depressed individuals, and thus commands greater attention when cued by information encountered in the environment, and is more difficult to inhibit or switch away from

than neutral content. Consistent with this, there is evidence that depressed individuals selectively attend to and process dysphoric stimuli (Mogg & Bradley, 2005) and exhibit reduced cognitive flexibility in the presence of emotionally negative material (Deveney & Deldin, 2006). It is of note however, that it is not clear how an impaired-interference-control-as-consequence model in which rumination is proposed to act as a working memory load can account for the correlational data associating trait rumination with improved performance on tasks implicating interference control.

2.6.5 The role of mood state

An important dimension to consider when interpreting these studies is the role of mood. The rumination and distraction inductions adopted by these studies differ in emotionality (Philippot & Brutoux, 2008). Relative to rumination, distraction temporarily improves low mood in depressed individuals (Nolen-Hoeksema & Morrow, 1993; Lavender & Watkins, 2004). Moreover, rumination exacerbates negative mood relative to distraction, but has little emotional impact on people in a neutral mood. Negative mood is itself associated with poor performance on executive tasks (e.g., Channon, 1996; Snyder, 2013), reduced attentional flexibility (Ellenbogen, Schwartzman, Stewart, & Walker, 2002), mood-congruent biases in attention and memory (Koster, De Raedt, Leyman, & De Lissnyder, 2010), and more frequent attentional lapses when completing tasks requiring sustained attention (Smallwood, Fitzgerald, Miles, & Phillips, 2009). Moreover, negative mood is hypothesised to narrow attentional focus at the expense of flexible and creative thinking (e.g., Clore & Gasper, 2000; Koster et al., 2011). As a consequence it is possible that change in mood mediates the effects of distraction on improving performance on purported measures of interference control.

2.6.6 *Role of motivation*

Once activated, ruminative thoughts might be expected to be prioritised at the expense of optimal task performance because such thoughts pertain to personally important concerns. However, Whitmer and Gotlib (2012) reported evidence that induced rumination had a negative impact upon set-switching, but did not impact upon participants tendency to make use of longer CSIs to prepare for a switch and thus reduce their switch costs. Thus, in this study the findings are not consistent with a motivational account of the impact of rumination upon task performance. Additionally, the negative mood states associated with ongoing rumination are aversive, and thus it could alternatively be argued that distraction from such thinking would be prioritised over continued dwelling on sad mood. Further, when faced with demanding tasks, individuals experiencing high levels of self-criticism and sad mood might be predicted to place greater importance on ensuring that the task is performed to a high standard and mistakes are avoided. Consistent with this, a considerable number of studies report evidence that when tasks are more attentionally demanding and when strategies and structure is imposed then depressive impairments are no longer evident (e.g., Hertel & Rude, 1991; Krames & MacDonald, 1985; Thomas, Goudemand, & Rousseaux, 2009). This suggests that when the task is designed in such a way that continued task-focus is supported, depressed individuals do not deprioritise task performance in order to preferentially process negative cognitive content. Additionally, the findings of Whitmer and Gotlib (2012) provide direct support for the proposal that the relationship between depressive symptoms and cognitive task impairments cannot be adequately accounted for by motivational accounts.

2.7 Evidence relevant to the third factor (non-causal) hypothesis of relationship between rumination and cognitive control

A third possible account of the relationship between rumination and interference control is non-causal (i.e., both increased rumination and decreased interference control may be attributed to a third factor, such as low mood). It is possible that the relationship between rumination and impaired interference control is mediated by a third factor, such as low mood. It is important to distinguish such accounts from models in which the impact of rumination on interference control is moderated by a third factor, such as mood or working memory load, and which still retain a causal relationship between interference control and rumination. In order to directly contrast this putative account with causal models, it is necessary to conduct experiments that, in addition to a rumination manipulation, also include a control condition that manipulates the proposed third factor (e.g., mood).

2.8 Future challenges

2.8.1 Nature of causality

There is experimental evidence of rumination causally influencing performance on measures of cognitive control tasks (the *interference-control-as-consequence* account), and there is some emerging prospective longitudinal evidence that is consistent with the reverse (the *interference-control-as-cause* account) although it is of note that the correlational nature of these prospective studies means that it is not possible to infer causality. A significant limitation of the majority of the research into this relationship is the reliance on correlational designs. To date, there have been studies

that relate individual differences in trait rumination to cognitive control, and studies that manipulate state rumination and measure subsequent cognitive control. Additionally, three recent studies have begun to investigate the relationship between individual differences in interference control and trait rumination longitudinally.

There is a clear need for further studies to directly examine the predictions of an *interference-control-as-cause-of-rumination* model. No studies have yet examined the hypothesis that manipulating interference control influences subsequent rumination. This prediction needs to be directly tested by manipulating interference control and measuring levels of rumination before and after the manipulation.

2.8.2 *A two-level model of state and trait rumination*

The evidence regarding state and trait rumination suggests distinct relationships between state and trait level rumination and interference control processes. We therefore propose a two-level model of the relationship between rumination and interference control, whereby a bout of state rumination would be predicted to differentially impact interference control processes, relative to a trait level tendency to pathological rumination. Additionally, trait and state levels rumination are typically related: individuals high in trait rumination are more susceptible to bouts of state rumination, and these bouts are likely to be more intense and preoccupying than for individuals low in trait rumination. As a consequence, the role of state and trait rumination in individual differences in interference control processes is necessarily complex and interactive.

There is clear evidence that state rumination impairs performance on a range of cognitive tasks. The evidence is consistent with the impact of state rumination on interference control processes being a consequence of on-going rumination acting as a working memory load. Thus, the data best supports the *impaired-interference-control-*

as-consequence-of-rumination model: that on-going rumination acts as working memory load, thereby depleting available resources for concurrent performance of complex cognitive tasks. Individuals high in trait rumination are more susceptible to more frequent and intense bouts of state rumination, thus we further predict that these individuals are at increased vulnerability to the negative consequences of state rumination, and depleted interference control processes.

The pattern of findings regarding trait rumination is more complex. There are three distinct ways in which elevated trait rumination impacts upon interference control processes: First, several studies demonstrate that trait rumination is associated with cognitive inflexibility (Altamirano et al., 2010; Davis & Nolen-Hoeksema, 2000; Demeyer et al., 2012; De Lissnyder et al., 2010; De Lissnyder et al., 2011; De Lissnyder et al., 2012; Joormann & Gotlib, 2008; Joormann et al., 2011; Levens et al., 2009; Stout & Rokke, 2010; Whitmer & Banich, 2007; von Hippel et al., 2008; Zetsche & Joormann, 2011). Although some studies suggest that this cognitive inflexibility is specific to emotional or negatively valenced material (Bernblum & Mor, 2010; Demeyer et al., 2012; De Lissnyder et al., 2011; De Lissnyder et al., 2012; Berman et al., 2010; Joormann & Gotlib, 2008; Joormann et al., 2011; Lau et al., 2007), a substantial number of studies demonstrate that trait rumination is associated with cognitive inflexibility when processing neutral material or irrespective of the emotionality of the material (Altamirano et al., Daches et al., 2010; Davis & Nolen-Hoeksema, 2000; De Lissnyder et al., 2010; Levens et al., 2009; Stout & Rokke, 2010; Whitmer & Banich, 2007; von Hippel et al., 2008). Thus we propose that higher trait rumination is associated with greater cognitive inflexibility, and that this inflexibility is not specific to emotional material.

Second, there is evidence that trait rumination is positively associated with a benefit to performance on tasks that index interference control processes (e.g., Joormann, 2006). Such performance benefits occur in two distinct contexts: first, when increased maintenance of a single task goal confers a benefit to performance, and second, when preferential processing of negative material confers a benefit to performance (see Koster et al., 2011 for a recent review of the evidence regarding the relationship between trait rumination and processing biases in depression). We argue that the first case constitutes evidence that trait rumination is associated with reliable benefits to certain types of cognitive tasks. The second case constitutes a processing bias that could confer a benefit or a deficit to task performance depending on the demands of the task, and is addressed in more detail in the discussion of the third way in which trait rumination impacts on interference control.

Altamirano et al. (2010) proposed that when a cognitive task requires the capacity to maintain a single goal under conditions of low goal reinforcement, trait rumination confers a benefit to performance. Consistent with this, there is evidence from several studies that high trait rumination is associated with a benefit to interference control tasks for which the materials are neutral (Altamirano et al., 2010; Whitmer & Banich, 2007; Whitmer & Banich, 2010; Whitmer & Gotlib, 2012). The use of neutral materials rules out alternative accounts in terms of processing biases and for all the paradigms employed by these studies, a parsimonious account of the performance benefits observed in high ruminators is increased goal maintenance relative to low ruminators. However further investigation is needed in order to directly test this prediction by contrasting performance on tasks that implicate goal maintenance with those that implicate other forms of interference control. Studies examining the effects of induced rumination versus distraction on measures of goal maintenance and goal

flexibility amongst individuals high and low in trait rumination will be an important next step in directly testing the key predictions of this two-level model of rumination and interference control.

The third impact of trait rumination upon interference control processes is attributable to a positive association between increased tendencies to ruminate and a bias towards the preferential processing of negative material (e.g., Joormann et al., et al., 2010; Vanderhasselt et al., 2011). This has been demonstrated to result in deficits to task performance in contexts where the task requires flexibility in shifting between processing emotional and neutral material (e.g., Joormann & Gotlib, 2008). However, in other contexts, it appears that it can also confer a benefit to task performance (De Lissnyder et al., 2010; Joormann & Gotlib, 2010; Joormann & Tran; 2009; Zetsche & Joormann, 2011). In the case of those studies for which there was a valence-specific benefit to performance, the most convincing account of these findings is that high trait ruminators preferentially process negative material resulting in enhanced rehearsal of, and more rapid responding to negative stimuli. This is consistent with the proposal that one mechanism underpinning the relationship between pathological rumination and vulnerability to depression is ruminative processing biases for negative material (e.g., Koster et al., 2011).

Rumination involves prolonged and repetitive focus upon and processing of negative material, and high trait ruminators preferentially process negative material and demonstrate difficulties resolving interference from negative distractors (Koster et al., 2011). Repeated and sustained processing of negative self-relevant material and difficulties disengaging from this is likely to exacerbate and prolong negative moods and dysphoric states, increasing vulnerability to depression (Nolen-Hoeksema, 1991).

2.8.3 *Taxonomies*

Different operationalizations of interference control have been implicated in models of rumination and inhibition. A number of studies have adopted paradigms that implicate the resistance to interference subtype (e.g., De Lissnyder et al., 2010; Hertel, 1998; Hertel & Gerstle, 2003; Joormann & Gotlib, 2008; Joormann & Tran, 2009; Joormann et al., 2010; Whitmer & Banich, 2007; Whitmer & Banich, 2010). This is consistent with theoretical accounts of this relationship (Linville, 1996; Joormann et al., 2007), to which the resistance to proactive interference operationalization of interference control is most relevant (e.g., Friedman & Miyake, 2004; Linville, 1996). A substantial number of additional studies provide further convergent evidence that rumination is related to interference control processes. Thus, on the basis of existing evidence, trait rumination appears to be most clearly related to the resistance to interference subtype.

However, the evidence regarding rumination and the prepotent response inhibition subtype is relatively weak, with few studies having examined this operationalization with respect to rumination. Thus, it is not clear if the relationship between trait rumination and interference control is specific to one or more of the subtypes of interference control. There is a need for studies adopting multiple measures in order to address the distinct operationalizations of inhibition proposed by the taxonomies (e.g., Friedman & Miyake, 2004).

2.8.4 *Role of valence of task stimuli*

The role of stimulus valence in rumination-related interference control difficulties is complex. Some studies report a valence-specific relationship between trait rumination and interference control (e.g., Joormann & Gotlib, 2008), whereas some

studies report a relationship between rumination and task impairments where the stimuli are neutral (e.g., Levens et al., 2009). A two-level model of rumination and interference control predicts both an association between trait rumination and interference control in the context of neutral materials, and a rumination-related processing bias for negative material. Further studies are needed to systematically examine the relationship between trait rumination, and interference resolution when processing positive, negative, and neutral stimuli.

To date, the data regarding the effects of induced rumination on interference control is limited to neutral stimuli. An impaired-interference-control-as-consequence-of-rumination account would predict that rumination-related impairments would be evident across neutral and emotional stimuli and attributable to reduced cognitive capacity. Additionally, the impact of induced rumination might be predicted to be strongest in the context of negative material, as depressive-related biases towards the processing of negative content would cause a greater pull on resource allocation.

2.8.5 The role of mood state

As noted previously, an alternative account of the association between rumination and poor interference control is that it is a consequence of elevated depressed mood. Watkins and colleagues have examined the effects of two variants of the standard rumination induction which are equivalent in emotional valence and effect of negative mood (e.g., Watkins & Teasdale; 2004; Watkins & Moulds, 2005). Only one of these is consistent with the phenomenology of depressive rumination by focusing on abstract thinking about “why”. Thus, the effect of rumination on interference control can be distinguished from that of low mood through the use of such inductions amongst

depressed or dysphoric individuals prior to a task that is regarded as a reliable index of resistance to proactive interference.

2.9 Clinical Implications

The different proposed accounts of the relationship between rumination and interference control processes have distinct implications for clinical understanding and interventions for rumination and depression. The three accounts specifying a causal relationship each predict very distinct approaches to reducing cognitive interference and rumination in depression.

The *impaired-interference-control-as-consequence-of-rumination* account would suggest that the extent of cognitive impairments reported across episodes of depression, and also during recovery, may be related to the extent and severity of pathological rumination. Moreover, it implies that rumination does not occur as a consequence of underlying interference control deficits, suggesting that other models (a habitual response style, Nolen-Hoeksema, 1991; control theory, Watkins, 2008) may account for rumination. Clinically, this would suggest that targeting interference control processes would not be an efficacious way to reduce rumination. Moreover, it suggests that specifically targeting pathological rumination through extant treatments focusing on processing style (Watkins et al., 2007, 2011) should be beneficial in reducing the cognitive impairments that are reported in depression.

In contrast, the *impaired-interference-control-as-cause-of-rumination* account would imply that underlying interference control deficits would need to be a key target for the assessment and treatment of rumination. This account would predict that for interventions to have a long-term benefit in reducing rumination, they would need to

address deficits in interference control, perhaps through cognitive training programmes designed to increase working memory capacity (see Shipstead et al., 2012 for recent review and critique of WM training approaches) or enhance inhibitory control (e.g., Muraven, 2010). Moreover, this account predicts that experimental assessment of interference control may be a good index of potential susceptibility to pathological rumination, to be used to identify individuals at high risk and to assess the impact of interventions. Moreover, this account would indicate the potential value of neurobiological interventions to improve interference control, whether through psychopharmacological intervention or through identifying relevant neural substrates through functional MRI and then manipulating their activity through repeated transcranial magnetic stimulation (for detailed discussion of the use of TMS in depression see Loo & Mitchell, 2005). A bi-directional relationship would indicate the potential value of both of these approaches.

2.10 Conclusions

In conclusion, we propose a two-level model of the relationship between rumination and interference control. There is evidence that state rumination is associated with impaired interference control. Few studies have attempted to disentangle which more precise specification of interference control is related to rumination; however the most parsimonious account of the relationship between state rumination and impaired interference control is as a result of on-going rumination acting as a working memory load. However, it will be important to rule out alternative accounts of these findings that may be attributable to induced dysphoric mood. Trait rumination is associated with impairments across a number of measures of cognitive

flexibility. Researchers have frequently proposed that interference control difficulties cause individuals to find it hard to suppress or switch away from intrusive negative thoughts (e.g., Whitmer & Banich, 2007; Joormann & Gotlib, 2008). An important next step will be the direct examination of this prediction. Additionally, there is robust evidence that high trait rumination is associated with beneficial outcomes for the performance of certain cognitive tasks (e.g., Whitmer & Banich, 2007). These findings are hypothesized to be attributable to two distinct mechanisms. First, high trait ruminators are predicted to be better at maintaining focus on a single task goal relative to low trait ruminators, conferring a benefit to performance on tasks that implicate such a strategy. Second, high trait ruminators are predicted to preferentially process negative material, resulting in increased rehearsal, which can confer a benefit to the performance of cognitive tasks in certain contexts, and a deficit in others. However this two-level model has yet to be directly tested and alternative accounts of the association between trait rumination and interference control need to be directly contrasted in order to establish the mechanisms underpinning rumination-related benefits to task performance. Systematic examination of the predictions of this model is thus a critical next step.

On the basis of existing evidence, the most parsimonious account of the extant data regarding the relationship between state rumination and interference control processes is an impaired-interference-control-as-consequence-of-rumination hypothesis: this model can be empirically justified. The data correlating high trait rumination with improved task performance suggests that a working memory load account is not sufficient. The association between trait rumination and interference control processes is indicative of a more complex two-level account, in which pathological rumination is associated with both benefits and deficits to task performance according to the specific mechanisms and processing biases that optimise task performance. The causal nature of

the relationship between trait rumination and interference control, and the predictions of an impaired-interference-control-as-cause-of-rumination have yet to be directly examined, and this will be important in developing a more highly specified model of these processes.

CHAPTER THREE: *Thesis Hypotheses*

Each of the hypotheses examined in the thesis and the chapter(s) in which this hypothesis is addressed are summarised below.

Hypothesis 1: Induced rumination impairs resistance to proactive interference from emotional material relative to a non-ruminative control condition

As discussed in Chapter Two, existing evidence regarding rumination and interference control is most consistent with an *impaired-interference-control-as-consequence-of-rumination* (e.g., Watkins & Brown, 2002), and the resistance to proactive interference subtype of interference control is the subtype of most theoretical relevance to rumination (e.g., Friedman & Miyake, 2004). To date, no studies have examined the impact of induced rumination on the ability to resolve interference from emotional material. It was therefore predicted that relative to non-ruminative control conditions, induced rumination would impair resistance to proactive interference in dysphoric (Chapters Four and Five) and unselected (Chapter Eight) samples. The task selected to measure resistance to proactive interference was specifically chosen as a task that is known to be related to trait rumination and for which the causal nature of this association has not previously been examined.

Hypothesis 2: Induced rumination impairs prepotent response inhibition relative to a non-ruminative control condition

As discussed in Chapter Two, prepotent response inhibition is the sub-type of interference control that most clearly implicates inhibition. Consistent with an *impaired-interference-control-as-consequence-of-rumination* (e.g., Watkins & Brown, 2002), it

was therefore predicted that induced rumination would impair prepotent response inhibition relative to a non-ruminative control condition (Chapters Six and Seven).

Hypothesis 3: Trait rumination increases susceptibility to state rumination

Trait rumination is conceptualised as the tendency to habitually ruminate (Nolen-Hoeksema, 1991). It was therefore predicted that trait rumination would moderate the impact of a rumination manipulation upon subsequent state rumination (Chapters Six, Seven, and Eight), such that individuals high in trait rumination are more sensitive to the effects of a rumination manipulation.

Hypothesis 4: Trait rumination increases susceptibility to the negative impact of state rumination on interference control

As detailed in the two-level model proposed in Chapter Two, it is hypothesised that individuals high in trait rumination experience state rumination as more intense and persistent. It was therefore predicted that state rumination would occupy greater cognitive resources and be more difficult to disengage from for such individuals resulting in greater impairments on concurrent cognitive tasks (Chapters Six, Seven, and Eight).

Hypothesis 5: Personal goal discrepancies elicit state rumination

The thesis additionally sought to develop and validate a more powerful and ecologically valid manipulation of state rumination that was not reliant on instructed focus on depressed mood. As noted in Chapter Two (2.2.1), control theory of rumination makes detailed predictions regarding the proximal causes of state rumination. Specifically, control theory predicts that negative discrepancies in progress

towards important personal goals elicit state rumination about the discrepancy in an attempt to restore anticipated progress towards the goal (e.g., Carver & Scheier, 1998).

It was therefore predicted that cueing personal goal discrepancies would elicit persistent ruminative thoughts about the unresolved goal, relative to cueing a past resolved goal (Chapters Six, Seven, and Eight).

CHAPTER FOUR: *Study One*4.1 *Introduction*

As reviewed in Chapter Two, there is considerable evidence demonstrating a relationship between depressive rumination and deficits in performance on tasks purported to index interference control processes (e.g., Davis & Nolen-Hoeksema, 2000; Watkins & Brown, 2002; Joormann & Gotlib, 2008). The majority of these studies have advanced the theory that deficits in interference control play a causal role in the susceptibility to rumination and difficulties disengaging from intrusive ruminative thoughts (e.g., Whitmer & Banich, 2007). However, most of the research thus far has adopted a correlational design. As a consequence the nature of causality in this relationship has not been thoroughly tested. A further limitation with many of these studies is that they frequently do not specify which operationalization of interference control is most relevant to the cognitive task that was used.

Five notable studies have adopted an experimental approach whereby the proximal consequences of state rumination were examined using purported measures of interference control (Hertel, 1998; Philippot & Brutoux, 2008; Watkins & Brown, 2002; Whitmer & Gotlib, 2012; Wong & Moulds, 2009). However, for three of these studies it was not clear that rumination was successfully induced as a consequence of either the absence of a manipulation check (Hertel, 1998; Philippot & Brutoux, 2008), or the depressive rumination induction not resulting in the increased negative affect that such manipulation checks for this induction commonly predict (Wong & Moulds, 2009). One of the studies did not adopt a clear measure of interference control (Watkins & Brown, 2002), and one of the studies reported a violation to the assumptions underlying the

measure of interference control (Hertel, 1998). Finally, Whitmer and Gotlib's (2012) study was published after the completion of Study One, thus at the time of design and completion there were no published experimental studies that successfully induced rumination as indicated by an appropriate manipulation check and examined the consequences using a clear measure of interference control.

Study One sought to examine the hypothesis that state rumination reduces the ability to resist proactive interference using the modified Sternberg task (Oberauer, 2001; 2005). Proactive interference occurs when information that has previously been remembered interferes with memory for subsequent task-relevant information; resistance to proactive interference therefore refers to the ability to dampen the activation of, or resolve interference from, no longer relevant information. The modified Sternberg task is regarded as constituting a relatively clear index of interference control (Oberauer, 2001), and matches most closely the resistance to proactive interference operationalization. The modified Sternberg paradigm (Figure 4.1) presents participants with two lists of three words simultaneously, which they are instructed to remember. One list is presented in red, the other list in blue. The word lists can be of positive or negative, or mixed (positive and negative) valence. A cue is then presented (a red or blue box) indicating which list will be relevant for evaluating the probe word. Finally, a single word (the probe) is presented in black ink and participants are asked to indicate whether this word belongs to the relevant (cued) list. The difference in reaction times (RTs) between decisions to new words and intrusion words (words from the irrelevant list) is interpreted as reflecting the strength of residual activation of words from the to-be-ignored list in working memory.

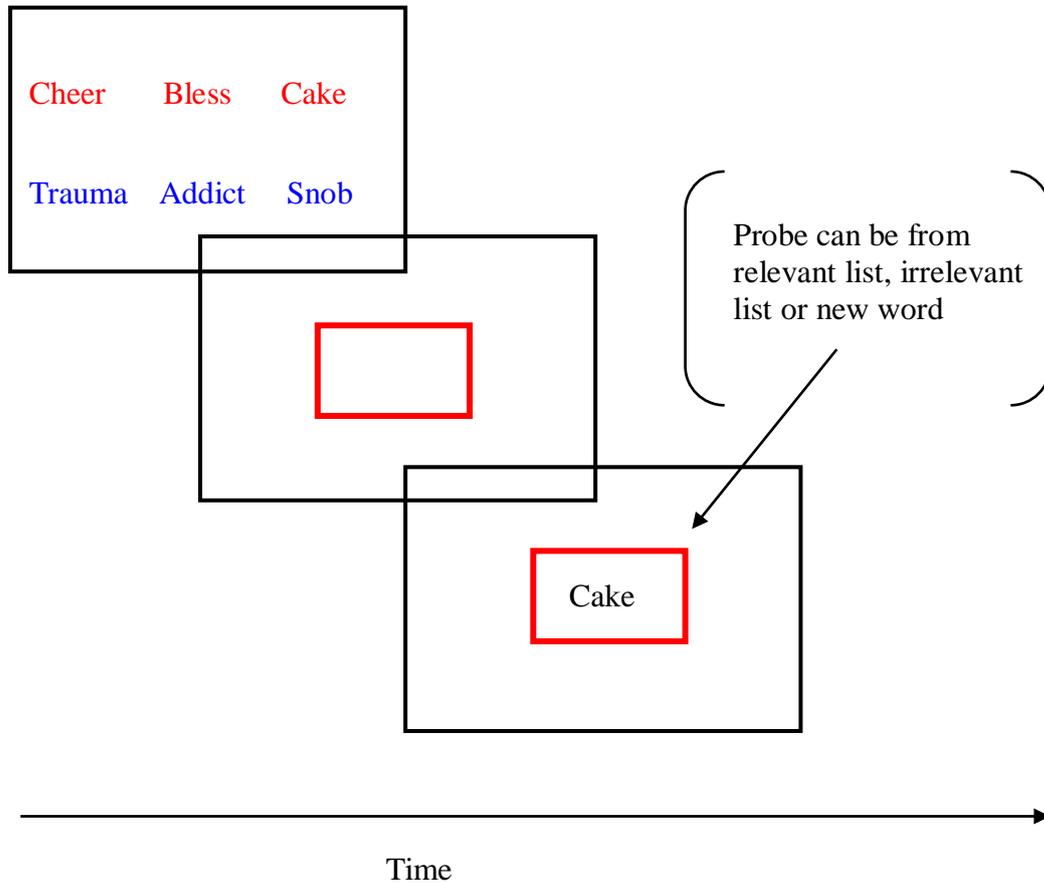


Figure 4.1: Schematic of the modified Sternberg paradigm

Joormann and Gotlib (2008) found a relationship between trait rumination and difficulties resolving interference from negatively valenced words amongst depressed individuals. The present study sought to extend Joormann and Gotlib's (2008) finding by directly testing the hypothesis that rumination causally influences interference control processes, using the modified Sternberg task.

Experimental studies have used standard rumination and distraction manipulations (Nolen-Hoeksema & Morrow, 1993) to examine a number of potential consequences of depressive rumination (see 1.2.2). These manipulations have been

demonstrated to produce reliable, temporary effects on both degree of self-focus and mood amongst individuals already experiencing low mood (Watkins & Teasdale, 2001). These manipulations have been used to demonstrate differential effects on a number of areas of cognition and functioning (e.g., Watkins, Teasdale & Williams, 2000; Lavender & Watkins, 2004; Watkins & Moulds, 2005; Moberly & Watkins, 2006). In the current study, these manipulations were used to directly compare the effects of induced rumination and distraction on performance on the modified Sternberg task, and thus to examine the causal influence of rumination on the resistance to proactive interference operationalization of the inhibition construct (Friedman & Miyake, 2004).

4.1.1 *Hypotheses*

It was hypothesised that difficulties resisting interference from unwanted intrusions from memory in response to sad mood are related to rumination (e.g., Linville, 1996). Specifically, it was predicted that following a rumination induction, dysphoric participants will exhibit impaired resistance to proactive interference on the modified Sternberg task relative to both dysphoric participants who complete the distraction induction, and non-dysphoric participants in both induction conditions. It was therefore predicted that dysphoric participants in the rumination condition would have larger intrusion effects (calculated as decision latencies to intrusion probes minus decision latencies to new probes of the same valence) than either dysphoric participants in the distraction condition, or non-dysphoric participants. Correlational evidence regarding whether the association between rumination and interference control is valence specific is mixed, consequently no specific predictions were made regarding whether rumination-related deficits would be specific to negative material or observed for both positive and negative intrusions.

Task performance was not predicted to differ according to induction condition amongst non-dysphoric individuals. Joormann and Gotlib (2008) found low overall error rates on the modified Sternberg task; as a consequence group differences in error rates were not predicted in the current study.

Consistent with previous studies using rumination and distraction inductions (e.g., Lyubomirsky & Nolen-Hoeksema, 1993; 1995), it was predicted that following the induction tasks, dysphoric participants who received the rumination induction would report increases in dysphoria relative to dysphoric participants who underwent a distraction induction. Such an observation is commonly interpreted as evidence that the inductions have been successful (e.g., Watkins & Teasdale, 2001). Non-dysphoric participants were not predicted to report differential affective consequences of the rumination and distraction tasks.

4.2 *Method*

4.2.1 *Participants*

Participants were recruited from the student population of the psychology department at Exeter University, and from the departmental databases of individuals who wished to take part in research at the department. Participants received either course credits (first year undergraduates) or £5 for their time. Participants' responses to an electronic screening questionnaire provided the requisite selection information. The Beck Depression Inventory-II (BDI-II) is a self-report instrument for measuring severity of depression according to symptoms corresponding to the diagnostic criteria for depressive disorders; scores from 0-13 are classified as minimal, and 14-19 as mild (Beck, Steer, & Brown, 1996). In order to ensure that the study examined individuals with stable high and low levels of dysphoria, the following selection criteria were

therefore used: Individuals who returned a BDI-II scoring between 10 and 13 at screening were excluded; those scoring <10 were assigned to the non-dysphoric group, and those scoring > 16 were assigned to the dysphoric group. For the high dysphoric group, individuals scoring >13 at screening reported clinically significant symptoms of depression based on the standard cut-offs (Beck et al., 1996) and were therefore invited to the testing session, which was scheduled to be at least 5 days after completion of the screening questionnaire. The following criteria were then used for inclusion: individuals whose mean BDI-II was above 16, whose BDI-II had not varied by more than 3 points between the screen and the test, and who had not returned a BDI-II score below 14 on either occasion were included in the final dysphoric sample. Participants were also excluded if they reported severe head trauma or learning difficulties, current or lifetime bipolar disorder or psychotic symptoms on a self-report questionnaire administered with the initial screen BDI-II. Finally, it was established that all participants had normal or corrected-to normal vision. All individuals who met criteria at screening completed the full test session and were debriefed.

4.2.2 *Materials*

Beck Depression Inventory (BDI-II; Beck, Steer, & Brown, 1996)

The BDI-II is a 21-item self-report measure designed to assess the presence and severity of depressive symptoms. Symptoms of depression that are measured include both somatic and affective components of depression, such as sadness, guilt, appetite, and sleep. For each item, participants are asked to indicate which of four statements has best applied to them over the past two weeks. Responses for each items range from 0 (e.g., “I do not feel like a failure”) to 3 (“e.g., “I feel I am a total failure as a person”). Item scores are summed to generate an overall score; higher scores represent greater

severity of depressive symptoms (scores range 0-63). The BDI-II is known to have good psychometric properties (Strauss et al., 2006); it has high internal consistency (Dozois, Dobson, & Ahnberg, 1998) and good test-retest reliability (Sprinkle et al., 2002).

Ruminative Responses Scale (RRS; Nolen-Hoeksema, 1991)

The RRS of the Response Styles Questionnaire (RSQ, Nolen-Hoeksema, 1991) is a 22-item measure of depressive rumination. Ruminative responses to low mood measured by the RSQ include self-focused, symptom focused, and consequence-focused responses. For example; items include “analyze recent events and try to understand why you are depressed”; “think about how alone you feel”; and “think about all your shortcomings, failings, faults, mistakes”. For each item, participants rate on a four point scale from 1 (almost never) to 4 (almost always) what they “generally do” when they are feeling sad or depressed. Responses for each item are summed to generate an overall score, ranging from 22-88; higher scores represent a greater trait tendency to ruminate in response to negative mood. The RRS has high internal consistency, acceptable construct validity, and good test-retest reliability (Nolen-Hoeksema & Morrow, 1991; Treynor, Gonzalez, & Nolen-Hoeksema, 2003).

Visual Analogue Scales

Visual analogue scales were used to assess current levels of despondency, happiness, and self-focus (0-100). Participants indicated on 3 scales ranging from 0 (“not at all X”) to 100 (“extremely X”), where X was “despondent”, “happy”, and “focused on myself”, respectively, how they were feeling “at the present moment”. These measures have previously been found to be reliable and sensitive measures of current mood and self-focus (e.g., Watkins & Teasdale, 2001; 2004; Watkins, Moberly, & Moulds, 2008).

Rumination and distraction inductions

The tasks are based on Nolen-Hoeksema and Morrow's (1993) rumination and distraction tasks, as adapted by Watkins and Teasdale (2001). The manipulations are self-paced and ask participants to concentrate on one of two written lists of 45 items for 8 minutes. In the rumination condition, participants focus their attention on items that are self-focused, emotion-focused and symptom-focused (e.g., "think about the way you feel inside", "think about what your feelings might mean"). In the distraction condition, participants focus their attention on externally referenced items that are unrelated to emotions or symptoms (e.g., "think about clouds forming in the sky", "think about and picture the Eiffel tower").

Modified Sternberg task (Oberauer, 2001; 2005; Joormann & Gotlib, 2008)

The modified Sternberg task used was obtained from Jutta Joormann in order to ensure that it was identical to that used by Joormann and Gotlib (2008). The task was presented on computer, using E-Prime software. The modified Sternberg paradigm presents participants with two lists of three words simultaneously, which they are instructed to remember. One list is presented in red, the other list in blue. The word lists are presented for 7.8s. A blank screen is then presented for 800ms, followed by a cue displayed for 1s (a red or blue box) indicating which list will be relevant for evaluating the probe. Finally, a single probe word is presented in black and participants are asked to indicate as quickly and accurately as possible whether this word belongs to the relevant (cued) list. The word can come from the relevant list, the irrelevant list, or be a new word that was not presented in either list. The probe word remains on the screen until participants have made their response, using a button press (1 = yes, 2 = no). Participants are instructed to respond as quickly and accurately as possible. The accuracy and latency of participants' responses are recorded.

The words lists consist of the positively and negatively valenced nouns selected from the Affective Norms of English Words (Bradley & Lang, 1999) by Joormann and Gotlib (2008). A total of 208 positive words and 208 negative words are used (see Appendix One for a full list of the stimuli), and these lists were established not to differ in mean arousal rating, or average word length (Joormann & Gotlib, 2008).

The task comprises three blocks of 40 trials in total. For each participant, in each block a random sample of words from the word lists is selected without repetition; thus words are only used once within a block, but can be used up to three times across the experiment. The screen position of the red and blue lists and the valence of each colour of list are counterbalanced in each block. Block order and the sequencing of the trials within each block are random.

In the experimental trials, the red and blue lists contain only positive or negative words, and the valence of the two lists differs (i.e., one is positively valenced and one negatively valenced). The valence of the probe word is varied (positive or negative) as is the source of the probe word (relevant list, irrelevant list, or new). Consequently, there are a total of 8 experimental conditions (Table 4.1). Additionally, a ninth control condition presents lists containing both positive and negative words; this is designed to discourage participants from using the valence of the word lists to cue their responses to the probes. Each experimental condition is presented four times in each block, and the control condition is presented eight times in each block.

Participants take longer to reject words from the no longer relevant list (intrusion probes) than new words (Oberauer, 2001; 2005; Joormann & Gotlib, 2008). As such, the difference in RT between new words and intrusion words is interpreted as reflecting the strength of residual activation of words from the to-be-ignored list in

working memory. Therefore, this task appears to be a relatively clear index of resistance to proactive interference.

4.2.3 *Design*

The study had a 2 (mood group: dysphoric vs. non-dysphoric) x 2 (rumination manipulation: rumination vs. distraction) design, resulting in four between-subject cells (dysphoric ruminators; non-dysphoric ruminators; distracted dysphoric individuals; and distracted non-dysphoric individuals). The modified Sternberg task had a 2 (probe valence: positive, negative) x 4 (probe relevance: relevant, intrusion, new positive, new negative) design resulting in eight different experimental conditions (Table 4.1); a ninth (unanalysed) control condition presented lists of mixed valence.

4.2.4 *Procedure*

Participants attended one individual testing session of approximately 50 minutes. After completing the questionnaires (BDI-II, RRS), participants completed self-report measures of current mood and self-focus (the initial baseline measures of state mood and self-focus) and then were randomly allocated to work through either the rumination or the distraction induction. Participants were informed that the experiment was investigating the links between mood, imagination, thinking processes and memory. After the induction, participants completed the ratings of current mood and self-focus again (the post-induction Time 2 measures of state mood and self-focus) and then worked through the modified Sternberg task. All the instructions for the modified Sternberg task were presented on the computer, and participants worked through these at their own pace. Before beginning the experimental blocks, participants completed 5 practice trials. Between each experimental block they were asked to rate their current

mood and self-focus in order to monitor the degree to which the effects of the inductions were maintained during the task (block 1, block 2, block 3). Completion of the modified Sternberg task took approximately 30 minutes.

Following this, participants completed a final rating of their current mood and self-focus, and then received a full debrief. A funnelled debriefing was used such that participants were first asked to guess the purpose of the study and whether they believed that any of the tasks were related in any way, and if so in what way. During the debriefing, no participant reported any suspicions that there were two versions of the thinking task (the rumination and distraction inductions). Following this all participants received a full debriefing and the rumination manipulation was explained. Dysphoric participants in the rumination condition who were reporting worsened mood at the final rating ($N = 1$), as compared to their pre-induction ratings (i.e., persisting effects of the rumination induction), completed a shortened version of the distraction induction in order to alleviate any persisting rumination or worsened mood.

4.2.5 *Data analysis*

All data was analysed using IBM SPSS Statistics software, this was also the case for Studies Two, Three, Four, and Five. For all moderation analyses in the thesis, simple slopes were initially computed from first principles, and then convergent results obtained using a freely downloadable Excel macro from Dr Jeremy Dawson's personal webpage (<http://www.jeremydawson.co.uk/slopes.htm>).

Table 4.1: *Experimental conditions of the modified Sternberg paradigm*

Condition	Relevant	Irrelevant	Probe
1	Positive	Negative	Relevant
2	Negative	Positive	Relevant
3	Negative	Positive	Irrelevant
4	Positive	Negative	Irrelevant
5	Positive	Negative	New Positive
6	Negative	Positive	New Positive
7	Negative	Positive	New Negative
8	Positive	Negative	New Negative
9	Mixed	Mixed	Positive or Negative

4.3 Results

4.3.1 Participant characteristics

73 participants (76.71 % female) comprised the final dataset. The mean age of the sample was 21.49 years (SD = 5.76; range 18-52 years). 41 individuals met criteria for the non-dysphoric group; 32 met criteria for the dysphoric group. 36 participants received the distraction induction and 37 received the rumination induction. The groups did not reliably differ in the proportions of males and females ($\chi^2(1) = 0.75, p = 0.388$); this was also true of the two manipulation conditions ($\chi^2(1) = 0.80, p = 0.371$).

The demographic characteristics of the dysphoric and non-dysphoric groups are presented in Table 4.2. It was confirmed that the groups did not significantly differ in

age, $t(71) = 0.74$, $p = 0.459$. The majority of participants in both groups were female ($N = 56$). As expected, the dysphoric group reported a greater tendency to ruminate in response to sad mood on the RRS than the non-dysphoric group, $t(71) = 6.38$, $p < 0.001$. Baseline (i.e., pre-manipulation) group differences in mood were examined. As predicted, the groups significantly differed in despondency ratings, $t(71) = 8.60$, $p < 0.001$; the dysphoric group reported greater despondency ($M = 51.56$, $SD = 17.06$) than the non-dysphoric group ($M = 17.32$, $SD = 16.44$). The groups also significantly differed in happiness ratings, $t(71) = 7.21$, $p < 0.001$, reflecting less happiness amongst the dysphoric group ($M = 45.31$, $SD = 16.85$) than amongst the non-dysphoric group ($M = 70.98$, $SD = 13.57$).

Table 4.2: *Characteristics of participants (means with standard deviations in parentheses)*

Variables	Non-dysphoric		Dysphoric	
	Rumination	Distraction	Rumination	Distraction
N (N female)	21 (17)	20 (16)	16 (13)	16 (10)
Age	21.24 (7.56)	20.85 (3.38)	22 (6.35)	22.13 (5.19)
BDI-II	3.52 (2.68)	4.95 (2.84)	23.63 (6.74)	24 (6.04)
RRS	39.57 (9.96)	44.10 (10.28)	57.44 (9.27)	55.31 (8.73)

4.3.2 *Effects of rumination and distraction inductions on self-reported affect*

In order to examine whether the rumination induction had the expected effect of increasing negative affect in dysphoric participants relative to distraction, 2 (mood group: dysphoric vs. non-dysphoric) \times 2 (rumination manipulation: rumination vs. distraction) \times 2 (time: baseline: pre-induction; time 2: post-induction) mixed ANOVAs

were conducted on participants' ratings of their current mood. Happiness ratings were reversed scored to compute a single variable representing participant's ratings of their despondency and happiness. The predicted mood group x rumination manipulation x time interaction was significant, $F(1, 69) = 7.31, p = 0.009$, reflecting worsening mood following the rumination induction for dysphoric participants (pre-induction $M = 52.81, SD = 15.16$; post-induction $M = 61.56, SD = 15.35$, higher values reflect lower mood), but not for non-dysphoric participants (pre-induction $M = 19.52, SD = 10.36$; post-induction $M = 22.62, SD = 12.41$). Consistent with this, simple effects analyses revealed that the three-way interaction reflected no differences at baseline between rumination and distraction in either the dysphoric group, $F(1, 70) = 0.01, p = 0.931$, or the non-dysphoric group, $F(1, 70) = 1.63, p = 0.206$, and no effect of condition in the non-dysphoric group at time 2, $F(1, 70) = 0.81, p = 0.372$, but a trend towards an effect of condition (rumination versus distraction) in the dysphoric group at time 2, $F(1, 70) = 3.54, p = 0.064$. For dysphoric participants, there was a significant effect of time in the rumination condition, $F(1, 69) = 12.27, p = 0.001$, reflecting a worsening of mood following the rumination induction (Figure 4.2). There was also significant effect of time in the distraction condition, $F(1, 69) = 5.95, p = 0.017$, reflecting an improvement in mood following the distraction induction. For non-dysphoric participants, there was not a significant effect of time in either the rumination condition, $F(1, 69) = 2.01, p = 0.160$, or the distraction condition, $F(1, 69) = 0.20, p = 0.656$.

A 2 (mood group) x 2 (rumination manipulation) x 2 (time) mixed ANOVA on self-focus scores identified a significant main effect of rumination manipulation, $F(1, 69) = 12.72, p < 0.001$. This was qualified by a significant rumination manipulation x time interaction, $F(1, 69) = 17.25, p < 0.001$, reflecting an increase in self-focus across the groups following the rumination induction (before $M = 64.32, SD = 22.80$; after M

= 77.57, SD = 18.62) but not the distraction induction (before M = 57.50, SD = 22.73; after M = 51.67, SD = 22.74). There were no other significant main effects or interactions. The contrast between dysphoric ruminators and dysphoric distractors was significant, $F(1, 69) = 6.85$, $p = 0.011$, reflecting the predicted increase in self-focus following the rumination induction (before M = 61.88, SD = 23.16; after M = 74.38, SD = 19.31), but not following the distraction induction (before M = 51.88, SD = 28.10; after M = 48.13, SD = 23.44).

As predicted, the rumination and distraction inductions differentially influenced dysphoric participant's mood; the rumination induction resulted in worsened mood relative to the distraction induction. As predicted, these effects were not observed for non-dysphoric participants. Across both mood groups, the rumination manipulation increased self-focus relative to distraction.

4.3.3 *Duration of the effects of the inductions through the cognitive task*

A 2 (mood group) x 2 (rumination manipulation) x 3 (time: post block 1, post block 2, post block 3) mixed ANOVA was conducted to examine the extent to which the affective consequences of the rumination and distraction inductions persisted through the modified Sternberg task. There was a significant main effect of mood group, $F(1, 69) = 23.14$, $p < 0.001$, a trend towards an effect of rumination manipulation, $F(1, 69) = 3.54$, $p = 0.064$, and a main effect of time, $F(2, 138) = 7.917$, $p = 0.001$. The interaction of mood group and rumination manipulation was significant, $F(1, 69) = 4.21$, $p < 0.044$. Simple effects analyses revealed that there was a significant effect of rumination condition on self-reported mood among the non-dysphoric group at time 3 (the end of block 1), $F(1, 72) = 7.15$, $p = 0.009$, time 4 (end of block 2), $F(1, 72) = 6.45$, $p = 0.013$, and a trend towards an effect at time 5 (end of block 3), $F(1, 72) =$

3.89, $p = 0.053$. Contrary to predictions, distraction worsened mood relative to rumination for non-dysphoric participants. Mean mood ratings at each time point by group and condition are illustrated in Figure 4.2. The affective consequences of the rumination manipulation in dysphoric participants were no longer evident once participants were completing the modified Sternberg task. There was not an effect of rumination condition on self-reported mood in the dysphoric group at time 3, $F(1, 72) = 0.24$, $p = 0.627$, at time 4, $F(1, 63) = 0.16$, $p = 0.690$, or at time 5, $F(1, 63) = 0.10$, $p = 0.755$. There were no other significant interactions (all $p > 0.3$).

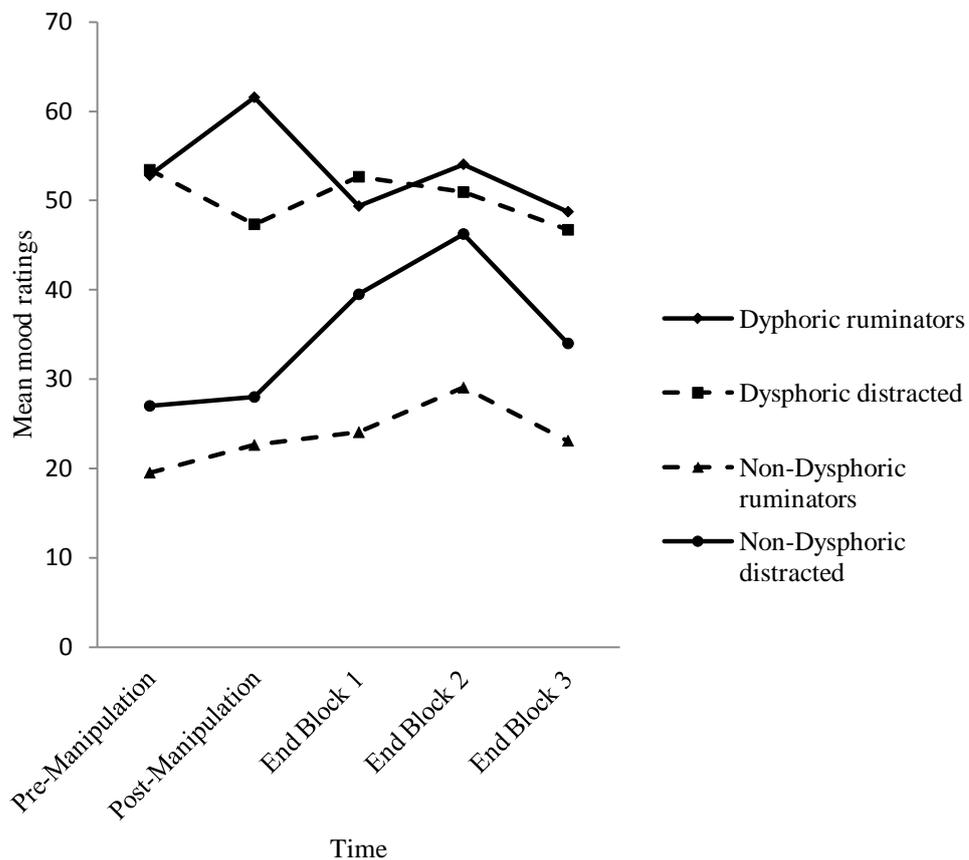


Figure 4.2: Mean mood ratings as a function of mood group, rumination manipulation, and time

A 2 (mood group: dysphoric, non-dysphoric) x 2 (rumination manipulation: rumination, distraction) x 3 (time: post block 1, post block 2, post block 3) ANOVA on self-focus ratings revealed a trend towards an effect of time, $F(1.813, 119.680) = 2.99$, $p = 0.059$, reflecting a decline in self-focus once the task began. There were no other significant main effects or interactions (all $p > 0.27$). In sum, the effects of the rumination manipulation upon self-focus were no longer evident once participants were completing the modified Sternberg task (Figure 4.3).

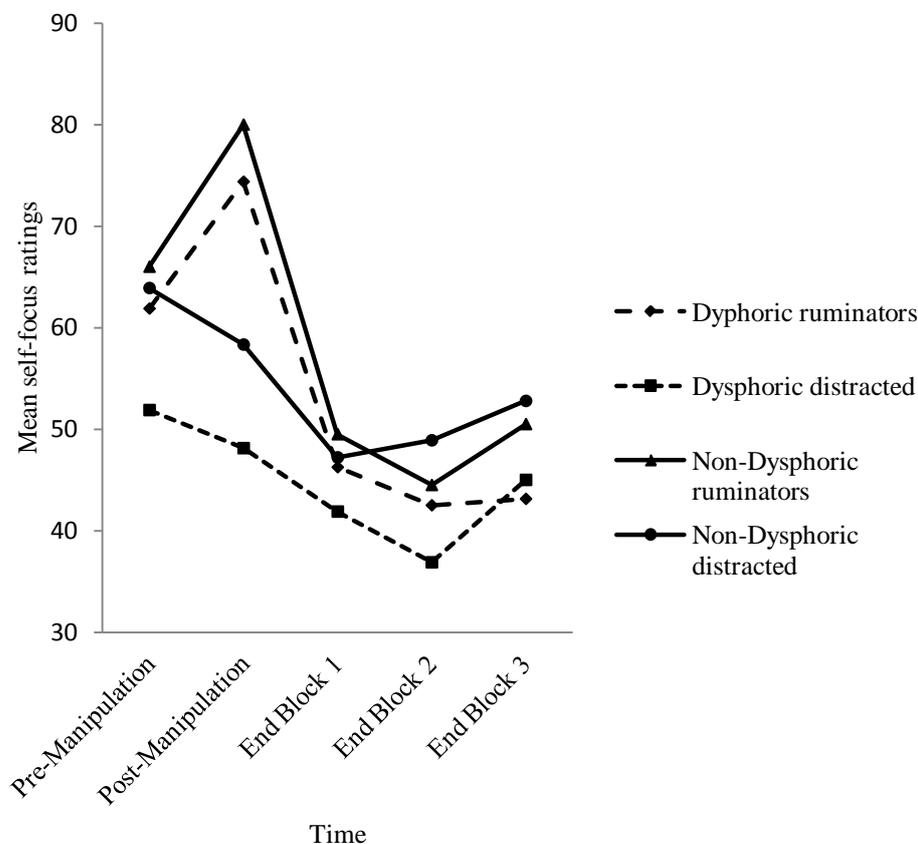


Figure 4.3: Mean self-focus ratings as a function of mood group, rumination manipulation, and time

4.3.4 Effects of rumination versus distraction on correct responses

Consistent with Joormann and Gotlib (2008), overall error rates were low (non-dysphoric group: 7.14%; dysphoric group: 7.29%). A 2 (mood group) x 2 (rumination

manipulation) x 2 (probe valence: positive, negative) x 2 (probe relevance: intrusion, new) ANOVA was conducted to compare accuracy of responses to intrusion probes (i.e., probes from the irrelevant list; task conditions 3 and 4) with responses to new probes of the same valence (task conditions 6 and 8). Consistent with Joormann and Gotlib (2008), there was a significant main effect of probe relevance, $F(1, 69) = 57.08$, $p < 0.001$, reflecting greater accuracy when responding to new probes ($M = 99.15\%$), than to intrusion probes ($M = 90.52\%$). There were no other significant main effects or interactions. Consequently, accuracy in responding to each of the probe types did not reliably vary according to either dysphoria status or rumination manipulation¹.

4.3.5 *Decision latencies to relevant probes*

For all conditions, analyses of decision latencies were restricted to trials on which participants made correct responses². A square root transformation was applied due to a non-normal distribution³.

¹ These analyses were repeated using different criteria for eliminating potential outliers, specifically by excluding data from participants exceeding 3 standard deviations from the mean and by correcting those to 3 standard deviations from the mean, and the results were not qualitatively different; consequently the uncorrected data is reported.

² Analyses were repeated using a number of different criteria for eliminating outliers both at the individual level for each trial type, and at the group level, specifically by limiting analyses to decision latencies that did not exceed 3s, by excluding data from individual participants whose responses exceeded 3 standard deviations from the mean, by correcting extreme responses to 3 standard deviations from the mean, and by a combination of these approaches. These methods did not qualitatively change the outcome of the critical analyses; consequently analyses of data for all correct responses are reported both in the manuscript and the tables and figures.

³ Histograms and tests for skewness indicated that the transformation brought the data closer to a normal distribution.

Joormann and Gotlib (2008) found no group differences in decision latencies to relevant probes. It was predicted that this observation would be replicated in this sample. As expected, a 2 (mood group) x 2 (rumination manipulation) x 2 (probe valence) mixed ANOVA identified no significant main effects or interactions (all p s > 0.6), indicating that participants' responses to relevant probes did not significantly differ according to probe valence, $F(1, 69) = 0.17, p = 0.682$.

4.3.6 Effects of the rumination and distraction inductions on decision latencies to irrelevant probes

The central hypotheses pertain to decision latencies for intrusion probes. Previous research (Joormann & Gotlib, 2008) has found that depressed individuals were slower than non-depressed participants to respond to negative intrusion probes and that rumination was correlated with slower responses to negative intrusions in depressed individuals. Consistent with this, it was predicted that dysphoric participants who had undergone the rumination induction would take longer to decide whether negative intrusion probes came from the relevant list than either the non-dysphoric participants, or the dysphoric participants who had received the distraction induction. The literature regarding whether the association between rumination and cognitive interference is specific to negative material is mixed, consequently no specific predictions were made regarding positive intrusion probes.

A 2 (mood group) x 2 (rumination manipulation) x 2 (probe valence: positive, negative) x 2 (probe relevance: intrusion, new) mixed ANOVA was conducted to examine the prediction that state rumination impairs resistance to proactive interference from negative material in dysphoric individuals. The four-way interaction of mood group, rumination manipulation, probe valence, and probe relevance was not significant,

$F(1, 69) = 0.22, p = 0.639$, neither was the three-way interaction of mood group, rumination manipulation, and probe relevance, $F(1, 69) = 0.01, p = 0.922$.

Consequently, these analyses found no evidence to suggest that rumination impaired resistance to proactive interference amongst dysphoric individuals. Mean decision latencies averaged across the task are presented in Table 4.3.

There was a significant main effect of probe relevance ($F(1, 69) = 197.76, p < 0.001$), reflecting faster decision latencies for new probes ($M = 934.79$) than for intrusions ($M = 1465.70$). There was a trend towards a three-way interaction of mood group, probe valence and probe relevance, $F(1, 69) = 3.88, p < 0.053$. Due to the within subjects design, separate follow-up analyses for each within subjects factor were conducted to unpack this. The analyses revealed that the trend reflected two non-significant differences in decision latencies amongst the dysphoric group. Dysphoric participants were slightly slower to respond to positive ($M = 1547.90$) than to negative ($M = 1452.62$) intrusions, and slightly faster to respond to positive ($M = 916.12$) than to negative ($M = 964.37$) new words, whereas non-dysphoric participants decision latencies for each probe type were closely matched for both valences. ANOVAs examining probe relevance and probe valence by mood group revealed no significant interactions (all $p_s > 0.1$).

Following Joormann and Gotlib (2008), separate follow-up tests were conducted for positive and negative probes. For positive probes, as expected, there was a main effect of probe relevance, $F(1, 69) = 181.85, p < 0.001$. No other main effects or interactions were significant.

Table 4.3: *Decision latencies (in ms) to positive and negative intrusion probes (means with standard deviations in parentheses)*

Probe type	Non-dysphoric		Dysphoric	
	Distraction	Rumination	Distraction	Rumination
Positive intrusions	1389.66 (496.61)	1453.62 (442.18)	1584.18 (809.12)	1511.61 (853.54)
Negative intrusions	1387.81 (656.67)	1493.42 (589.99)	1454.10 (646.24)	1451.13 (798.69)
New positive	899.22 (282.14)	983.22 (337.83)	955.04 (369.71)	877.21 (368.14)
New negative	889.85 (229.17)	945.00 (271.60)	972.09 (345.67)	956.65 (554.01)

For negative probes, a three-way interaction between mood group, rumination manipulation, and probe relevance was predicted. Specifically, it was expected that dysphoric ruminators would be reliably slower to decide whether a negative intrusion probe was relevant, than either non-dysphoric participants, or dysphoric participants who received the distraction induction. There was a significant main effect of probe relevance for negative probes, $F(1, 69) = 137.33, p < 0.001$; however, contrary to predictions no other main effects or interactions were significant (all $p > 0.6$).

In sum, contrary to predictions, the dysphoric participants who received the rumination induction did not take longer to decide whether a negative intrusion probe was relevant, than either the dysphoric participants who received the distraction induction, or the non-dysphoric participants. Consistent with this, dysphoric participants

in the rumination condition did not have higher intrusion effects for negative material than either dysphoric participants in the distraction condition, or non-dysphoric participants.

4.3.7 *Decision latencies to irrelevant probes in each block of the task*

In order to address the observation that the effects of the rumination induction had not lasted beyond the first block of the task, decision latencies to intrusion probes were examined for correct responses in each block separately. This was to investigate the possibility that the predicted elevated decision latencies for negative intrusion probes amongst dysphoric participants in the rumination condition (relative to participants in each of the other combinations of group and condition) might be observable in the early part of the task (block 1), but not be present in the later blocks as participants' moods improved.

A 2 (probe valence) x 2 (probe relevance) x 2 (group) x 2 (rumination manipulation) mixed ANOVA for only responses in block 1 yielded a significant main effect for probe relevance, $F(1, 69) = 225.40, p < 0.001$. No other main effects or interactions were significant (all $ps > 0.2$). In sum, the predicted effects were not evident during the portion of the task for which participants would be most likely to still be ruminating following the induction. In block 2, the same pattern of results was observed, with only a significant main effect of probe relevance, $F(1, 69) = 119.48, p < 0.001$. In block 3 there was a significant main effect of probe relevance, $F(1, 69) = 148.49, p < 0.001$, and also of probe valence, $F(1, 69) = 6.04, p = 0.016$, reflecting longer decision latencies for positive ($M = 34.30$) than negative ($M = 33.36$) probes.

4.4 Discussion

The present study sought to experimentally examine the prediction that state rumination impairs the ability to resolve interference from material that is no longer relevant. The study tested one proposed causal account of data correlating trait rumination with resistance to proactive interference from negative words on the modified Sternberg paradigm in depressed individuals (Joormann & Gotlib, 2008). Specifically, this study tested the hypothesis that state rumination plays a causal role in this relationship. It was predicted that dysphoric participants who received a rumination induction prior to completing the modified Sternberg task would demonstrate greater difficulties in resisting proactive interference from irrelevant negative words, than either dysphoric participants who had completed a distraction induction, or non-dysphoric participants (irrespective of which induction they had received). No specific predictions were made regarding whether state rumination would specifically impair the ability to resolve interference for negative intrusions, or whether interference control deficits would also be evident for positive intrusions.

Dysphoric participants who received the rumination induction did not take longer to decide whether a negative intrusion probe was relevant than either the dysphoric participants who received the distraction induction, or the non-dysphoric participants. This was also the case for positive intrusions. Consequently, the findings do not support the hypothesis advanced by Watkins and Brown (2002) that rumination occupies cognitive resources, and thus causally impairs concurrent executive control processes.

The predicted effects of the rumination and distraction inductions on mood and self-focus were evident pre- to post- manipulation. Additionally, the predicted main

effect of probe relevance on decision latencies on the modified Sternberg paradigm was obtained, indicating that the normal pattern of findings from basic science studies of proactive interference were observed. However, the induced changes in mood and self-focus following the rumination manipulation were no longer evident when participants were completing the modified Sternberg task. This is consistent with the argument that attentionally constraining cognitive tasks are an effective form of distraction from self-focus (e.g., Davis & Nolen-Hoeksema, 2000; Hertel, 2004).

There are a number of potential interpretations of the null finding regarding the consequences of manipulating rumination on decision latencies for the negative intrusion probes. One possibility is that rumination does not reduce the ability to resist proactive interference from negative material. However, the most straightforward interpretation of these results given the null findings for the mood and self-focus data during the modified Sternberg task is that the induced ruminative effects did not influence task performance because the modified Sternberg task distracted participants from ruminating, such that they were no longer ruminating when resistance to proactive interference was measured. According to this interpretation, participants were no longer ruminating when they completed the task designed to assess interference control (the modified Sternberg task) and as consequence the study was not successful in examining the causal effects of dysphoric rumination on resistance to proactive interference.

Moreover, there are a number of significant limitations to the present study that are relevant when considering the reliability of such an interpretation. One potential limitation to the study is that the two mood groups may not have been experiencing sufficiently distinct low and high levels of dysphoric mood respectively. The non-dysphoric group had a relatively high mean BDI-II score (4.22), when compared to the very low BDI scores of Joormann and Gotlib's (2008) control group ($M = 1.19$), and a

t-test confirmed that this difference was significant, $t(60) = 4.33$, $p < 0.001$. The difference in BDI scores between Joormann and Gotlib's depressed sample ($M = 27.48$) and Study One's dysphoric sample ($M = 23.81$) was also significant, $t(56) = 9.29$, $p < 0.001$. It is thus possible that the differences in mood between the two groups in the present study were less marked than differences between Joormann and Gotlib's (2008) depressed and control groups, and that this might contribute to the absence of reliable group differences on the modified Sternberg task in the present study and the non-significance of the predicted interactions.

However, it is unlikely that this is sufficient to account for the failure to detect the predicted relationship between dysphoric rumination and interference control difficulties. Firstly, because the BDI-II scores of the high dysphoric group, although lower than those of Joormann and Gotlib's (2008) depressed group, were sufficiently high that the rumination induction had the predicted effects upon mood, and this induction does not generally worsen mood in non-dysphoric samples (e.g., Watkins & Teasdale, 2001). Secondly, because other studies examining the relationship between rumination and cognitive control which have used both dysphoric (e.g., Philippot & Brutoux, 2008) and depressed (e.g., Watkins & Brown, 2002) samples have reported BDI data for their mood groups that is comparable to that obtained in the present study and have found evidence consistent with a causal relationship between depressive rumination and performance on a modified Stroop task (Philippot & Brutoux, 2008) and a random number generation task (Watkins & Brown, 2002).

A critical limitation to Study One is that the effects of the rumination and distraction inductions did not remain evident once participants had begun the cognitive task. Davis and Nolen-Hoeksema (2000) argue that cognitive tasks can be regarded to operate as an effective distraction induction. Consistent with this proposal, it was found

that by completion of the first block of the modified Sternberg task, the expected effects of the rumination induction had been reversed, and indeed participants reported a reliable decrease in both despondency and self-focus. Consequently, it cannot be reliably inferred that participants were engaged in ruminative thought whilst completing the task; and thus it is not clear that the study reliably examined resistance to proactive interference during state depressive rumination.

A further limitation is the relatively small cell sizes, and the large standard deviations for the reaction time data relative to Joormann and Gotlib's data (2008). Both of these factors may have limited the likelihood of detecting an effect of rumination on performance on the modified Sternberg task. Moreover, the mean decision latencies were slower than those reported by Joormann and Gotlib (2008), indicating that the samples may have differed in unmeasured characteristics (e.g., IQ, volition) that are of potential relevance to task performance.

In sum, contrary to predictions, the findings of Study One are not consistent with existing evidence of a relationship between depressive rumination and resistance to proactive interference (e.g., Joormann & Gotlib, 2008). However, due to limitations of the study, and specifically the short duration of the effects of the rumination and distraction inductions, it is not clear that the hypothesis that state rumination reduces the ability to resist proactive interference was reliably tested. Accordingly, Study Two was designed to address these limitations.

CHAPTER FIVE: *Study Two*5.1 *Introduction*

Study One sought to examine the causal nature of the previously reported relationship between rumination and interference control as indexed by the modified Sternberg task (Oberauer, 2001). The impact of induced rumination and distraction upon task performance was examined in dysphoric and non-dysphoric individuals. Contrary to predictions, there was no effect of induced rumination or distraction upon interference control, either for dysphoric or non dysphoric participants.

The findings of Study One are not consistent with existing evidence of a relationship between depressive rumination and resistance to proactive interference as indexed by the modified Sternberg task (e.g., Joormann & Gotlib, 2008). However, an important limitation of the study design in Chapter Four was that the rumination and distraction inductions had very short-lived effects. Specifically, the changes to mood and self-focus that are commonly reported following the use of these inductions were no longer evident by the end of the first block of the modified Sternberg task. This is consistent with the proposal that demanding cognitive tasks can interfere with rumination (e.g., Davis & Nolen-Hoeksema, 2000; Hertel, 2004). However, this prevented a reliable examination of the impact of state rumination upon interference control processes. Accordingly, Study Two was designed to address these limitations.

In Study One, both the rumination manipulations and the modified Sternberg task operated as predicted. However the effects of the rumination manipulation were no longer evident when participants were completing the modified Sternberg task. Study Two thus adopted the same task and manipulations as those described in Chapter One,

but with modifications to the procedure designed to maintain the effects of the manipulations whilst participants complete the modified Sternberg task. First, in order to reduce both the time between the rumination induction and the experimental blocks of the modified Sternberg task and the extent to which learning a new task may have interfered with the impact of the rumination induction, participants practiced the modified Sternberg task prior to completing the rumination induction.

Second, prompts taken from the rumination and distraction inductions were presented periodically during the modified Sternberg task in order to encourage participants to continue thinking in the way that they had practised in the original induction phase. Thirdly, in order to address a further potential limitation of Study One (that the two mood groups may not have been experiencing sufficiently high and low levels of dysphoria respectively), the BDI-II minimum score for the high dysphoric group was increased, and the maximum score for the low dysphoric group was decreased. As in Study One, participants rated their mood and self-focus at the end of each of the three blocks of the modified Sternberg task in order to permit a direct examination of the extent to which the previously documented (e.g., Watkins & Teasdale, 2001) mood-related effects of the manipulations persisted during the modified Sternberg task.

5.1.1 *Hypotheses*

Consistent with the hypotheses reported in Chapter Four, it was hypothesised that ruminative thought and the cognitive processes involved in resistance to proactive interference make demands on a common limited resource. It was therefore predicted that induced rumination would cause dysphoric individuals to exhibit difficulties resisting proactive interference from no longer relevant negative words on the modified

Sternberg task. Specifically, it was predicted that dysphoric individuals who were induced to ruminate would exhibit longer decision latencies to negative intrusions than non-dysphoric participants and dysphoric participants who were distracted from ruminating. An interaction of mood group (dysphoric vs. non-dysphoric), rumination manipulation (rumination vs. distraction) and probe relevance (intrusion probes vs. new probes of the same valence) was therefore predicted for negative probes. No specific predictions were made regarding positive intrusions.

Consistent with the predictions of Study One and the findings of previous studies using rumination and distraction inductions (e.g., Lyubomirsky & Nolen-Hoeksema, 1993; 1995), it was predicted that for dysphoric participants, the rumination induction would result in negative affect and self-focus relative to the distraction induction. As in Study One, these differential effects of the inductions on mood were not predicted in the non-dysphoric participants, since in the absence of low mood focus resolving symptoms is not an on-going concern, and there is not depressed mood to be exacerbated by self-focus. As in Study One, the rumination induction was predicted to increase self-focus relative to distraction in both dysphoric and non-dysphoric individuals.

It was further predicted that the effects of the inductions on reported levels of dysphoria would remain evident during the modified Sternberg task. Specifically, it was predicted that at the end of each block of the task, dysphoric participants who received the rumination induction would continue to report greater levels of dysphoria than dysphoric participants who received the distraction induction.

5.2 *Method*

5.2.1 *Participants*

Participants were recruited from the student population of the psychology department at Exeter University, from the departmental databases of individuals who wished to take part in research in the department's Mood Disorders Centre and at the University, via emails to undergraduate and postgraduate students in the College of Life and Environmental Sciences, and through advertisements on the University's college noticeboards and in coffee shops and libraries. Participants received either course credits or £5 for their time. Participants' responses to an electronic screening questionnaire provided the requisite selection information. In order to increase group differences in depressive symptoms, the inclusion and exclusion criteria were more conservative than those used in Study One. Specifically, individuals who returned a BDI-II scoring between 6 and 15 at screening were excluded; those scoring <6 were assigned to the non-dysphoric group, and those scoring > 15 were assigned to the dysphoric group. Participants were also excluded if they reported severe head trauma or learning difficulties, current or lifetime bipolar disorder or psychotic symptoms. Finally, it was established that all participants had normal or corrected-to normal vision. All individuals who met criteria at screening completed the full test session and were debriefed.

5.2.2 Materials

The materials were identical to those in Study One, with the following exceptions:

Visual Analogue Scales: In response to some participants in Study One reporting confusion regarding the meaning of the term “despondent”, the “despondent” scale was replaced with “sad” and “depressed” scales.

Modified Sternberg task: Every ten trials, in the inter-trial interval, an item selected from the manipulation (rumination or distraction) to which the participant was randomly allocated (items from the rumination induction were selected on the basis of their relevance to rumination and their simplicity to think about; items appearing in the same position in the fixed order from the rumination and distraction induction were selected) was presented on the screen for 10s. The order of these items was fixed for all participants; a total of 12 items was presented over the three blocks. Participants were informed during the instructions that these prompts would be presented, and were instructed to use their imagination to concentrate on these items in the way that they did during the earlier manipulation.

5.2.3 Design

As with Study One, the study had a 2 (mood group: dysphoric; non-dysphoric) x 2 (rumination manipulation: rumination; distraction) between subjects design. The modified Sternberg task included two critical within-subjects variables, each with two levels: the valence of probe word (positive or negative) was varied, as was the type of non-relevant probe (intrusion probes: words from the irrelevant list; and new words that did not appear on either of the lists to be encoded). Thus, the critical predictions were

examined using a 2 (mood group) x 2 (rumination manipulation) x 2 (probe valence) x 2 (probe relevance) mixed design.

5.2.4 Procedure

The procedure was identical to Study One, with the following exceptions. After completing the questionnaires and baseline self-report measures of current mood and self-focus, participants were given instructions on how to complete the modified Sternberg task and asked to complete one block of the task. This practice was designed to familiarise participants with the task. Once the practice phase of the modified Sternberg task had been completed, participants were randomly allocated to work through either the rumination or the distraction induction.

In addition, participants were instructed that the modified Sternberg task was an indirect measure of their ability to maintain the thinking style that they had practised during the induction. This was intended to encourage participants to maintain their focus on the thought content and style elicited by the inductions. Participants were instructed to complete the modified Sternberg task as quickly and accurately as possible whilst trying their best to maintain the style of thinking that they had been practising. Every ten trials, in the inter-trial interval, an item selected from the rumination or distraction manipulation was presented on the screen. Participants were informed that this was to assist them in maintaining the thinking style that they had been practising, and were instructed to try their best to focus on the ideas that these prompts raised in the way that they had been practising during the induction. Due to the addition of the ruminative/distraction prompts to the experimental blocks of the modified Sternberg task, the procedure was slightly longer than in Study One, taking 70 minutes overall. Between each experimental block, participants were asked to rate their current mood

and self-focus in order to monitor the degree to which the effects of the inductions were maintained during the task.

Completion of the modified Sternberg task took approximately 45 minutes. Following this, participants completed a final rating of their current mood and self-focus.

As with Study One, a funnelled debriefing was used such that participants were asked to guess the purpose of the study and whether they believed that any of the tasks were related in any way, and if so in what way. During the debriefing, no participant reported any suspicions that there were two versions of the rumination manipulations and no one reported a hypothesis regarding the way in which mood and word valence was related. Following this, participants were fully debriefed and the rumination manipulation was explained.

5.3 Results

5.3.1 Participant characteristics

67 participants (55 females and 12 males) contributed to the full dataset⁴. The mean age of the sample was 21.27 years ($SD = 7.35$; range 18-59 years). 41 individuals met criteria for the non-dysphoric group; 26 met criteria for the dysphoric group. Of those individuals who met the criteria for the two mood groups, 34 received the distraction induction and 33 received the rumination induction.

⁴ Eight participants were excluded due to having exhibited a general difficulty with completing the modified Sternberg task, as indicated by extremely high error rates and decision latencies. Four were non-dysphoric participants in the distraction condition, two were dysphoric participants in the distraction condition, and two were dysphoric participants in the rumination condition. Consequently, these difficulties with the task do not appear to be related to dysphoria or rumination condition.

The demographic characteristics of the dysphoric and non-dysphoric groups are presented in Table 5.1. The groups significantly differed in age, $t(27.03) = 2.48$, $p = 0.020$, (Welsch's test applied to correct for inequality of variances); the dysphoric group was older than the non-dysphoric group.⁵ As expected, the dysphoric group reported a greater tendency to ruminate in response to sad mood on the RRS than the non-dysphoric group, $t(65) = 10.62$, $p < 0.001$.

Table 5.1: *Characteristics of participants (means with standard deviations in parentheses)*

Variables	Non-dysphoric		Dysphoric	
	Distraction	Rumination	Distraction	Rumination
<i>N</i> (<i>N</i> female)	22 (18)	19 (17)	12 (10)	14 (10)
Age	19.04 (1.00)	19.42 (3.82)	21.00 (3.07)	27.50 (13.76)
BDI-II	1.77 (1.48)	1.32 (1.60)	24.17 (5.69)	28.57 (7.17)
RRS	39.68 (9.82)	33.00 (6.06)	59.67 (10.81)	60.86 (7.47)

5.3.2 *Effects of rumination and distraction inductions on self-reported affect*

In order to examine whether the rumination induction had the expected effect of increasing negative affect in dysphoric participants relative to distraction, 2 (mood group: dysphoric vs. non-dysphoric) x 2 (rumination manipulation: rumination vs. distraction) x 2 (time: baseline; post-induction) mixed ANOVAs were conducted on participants' ratings of their current mood. Happiness ratings were reversed scored to

⁵ Inclusion of age as a covariate in the analyses did not qualitatively change the results, consequently the analyses reported do not include age as a covariate.

compute a single variable representing participant's ratings of their mood across the three mood items (levels of sadness, depression, and happiness). The predicted three-way interaction was significant, $F(1, 61) = 7.55, p = 0.008$. Simple effects analyses confirmed that there was a significant interaction of time and rumination manipulation in the dysphoric group, $F(1, 62) = 13.25, p < 0.001$, and not in the non-dysphoric group, $F(1, 70) = 0.05, p = 0.828$. In the dysphoric group, the rumination induction worsened mood relative to distraction, whereas there was no evidence of differential affective consequences of the manipulations for non-dysphoric individuals (see Figure 5.1).

A 2 (mood group) x 2 (rumination manipulation) x 2 (time) mixed ANOVA on self-focus scores identified a significant main effect of time, $F(1, 61) = 34.98, p < 0.001$, and a trend towards an effect of rumination manipulation, $F(1, 61) = 2.90, p = 0.094$. This was qualified by a significant rumination manipulation x time interaction, $F(1, 61) = 55.64, p < 0.001$, reflecting an increase in self-focus across the groups following the rumination induction, but not the distraction induction. There was a trend towards an interaction of mood group and time, $F(1, 61) = 3.21, p = 0.078$, reflecting a greater increase in self-focus in the dysphoric group than in the non dysphoric group (Figure 5.2). However, the three-way interaction of mood group, rumination manipulation and time was not significant ($p = 0.246$). There were no other significant main effects or interactions (all $ps > 0.18$).

As predicted, the rumination and distraction inductions differentially influenced dysphoric participants' mood; the rumination induction resulted in worsened mood relative to the distraction induction. The mood effects were not observed for non-dysphoric participants. As predicted, the rumination induction increased levels of self-focus relative to the distraction induction.

A 2 (mood group) x 2 (rumination manipulation) x 3 (time: post block 1, post block 2, post block 3) mixed ANOVA was conducted to examine the extent to which the affective consequences of the rumination and distraction inductions persisted through the modified Sternberg task. There was a significant main effect of mood group, $F(1, 62) = 179.89, p < 0.001$, and of rumination manipulation, $F(1, 62) = 10.49, p = 0.002$, and of time, $F(2, 124) = 7.00, p = 0.001$. The interaction of mood group and rumination manipulation was significant, $F(1, 62) = 16.58, p < 0.001$. Simple effects analyses revealed that there was a significant effect of rumination condition on self-reported mood among the dysphoric group at time 3 (the end of block 1), $F(1, 63) = 7.78, p = 0.007$, time 4 (end of block 2), $F(1, 63) = 9.60, p = 0.003$, and time 5 (end of block 3), $F(1, 63) = 7.45, p = 0.008$. The elevated negative mood in dysphoric individuals in the rumination condition, relative to the distraction condition remained evident at the end of each block of the modified Sternberg task. There was not an effect of rumination condition on self-reported mood in the non-dysphoric group at time 3, $F(1, 63) = 0.01, p = 0.930$, at time 4, $F(1, 63) = 0.01, p = 0.925$, or at time 5, $F(1, 63) = 0.01, p = 0.912$. There were not differential affective consequences of the manipulations in the non-dysphoric group either post-induction, or during the modified Sternberg task. There were no other significant interactions (all $p > 0.3$). Thus, as predicted, the effect of the rumination manipulation upon dysphoric participants' mood persisted throughout the modified Sternberg task (see Figure 5.1).

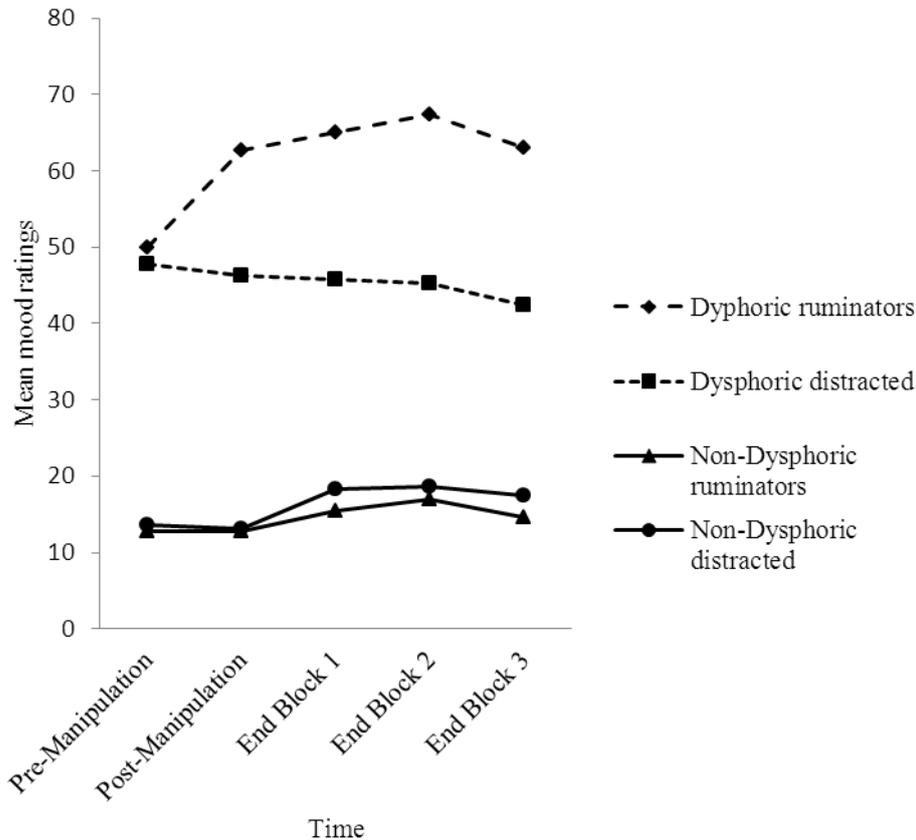


Figure 5.1: Mean mood ratings as a function of mood group, rumination manipulation, and time

A 2 (mood group) x 2 (rumination manipulation) x 3 (time) was conducted to examine the effects of the rumination manipulation on self-focus during the modified Sternberg task. There was a significant main effect of rumination manipulation, $F(1, 62) = 9.012, p = 0.004$, reflecting greater self-focus in the rumination condition ($M = 69.33$) than in the distraction condition ($M = 52.94$). There were no other significant main effects or interactions (all p s > 0.16). The differential effects of rumination and distraction on self-focus thus remained evident during the modified Sternberg task (see Figure 5.2).

The study thus successfully addressed a central methodological limitation of Study One.

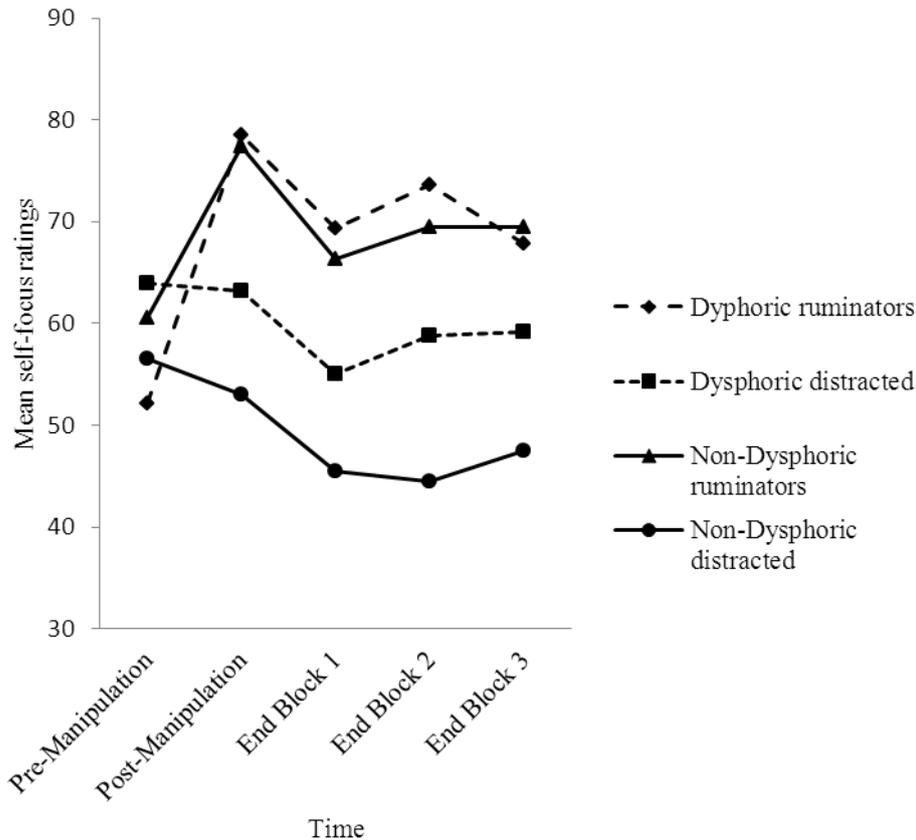


Figure 5.2: Mean self-focus ratings as a function of mood group, rumination manipulation, and time

5.3.3 Effects of rumination versus distraction on correct responses

Consistent with Joormann and Gotlib (2008), overall error rates were low (non-dysphoric group: rumination condition 9.34%, distraction condition 8.18%; dysphoric group: rumination condition 10.18%, distraction condition 9.10%). A 2 (mood group) x 2 (rumination manipulation) x 2 (probe relevance: intrusion, new) x 2 (probe valence: positive, negative) ANOVA was conducted to compare accuracy of responses to intrusion probes (i.e., probes from the irrelevant list; task conditions 3 and 4) with responses to new probes of the same valence (task conditions 6 and 8). There were no main effects or interactions involving the rumination manipulation, thus induced rumination did not differentially impact on error rates. There was a significant main

effect of probe relevance, $F(1, 63) = 55.07$, $p < 0.001$, reflecting greater accuracy when responding to new probes ($M = 99.64\%$), than to intrusion probes ($M = 95.87\%$). There was a significant main effect of valence, $F(1, 63) = 4.50$, $p = 0.038$, reflecting greater accuracy when responding to positive probes ($M = 98.08\%$) than to negative probes ($M = 97.42\%$). There were no other significant main effects or interactions (all $ps > 0.117$).

Thus, there was no evidence to suggest that induced rumination impaired dysphoric individuals' abilities to resolve interference as indexed by error rates.

5.3.4 *Decision latencies to relevant probes*

A square root transformation was applied to reaction time data due to a non-normal distribution⁶. For all conditions, analyses of decision latencies were restricted to trials on which participants made correct responses. Joormann and Gotlib (2008) found no group differences in decision latencies to relevant probes. It was predicted that this observation would be replicated in this sample. As expected, a 2 (mood group) x 2 (rumination manipulation) x 2 (probe valence) mixed ANOVA identified no significant main effects or interactions (all $ps > 0.198$), indicating that participants responses to relevant probes did not significantly differ according to probe valence, $F(1, 63) = 1.69$, $p = 0.198$.

5.3.5 *Effects of the rumination and distraction inductions on decision latencies to irrelevant probes*

A 2 (mood group) x 2 (rumination manipulation) x 2 (probe relevance) x 2 (probe valence) mixed ANOVA was conducted to test the prediction that induced

⁶ Histograms and tests for skewness indicated that the transformation brought the data closer to a normal distribution.

rumination differentially increased dysphoric participants' difficulties resolving interference relative to distraction. Contrary to predictions, the four-way interaction was not significant, $F(1, 63) = 0.55$, $p = 0.462$, and neither was the three-way interaction of mood group, rumination manipulation, and probe relevance, $F(1, 63) = 2.18$, $p = 0.145$. Dysphoric ruminators were not reliably slower to decide whether intrusions of either valence were relevant than the dysphoric participants who had received the distraction induction. Mean decision latencies averaged across the task are presented in Table 5.2.

There was a significant main effect of probe relevance, $F(1, 63) = 248.21$, $p < 0.001$; consistent with previous studies using the modified Sternberg task participants were slower to reject intrusion probes than new probes. There was a trend towards an interaction of mood group and probe relevance, $F(1, 63) = 3.64$, $p = 0.061$. However, simple effects analyses revealed significant effects of probe relevance in both the non-dysphoric ($p < 0.001$) and the dysphoric ($p < 0.001$) groups. There was not a significant effect of mood group on decision latencies to new probes, $F(1, 63) = 0.03$, $p = 0.860$, or to intrusion probes, $F(1, 63) = 1.21$, $p = 0.276$. Moreover, it is not possible to meaningfully interpret any potential effects of dysphoria averaged across the two manipulations which in themselves differentially influenced negative mood. There were no other significant main effects or interactions (all $ps > 0.145$).

Table 5.2: *Decision latencies (in ms) to positive and negative intrusion probes (means with standard deviations in parentheses)*

	Dysphoric		Non-Dysphoric	
	Rumination	Distraction	Rumination	Distraction
Positive	1508.76	1505.36	1308.32	1397.63
intrusions	(572.11)	(455.19)	(383.67)	(541.84)
Negative	1501.49	1547.85	1407.63	1382.01
intrusions	(646.12)	(523.58)	(471.23)	(503.13)
New positive	1049.23	980.37	952.10	1049.04
	(448.27)	(423.02)	(291.76)	(340.03)
New negative	1030.74	996.28	945.49	1026.31
	(505.59)	(372.68)	(284.21)	(386.27)

5.4 Discussion

Study Two sought to overcome the methodological limitations of Study One in order to test the prediction that on-going rumination depletes interference control resources, thereby resulting in impaired interference resolution on the modified Sternberg task. The modified Sternberg task was selected because it is a relatively clear measure of interference control, and a previous study has demonstrated that depressed individuals exhibit difficulties resolving interference from negative material on the task, and that trait rumination is correlated with these difficulties (Joormann & Gotlib, 2008).

Study Two successfully overcame the methodological difficulties encountered in Study One; specifically, modifications to the procedure resulted in the differential

effects on mood of the rumination induction relative to the distraction manipulation across all three blocks of the modified Sternberg task. This allowed examination of the central hypothesis regarding state rumination and interference control. Contrary to predictions there was no evidence that induced rumination impaired dysphoric individuals' ability to resolve interference from positive or negative words. The findings therefore do not support the proposal that on-going rumination acts as a cognitive load, thereby impairing interference control.

As with Study One, a limitation to interpreting the findings of Study Two is the relatively small cell sizes and large standard deviations, both of which reduce the power to detect any effects of rumination on performance on the modified Sternberg task. It is therefore important that the findings of these studies are interpreted with caution.

The fact that the two mood groups differed in age is a potential confound. However, there were no significant effects of mood group upon task performance, and the results of the analyses were not qualitatively changed by inclusion of age as a covariate in the analyses. Thus, whilst an important limitation, it is unlikely that group differences in age are driving any of the findings. The group differences in age are likely to have occurred as a consequence of the recruitment strategies adopted for the two mood groups. Dysphoric individuals were recruited both from the University student population and from the general population in Devon in order to recruit a sufficiently dysphoric sample within a feasible time scale, thereby overcoming a potential limitation of Study One. Non-dysphoric individuals were recruited in the same manner as in Study One (i.e., from the University student population). More closely matched recruitment strategies were employed in Studies Three – Six in order to address this.

An important limitation of the methodology adopted in Chapters Four and Five is that they do not include a direct measure of state rumination; rumination is inferred from increased negative affect and self-focus, following differential rumination inductions, consistent with prior work in the field (Nolen-Hoeksema, 1991). However, this approach does not allow for the distinction between state mood effects, and state rumination. Moreover, it leaves the extent of state rumination, as opposed to negative affect, in response to symptoms of depression, ambiguous. Given that it is widely documented that depressed mood interferes with effortful processing (e.g., Hartlage, Alloy, Vasquez, & Dykman, 1993) it is important that the effects of state rumination are adequately disentangled from the effects of depressed mood and/or depressive symptoms.

A direct measure of state rumination is necessary in order to directly assess the extent of rumination and thus rule out the possibility of naturally occurring rumination in non-ruminative control conditions, as well as confirming that manipulations increase state rumination. Therefore an important next step in clarifying the proposed causal role of rumination in interference control deficits and disentangling the effects of rumination from the effects of depressed mood and/or symptoms will be the development of a valid procedure for inducing and measuring state rumination that is not symptom focused or feelings focused. As a consequence, Study Three sought to develop such a measure through the application of control theories of rumination (e.g., Carver & Scheier, 1998) to individual's experiences of goal discrepancies.

CHAPTER SIX: *Study Three*6.1 *Preface*

The paper reported in the main section of this chapter was submitted for publication to the *Journal of Behavior Therapy and Experimental Psychiatry* and is currently under revision. An appendix then reports additional analyses conducted and provides an overall summary of the study. The primary aim of Study Three was to develop and validate a direct measure of state rumination that did not involve affective or depressive components in order to provide a clearer means of assessing the causal impact of state rumination (as opposed to affective outcomes) upon interference control processes. This constitutes an important development to existing experimental studies of rumination and interference control (e.g., Whitmer & Gotlib, 2012) as it provides the means to examine the impact of state rumination whilst controlling for negative mood. The study additionally developed a novel means of inducing rumination based on theoretical derived predictions regarding proximal causes of state rumination (Carver & Scheier, 1998).

A secondary aim was to conduct a preliminary examination of the causal impact of state rumination on prepotent response inhibition, as measured by the Sustained Attention to Response Task (SART; Robertson, Manly, Andrade, Baddeley, & Yiend, 1997). As discussed in Chapter Two, there are several studies demonstrating a relationship between trait rumination and resistance to proactive interference (e.g., Joormann & Gotlib, 2008; Joormann, Nee, Berman, Jonides, & Gotlib, 2010). Study Two found no evidence that induced depressive rumination impaired resistance to proactive interference. The evidence regarding trait rumination and prepotent response

inhibition is less clear (Lau, Christensen, Hawley, Gemar, & Segal, 2007; Vanderhasselt, Kuhn, & De Raedt, 2011): there is evidence consistent with trait rumination being associated with difficulties resolving interference from emotional material, but not with inhibiting prepotent responses to neutral stimuli. Study Three thus sought to examine whether state rumination impairs prepotent response inhibition. The paper in the main section of this chapter reports the results of these predictions.

In contrast to Studies One and Two, Study Three sought to examine the impact of state rumination in a non-clinical sample. A number of models of rumination and interference control processes posit that state rumination acts as a working memory load, and consistent with this, there is evidence that rumination inductions cause performance deficits on cognitive tasks in depressed and dysphoric participants (Hertel, 1998; Philippot & Brutoux, 2008; Watkins & Brown, 2002; Whitmer & Banich, 2012). However, there is no clear evidence to date regarding the impact of induced rumination upon concurrent cognitive performance in a non-clinical sample. Several of the theoretical models which predict that on-going rumination depletes concurrent cognitive control capabilities specifically model this relationship with respect to rumination on depressive content (e.g., Beevers, 2005; Ellis & Ashbrook, 1988). However, other theoretical accounts predict that rumination on personally important content and uncontrollable conditions depletes cognitive capacity (e.g., Hertel, 2004; Kofta & Sedak, 1998), and thus do not explicitly require the presence of depressive symptomatology. However, these models specify that depressed individuals are at increased susceptibility to the negative consequences of rumination as a result of depressive tendencies to pathological rumination. Thus, whilst rumination is not depression-specific, the content and process may differ from that observed in non-

clinical populations, and the trait tendency to ruminate may moderate the impact of state rumination upon cognitive control and self-regulation.

The study additionally sought to examine the role of working memory capacity (WMC) in state rumination and its impact on SART performance (Appendix A). Finally, intraindividual reaction time (RT) variability is argued to provide an estimate of attentional fluctuations and is related to self-reported task unrelated thought (e.g., McVay & Kane, 2009). Study Three thus examined whether intraindividual RT variability was related to state rumination during the SART (Appendix A).

Studies One and Two adopted rumination and distraction instructions adapted from those developed by Nolen-Hoeksema and Morrow (1993) and measured affective outcomes as a proxy to assess rumination in dysphoric and non-dysphoric individuals. A significant methodological limitation to this approach is that rumination is not directly assessed, and any inferred consequences of rumination on interference control processes cannot be reliably disentangled from potential affective and depression-related consequences for interference control. Moreover, existing rumination manipulations are reliant on instructed rumination about depressive symptoms and thus may differ in important ways from naturally occurring, uninstructed rumination about personal concerns. Study Three therefore sought to overcome these methodological limitations in order to permit a direct test of the prediction that state rumination impairs interference control. This was done through adopting a control theory operationalization of rumination (Carver & Scheier, 1998) and examining the prediction that negative personal goal discrepancies elicit rumination.

A direct measure of rumination was developed through the insertion of thought probes in to a task known to elicit mind-wandering, the SART (Robertson et al., 1997). The SART is a simple go/no-go task in which no-go trials are infrequent and thus

participants tend to adopt a repetitive mindless style of responding on the task. The go/no-go design of the task initially permits the opportunity to examine the prediction that state rumination impairs prepotent response inhibition, as indexed by errors of commission (incorrectly responding on a no-go trial) on the SART.

The study additionally examined two predictions regarding the role of WMC in state rumination and the relationship between state rumination and cognitive control (6.7 Appendix A). Firstly, if difficulties controlling the contents of working memory underpin rumination (e.g., Joormann & Gotlib, 2008) then individuals lower in WMC would be predicted to report greater intrusive ruminative thoughts about personal goal discrepancies during the SART. Secondly, if state rumination acts as a working memory load, thereby depleting performance on concurrent cognitive tasks, then individuals lower in working memory capacity would be predicted to be more susceptible to the deleterious effects of an episode of rumination as a consequence of having a lower baseline processing capacity. Study Three thus made a preliminary attempt to examine these predictions through the inclusion of a measure of working memory capacity.

Finally, the study examined whether intraindividual RT variability was related to state rumination during the SART and WMC (6.7 Appendix A). If intraindividual RT variability provides an estimate in attentional fluctuations and task irrelevant thought (e.g., Robertson et al., 1997; Stuss & Gow, 1992) then it would be predicted to be sensitive to the occurrence of state rumination. It was thus predicted that state rumination would be related to greater intraindividual RT variability. Previous studies report a relationship between WMC and intraindividual RT variability (e.g., McVay & Kane, 2009), and a relationship between intraindividual RT variability and errors of commission (e.g., Robertson et al., 1997), Study Three thus additionally examined these relationships.

Cueing an unresolved personal goal causes persistent ruminative self-focus: an experimental evaluation of control theories of rumination.

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6.7 *Appendix A: Rumination, working memory capacity, and SART performance*

6.7.1 *Introduction*

The Automated Operation Span Task (AOSPAN; Unsworth, Heitz, Schrock, & Engle, 2005) was used to examine the possibility that individual differences in working memory capacity (WMC) moderated the impact of the goal manipulation on SART performance. Two central predictions were made regarding WMC. First, it was predicted that individuals lower in WMC would have more difficulties in resisting interference from goal-relevant thoughts, resulting in greater rumination during the SART. This was based on the proposal that difficulties controlling the contents of working memory increase susceptibility to rumination (e.g., Joormann et al., 2007), and that individuals lower on WMC will have greater difficulties in managing the contents of working memory due to lowered processing capacity. Specifically, it was predicted that WMC would moderate the impact of the goal manipulation upon state rumination such that individuals low in WMC would be more susceptible to the impact of the goal manipulation than individuals high in WMC.

Second, it was predicted that individuals lower in WMC would be more susceptible to the deleterious consequences of state rumination for SART performance. Specifically, it was predicted that lower WMC would result in state rumination causing greater impairments to concurrent cognitive control, and thus that WMC would moderate the impact of the goal manipulation on errors of commission and reaction times (RTs) to correct go-trials on the SART.

In previous SART studies, intraindividual RT variability has increased over blocks and working memory capacity (WMC), as indexed by the Operation Span

(OSPAN; Turner & Engle, 1989), has been related to RT variability (McVay & Kane, 2009). RT variability is hypothesised to index attentional fluctuations and thus should be greater for individuals experiencing more task-irrelevant thoughts (McVay & Kane, 2009). As a consequence, it was predicted that individuals in the unresolved goal condition would exhibit greater reaction time variability, and that WMC would moderate the impact of the goal manipulation on RT variability.

There are two estimates of RT variability: means of individual subjects' standard deviations, and the coefficients of variation, calculated as participants' standard deviations divided by their mean reaction times. The coefficients of variation, as opposed to the means of standard deviations were examined because the size of a standard deviation is frequently related to the magnitude of reaction times.

6.7.2 Method

6.7.2.1 Additional measures

The Automated Operation Span Task (AOSPAN; Unsworth, Heitz, Schrock, & Engle, 2005)

The AOSPAN is a computerized version of Turner and Engle's OSPAN task (Turner & Engle, 1989), which indexes WMC. Participants are presented with a series of simple maths problems to solve; following each problem a word is presented, which the participant is required to remember. At the end of each set (set sizes range from 3 to 7) of maths problems participants are required to recall all the words for that set. Participants are required to complete a total of 3 sets of each set size. The task takes approximately 20-25 minutes. The AOSPAN has good construct validity, internal consistency, and high test-retest reliability (Unsworth et al., 2005).

There are a number of possible ways of scoring WMC. Conway et al (2005) reviewed methodological approaches to measuring WMC and report that the majority of studies using the standard WMC tests (e.g., OSPAN, reading span, counting span) have used the all-or-nothing load method of scoring (summing recalled words for only those sets completely recalled in the correct order). Consequently this scoring method was employed in Study Three in order to maximize the correspondence of the scoring of the WMC measure with the approach reported in previous relevant studies (e.g., Friedman & Miyake, 2004; Kane & Engle, 2003; McVay & Kane, 2009). Conway et al. (2005) note that accuracy on the primary task is positively correlated with working memory span on the secondary task, indicating that there does not seem to be a major speed accuracy trade-off concern with WMC tasks. Consequently, once potential outliers on operation accuracy had been screened for, recall for sets in which there were operation errors were included.

6.7.3 Results

6.7.3.1 WMC and self-reported rumination during the modified SART

Hierarchical regression was used to examine whether WMC (indexed by the AOSPAN) moderated the effect of the goal manipulation on self-reported rumination during the modified SART. Goal condition and centred AOSPAN scores (AOSPANc; AOSPAN scores centred around zero) were entered in block one of the regression, and the interaction term (goal condition x AOSPANc) in block 2. Goal condition was a significant predictor of state rumination, $t(36) = 2.77, p = 0.009$. WMC was not a significant predictor of state rumination, $t(36) = -0.59, p = 0.555$, and the addition of the interaction term did not explain a significant increase in the variance of self-reported

rumination, $\Delta R^2 < 0.001$, $F(1, 35) = 0.002$, $p = 0.968$. Thus, WMC was not a significant moderator of the effect of the goal manipulation on ruminative thoughts during the modified SART (Table 6.3).

Table 6.3: *Hierarchical linear regression estimating state rumination during the modified SART.*

	B	S.E.	β
Step 1			
Condition	10.783**	3.893	-0.090
AOSPANc	-0.081	0.137	0.419
Step 2			
Condition	10.783**	3.948	0.419
AOSPANc	-0.098	0.449	-0.109
Condition x AOSPANc	0.011	0.278	0.020

Step 1: $F(2, 36) = 3.918$, $p = 0.029$, $R^2 = 0.179$

Step 2: $F(3, 35) = 2.540$, $p = 0.072$, $R^2 = 0.179$

* $p < 0.05$, ** $p < 0.01$

6.7.3.2 WMC and errors of commission and RTs during the modified SART

Hierarchical regression was used to examine whether WMC moderated the effect of the goal manipulation on errors of commission. Goal condition and centred AOSPAN scores (AOSPANc) were entered in block one of the regression, and the interaction term (goal condition x AOSPANc) in block 2. Goal condition was a significant predictor of errors of commission, $t(36) = 2.96$, $p = 0.005$. WMC was not a

significant predictor of errors of commission, $t(36) = -0.34$, $p = 0.739$, and the addition of the interaction term did not explain a significant increase in variance in error rates, $\Delta R^2 = 0.01$, $\Delta F(1, 35) = 0.50$, $p = 0.485$. Thus, WMC was not a significant moderator of the effect of the goal manipulation on errors of commission in the modified SART (Table 6.4).

Table 6.4: *Hierarchical linear regression estimating errors of commission.*

	B	S.E.	β
Step 1			
Condition	-41.727**	14.117	-0.442
AOSPANc	-0.167	0.498	0.050
Step 2			
Condition	-41.693**	14.217	-0.441
AOSPANc	-1.252	1.617	-0.377
Condition x AOSPANc	0.706	1.001	0.344

Step 1: $F(2, 36) = 4.516$, $p = 0.018$, $R^2 = 0.201$

Step 2: $F(3, 35) = 3.134$, $p = 0.038$, $R^2 = 0.212$

* $p < 0.05$, ** $p < 0.01$

Hierarchical regression was used to examine whether WMC moderated the effect of the goal manipulation on response latencies. Goal condition and centred AOSPAN scores (AOSPANc) were entered in block one of the regression, and the interaction term (goal condition x AOSPANc) in block 2. Goal condition was a significant predictor of RTs, $t(36) = 2.13$, $p = 0.040$. WMC was not a significant

predictor of RTs, $t(36) = -0.47$, $p = 0.642$, and the addition of the interaction term did not explain a significant increase in variance in decision latencies, $\Delta R^2 = 0.008$, $\Delta F(1, 35) = 0.333$, $p = 0.567$. Thus, WMC was not a significant moderator of the effect of the goal manipulation on decision latencies in the modified SART (Table 6.5).

Table 6.5: *Hierarchical linear regression estimating RTs for correct go-trials*

	B	S.E.	β
Step 1			
Condition	60.700*	28.540	0.334
AOSPANc	-0.470	1.002	-0.074
Step 2			
Condition	60.643*	28.808	0.334
AOSPANc	1.330	3.277	0.209
Condition x AOSPANc	-1.171	2.028	-0.297

Step 1: $F(2, 36) = 2.313$, $p = 0.113$, $R^2 = 0.114$

Step 2: $F(3, 35) = 1.625$, $p = 0.201$, $R^2 = 0.122$

* $p < 0.05$, ** $p < 0.01$

6.7.3.3 Intraindividual reaction time variability

A 2 (goal condition: resolved, unresolved) x 4 (time: block 1, block 2, block 3, block 4) ANOVA examined the prediction that ruminating about unresolved personal goals caused greater fluctuations in attention as assessed by intraindividual RT variability. There was a significant main effect of time, $F(2.79, 103.29) = 4.95$, $p = 0.004$, (Huynh-Feldt correction applied), and a significant main effect of goal condition,

$F(1, 37) = 4.45, p = 0.042$. This was qualified by a significant interaction, $F(2.79, 103.29) = 5.88, p = 0.001$. Simple effects analyses revealed that this reflected a significant effect of time on RT variability in the resolved goal condition, $F(2.79, 103.29) = 10.56, p < 0.001$ (Huynh-Feldt correction applied due to epsilon estimates greater than 0.75); RT variability increased as the task progressed in the resolved goal condition. There was no effect of time on RT variability in the unresolved goal condition, $F(2.79, 103.29) = 0.53, p = 0.590$ (Huynh-Feldt correction applied). Thus, participants in the unresolved goal condition exhibited more stable RT variability.

Previous SART studies (McVay & Kane, 2009) report a relationship between WMC and RT variability. Hierarchical regression was used to examine whether WMC moderated the effect of the goal manipulation on response latencies. Goal condition and centred AOSPAN scores (AOSPANc) were entered in block one of the regression, and the interaction term (goal condition x AOSPANc) in block 2. Goal condition was a significant predictor of RT variability, $t(36) = 2.05, p = 0.048$. WMC was not a significant predictor of RT variability, $t(36) = 0.69, p = 0.494$, and the addition of the interaction term did not explain a significant increase in variance in RT variability, $\Delta R^2 = 0.016, \Delta F(1, 35) = 0.64, p = 0.428$. Thus, AOSPAN was not a significant moderator of the effect of the goal manipulation on RT variability in the modified SART (Table 6.6).

Previous SART studies (Manly, Davison, Heutink, Galloway, & Robinson (2000) report a relationship between RT variability and errors of commission. Consistent with predictions, RT variability was significantly correlated with errors of commission, $r(39) = 0.73, p < 0.001$. When this relationship was examined for each of the conditions, RT variability was significantly correlated with errors of commission

both in the resolved goal condition, $r(20) = 0.72$, $p < 0.001$, and in the unresolved goal condition, $r(19) = 0.73$, $p < 0.001$.

Table 6.6: *Hierarchical linear regression estimating RT variability*

	B	S.E.	β
Step 1			
Condition	-0.109*	0.053	-0.323
AOSPANc	0.001	0.002	0.109
Step 2			
Condition	-0.109*	0.053	-0.323
AOSPANc	0.006	0.006	0.500
Condition x AOSPANc	-0.003	0.004	-411

Step 1: $F(2, 36) = 2.249$, $p = 0.120$, $R^2 = 0.111$

Step 2: $F(3, 35) = 1.699$, $p = 0.185$, $R^2 = 0.127$

* $p < 0.05$, ** $p < 0.01$

6.7.4 Discussion

Prominent models of rumination and interference control processes posit that difficulties controlling the contents of working memory cause increased susceptibility to intrusive ruminative thoughts (e.g., Joormann & Gotlib, 2008), and that state rumination acts as a cognitive load reducing available working memory resources for concurrent cognitive tasks (e.g., Watkins & Brown, 2002). These models led to the predictions that individuals lower in WMC would be (i) at increased susceptibility to intrusive

ruminative thoughts, and (ii) exhibit greater rumination-related performance deficits on the SART due to a lower baseline processing capacity. Contrary to predictions, WMC was not related to intrusive ruminative thoughts during the SART, and did not moderate the impact of state rumination on task performance. WMC scores ranged from 6 -65, it therefore seems unlikely that these null findings are attributable to a restriction in range of WMC.

The prediction that WMC would moderate the impact of the goal manipulation upon subsequent state rumination makes the assumption that individuals would attempt to control or suppress task-irrelevant intrusive rumination during the SART in order to focus processing resources on the task. However, the experiment did not directly evaluate this assumption and found no evidence that state rumination was aversive (as assessed through state mood measures) or had negative consequences for task performance (in terms of error rates). Thus the most parsimonious interpretation of this null finding is that rumination was not experienced as problematic and thus cognitive control resources were not deployed in order to try to resist or disengage from ruminative thoughts during the SART. Future studies that more clearly assess unhelpful state rumination (for example through distinguishing abstract and concrete forms of state rumination) are needed in order to clarify the potential role of WMC in susceptibility to unwanted intrusive rumination.

Participants in the unresolved goal condition exhibited reduced RT variability relative to the resolved goal condition. Thus RT variability was not sensitive to fluctuations in attention caused by intrusive ruminative thoughts. As discussed in 6.6, one possible interpretation of the differing RTs and error rates in the two goal conditions is that individuals in the unresolved goal condition adopted a compensatory strategy of slowed responding in order to reduce the risk of errors as a consequence of

intrusive ruminative thoughts. If this was the case, then reduced intraindividual reaction time variability would be predicted in this condition and RT variability would be predicted to be correlated with error rates. Consistent with this, the unresolved goal condition exhibited reduced RT variability and RT variability significantly predicted errors of commission, suggesting that the strategy of consistently slowing RTs was effective in reducing errors. These results therefore lend further support to the interpretation that participants in the unresolved goal condition adopted a compensatory strategy of using a more conservative response style resulting in decreased RT variability, slower RTs and fewer errors. As a consequence of these group differences in task strategy, it is not possible to draw reliable conclusions regarding the impact of state rumination on interference control as indexed by the SART.

Study Three found no clear evidence that state rumination impaired SART performance; state rumination appeared to elicit a more conservative response style with slower RTs and fewer errors. It is therefore unsurprising that WMC did not moderate the impact of the goal manipulation on task performance since the predicted rumination-related performance deficits were not observed. Studies that establish clear interference control deficits as a consequence of state rumination are necessary in order to examine the potential role of WMC in such deficits.

6.7.5 Overall summary

Study Three was successful in validating a measure of state rumination based on control theory of goal pursuit (e.g., Carver & Scheier, 1998). Moreover, trait rumination moderated the impact of the goal manipulation on state rumination, providing convergent evidence that the measure was sensitive to state rumination. The study

additionally attempted a preliminary analysis of the impact of state rumination on prepotent response inhibition as indexed by SART performance. Participants in the two goal conditions were found to adopt different speed accuracy trade-off thresholds, indicating a more conservative style of responding in the rumination condition (slower RTs and fewer errors). It is thus unclear whether state rumination impaired or enhanced performance on the SART. In order to clarify this, a variant of the SART designed to reduce intraindividual RT variability is necessary (e.g., Manly, Davidson, Heutink, Galloway & Robertson, 2000). Study Four was therefore designed to clarify the impact of state rumination upon SART performance.

CHAPTER SEVEN: *Study Four*7.1 *Introduction*

Study Three constituted a preliminary validation of the modified SART as measure of state rumination, and reported experimental evidence supportive of a central prediction of control theory of rumination, namely, that cueing focus on goal discrepancies triggered state rumination, as measured by thought probe questions during the modified SART. However, the adaptation of the SART as an index of online rumination in Chapter Six was also intended to provide a direct test of the causal relationship between state rumination and prepotent response inhibition.

It was hypothesized that the frequency of errors of commission in the SART is a measure of the adequacy of a person's prepotent response inhibition, with lower errors indicating better response inhibition. If state rumination reduces the effectiveness of prepotent response inhibition, then it should increase errors of commission on the SART. Given previous reports that task-unrelated thought increases errors on the SART (Smallwood et al., 2004), it was expected that a similar effect would be observed when manipulating rumination. However, contrary to predictions, inducing state rumination reduced commission errors on the SART, relative to a control condition. However, this result was complicated by the fact that state rumination also increased reaction times. It was therefore unclear what the balance of consequences of state rumination for task performance was because rumination appeared to alter participants' speed accuracy trade-off threshold such that they were slower and more accurate. Chapter Seven reports a further investigation of the relationship between state rumination and prepotent

response inhibition, which was designed to overcome the difficulties in interpreting the behavioural data reported in Chapter Six.

Study Three examined the impact of ruminating about personal goal discrepancies, as opposed to ruminating about depressive symptoms (which is one specific goal discrepancy for depressed individuals). However, as a consequence of the differential speed accuracy trade-offs that were observed between the two groups, it remains unclear what the balance of consequences of rumination was for SART performance, relative to the consequences of focusing on a resolved goal. Study Four sought to clarify the relationship between on-going rumination and cognitive control during the modified SART.

There are two main variants of the SART – the unconstrained version (Robertson, Manly, Andrade, Baddeley, & Yiend, 1997) employed in Chapter Six, and a more constrained version in which every word is followed by a tone (Manly et al., 2000). The tone in the constrained version is assumed to increase attention to the task and constrain RTs through cueing responses, thereby eliminating a confound to interpretation of speed and accuracy data. Study Four thus adopted the constrained version in order to address the differential speed accuracy trade-offs observed in Study Three.

It has been argued (Robertson et al., 1997; Manly et al., 2000) that errors of commission in the unconstrained version of the SART primarily reflect failures of sustained attention - the initiation of a go response on a no-go trial could reflect mindless responding as a result of insufficient attention to the task, as opposed to a failure to inhibit the go response. However, in the standard (unconstrained) version of the SART, longer reaction times (RTs) are associated with both fewer errors of commission and increased reaction time variability. There are two possible

interpretations to the speed accuracy relationship because increased reaction time variability is additionally associated with higher error rates.

First, variability in RTs could be the result of participants strategically searching for optimum response time, with the fastest of the individuals' RT range causing an error of commission. Consistent with this, participants tend to slow their RTs down following the detection of an error, and tend to exhibit faster RTs ahead of an error than ahead of a correctly withheld response (Manly et al., 2000). As a consequence, errors could occur despite the maintenance of adequate attention to the task (Seli et al., 2012; Peebles & Bothell, 2004; Helton, 2009). This is because an error could be caused by speeding of responses at the faster end of a participants' strategic speeding and slowing of RTs in search for the optimum RT in order to respond as quickly as possible whilst maintaining accuracy. Moreover, an error could be a consequence of failures of inhibitory control which could also occur despite maintained attention to the task. Alternatively, speeding of responses could reflect attentional lapses, which would again trigger an error of commission.

Manly et al. (2000) developed a "response locked" version of the SART in order to contrast these accounts. When responses are cued with a tone, participants should not strategically (and attentively) attempt to find an optimum speed-accuracy trade-off, therefore errors of commission are argued to provide a more unambiguous index of attentional lapses, and the patterns of speeding and slowing observed in the standard SART should be eliminated (Manly et al., 2000).

However, it has been argued that by including a tone participants' attention will remain focussed upon the task (Manly et al., 2004; O'Connell et al., 2006), and their response times are cued meaning that prepotent response inhibition can be disentangled from response strategy (Helton, Head & Russell, 2011). According to this account,

errors of commission are likely to reflect deficits in response inhibition, under the assumption that prompting sustained attention will not change basic prepotent response capabilities. Consistent with this account, there is evidence that the inclusion of a tone is effective in prompting task focus and reducing attentional lapses (Manly et al., 2004). The constrained version of the SART therefore provides a more convincing measure of prepotent response inhibition than the unconstrained version.

Much of the methodology of Study Four was the same as that of Study Three but with two critical modifications to the modified SART. First, the length of the task was halved in order to reduce participant fatigue and the overall length of the experiment. Second, the unconstrained SART of Chapter Six was replaced with a constrained (“response locked”) version in order to address the differential speed accuracy trade-offs observed in Study Three. The AOSPAN was not included in the study design as a consequence of the lack of evidence of a relationship with the variables of interest in Study Three and to reduce participant burden.

If on-going rumination about personally important goals acts as a working memory load, resulting in impairments on concurrent cognitive tasks, then state rumination would be predicted to cause increased errors of commission on the SART. Study Four therefore sought to test this prediction by examining whether on-going rumination about an unresolved personal goal caused deficits in prepotent response inhibition on a constrained SART. In contrast to unconstrained SART variants in which accelerated RTs on trials preceding an error might be predicted as a consequence of mindless responding, this constrained version cues responses and thus is predicted to eliminate the mindless repetitive responding which elicits such a pattern of behavioural data. Thus, Study Four examined the prediction that state rumination acts as a working memory load, as opposed to whether rumination elicits a mindless response style.

Study Four thus sought to replicate the key findings of Study Three with respect to control theory and state rumination and additionally to examine the impact of state rumination about unresolved goals on performance on a more constrained version of the modified SART. The use of the goal manipulation to induce rumination is advantageous as a more ecologically valid means of investigating the consequences of rumination than the previous use of voluntary instructed rumination to examine possible consequences for cognitive control (e.g., Watkins & Brown, 2002). Moreover, the direct assessment of ruminative thoughts about personal goals during the modified SART to assess rumination permits the examination of the impact of spontaneous uninstructed rumination about idiographic concerns. The rumination captured by the modified SART is likely to be closer both in content and process to that which individuals experience in everyday life.

7.1.1 Hypotheses

First, it was predicted that cueing both resolved and unresolved goals would cause increases in self-reported self-focus, therefore the goal manipulation was not expected to differentially impact on self-focus. No specific predictions were made regarding the impact of goal-focused rumination upon sadness and tension during the modified SART. Second, it was predicted that, consistent with the findings of Study Three, participants allocated to the unresolved goal task would report more intrusive ruminative thoughts about their goal during the modified SART than participants allocated to the resolved goal task. Third, it was predicted that trait rumination would moderate the impact of the goal manipulation on subsequent ruminative thought, such that the impact of the manipulation would be greater for high trait ruminators. Fourth, it was predicted that on-going state rumination would act as a working memory load,

thereby resulting in greater errors of commission on the constrained version of the modified SART because the opportunity for differential speed accuracy trade-off thresholds was limited. Fifth, it was predicted that trait rumination would moderate the impact of the goal manipulation on errors of commission. Specifically, it was predicted that because high trait ruminators would have more intrusive ruminative thoughts about the goal discrepancy, they would experience greater disruption to task performance, resulting in higher error rates.

7.2 Method

7.2.1 Participants

60 participants were recruited from the University of Exeter undergraduate and postgraduate population, and were offered course credit or £10 for participating. Participants were required to have normal or corrected to normal vision. As with Studies One, Two and Three, participants were excluded if they reported severe head trauma or learning difficulties. No specific exclusion criteria were applied regarding current or lifetime mental health difficulties.

7.2.2 Design and Materials

Study Four adopted the same design and materials as Study Three, with the following modifications. The modified SART presented participants with 900 individually presented words. Each word was presented for 200ms and then followed by a 900ms mask. 100ms after word onset, a brief tone was presented. The tone was presented on both go and no-go trials. On the majority of trials, when the word was in lowercase, participants were required to respond to the word with a button press (go-

trials). Participants were asked to try their best to make their responses in time with the tone, whilst trying to make as few errors as possible. On a minority of trials, when the word was in uppercase, participants were required to withhold their response (no-go trials). The task comprised two blocks, each presenting 450 trials consisting of 45 words repeated ten times in a different order. Within each set of 45 words, 5 uppercase words (no-go trials) appeared randomly among 40 lowercase words (go trials).

As in Study Three, thought probes followed 60% of no-go trials and ratings of mood and self-focus followed each thought probe. There was no discernible break between blocks. The task took approximately 40 minutes to complete.

7.2.3 Procedure

Participants attended a single session, lasting approximately 80 minutes. Following an explanation of what the experiment would involve, participants completed the BDI-II and RRS. The goal cueing task was then completed; as in Study Three participants rated their mood and self-focus before and after the task. Finally, participants completed the modified SART.

As with Studies One, Two, and Three, a funnelled debriefing was used such that participants were first asked to guess the purpose of the study and whether they believed that any of the tasks were related in any way, and if so in what way. During the debriefing, no participant reported any suspicions that there were two versions of the goal cueing task. Many participants in both conditions reported that they felt that the experiment was concerned with concentration abilities. Following this, participants were fully debriefed and the goal manipulation was explained.

7.3 Results

7.3.1 Participant characteristics

56 participants (75% female) comprised the final sample⁷. 26 participants completed the unresolved goal cueing task, and 30 participants completed the resolved goal cueing task. The mean age was 19.52 (S.D. = 1.81; range 17-28) and the goal conditions did not differ in age, $t(54) = 1.74$, $p = 0.88$. The two goal conditions did not differ in self-reported symptoms of depression, $t(54) = 1.25$, $p = 0.22$, or trait rumination, $t(54) = 0.35$, $p = 0.73$. Table 7.1 reports the mean levels of depressive symptoms and trait tendencies to ruminate in each goal condition.

It was confirmed that the two goal conditions reliably differed in their evaluations of their current level of concern regarding the goal that was focused on in the goal cueing manipulation: participants in the unresolved goal condition reported having more thoughts of the concern in the past week, $t(54) = 19.30$, $p < 0.001$, ($M = 7.58$, $SD = 0.90$) than participants in the resolved goal condition ($M = 1.90$, $SD = 1.26$), and being more bothered by the concern, $t(54) = 18.16$, $p < 0.001$, ($M = 7.17$, $SD = 0.76$) than participants in the resolved goal condition ($M = 2.14$, $SD = 1.25$). There was no effect of goal condition on participants evaluations of how much the concern had bothered them when at its worst ($p > 0.2$), or the duration of the concern ($p > 0.3$). Thus, the concerns identified by participants in the two goal conditions did not differ in subjective evaluations of aspects of their nature or severity, but participants who were

⁷ Four participants were excluded from the final sample due to not having correctly followed the experiment protocol (one for using a mobile telephone during the experiment, two for reporting at the end of the experiment that they did not understand the task requirements and one for not making any responses to any of the stimuli).

asked to think about an unresolved goal reported that the concern was one that was bothering them more than participants who were asked to think about a resolved concern. However, there was a trend towards participants in the unresolved goal condition rating the concern as more important, $t(54) = 1.91$, $p = 0.06$, ($M = 7.89$, $SD = 0.99$) than participants in the resolved goal condition ($M = 7.31$, $SD = 1.00$). It is possible that unresolved goals were perceived as more important due to the on-going discrepancy between desired and actual status in goal pursuit. Additionally, participants in the unresolved goal condition rated that the concern was more related to other problems, $t(54) = 4.36$, $p < 0.001$, ($M = 5.73$, $SD = 1.95$) than participants in the resolved goal condition ($M = 3.38$, $SD = 1.99$).

7.3.2 Effects of goal manipulation on mood and self-focus

Ratings of sadness, tension and self-focus were centred around zero such that positive scores represent sadness/tension/high self-focus and negative scores represent happiness/relaxation/low self-focus. 2 (goal condition: resolved, unresolved) x 2 (time: pre goal manipulation, post goal manipulation) mixed ANOVAs were conducted to examine the effects of the goal manipulation on sadness, tension and self-focus. There was a significant main effect of goal condition on sadness, $F(1, 54) = 6.99$, $p = 0.01$, and a significant main effect of time, $F(1, 54) = 79.81$, $p < 0.001$, this was qualified by a significant interaction, $F(1, 54) = 7.83$, $p = 0.007$. Simple effects analyses revealed that the goal conditions did not differ in sadness prior to the goal manipulation, $F(1, 54) = 0.24$, $p = 0.623$, but significantly differed in sadness following the goal manipulation, $F(1, 54) = 13.79$, $p < 0.001$, reflecting greater sadness in the unresolved goal condition than in the resolved goal condition (Table 7.1). Thus the goal manipulations differentially impacted upon sadness.

There was a significant main effect of goal condition on tension, $F(1, 54) = 8.58, p = 0.005$, reflecting higher levels of tension in the unresolved goal condition, relative to the resolved condition. Surprisingly, participants in the unresolved goal condition reported greater baseline tension than participants in the resolved goal condition. There was significant main effect of time, $F(1, 54) = 4.25, p = 0.04$, reflecting an increase in tension following the goal manipulations. The interaction was not significant, $F(1, 54) = 2.27, p > 0.1$. Thus the goal manipulations did not differentially impact upon tension, although levels of tension were higher in the unresolved goal condition.

There was a significant main effect of time on self-focus, $F(1, 54) = 11.47, p = 0.001$, reflecting an increase in self-focus following the goal manipulations. The effect of goal condition was not significant, $F(1, 54) = 0.18, p > 0.6$, and neither was the interaction, $F(1, 54) = 1.41, p > 0.2$. Thus, as predicted, both goal manipulations conditions equally increased self-focus. Table 7.1 details the mean ratings before and after the goal manipulation for each condition.

Table 7.1: *Mean depressive symptoms, trait rumination and ratings of sadness, tension and self-focus (standard deviations in parentheses)*

Condition	Unresolved goal	Resolved goal
BDI-II	9.92 (6.22)	7.80 (6.48)
RRS	43.31 (11.09)	42.23 (11.64)
Baseline Sadness	3.92 (1.29)	3.77 (1.07)
Post Manipulation Sadness	6.15 (1.05)	4.93 (1.36)
Baseline Tension	4.38 (1.75)	3.87 (1.41)
Post Manipulation Tension	5.46 (1.58)	4.03 (1.92)
Baseline Self-Focus	5.38 (1.10)	4.97 (1.22)
Post Manipulation Self-Focus	5.96 (1.68)	6.17 (1.37)

BDI-II = Beck Depression Inventory II, RRS = Ruminative Responses Scale

7.3.3 *Mood and self-focus during the modified SART*

Mean ratings of sadness, tension and self-focus throughout the SART were each centred around zero, such that positive scores reflected greater sadness, tension and self-focus respectively. There was a significant effect of goal condition on sadness, $t(54) = 2.63$, $p = 0.01$, reflecting greater sadness ($M = 0.49$, $SD = 0.86$) in the unresolved goal condition than in the resolved goal condition ($M = -0.13$, $SD = 0.90$). Thus, in contrast to the findings of Study Three, Study Four found that the goal focus manipulation differentially impacted on subsequent levels of sadness.

There was a significant effect of goal condition on tension, $t(54) = 2.21$, $p = 0.03$, reflecting greater tension in the unresolved goal condition ($M = 1.10$, $SD = 1.41$) than in the resolved goal condition ($M = 0.18$, $SD = 1.68$). However, the conditions

differed in baseline levels of tension and a 2 (goal condition) x 2 (time: baseline tension, tension during the SART) revealed that the interaction of goal condition and time was not significant, $F(1, 54) = 0.64, p = 0.43$. Thus, group differences in tension appear to be attributable to baseline differences as opposed to a consequence of the goal manipulation. Consistent with this, correlations revealed that ruminative thoughts during the modified SART and tension were not related, $r = 0.011, p = 0.467$.

Consistent with the findings of Study Three, there was no effect of condition on self-focus during the modified SART, $t(36.25) = 0.38, p = 0.71$ (Welsch's t-test applied to correct for inequality of variances).

7.3.4 State rumination during the modified SART

T-tests were conducted to examine the differential impact of the goal manipulation on thought content and state rumination during the modified SART. There was a significant effect of goal condition on rumination during the modified SART, $t(54) = 2.63, p = 0.01$. Participants in the unresolved goal condition reported more thoughts of the concern focused on during the goal manipulation ($M = 4.15, SD = 3.55$) than participants in the resolved goal condition ($M = 2.07, S.D. = 2.33$). There was no effect of goal condition of reports of any other thought type (task: $p > 0.2$; task performance: $p > 0.7$; physical state: $p > 0.5$; other worries: $p > 0.6$; all other thoughts: $p > 0.6$). On average, participants in the unresolved goal condition reported ruminative thoughts on 6.92% of probes, relative to thoughts about the cued goal on 3.45% of probes in the resolved goal condition. Thus, as predicted, the differential effects of cueing resolved and unresolved goals on subsequent state rumination observed in Study Three were replicated in Study Four.

A 2 (goal condition: resolved, unresolved) x 2 (time: block 1; block 2) mixed ANOVA on ruminative responses to the thought probes revealed a significant main effect of time, $F(1, 54) = 7.39, p < 0.01$, and a significant main effect of goal condition, $F(1, 54) = 6.92, p = 0.01$. The interaction approached significance, $F(1, 54) = 2.88, p = 0.095$. Simple effects analyses revealed that there was a significant main effect of goal condition on thoughts of the concern during block 1, $F(1, 54) = 8.15, p = 0.006$, reflecting more thoughts of the concern in the unresolved goal condition than in the resolved goal condition. There was no effect of goal condition on thoughts of the concern during block 2, $F(1, 54) = 2.00, p = 0.16$. Thus, the impact of the goal manipulation upon intrusive ruminative thoughts appears to have weakened as the modified SART progressed (see Figure 7.1).

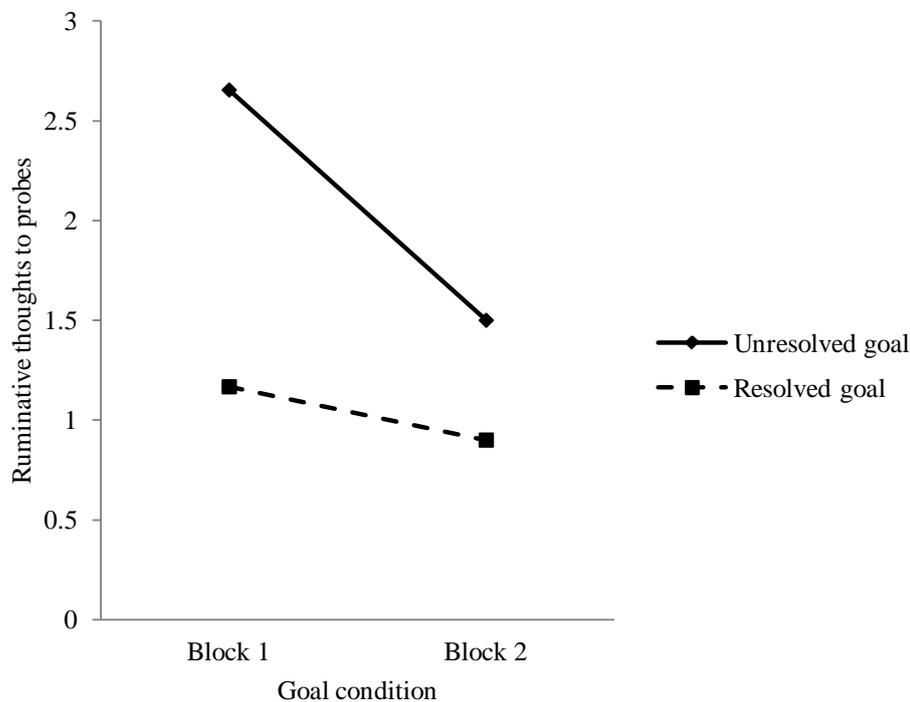


Figure 7.1: Mean goal-related ruminative thoughts as a function of time

7.3.5 Trait rumination and state rumination during the modified SART

Hierarchical regression was used to examine whether trait rumination (indexed by the RRS) moderated the effect of the goal manipulation on state rumination during the modified SART. Goal condition and centred RRS scores (RRSc) were entered in step one of the regression, and the interaction term (goal condition x RRSc) in step 2. The results of these analyses are detailed in Table 7.2. The addition of the interaction term explained a significant increase in variance of rumination, $\Delta R^2 = 0.07$; $F(1, 52) = 5.12$, $p = 0.03$. Thus, as expected, trait rumination was a significant moderator of the effect of the goal manipulation on ruminative thoughts during the modified SART.

Table 7.2: *Hierarchical linear regression estimating state rumination during the modified SART*

	B	S.E.	β
Step 1			
Goal Condition	2.00*	0.76	0.32
RRSc	0.08*	0.03	0.28
Step 2			
Goal Condition	1.99**	0.74	0.32
RRSc	0.01	0.04	0.05
Condition x RRSc	0.15*	0.07	0.36

Step 1: $F(2, 53) = 6.38$, $p < 0.01$, $R^2 = 0.19$

Step 2: $F(3, 52) = 6.29$, $p = 0.001$, $R^2 = 0.27$

* $p < 0.05$, ** $p < 0.01$

Simple slopes analyses (see Figure 7.2) revealed that the unstandardized simple slope for participants 1 SD below the mean for trait rumination was 0.29, which was not significantly different from 0, $t(55) = 0.28$, $p > 0.7$. The unstandardized simple slope for participants 1 SD above the mean for trait rumination was 3.68, which was significantly greater than 0, $t(55) = 3.59$, $p = 0.001$. Thus, consistent with the prediction that the modified SART would be sensitive to individual differences in trait rumination, the effect of the goal manipulation on subsequent rumination was greater for participants reporting high levels of trait rumination on the RRS.

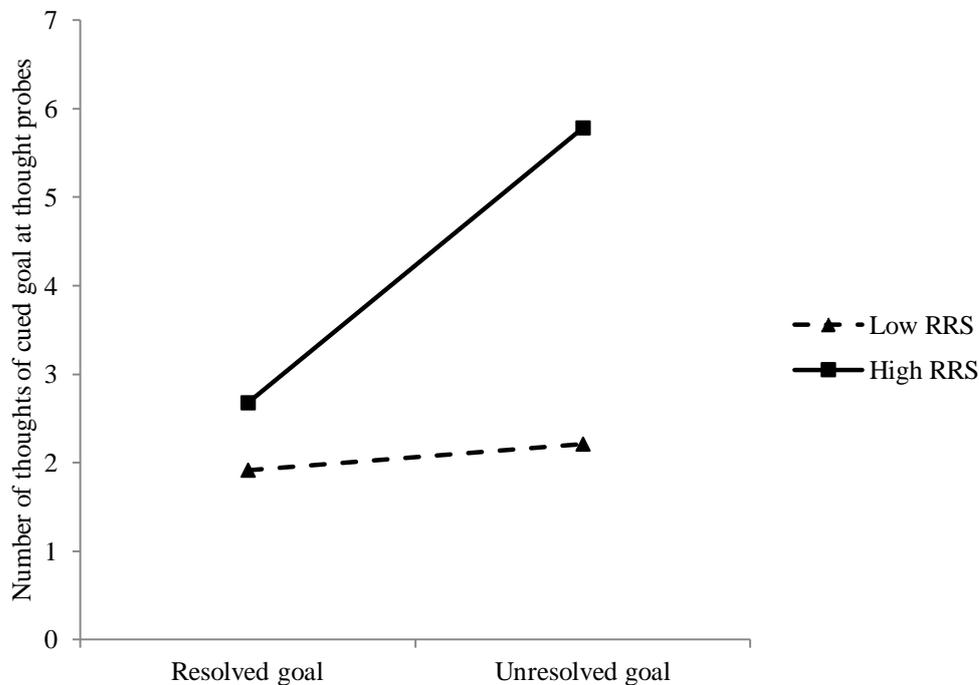


Figure 7.2: Simple slopes for state rumination one standard deviation above and below the mean RRS score

7.3.6 Errors of commission and correct go-trial RTs during the modified SART

There were very high rates of errors of commission ($M = 70.82\%$, $S.D. = 17.89$). A 2 (goal condition: resolved, unresolved) \times 2 (time: block 1, block 2) mixed ANOVA examined the prediction that state rumination caused increased errors of commission

relative to a control condition. There were no significant main effects (all $p > 0.2$).

There was a trend towards an interaction of time and goal condition, $F(1, 54) = 3.99$, $p = 0.051$. Simple effects analysis revealed that this reflected no effect of time on errors in the resolved goal condition, $F(1, 54) = 0.37$, $p = 0.543$, and a significant effect of time on errors in the unresolved goal condition, $F(1, 54) = 4.66$, $p = 0.035$, reflecting an increase in errors from block 1 to block 2. There was no main effect of goal condition on errors of commission during either block 1 or block 2 (all $p > 0.2$). Table 7.3 reports percentage errors of commission during each block of the task. Contrary to predictions, participants in the unresolved goal condition did not make more errors of commission than participants in the resolved goal condition.

Table 7.3: % Errors of commission and mean RTs (in ms) for correct go-trials
(standard deviations in parentheses)

	Unresolved Goal		Resolved Goal	
	RTs	Errors	RTs	Errors
Block 1	315.47 (82.19)	66.54 (9.67)	347.97 (112.63)	72.93 (10.70)
Block 2	311.72 (101.41)	71.846 (8.54)	396.84 (162.51)	71.533 (8.93)

A 2 (goal condition: resolved, unresolved) x 2 (time: block 1, block 2) mixed ANOVA on RTs for correct go-trials examined the prediction that state rumination resulted in slower RTs relative to the control condition when error rates for the two conditions were equivalent. There was a trend towards a main effect of goal condition, $F(1, 54) = 3.98$, $p = 0.051$, reflecting faster responses in the unresolved goal condition (M

= 313.35, SD = 85.58) than in the resolved goal focus condition (M = 371.62, SD = 126.94). Contrary to predictions, participants in the unresolved goal condition were faster, not slower, than participants in the resolved goal condition. There was a trend towards a main effect of time, $F(1, 54) = 3.02$, $p = 0.09$, reflecting an increase in RTs as the task progressed (block 1 M = 332.88; block 2 M = 357.32).

There was a significant goal condition x time interaction, $F(1, 54) = 4.11$, $p = 0.048$. Simple effects analysis revealed that this reflected a significant effect of time on RTs in the resolved goal condition, $F(1, 54) = 7.63$, $p = 0.008$, reflecting an increase in RTs as the task progressed. There was no effect of time on RTs in the unresolved goal condition, $F(1, 54) = 0.04$, $p = 0.844$. There was no effect of goal condition on RTs for correct go trials during block 1, $F(1, 54) = 1.48$, $p = 0.23$. There was a significant main effect of goal condition on RTs for correct go trials during blocks 2, $F(1, 54) = 5.33$, $p = 0.03$, reflecting faster responses in the unresolved goal condition than in the resolved goal condition. Thus, contrary to predictions, participants in the unresolved goal condition exhibited faster response times and slowed down less as the task progressed relative to participants in the resolved goal condition. Table 7.3 reports mean decision latencies for correct goal trials. In sum, there was no evidence that state rumination resulted in either increased errors of commission or slower RTs for correct go-trials on the modified SART. In fact, participants in the unresolved goal condition were faster without any cost in terms of errors.

7.3.7 Intraindividual reaction time variability

In previous SART studies, intraindividual RT variability has increased over blocks (McVay & Kane, 2009). A 2 (goal condition) x 2 (time) ANOVA revealed a trend towards an effect of time, $F(1, 54) = 3.17$, $p = 0.081$, reflecting an increase in RT

variability from block 1 ($M = 0.54$, $SD = 0.31$) to block 2 ($M = 0.59$, $SD = 0.29$). There was a trend towards an effect of goal condition, $F(1, 54) = 2.99$, $p = 0.089$, reflecting greater RT variability in the resolved goal condition ($M = 0.62$, $SD = 0.30$) than in the unresolved goal condition ($M = 0.50$, $SD = 0.24$). The interaction was significant, $F(1, 54) = 4.41$, $p = 0.048$, reflecting an increase in RT variability in the unresolved goal condition (block 1 $M = 0.44$, $SD = 0.24$; block 2 $M = 0.55$, $SD = 0.30$) and no change in the resolved goal condition (block 1 $M = 0.63$, $SD = 0.34$; block 2 $M = 0.62$, $SD = 0.29$). Thus, consistent with Study Three participants in the unresolved goal exhibited less RT variability, and in contrast to Study Three they exhibited less stable RT variability. Consistent with previous SART studies RT variability was significantly correlated with errors of commission, $r = 0.54$, $p < 0.001$, and this was the case for both the unresolved goal condition, $r = 0.42$, $p = 0.031$, and the resolved goal condition, $r = 0.61$, $p < 0.001$.

7.3.8 Trait and state rumination and decision latencies and error rates during the modified SART

Hierarchical regression was used to examine whether trait rumination (indexed by the RRS) moderated the effect of the goal manipulation on RTs to correct go-trials on the modified SART. Goal condition and centred RRS scores (RRSc) were entered in step one of the regression, and the interaction term (goal condition x RRSc) in step 2. The results of these analyses are detailed in Table 7.4. The addition of the interaction term did not explain a significant increase in variance in RTs ($\Delta R^2 = 0.014$; $F(1, 52) = 0.87$, $p = 0.356$). Thus, trait rumination was not a significant moderator of the effect of the goal manipulation on RTs during the modified SART.

Table 7.4: *Hierarchical linear regression estimating RTs for correct go-trials.*

	B	S.E.	β
Step 1			
Goal Condition	-55.50	28.64	-0.25
RRSc	-2.57*	1.28	-0.26
Step 2			
Goal Condition	-55.77	28.67	-0.25
RRSc	-3.63*	1.71	-0.36
Condition x RRSc	2.40	2.57	0.16

Step 1: $F(2, 53) = 4.11, p = 0.022, R^2 = 0.13$

Step 2: $F(3, 52) = 3.02, p = 0.038, R^2 = 0.15$

* $p < 0.05$, ** $p < 0.01$

Hierarchical regression was conducted to examine the prediction that state and trait rumination interacted to predict errors of commission. Goal condition and centred RRS scores (RRSc) were entered in step one of the regression, and the interaction term (goal condition x RRSc) in step two. The results of these analyses are detailed in Table 7.5. The model was a poor fit, and the addition of the interaction term did not explain a significant increase in variance in error rates ($\Delta R^2 = 0.026; F(1, 52) = 1.50, p = 0.226$). Trait and state rumination did not interact to predict errors of commission on the modified SART.

Table 7.5: *Hierarchical linear regression estimating errors of commission*

	B	S.E.	β
Step 1			
Goal Condition	-3.42	4.75	-0.10
RRSc	0.35	0.21	0.22
Step 2			
Goal Condition	-3.36	4.73	-0.10
RRSc	0.58*	0.28	-0.37
Condition x RRSc	-0.52	0.42	-0.22

Step 1: $F(2, 53) = 1.61, p = 0.210, R^2 = 0.06$

Step 2: $F(3, 52) = 1.58, p = 0.205, R^2 = 0.08$

* $p < 0.05$, ** $p < 0.01$

7.3.9 Interactions of goal condition, state rumination, and sadness during the modified SART

Regressions were conducted to examine whether intrusive ruminative thoughts mediated the impact of the goal manipulation on self-reported sadness to the probes. Goal condition was a significant predictor of ruminative thoughts (the mediator) during the modified SART, $\beta = 0.34, t(54) = 2.63, p = 0.011$. Goal condition was also a significant predictor of mean sadness during the modified SART, $\beta = 0.34, t(54) = 2.63, p = 0.011$. However, with ruminative thoughts added to the equation, the strength of the relationship between goal condition and sadness was reduced, $\beta = 0.23, t(53) = 1.73, p = 0.089$, and the mediator (ruminative thoughts) was a significant predictor of

sadness, $\beta = 0.33$, $t(53) = 2.58$, $p = 0.013$. The overall regression was significant, $R^2 = 0.212$, $F(2, 53) = 7.13$, $p = 0.002$. This suggests that the impact of the goal manipulation upon sadness during the modified SART may have been partially mediated by repetitive intrusive rumination about the goal. A Sobel test confirmed that the indirect effect of the goal manipulation on sadness, via the mediator of ruminative thoughts, was marginally significantly different from zero, $z = 1.86$, $p = 0.063$. Thus there was a trend towards intrusive ruminative thoughts partially mediating the impact of the goal manipulation upon subsequent sadness.

However, an alternative model of the relationship would predict that rather than rumination driving sadness, sadness in response to goal discrepancies drives rumination. Consequently, regressions were conducted to examine whether changes to levels of sadness mediated the impact of the goal manipulation on the number of ruminative thoughts during the modified SART. Goal condition was a significant predictor of mean sadness (the mediator) during the modified SART, $\beta = 0.34$, $t(54) = 2.63$, $p = 0.01$. Goal condition was also a significant predictor of ruminative thoughts to the probes, $\beta = 0.34$, $t(54) = 2.63$, $p = 0.01$. However, with sadness added to the equation, the strength of the relationship between goal condition and ruminative thoughts was reduced, $\beta = 0.23$, $t(53) = 1.74$, $p = 0.09$, and the mediator (sadness) was a significant predictor of ruminative thoughts, $\beta = 0.33$, $t(53) = 2.58$, $p = 0.01$. The overall regression was significant, $R^2 = 0.212$, $F(2, 53) = 7.14$, $p = 0.002$. This suggests that the impact of the goal manipulation upon ruminative thoughts may have been partially mediated through increased sadness in the unresolved goal condition. A Sobel test confirmed that the indirect effect of the goal manipulation on ruminative thoughts, via the mediator of sadness, was significantly different from zero, $z = 2.06$, $p = 0.040$. Thus,

sadness partially mediated the impact of the goal manipulation on subsequent intrusive ruminative thoughts.

7.4 Discussion

Study Four replicated the critical findings of Study Three with respect to the influence of cueing resolved and unresolved goals. When participants were cued with a personal goal on which they were failing to make the progress that they desired, they reported greater rumination about this during the modified SART than when they were cued with a personal goal that they had already achieved. Thus, Study Four provides support for the conclusions of Study Three with respect to control theories of rumination: the detection of a discrepancy between the current and desired status of a personally important goal drives rumination. Taken together, the findings of Studies Three and Four provide the first direct experimental evidence in support and development to Moberly and Watkins (2010) preliminary examination of one of the central predictions of Martin and Tesser's (1996) theory of rumination.

Contrary to predictions, there was no evidence that state rumination about personal goal discrepancies caused performance deficits on the modified SART. Taken together, the findings of Studies Three and Four provide consistent evidence that does not support the prediction that state rumination impairs interference control as measured by the modified SART. Across both studies, the pattern of findings is consistent with the possibility that participants who were ruminating about an unresolved personal goal performed better on the modified SART than participants who were not ruminating about personal goal discrepancies. These findings are at odds with the hypothesis that

state rumination acts as a working memory load thereby causing impaired performance on concurrent cognitive tasks.

7.4.1 Rumination and interference control on the modified SART

As was the case in Study Three, induction of state rumination during the SART did not result in either increased errors of commission or slower decision latencies on correct go-trials, relative to a non-ruminative control. Study Four was successful in eliminating the differential speed accuracy trade-offs between conditions which were observed in Study Three. However, surprisingly, the pattern of data is still suggestive of participants in the unresolved goal condition having performed better on the modified SART than participants in the resolved goal condition. There were no group differences in error rates, but there was a trend towards participants in the unresolved goal condition responding faster on correct go-trials than participants in the resolved goal condition.

Although these results must be interpreted with some caution and require replication, one hypothesis is that participants in the unresolved goal condition increased their effort and focus on the modified SART in an attempt to distract themselves from ruminating and from the sadness associated with rumination on unresolved goals in this Study. If effective, such a strategy would be expected to result in both a decline in rumination and a benefit to task performance. The benefit to task performance is observed, and the fact that ruminative thoughts reduce from block 1 to block 2 of the SART in the unresolved goal condition suggest that the strategy may be somewhat effective in controlling rumination (although not sadness).

It is also possible that the constrained version of the modified SART was sufficiently effortful and attentionally demanding that it was effective in reducing rumination without the adoption of a conscious compensatory or distraction strategy.

However, such an account cannot explain the differential benefits of rumination on task performance relative to a non-ruminative control condition.

It is important to note that the sample was not selected on the basis of mood, and was not experiencing clinical levels of depressive symptomology. Previous studies reporting that induced rumination impairs performance on measures of cognitive control have used clinical populations and manipulations that explicitly instruct participants to focus on depressive symptoms, and it is likely that state depressive rumination about on-going and distressing symptoms will be both more upsetting and more difficult to distract oneself from. Moreover, depression is known to reduce motivation and strategy initiation (e.g., Abramson, Metalsky, & Alloy, 1989; Hertel & Hardin, 1990), and thus would be predicted to interfere with the redirection of cognitive resources onto task-relevant processing as a means of distraction from ruminating. Thus, whilst the proposal that the modified SART was used as an effective means of distraction from goal-focused (as opposed to symptom-focused) rumination in this sample is a plausible one, it remains to be established whether this strategy would extend to depressed individuals. Further research is needed in order to establish a clearer pattern of findings regarding the impact of state rumination on performance on the SART, whether depressed and non-depressed individuals differ in the impact that state rumination has upon interference control and resource allocation, and whether the effects of state rumination may relate to depressed mood.

It is of note that the SART task involves the active maintenance of a single task goal (withhold response when the stimuli are in uppercase) without reinforcement. Accordingly an alternative interpretation of the findings of Study Four is that the findings are tentatively consistent with the proposal that rumination is associated with a narrowing of attentional focus thereby resulting in enhanced maintenance of a single

task goal at the expense of cognitive flexibility (Altamirano et al., 2010; Whitmer & Gotlib, 2012). State rumination caused faster responses with no cost in terms of errors. Trait rumination was negatively correlated with RTs, but was not a significant moderator of the effects of goal condition on RTs. Taken together however, the pattern of findings in Study Four tentatively suggest that both state and trait rumination was associated with a benefit to performance on a task that requires the maintenance of a single goal without reinforcement. These findings must be interpreted with caution but are potentially consistent with the proposal that rumination enhances goal maintenance.

7.4.2 Integration of RST and control theory

Consistent with the findings of Study Three, the impact of the goal manipulation on subsequent state rumination was moderated by the trait tendency to ruminate. Thus, those individuals who have a stronger tendency to habitually respond to sadness by ruminating were more susceptible to the rumination inducing effects of the goal manipulation. The replication of an interaction of trait rumination and goal discrepancies in predicting state rumination is supportive of an integration of response styles theory of habitual pathological rumination and control theories of goal-related state rumination. As discussed in Chapter Six, these findings indicate that depressive rumination may be sensitive to fluctuations in the rate of progress in pursuing personal goals.

7.4.3 State rumination and sadness and tension during the modified SART

In contrast to Study Three, Study Four found a reliable effect of the rumination manipulation upon sadness during the modified SART, such that individuals cued with an unresolved goal reported greater sadness than individuals cued with a resolved goal.

Previous studies (e.g., Moberly & Watkins 2008a, 2008b) have proposed a reciprocal relationship between rumination and negative affect, whereby intrusive ruminative thoughts increase negative affect, which in turn triggers further rumination. Moreover, a number of theoretical accounts of rumination (e.g., RST, Nolen-Hoeksema, 1991) posit that negative affect and sad mood states elicit ruminative responding. Whilst it is understood that rumination and negative affect are closely related, the causal nature of this relationship is methodologically difficult to disentangle, and beyond the scope of this experiment. There was a trend towards intrusive ruminative thoughts partially mediating the impact of the goal manipulation upon sadness during the modified SART. This is consistent with the considerable data demonstrating that rumination has unhelpful consequences for mood and self-regulation (e.g., Nolen-Hoeksema, 2000, Watkins, 2008). Moreover, the elevated sadness in the unresolved goal condition persisted beyond the occurrence of elevated levels of intrusive ruminative thoughts about the goal. Sadness partially mediated the impact of the goal manipulation upon subsequent intrusive ruminations about the goal that was cued. This is consistent with evidence from experience sampling data demonstrating that frustrations to goal progress are a source of negative affect (Moberly & Watkins, 2010). There is no clear theoretical reason to adopt one model of this relationship over the other; however these findings are consistent with previous data demonstrating that rumination and negative affect are closely related.

It is not clear why the goal manipulation differentially elicited sustained sadness in Study Four, but did not in Study Three. One possible interpretation of the sustained sadness observed in the present study is that the demanding nature of the constrained version of the modified SART was experienced as fatiguing and aversive (consistent with the high error rates) and this had a negative impact on participants mood, which

was greater for participants in the unresolved goal condition as they were already experiencing greater sadness and tension following the goal cueing task. However, such an account is speculative and further studies are needed in order to establish a clearer pattern of findings regarding the interaction and temporal relationship between ruminating on unresolved goals and negative affect. Moreover, such an account does not explain the findings that the goal manipulation differentially influenced sadness following the task in Study Four, but not in Study Three. It is possible that the larger sample in Study Four relative to Study Three resulted in increased sensitivity to detect potential affective consequences of focusing on personal goal discrepancies. However, due to baseline group differences in self-reported tension, it is not possible to rule out the possibility that the unresolved goal condition were more susceptible to experiencing an exacerbation of negative mood as consequence of pre-existing elevated tension relative to the resolved goal condition.

7.4.4 Replication of the preliminary validation of an online measure of state rumination

As in Study Three, Study Four found the probe questions of the modified SART to be sensitive to the effects of the goal manipulation. Moreover, the interaction of trait rumination and the goal manipulation in predicting state rumination during the modified SART replicated the convergent evidence reported in Study Three that the task constitutes a valid approach to measuring uninstructed bouts of ruminative thoughts about personal goal discrepancies. However, it is not clear that this second version of the task permitted a sensitive assessment of the temporal course of state rumination. As discussed in 7.4.1, it is possible that the decline in rumination as the task progressed is a consequence of the task being strategically used to distract from ruminating, or as a consequence of the highly effortful nature of the task. Given that the task is

considerably more demanding than the version used in Study Three, it is also possible that such a strategy would prove effective with this constrained SART, but not with the unconstrained SART used previously. Consistent with this, there were extremely high error rates in Study Four, which was not the case in Study Three. This increase in error rates is likely to be attributable to the substantial difficulty of the constrained SART which required participants to initiate a response every 1100ms for a sustained time period (900) trials, and instructed participants to try their best to initiate these responses in time with a tone presented 100ms after stimulus onset for each trial.

However, it is of note that a second possible account of the differential duration of rumination across the two SART types is as a consequence of the increased difficulty of the constrained version resulting in fatigue and consequently eliminating the ability to concurrently engage in sustained processing of off-task thoughts. This is consistent with the proposal that highly constrained situations counteract the effects of induced rumination as the current task occupies sufficient cognitive capacity that sustained concurrent off-task thinking is not possible (e.g., Hertel, 2004).

7.4.5 *Summary*

In sum, consistent with Study Three, cueing a negative discrepancy between a desired goal status and its current status prompted state rumination, and the probe questions in a modified SART were found to be a valid measure of this state-level rumination. Surprisingly, when the differential speed accuracy trade-offs observed in Study Three were eliminated; participants who were concurrently ruminating about unresolved goals exhibited a trend towards more efficient task performance (faster RTs and equivalent error rates). One possible account for these observations is that the task was strategically used as a means of distraction. An alternative account is that

participants who were experiencing intrusive ruminative thoughts attempted to compensate for potential deleterious effects of these on task performance by increasing efforts to perform well on the task. A third possibility is that rumination enhances goal maintenance thereby conferring a benefit to performance on measures that implicates holding a single goal in mind without reinforcement (e.g., Whitmer & Gotlib, 2012). However, these findings were not predicted and replication of this data will be an important next step in clarifying the impact of state rumination on prepotent response inhibition on the SART.

CHAPTER EIGHT: *Study Five*8.1 *Introduction*

Chapters Six and Seven reported evidence that a goal-cueing procedure was a valuable method to elicit uninstructed ruminative self-focus that was not contaminated by depressive symptoms. Moreover the use of thought probes was validated as a means of directly assessing state rumination on personal goal discrepancies. The studies in Chapters Six and Seven examined the hypothesis that state rumination reduces prepotent response inhibition, using the SART to measure response inhibition. Across both studies there was no evidence to support this prediction, and some evidence to suggest that state rumination was associated with better task performance.

The resistance to proactive interference operationalization is the hypothesized sub-type of inhibition (e.g., Friedman & Miyake, 2000) that is most theoretically relevant to rumination and is more clearly associated with trait rumination than the other proposed inhibitory sub-types in previous correlational studies (e.g., Joormann & Gotlib, 2008; De Lissnyder, Koster & De Raedt, 2011). Studies One and Two sought to test this causal relationship by using the standard instructed rumination and distraction manipulations to manipulate state rumination prior to a measure of proactive interference – the modified Sternberg task. However, to date, there have been no experimental studies that have examined the causal effect of state rumination on resistance to proactive interference using (i) a direct measure of state rumination, and (ii) a rumination induction that pertains to idiographic concerns and does not explicitly instruct focus on depressed mood.

Moreover, the rumination manipulation employed in Studies Three and Four has a number of advantages over that employed in Studies One and Two. Firstly, the goal manipulation is idiographic and therefore likely to be more salient and powerful since personally relevant discrepancies that have been ruminated on in everyday life are cued. Secondly, the subsequent ruminative thought is uninstructed and therefore likely to more closely match naturally occurring ruminative thinking in everyday life. Thirdly, the manipulation is not focused on depressive symptoms or negative affective states and therefore more unambiguously examines the potential consequences of rumination as opposed to the consequences of exacerbating depressed mood. Finally, through directly measuring the extent of ruminative thinking during the cognitive task it is possible to more clearly examine whether intrusive ruminations interfere with concurrent task performance.

Consequently, Study Five sought to examine the impact of state rumination upon performance on the modified Sternberg task in an unselected sample using a clear measure of state rumination, and the goal-cuing procedure described in Chapters Six and Seven, thereby directly examining the consequences of personally-relevant uninstructed rumination. Through using the goal-cueing procedure, the study additionally attempted to disentangle the potential effects of state rumination from those of temporarily exacerbating depressive symptoms. The modified Sternberg task was selected because it is a relatively clear measure of resistance to proactive interference (e.g., Oberauer, 2005) that a previous study has found correlates with individual differences in trait depressive rumination in depressed individuals (Joormann & Gotlib, 2008). Thus, this experiment provides convergence between Studies One and Two and Studies Three and Four.

The modified Sternberg task implicates the ability to flexibly update the contents of working memory in response to cues indicating changes to task relevant and task irrelevant material. The two level model of state and trait rumination outlined in Chapter Two predicted that trait rumination confers a benefit to tasks implicating goal maintenance and a deficit to tasks implicating cognitive flexibility. Moreover, individuals high in trait rumination are predicted to experience state rumination as more frequent, intense, and preoccupying and therefore be more susceptible to the hypothesised working memory load effects caused by state rumination. The two level model therefore generates the prediction that trait rumination moderates the impact of state rumination upon performance on the modified Sternberg task such that individuals higher in trait rumination would be more susceptible to performance deficits caused by state rumination. Study Five thus additionally constituted a preliminary examination of the predictions of the proposed two level model for cognitive flexibility.

In order to directly examine the prediction that state rumination reduces resistance to proactive interference on the modified Sternberg task, personal goal discrepancies were cued to manipulate rumination and thought probes assessing state rumination on the goal discrepancies were presented pseudo-randomly throughout the task. As in Studies Three and Four, the probes asked participants to report on the focus of their attention immediately before the probe. As with Studies Three and Four, a control condition in which a resolved goal was cued was included in order to directly contrast rumination about a personal goal discrepancy from the potential impact of other aspects of goal focus.

8.1.1 *Hypotheses*

Firstly, both past and on-going goal discrepancies were predicted to increase self-focus, therefore no differential effect of the goal manipulation was predicted on self-focused attention. As with Studies Three and Four, no specific predictions were made regarding the impact of goal-focused rumination upon sadness and tension during the modified Sternberg task as the measure of state rumination was not sensitive to whether rumination functioned as constructive problem solving (which might reduce sadness and tension) or had more passive and depressive content (which might increase sadness and tension).

Secondly, it was predicted that cueing an unresolved goal discrepancy would result in greater intrusive ruminative thoughts during the modified Sternberg task than cueing a resolved goal. Thirdly, it was predicted that trait rumination would modify the effect of the goal cueing manipulation on state rumination such that individuals high in trait rumination would report greater rumination about an unresolved goal than individuals low in trait rumination.

Fourthly, the critical prediction was that state rumination, as indexed by the thought probes in the modified Sternberg task, would act as a working memory load, causing poorer resistance to proactive interference. Specifically, it was predicted that individuals who were ruminating about unresolved goal discrepancies would take longer to resolve interference from recently processed but no longer relevant words on the modified Sternberg task than individuals cued with a resolved goal discrepancy. It was therefore predicted that intrusion effects (RT irrelevant probes – RT new probes) would be greater in the unresolved goal condition than in the resolved goal condition. The pattern of findings regarding whether the relationship between rumination and interference control is valence-specific or not is mixed, and is complicated by the fact

that the majority of previous studies have used depressed or dysphoric samples; as a consequence no specific predictions regarding the role of valence were made. Finally, in keeping with the two level model outlined in Chapter Two, it was predicted that trait rumination would moderate the impact of state rumination upon interference, such that individuals high in trait rumination would be more susceptible to interference control impairments caused by state rumination.

8.2 *Method*

8.2.1 *Participants*

58 participants were recruited from the University of Exeter student population, and received course credit or £10 for participating. Participants were required to have normal or corrected to normal vision. As with Studies One, Two, Three, and Four, participants were excluded if they reported severe head trauma or learning difficulties. No specific exclusion criteria were applied regarding current or lifetime mental health difficulties.

8.2.2 *Measures and Materials*

As in Studies One, Two, Three and Four, the BDI-II was administered to index depressive symptoms and the RRS indexed trait depressive rumination. As in Studies Three and Four, visual analogue scales were used to assess current levels of sadness, tension, and self-focus. The goal cueing task was the same as that adopted in Studies Three and Four.

The modified Sternberg task used was the same as that used by Joormann and Gotlib (2008) and as that used in Studies One and Two with the following changes:

First, an additional block was included so the task comprised four blocks of 40 trials in total with a break between each block. As in Studies One and Two the valence of the probe word was varied (positive or negative) as was the source of the probe word (relevant list, irrelevant list, or a new word that was not presented during the learning phase). The modified Sternberg task had a 2 (probe valence: positive, negative) x 4 (probe relevance: relevant, intrusion, new positive, new negative) design resulting in eight different experimental conditions; a ninth (unanalysed) control condition presented lists of mixed valence. Each experimental condition was presented four times in each block, and the control condition is presented eight times in each block. The difference in RT between new words and intrusion words was used to index the strength of residual activation of words from the to-be-ignored list in working memory.

Secondly, as in Studies Three and Four, the task was adapted to measure state rumination through the insertion of thought probes. Participants were pseudo-randomly (following 40% of trials within each block, resulting in a total of 56 probes) probed regarding the focus of their attention immediately prior to the probe. The probes asked participants to select from six response options, which were explained before the task, to describe what they were thinking about just before the probe. These options were: (a) task (i.e., the stimuli or appropriate response); (b) task performance; (c) current physical state (i.e., conditions such as hunger or sleepiness); (d) the concern identified and thought about in the previous task (i.e., the unresolved/resolved goal, and our index of state rumination); (e) other personal worries that were not connected to the problem identified in the previous task; (f) other thought types. Participants pressed a key corresponding to the option that best described the focus of their attention. Participants additionally rated their mood and degree of self-focus following each probe using bipolar computerized scales where they pressed the key (1-9) that best described their

degree of sadness, tension, and self-focus respectively. The task took approximately 50 minutes to complete.

8.2.3 *Design and Procedure*

The study had a between subjects design with one main independent variable: goal condition (resolved vs. unresolved goal). Critical dependent variables were state rumination reported during thought probes and error rate and reaction time data for new and intrusion probes during the modified Sternberg task.

Participants first completed the BDI-II and RRS. Then they completed the goal cueing task followed by the modified Sternberg task. Participants were randomly allocated to the unresolved or resolved goal condition. Before and after completing the goal manipulation, participants rated their current level of sadness, tension, and self-focus using the visual analogue scales.

As with Studies One, Two, Three, and Four, a funnelled debriefing was used such that participants were first asked to guess the purpose of the study and whether they believed that any of the tasks were related in any way, and if so in what way. During the debriefing, no participant reported any suspicions that there were two versions of the goal cueing task. Following this, participants were fully debriefed and the goal manipulation and hypotheses were explained.

8.3 *Results*

8.3.1 *Participant characteristics*

58 participants (38 females and 20 males) contributed to the full dataset. 29 participants completed the unresolved goal cueing task, and 29 completed the resolved

goal cueing task. The mean BDI-II of the sample was 7.57 (SD = 7.57; range 0-34) and mean RRS was 43.52 (SD = 12.31; range 24-70). The mean age of the sample was 25.28 years (SD = 7.27; range 18-59 years) and the goal conditions did not differ in age, $t(56) = 0.11, p = 0.92$. The two goal conditions did not differ in self-reported symptoms of depression, $t(56) = 0.12, p = 0.91$, or trait rumination, $t(56) = 0.77, p = 0.45$. Table 8.1 reports the mean levels of depressive symptoms and trait tendencies to ruminate in each goal condition.

It was confirmed that the two goal conditions reliably differed in their evaluations of their current level of concern regarding the goal that was focused on in the goal cueing manipulation: participants in the unresolved goal condition reported having more thoughts of the concern in the past week, $t(56) = 20.23, p < 0.001; M = 7.48, SD = 0.95$, than participants in the resolved goal condition ($M = 1.90, SD = 1.14$), and being more bothered by the concern, $t(56) = 20.10, p < 0.001; M = 7.03, SD = 1.05$, than participants in the resolved goal condition ($M = 2.00, SD = 0.85$). There was no effect of goal condition on participants' evaluations of how much the concern had bothered them when at its worst, $t(52.077) = 0.59, p = 0.555$, or the importance of the concern, $t(56) = 1.57, p > 0.123$. Thus, participants in the two goal conditions did not differ in subjective evaluations of aspects of the nature or severity of the concerns identified, but participants who were asked to think about an unresolved goal reported that the concern was one that was bothering them more than participants who were asked to think about a resolved concern. Participants in the resolved goal condition reported a greater mean duration of the concern, $t(35.998) = 2.55, p = 0.015 (M = 54.38, SD = 80.58^8)$, than participants in the unresolved goal condition ($M = 13.62, SD$

⁸ This difference remained significant when four outliers were excluded, thus the results based on the full sample are reported.

= 30.77). Participants in the unresolved goal condition reported that their concern was more related to other problems, $t(56) = 2.69$, $p = 0.010$ ($M = 5.90$, $SD = 2.18$), than participants in the resolved goal condition ($M = 4.41$, $SD = 2.03$).

Table 8.1: *Mean depressive symptoms, trait rumination, and ratings of sadness, tension, and self-focus (standard deviations in parentheses)*

Measure	Unresolved goal focus	Resolved goal focus
BDI-II	7.45 (7.81)	7.69 (7.47)
RRS	42.26 (13.34)	44.76 (11.29)
Baseline Sadness	-1.07 (1.71)	-1.57 (1.13)
Post Manipulation Sadness	0.59 (1.66)	-0.24 (1.57)
Baseline Tension	-1.31 (2.05)	-1.21 (1.66)
Post Manipulation Tension	0.38 (1.97)	-1.24 (1.68)
Baseline Self-Focus	0.31 (1.97)	0.45 (1.33)
Post Manipulation Self-Focus	1.55 (1.84)	0.69 (1.71)

BDI-II = Beck Depression Inventory II, RRS = Ruminative Responses Scale

8.3.2 *Effects of goal manipulation on mood and self-focus*

Mood and self-focus ratings were centred around zero such that positive scores represent sadness/tension/high self-focus and negative scores represent happiness/relaxation/low self-focus. 2 (goal condition: resolved, unresolved) x 2 (time: pre goal manipulation, post goal manipulation) mixed ANOVAs were conducted to examine the effects of the goal manipulation on sadness, tension and self-focus.

There was a significant main effect of time, $F(1, 56) = 51.72, p < 0.001$, reflecting worsening of sadness pre- to post- goal manipulation (Table 8.1). There was a trend towards an effect of goal condition on sadness, $F(1, 56) = 3.68, p = 0.060$, reflecting greater sadness in the unresolved goal condition. Thus, surprisingly, the unresolved goal condition reported slightly higher baseline levels of sadness. The goal condition by time interaction was not significant, $F(1, 56) = 0.62, p = 0.433$. Thus, the goal manipulations did not reliably differentially impact on participants' sadness immediately after goal discrepancies were cued.

There was a significant main effect of time on tension, $F(1, 56) = 14.91, p < 0.001$, and a trend towards an effect of goal condition, $F(1, 56) = 3.03, p = 0.087$. This was qualified by a significant interaction, $F(1, 56) = 16.18, p < 0.001$. Simple effects analyses revealed that this reflected a significant increase in tension in the unresolved goal condition, $F(1, 56) = 31.08, p < 0.001$, and no significant change in the resolved goal condition, $F(1, 56) = 0.01, p = 0.910$ (see Table 8.1). Thus the goal manipulations differentially impacted upon participants' self-reported tension.

There was a significant main effect of time on self-focus, $F(1, 56) = 7.48, p = 0.008$, reflecting an increase in self-focus following the goal manipulation. The effect of goal condition was not significant, $F(1, 56) = 0.99, p = 0.324$. There was a trend towards an interaction, $F(1, 56) = 3.40, p = 0.070$. Simple effects analyses revealed that this reflected a significant increase in self-focus in the unresolved goal condition, $F(1, 56) = 10.49, p = 0.002$, but not in the resolved goal condition, $F(1, 56) = 0.40, p = 0.531$. Thus, contrary to predictions, the goal manipulation differentially impacted on self-focused attention immediately after the manipulation. Table 8.1 details the mean ratings before and after the goal manipulation for each condition.

8.3.3 *Mood and self-focus during the modified Sternberg task*

Sadness, tension, and self-focus scores were centred around zero such that positive scores reflect greater sadness, tension and less self-focus, and negative scores reflect greater happiness, calmness and self-focus. There was a significant effect of goal condition on sadness, $t(56) = 2.15$, $p = 0.036$, reflecting less happiness in the unresolved goal condition ($M = -0.19$, $SD = 0.94$) than in the resolved goal condition ($M = -0.81$, $SD = 1.22$). However, there was a trend towards a baseline group difference in sadness and a 2 (goal condition) x 2 (time: baseline sadness, sadness during the SART) revealed that the interaction of goal condition and time was not significant, $F(1, 56) = 0.12$, $p = 0.735$. Thus group differences in sadness appear to be attributable to baseline differences as opposed to a consequence of the goal manipulation. There was no effect of goal condition on tension, $t(56) = -1.67$, $p = 0.101$, or self-focus, $t(56) = -0.73$, $p = 0.470$, to the probes in the Sternberg task. Thus, on-going goal discrepancies did not worsen mood during the modified Sternberg task.

8.3.4 *State rumination to probes during the modified Sternberg task*

T-tests were conducted to examine the differential impact of the goal manipulation on thought content and state rumination during the modified Sternberg task. There was a significant effect of goal condition on rumination during the modified Sternberg task, $t(30.741) = 2.72$, $p = 0.011$ ⁹. Participants in the unresolved goal condition reported more thoughts of the concern focused on during the goal manipulation ($M = 5.17$, $S.D. = 8.14$) than participants in the resolved goal condition

⁹ This analysis remained significant when two outliers were corrected to three standard deviations from the mean, and also when they were excluded from the analysis, consequently the analysis on the uncorrected data is reported.

($M = 0.97$, $S.D. = 1.80$). There was no effect of goal condition of reports of any other thought type (task: $p > 0.5$; task performance: $p > 0.1$; physical state: $p > 0.2$; other worries: $p > 0.8$; all other thoughts: $p > 0.6$). On average, participants in the unresolved goal condition reported ruminative thoughts on 9.23% of probes, relative to thoughts about the cued goal on 1.73% of probes in the resolved goal condition. Thus, as predicted, the differential effects of cueing resolved and unresolved goals on subsequent state rumination that were observed in Studies Three and Four were replicated in Study Five.

A 2 (goal condition: resolved, unresolved) x 4 (time: block 1; block 2; block 3; block 4) mixed ANOVA on ruminative responses to the thought probes revealed a significant main effect of goal condition, $F(1, 56) = 7.39$, $p = 0.009$, reflecting greater rumination in the unresolved goal condition than the resolved goal condition. The effect of time was not significant, $F(2.33, 130.49) = 1.40$, $p = 0.251$, and neither was the interaction, $F(2.33, 130.49) = 0.31$, $p = 0.768$. Thus, the differential impact of the goal manipulations on participants' ruminative thoughts during the task appears to have persisted across the four blocks (see Figure 8.1).

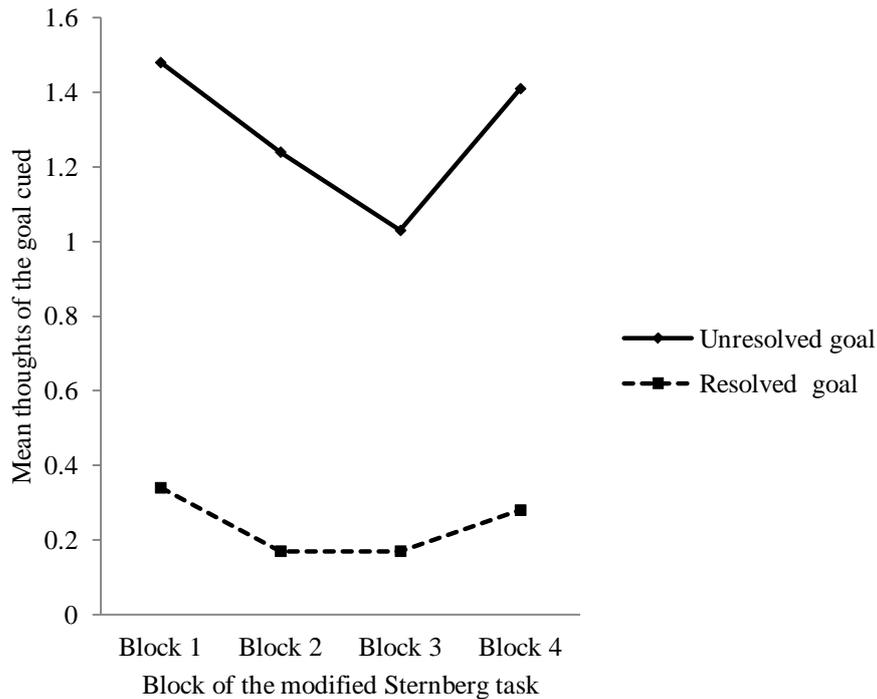


Figure 8.1: Mean goal-related ruminative thoughts as a function of time.

8.3.5 Trait rumination and state rumination during the modified Sternberg task

Hierarchical regression was used to examine whether trait rumination moderated the effect of the goal manipulation on rumination during the modified Sternberg task (Table 8.2). Goal condition (1: unresolved goal, 0: resolved goal) and centred RRS scores (RRSc) were entered in block one of the regression, and the interaction term (goal condition x RRSc) in block 2. The interaction term did not explain a significant increase in variance of state rumination, $\Delta R^2 < 0.001$, $F(1, 54) = 0.008$, $p = 0.928$ ¹⁰. Thus, trait rumination was not a significant moderator of the effect of the goal manipulation on ruminative thoughts during the modified Sternberg task.

¹⁰ This result was not qualitatively different when two outliers were corrected to three standard deviations from the mean and when they were excluded from the analyses; consequently the result with the uncorrected data is reported.

Table 8.2: *Hierarchical linear regression estimating state rumination during the modified Sternberg*

	B	S.E.	β
Step 1			
Goal Condition	4.35**	1.56	0.35
RRSc	0.06	0.06	0.12
Step 2			
Goal Condition	4.35**	1.57	0.35
RRSc	0.05	0.10	0.10
Condition x RRSc	0.01	0.13	0.02

Step 1: $F(2, 55) = 4.11, p = 0.022, R^2 = 0.13$

Step 2: $F(3, 54) = 2.68, p = 0.055, R^2 = 0.13$

* $p < 0.05$, ** $p < 0.01$

8.3.6 Error rates on the modified Sternberg task

Consistent with Joormann and Gotlib (2008), overall error rates were low (resolved goal: 9.38%; unresolved goal: 12.37%). A 2 (goal condition: resolved, unresolved) x 2 (probe valence: positive, negative) x 2 (probe relevance: new, intrusion) ANOVA was conducted to compare accuracy of responses to intrusion probes (i.e., probes from the irrelevant list; task conditions 3 and 4) with responses to new probes of the same valence (task conditions 6 and 8). Consistent with Joormann and Gotlib (2008), there was a significant main effect of probe relevance, $F(1, 56) = 75.22, p < 0.001$, reflecting greater accuracy when responding to new probes ($M = 98.95\%$), than to intrusion probes ($M = 92.67\%$). There were no other significant main effects or

interactions (all $F_s < 2.4$, all $p_s > 0.13$). Consequently, accuracy in responding to each of the probe types did not reliably vary according to goal manipulation.

8.3.7 *Decision latencies to relevant probes*

As with Studies One and Two, for all conditions, analyses of decision latencies were restricted to trials on which participants made correct responses. A square-root transformation was not indicated by histograms and normality tests; however analyses were repeated with a square-root transformation applied in order to ensure consistency with the data-analytic approach adopted in Studies One and Two. The results of the analyses with and without the transformation applied were not qualitatively different; consequently analyses on the untransformed data are reported.

There is no theoretical reason to predict an effect of rumination on decision latencies to relevant probes since responses to relevant probes do not involve the deployment of interference control processes. It was thus predicted that decision latencies to relevant probes would not be sensitive to the effects of state rumination. As expected, a 2 (goal condition: resolved, unresolved) x 2 (probe valence: positive, negative) mixed ANOVA on decision latencies to relevant probes identified no significant main effects or interactions (all $p_s > 0.19$), indicating that for both goal conditions, participants' responses to relevant probes did not significantly differ according to probe valence, $F(1, 56) = 0.14$, $p = 0.712$.

8.3.8 *Decision latencies to irrelevant probes*

In order to test the hypothesis that state rumination acts as a working memory load thereby depleting interference control capabilities, a 2 (goal condition: resolved, unresolved) x 2 (probe valence: positive, negative) x 2 (probe relevance: new,

intrusion) ANOVA was conducted on decision latencies to irrelevant probes. There was a significant main effect of probe relevance, $F(1, 56) = 129.62, p < 0.001$, reflecting longer decision latencies to intrusion probes ($M = 1471.25$) than to new probes ($M = 978.93$), replicating previous findings. There were no other significant main effects or interactions (all p s > 0.13). Contrary to predictions, participants in the unresolved goal condition did not exhibit greater interference from either positive or negative intrusion probes than participants in the resolved goal condition, $F(1, 56) = 2.19, p = 0.144$ ¹¹. Table 8.3 reports mean decision latencies to positive and negative irrelevant probes for each goal condition.

Table 8.3: *Mean decision latencies to positive and negative intrusion probes (standard deviations in parentheses)*

	Unresolved goal	Resolved goal
Positive intrusions	1571.76 (686.10)	1353.59 (356.61)
Negative intrusions	1611.99 (778.87)	1347.68 (368.24)
New positive	1062.65 (512.91)	920.39 (261.95)
New negative	1008.36 (416.11)	924.32 (236.31)

Linear regression was conducted to examine the prediction that trait and state rumination interact to impair flexible updating of working memory as indexed by positive and negative intrusion effects on the modified Sternberg task. Goal condition and centred RRS scores (RRSc) were entered in step one, and their interaction (goal

¹¹ These analyses were re-run with two potential outliers corrected to three standard deviations from the mean and with those individuals excluded; in both cases, the results were not qualitatively different, consequently the uncorrected data are reported.

condition x RRS_c) in step two. The models were a poor fit (all R^2 's < 0.08), and did not explain a significant proportion of variance in either positive (p 's > 0.6) or negative (p 's > 0.14) intrusions. Neither trait rumination nor the interaction of state and trait rumination significantly predicted resistance to proactive interference on the modified Sternberg task (β 's < 0.17, p 's > 0.2).

8.4 Discussion

Study Five was designed to examine the prediction that state rumination about personal goal discrepancies acts as a working memory load thereby depleting interference control capabilities on the modified Sternberg task. Specifically, it was predicted that on-going rumination about a personal goal discrepancy would result in difficulties resolving interference from previously relevant material causing longer decision latencies to intrusion probes (words from a recently processed but irrelevant list), relative to an resolved goal condition. Due to the mixed findings regarding rumination and valence-specific effects, and the findings of non-valence specific effects in non-dysphoric samples (e.g., De Lissnyder et al., 2012), no specific predictions were made regarding whether intrusion effects would be specific to negative words, or observed for both positive and negative intrusions.

As in Studies Three and Four, the goal manipulation was successful in manipulating state rumination. Contrary to predictions, there was no evidence that ruminating about personal goal discrepancies caused performance deficits on the modified Sternberg task. Thus, consistent with the findings of Studies Two, Three, and Four, Study Five found no evidence to support an *impaired-interference control-as-a-consequence-of-rumination* account of the relationship between rumination and

interference control. Whilst the absence of evidence does not in itself equate to evidence of absence, an important next step would be the direct examination of *impaired-interference-control-as-cause-of-rumination* accounts, developing recent longitudinal studies (e.g., De Lissnyder et al., 2012).

Consistent with the findings of Studies Three and Four, cueing an on-going personal goal discrepancy elicited state rumination, as indexed by thought probes, relative to cueing a resolved goal.

In contrast to the findings reported in Chapters Six and Seven, the impact of the goal cueing manipulation upon subsequent state rumination was not moderated by trait rumination; individuals higher in trait rumination did not ruminate more in response to a personal goal discrepancy than individuals lower in trait rumination. There is no obvious explanation for this discrepancy between Study Five and Studies Three and Four in terms of statistical power, since the sample size in Study Five was not smaller than that in Studies Three or Four, the mean levels of trait and state rumination were not lower, and the range of responses on both the RRS and the thought probes was not smaller. Trait rumination is hypothesised to be characterised by repetitive focus on the abstract higher level causes, consequences and meanings of personal goal discrepancies, whereas ruminating on the concrete specific steps that might help reduce goal discrepancies is hypothesised to be constructive and is not implicated in trait rumination (e.g., Watkins, 2008; 2010). The measure of state rumination adopted in Studies Three, Four, and Five does not assess process or outcome aspects of rumination that examine whether state rumination is consistent with RST characterisations of depressive self-focus. Studies that include a direct examination of process aspects of state rumination are needed in order to clarify the interaction between trait rumination and personal goal

discrepancies in causing state rumination and potential proximal mediators or moderators of this relationship.

Interestingly, and consistent with the findings of Study Three, there was little evidence to suggest that state rumination had negative affective consequences. Individuals in the unresolved goal condition reported increased tension after the goal manipulation but there were no group differences in tension during the modified Sternberg task and the reduced happiness during the modified Sternberg task relative to individuals in the resolved goal condition was attributable to baseline group differences (it is additionally of note that on the bipolar mood scales, overall mood levels in both conditions were rated as within the positive end of the scale). This is consistent with control theory conceptualizations of rumination (e.g., Carver & Scheier, 1998) which emphasise more functional aspects of rumination as a form of problem solving. In summary, consistent with the findings of Studies Three and Four, these results suggest that state rumination about personal goal discrepancies does not impair interference control capabilities on the modified Sternberg task. Thus, no evidence was found to support an *impaired-interference control-as-a-consequence-of-rumination* account of the relationship between rumination and interference control. The findings additionally do not support the two level model of state and trait rumination proposed in Chapter Two. Consistent with the findings of Study Three, but not Study Four, there was little evidence that state rumination worsened mood. Further research is needed to clarify the nature of the relationship between state rumination and affect regulation. Finally, in contrast to the findings of Studies Three and Four, the effect of the goal manipulation on subsequent state rumination was not moderated by individual differences in trait rumination.

CHAPTER NINE: *General Discussion*

9.1 Summary of thesis findings

The primary aim of the thesis was to examine the causal nature of the relationship between rumination and interference control processes that implicate the theoretical construct of inhibition. Considerable research demonstrates an association between trait rumination and tasks requiring the control of interference, but there is little evidence regarding proposed causal accounts of this relationship. Five studies examined the prediction that state rumination causally impairs performance on concurrent demanding executive tasks. Studies One and Two examined the causal effect of induced depressive rumination on resistance to proactive interference in dysphoric and non-dysphoric individuals. Studies Three and Four examined the causal effect of induced rumination about personal goal discrepancies on prepotent response inhibition in unselected samples. Study Five examined the causal effect of induced rumination about personal goal discrepancies on resistance to proactive interference in an unselected sample. Studies One, Two and Five examined the ability to resolve interference from emotional material thereby providing the first experimental examination of the causal impact of state rumination on interference control when processing emotional stimuli. Studies Three and Four examined interference control when processing neutral stimuli. Table 9.1 summarise the main hypotheses and findings of each of the thesis studies.

Table 9.1 *Summary of thesis findings*

Study	Sample	Manipulation	Cognitive task	Interference sub-type	Materials	Prediction	Finding
1	Dysphoric and non-dysphoric adults	Instructed rumination and distraction tasks	Modified Sternberg task	Resistance to proactive interference	Positive and negative words	Relative to distraction induced rumination impairs resistance to proactive interference in dysphoric adults	Affective consequences of rumination manipulation no longer evident during cognitive task therefore unable to examine prediction
2	Dysphoric and non-dysphoric adults	Instructed rumination and distraction tasks	Modified Sternberg task	Resistance to proactive interference	Positive and negative words	Relative to distraction induced rumination impairs resistance to proactive interference in dysphoric adults	Affective consequences of rumination manipulation sustained. No differential effects of rumination and distraction on resistance to proactive interference
3	Unselected sample	Goal-cueing manipulation (resolved vs unresolved goals)	Modified SART	Prepotent response inhibition	Neutral words	Relative to the control condition, uninstructed rumination impairs prepotent response inhibition	Differential effect of goal manipulation on uninstructed rumination. Rumination condition slower and more accurate on SART
4	Unselected sample	Goal-cueing manipulation	Modified SART (constrained)	Prepotent response inhibition	Neutral words	Relative to the control condition, uninstructed rumination impairs prepotent response inhibition	Differential effect of goal manipulation on uninstructed rumination. No differences in error rates, rumination condition faster.
5	Unselected sample	Goal-cueing manipulation	Modified Sternberg task	Resistance to proactive interference	Positive and negative words	Relative to the control condition, uninstructed rumination impairs resistance to proactive interference	Differential effect of goal manipulation on uninstructed rumination. No group differences in resistance to proactive interference

Study One used Nolen-Hoeksema and Morrow's (1993) rumination and distraction inductions to examine the impact of state rumination upon performance on a modified Sternberg task in dysphoric and non-dysphoric individuals. According to a structural interference account of the proposed causal impact of rumination upon performance on cognitive tasks (e.g., Philippot & Brutoux, 2008), performance is most likely to be impaired on tasks that constitute clear measures of the processes that are most theoretically relevant to rumination. Rumination is conceptualised as involving repetitive activation and focus on information pertaining to personal goal discrepancies that are not necessarily relevant to one's current task. Resistance to proactive interference is therefore especially relevant to rumination (Friedman & Miyake, 2004). The modified Sternberg task (Oberauer, 2001, 2005) was selected because it is a relatively clear measure of resistance to proactive interference. Consistent with previous studies (e.g., Watkins & Teasdale, 2001), state rumination was inferred from self-reported worsened mood and increased self-focus relative to the distraction induction.

It was hypothesized that dysphoric participants in the rumination condition would demonstrate impaired performance on the modified Sternberg task relative to dysphoric participants in the distraction condition and to non-dysphoric participants. However, it was not possible to examine this hypothesis. In keeping with the proposal that effortful cognitive tasks interfere with rumination and act as a form of distraction (e.g., Hertel, 1998), Study One found that the effects of the rumination induction on mood and self-focus were no longer evident during the modified Sternberg task. As a consequence, the study was unable to reliably assess whether state rumination impaired interference control during the modified Sternberg task.

Study Two was designed to overcome this difficulty through modifications to the experimental paradigm that removed the distraction of learning a new task after the

inductions, and encouraged participants to continue ruminating during the modified Sternberg task. Further, a more dysphoric sample was recruited for this study. Study Two was successful in overcoming the difficulties in sustaining the effects of the rumination manipulations on mood that were observed in Study One. However, as in Study One, there was no evidence that induced rumination impaired task performance amongst dysphoric individuals, relative to the other experimental cells. The findings were thus not consistent with the hypothesis that state rumination contributes to impaired interference control, at least on the modified Sternberg task.

A particular limitation of past research examining the consequences of state rumination, and of Studies One and Two is the lack of a direct means of assessing state rumination, necessary to confirm that the manipulations of rumination were effective as intended. Moreover, the standard Nolen-Hoeksema and Morrow (1993) rumination induction explicitly instructs focus on self, feelings and symptoms and therefore does not disentangle the possible consequences of rumination from the consequences of depression, in individuals with elevated depression symptoms. Therefore, Studies Three to Five adopted a more powerful and personally relevant goal-based rumination manipulation that did not implicate depressive symptomology, and included a direct measure of state rumination in order to address these limitations.

Study Three sought to develop and validate a direct measure of state rumination through the insertion of thought probes into a cognitive task. Study Three additionally sought to develop a rumination manipulation that was focused on personally-relevant active concerns as opposed to depressive symptoms. By utilising a manipulation focused on personal goal discrepancies and examining uninstructed rumination, the manipulation was intended to be both more powerful and a more ecologically valid analogue to rumination in everyday life. Additionally, the study directly examined the

consequences of rumination, as opposed to relying on affective outcomes as a proxy from which rumination is inferred.

Study Three examined the impact of state rumination on personal goal discrepancies on performance on a task that implicates prepotent response inhibition (the Sustained Attention to Response Task, SART; Robertson, Manly, Andrade, Baddeley, & Yiend, 1997) in an unselected sample. It has been argued that inhibition is most clearly implicated in the withholding of prepotent responses (e.g., Aron, 2007). The SART was therefore selected as a task implicating prepotent response inhibition and thus of particular relevance to examining the proposal that state rumination plays a causal role in the proposed relationship between rumination and inhibitory deficits. Personal goal discrepancies were predicted to elicit state rumination during the SART. State rumination was predicted to occupy working memory capacity, thereby impairing prepotent response inhibition relative to a non-ruminative control condition.

The rumination manipulation was successful: participants cued with on-going personal goal discrepancies reported greater rumination on their goals on the thought probes during the modified SART than participants cued with a past goal discrepancy. Participants cued with an unresolved goal were both slower and more accurate on the modified SART than participants cued with a past resolved goal; consequently it was unclear whether rumination impaired or enhanced task performance.

Study Four sought to address the differential speed accuracy trade-offs observed in Study Three in order to clarify the consequences of state rumination for performance on the modified SART. Following Manly and colleagues (2000), a tone was added to the task which cued responses; this was intended to reduce intraindividual reaction time variability and variations in speed accuracy trade-offs. Study Four was successful in eliminating group differences in speed accuracy trade-offs and found no evidence that

rumination impaired performance on the modified SART (no group differences in error rates) and some evidence that inducing rumination may have enhanced performance (participants in the unresolved goal condition tended to exhibit faster RTs than those in the resolved goal condition). The findings were thus not consistent with the hypothesis that state rumination contributes to impaired interference control, at least in terms of prepotent inhibition on the SART.

Study Five sought to examine the impact of the more powerful goal-based manipulation of state rumination developed in Study Three on the modified Sternberg measure used in Studies One and Two, a measure that implicates processes that are of clear theoretical relevance to state rumination. Study Five examined the hypothesis that state rumination impairs performance on a clear measure of resistance to proactive interference using a direct measure of state rumination. Dual-task interference is greatest when the tasks share a common processing domain (e.g., Baddeley & Logie, 1999), therefore the modified Sternberg task was selected as a task that implicates processes of theoretical relevance to rumination (i.e., repetitive retrieval and activation of verbal emotional content). As in Studies Three and Four, the rumination manipulation was successful, producing prolonged state rumination. However, contrary to the hypothesis, there was no evidence that state rumination impaired performance on the modified Sternberg task.

Together with Study Two, Study Five therefore provided convergent evidence across two means of manipulating rumination (the standard Nolen-Hoeksema manipulation adopted in Studies One and Two and the goal-focused manipulation adopted in Study Five) regarding the prediction that induced rumination impairs resistance to proactive interference on the modified Sternberg task.

9.2 Discussion of thesis findings

The five experiments reported in the thesis manipulated rumination on depressive symptoms and on personal goals in dysphoric and unselected samples in order to test the hypothesis that rumination occupies working memory resources (i.e., the *impaired-interference-control-as-consequence-of-rumination hypothesis*), thereby depleting cognitive control capabilities necessary for the performance of concurrent effortful tasks (Hartlage, Alloy, Vasquez, & Dykman, 1993; Hertel, 2004; Watkins & Brown, 2002). The causal impact of state rumination was examined on measures of interference control that implicate different inhibitory sub-types: resistance to proactive interference from positive and negative material, and prepotent response inhibition on a go/no-go paradigm. No evidence was found to support the prediction that state rumination causes difficulties resolving interference from irrelevant emotional material (Studies One, Two, and Five) or inhibiting prepotent responses relative to non-ruminative control conditions (Studies Three and Four). There was some tentative evidence to suggest that ruminating on personal goal discrepancies increased efficiency in inhibiting prepotent responses (Study Four). Whilst the absence of evidence does not equate to evidence of absence, the convergence across five studies suggests that models proposing a causal impact of state rumination on available working memory capacity are insufficient to fully account for the established association between the trait tendency to ruminate and increased susceptibility to interference from irrelevant material.

Studies One, Two and Five found no evidence that a causal effect of state rumination upon interference control is responsible for the established association between trait rumination and resistance to proactive interference on the modified

Sternberg task. Previous experimental studies of the relationship between rumination and interference control have found different patterns of effects when examining the causal effect of induced rumination on interference control tasks from those reported in correlational studies adopting the same measures (Whitmer & Gotlib, 2012; Wong & Moulds, 2009). Taken together, these patterns of findings suggest that an *impaired-interference-control-as-consequence-of-rumination* hypothesis is insufficient to fully account for the extant data correlating trait rumination and interference control processes.

Consistent with the findings of Zetsche, D'Avanzato and Joormann (2012), Study Two found no evidence that dysphoric individuals experienced greater difficulties resolving proactive interference than non dysphoric individuals. However, in contrast to Zetsche et al.'s report of a correlation between trait rumination and difficulties discarding no longer relevant material from working memory, when the relationship between rumination and resistance to proactive interference was examined experimentally there was no evidence to suggest that manipulating rumination impaired such abilities. This was the case both for rumination focused on depressive symptoms (Study Two) and rumination on personal goal discrepancies (Study Five).

Previous studies that have found evidence that state rumination impairs cognitive control have used depressed (Watkins & Brown, 2002; Whitmer & Gotlib, 2012) and dysphoric (Hertel, 1998; Philippot & Brutoux, 2008) samples. Depressed individuals are at increased susceptibility to rumination and it is possible that state rumination is especially persistent and depleting for depressed individuals and less problematic for individuals who are not susceptible to depressive episodes (e.g., Koster, De Lissnyder, Derakshan, & De Raedt, 2011). As a consequence, state rumination might impair interference control in depressed and dysphoric individuals, but not in

non-depressed individuals. According to this interpretation, the absence of evidence for an *impaired-interference-control-as-consequence-of-rumination* hypothesis in Studies Three to Five might be partially attributable to the use of unselected samples. However, it is less clear that this prediction can account for the findings of Study Two given the previous data indicating that state rumination impairs interference control in dysphoric samples (Philippot & Brutoux, 2008).

Of the five previous studies that have experimentally examined the prediction that state rumination impairs cognitive control, two have not included a manipulation check (Hertel, 1998; Philippot & Brutoux), one reported that rumination worsened mood relative to distraction but did not report levels of self-focus (Whitmer & Gotlib, 2012), one reported that rumination increased self-focus relative to distraction but did not differentially impact on mood (Wong & Moulds, 2009), and one reported a differential effect of the manipulations on both mood and self-focus (Watkins & Brown, 2002). Thus, it is not clear that the manipulations were reliably operating in the same manner across these studies, and none of the studies include a direct measure of rumination.

Two of these studies used clinically depressed samples (Watkins & Brown, 2002; Whitmer & Gotlib, 2012), which would be expected to differ in significant ways from the dysphoric and unselected samples examined in the studies reported in the thesis. Of the two studies that used samples more closely analogous to those of Studies One and Two, one reported a violation to one of the assumptions used to calculate controlled processing (Hertel, 1998), and one reported a differential effect of rumination relative to distraction on the Stroop (Philippot & Brutoux, 2008). The study that used a sample more closely analogous to those of Studies Three to Five (Wong & Moulds, 2009) also reported no evidence that rumination impaired interference control. Thus,

taken together these ten experimental studies suggest that it is not clear that the evidence that state rumination impairs interference control in non-clinical populations is reliable and further investigation is needed to clarify how robust previous statistically significant results are.

Chapter Two proposed a two-level model of the impact of state and trait rumination on interference control processes. The two-level model first proposed that state rumination occupies working memory capacity, thereby impairing concurrent performance on tasks implicating interference resolution. Individuals high in trait rumination were predicted to be at increased vulnerability to these negative consequences of rumination because they would ruminate more frequently and intensely. Second, trait rumination was predicted to impair cognitive flexibility but enhance goal maintenance (e.g., Altamirano, Miyake, & Whitmer, 2010; Whitmer & Gotlib, 2012), and to bias information processing such that negative material is preferentially processed (e.g., Everaert, Koster, & Derakshan, 2012; Koster et al., 2011). However, across five studies, no evidence was found to support the predictions that state rumination impairs interference control and that trait rumination moderates this causal relationship.

Studies One, Two, and Five examined the causal impact of state rumination on a task that requires the flexible updating of working memory in response to changing task demands and found no evidence that state rumination impaired flexible processing on this measure.

Studies Three and Four examined the causal impact of state rumination on a measure that implicates the maintenance of a single task goal (withhold response for words in uppercase) without any goal reinforcement. Study Three was unable to determine whether state rumination was detrimental or beneficial to task performance

due to differential speed accuracy trade-offs between the ruminative and control conditions. Study Four found tentative evidence to suggest that rumination may have enhanced task performance relative to the control condition. Trait rumination was negatively correlated with decision latencies on the SART, although it did not moderate the effect of state rumination upon this measure. Whilst these findings are not quite significant and need replication, they constitute the first test of the prediction that state rumination causally enhances goal maintenance and lend some support to this hypothesis. The study therefore develops previous data indicating that high trait rumination is associated with reduced cognitive flexibility and enhanced goal maintenance relative to low trait rumination (Altamirano et al., 2010), and indicates that state rumination may play a causal role in enhancing goal maintenance. Future studies examining the causal impact of state rumination upon clear measures of goal maintenance and potential interactions with trait rumination in samples with a broader range of trait ruminative tendencies are needed to systematically test this relationship.

The studies found no evidence that induced rumination impairs interference control when processing either neutral or emotional stimuli. As a consequence, the studies found no evidence of either a general impairment to interference control, or a valence-specific bias for negative material. Study Two found no support for the prediction that for dysphoric individuals the negative consequences of state rumination upon interference control would be greatest in the context of negative stimuli. Future studies systematically examining this possibility in clinically depressed samples will be important in clarifying the potential role of depressive processing biases in the relationship between rumination and interference control.

Previous studies have reported evidence that interference control deficits are specifically related to the brooding subcomponent of trait rumination (e.g., De

Lissnyder, Koster, Derakshan, & De Raedt, 2010). In both Studies Three and Four, brooding but not reflection moderated the impact of the goal manipulation on state rumination such that individuals high in trait rumination reported greater intrusive thoughts about unresolved personal goals. However, Studies Three to Five found no evidence that trait brooding moderated the impact of state rumination upon either resistance to proactive interference on the modified Sternberg task (Study Five) or prepotent response inhibition on the modified SART (Studies Three and Four). Appendix Five reports these analyses in full. Taken together, the studies found no evidence to support the proposal that trait brooding is specifically associated with deficits in interference control processes as assessed using the modified Sternberg task and the modified SART.

Contrary to predictions there was a trend towards trait reflection moderating the impact of the goal manipulation upon errors of commission in Study Four, such that individuals high in trait reflection tended to be more susceptible to making errors in the unresolved goal condition. However, this unexpected finding was not quite statistically reliable, and there is no clear theoretical basis to predict such a pattern of findings. Thus, future work examining the possible role of trait reflection in the impact of state rumination on prepotent response inhibition and SART performance will be important in order to determine whether this is a reliable observation.

9.3 *Limitations of current studies*

First, the thesis only examined one of the proposed causal models of the association between rumination and interference control (*impaired-interference-control-as-consequence-of-rumination*). Additional studies examining the *impaired-*

interference-control-as-cause-of-rumination hypothesis were planned (see 9.9), but due to the time required to recruit dysphoric samples for Studies One and Two, and further studies to follow up unexpected patterns of results in Studies One and Three, examination of this prediction were beyond the scope of what was feasible within the PhD. Studies directly examining *impaired-interference-control-as-cause-of-rumination* models are clearly an important next step.

Second, one limitation of the empirical studies reported in the thesis is that they were only powered to detect medium to large effect sizes. It is of note that this is an issue observed in other studies in the field (e.g., Whitmer & Gotlib, 2012), and the current studies utilised sample sizes similar to those used in much rumination research (e.g., Lyubomirsky & Nolen-Hoeksema, 1995). This limitation partially reflects the time required to recruit substantial depressed or dysphoric samples without access to clinical facilities and databases (for example, Studies One and Two involved the screening, initial assessment, and then exclusion of over 150 participants due to not consistently meeting the specified mood criteria across the two assessment points – screening questionnaire and experimental session).

Third, the thesis studies used dysphoric and unselected samples as opposed to clinically depressed ones. The evidence regarding whether the association between trait rumination and interference control is specific to depressed individuals is mixed, and trait rumination in itself implicates depressive symptoms. The thesis findings therefore cannot be generalised to clinically depressed populations. Studies that examine the impact of state rumination using a direct measure of rumination (as in Studies Three - Five) in clinically depressed and never depressed samples are needed in order to examine the possible causal impact of state rumination upon interference control in depression.

Fourth, the findings of the thesis are limited to two measures of interference control. Whilst these tasks were selected as some of the clearer indices of interference control and to provide convergent data from distinct measures indexing different aspects of interference control, future studies adopting other relatively clear measures such as the Stroop task and the Stop-Signal task are needed in order to clarify the pattern of findings across multiple measures.

Fifth, the measure used to assess state changes in affect comprised a single bipolar scale which may be limited both in sensitivity and detail. Positive and negative affect can vary independently (e.g., Watson, Clark, & Tellegen, 1988), and both increases in negative affect and decreases in positive affect are common symptoms of depression and dysphoria. Future studies adopting separate measures of positive and negative affect such as the PANAS (Watson et al., 1988) will therefore be important in order to clarify the pattern of affective consequences of goal-focused and symptom-focused rumination.

Finally, whilst the goal manipulation and thought probe methodology adopted in Studies Three to Five had a number of advantages and was found to detect statistically reliable differential effects on uninstructed rumination, it is of note that the mean number of ruminative thoughts reported during the cognitive tasks was relatively low and that some participants reported no ruminative thoughts. Thus although these studies were successful in obtaining sustained group differences in self-reported ruminative thoughts during effortful and potentially distracting cognitive tasks, the low overall rates of ruminative thoughts might not constitute a sufficiently substantial cognitive load to detect reliable group differences in task performance.

9.4 *Implications of thesis findings for impaired-interference-control-as-consequence-of-rumination hypothesis*

The primary aim of the thesis was to systematically test an *impaired-interference-control-as-consequence-of-rumination* account of the established association between trait rumination and interference control by examining the impact of state rumination on clear measures of interference control. The *impaired-interference-control-as-consequence-of-rumination* hypothesis predicts that the observed relationship between trait rumination and interference control is due to trait rumination increasing the propensity to state rumination, which occupies working memory capacity and therefore impairs concurrent interference control. Working memory is understood to represent a capacity limited processing system (cf. James, 1890, Miller, 1956); therefore repetitive processing of personal goal discrepancies and repeated focus on self and symptoms (i.e., state rumination) would be predicted to reduce available capacity for processing of a concurrent task.

It is possible that rumination during dual task conditions may also invoke executive resources in order to switch away from intrusive ruminations in service of performing the primary task, thereby overloading or fatiguing the central executive. However, it is not possible to experimentally distinguish this possibility from a capacity-reducing account of the proposed impact of state rumination on cognitive tasks. There is some consensus that working memory does not represent a unitary construct (see Miyake & Shah, 1999), and there is evidence from dual task experiments that interference is greatest when both tasks implicate the same processing domain (e.g., verbal or visuo-spatial, see Baddeley & Logie, 1999). Consequently rumination-related task impairments would be predicted to be most likely when the task implicates the

proposed sub-components that are most theoretically relevant to rumination.

Specifically, greatest interference would be predicted on tasks that involve phonological processing and articulatory rehearsal (for example verbal memory tasks such as the modified Sternberg task, and complex tasks which benefit from rehearsal of the task demands) because rumination is assumed to involve a substantial verbal component (Harvey, Watkins, Mansell, & Shafran, 2004; Watkins & Brown, 2002).

Moreover, interference would be predicted to be most likely on measures that implicate processes that are theoretically relevant to rumination, since rumination and task performance would be predicted to share a common processing stage. The modified Sternberg task was hypothesised to constitute a measure of theoretical relevance to rumination and was therefore selected to examine this prediction in Studies One, Two and Five. The modified SART was selected to examine whether state rumination impairs prepotent response inhibition, which is the sub-type that is understood to most clearly implicate the theoretical construct of inhibition.

Across five studies, no evidence was found to support the hypothesis that the established association between trait rumination and interference control processes is a consequence of state rumination occupying working memory capacity and causing impairments to task-relevant processing. A major limitation of the majority of existing research in this area is the reliance on correlational designs and measures that cannot reliably distinguish the potential role of rumination from that of depressive symptoms.

Studies One to Five sought to address the limitations of existing correlational data through the use of fully experimental designs to examine the potential consequences of manipulating rumination for interference control. Studies Three - Five sought to overcome the limitations of reliance upon indirect measures of rumination that have significant affective components. Four of these studies were successful in inducing

rumination, and in all of these studies the cognitive task adopted performed as expected (i.e., the pattern of data observed in prior basic science studies using the paradigm was replicated). The studies were only powered to detect moderate to large effect sizes, although it is of note that this methodological limitation is not specific to the studies in the thesis; previous studies that have examined the impact of a variant of Nolen-Hoeksema and Morrow's (1993) rumination manipulations on interference control have been similarly powered (e.g., Whitmer & Gotlib, 2012). Moreover, the studies were sufficiently powered to detect other relevant effects (e.g., interactions with trait rumination, affective consequences of rumination in dysphoric individuals, potential enhanced task efficiency in Study Four).

Whilst the absence of evidence does not in itself equate to evidence of absence, the consistent null findings on the modified Sternberg task, and tentative evidence that state rumination may have enhanced performance of the modified SART suggest that existing *impaired-interference-control-as-consequence-of-rumination* models may be too simplistic and insufficient to fully account for the association between trait rumination and interference control. The convergence of evidence across the five experiments suggests that on balance of probability, it is unlikely that state rumination contributes to impaired interference control. The findings of the thesis therefore emphasise the importance of further systematic experimental examination of the predictions derived from the alternative causal directions such as *impaired-interference-control-as-cause-of-rumination*, which predicts that impaired interference resolution increases the vulnerability to both the initiation and maintenance of ruminative self-focus.

9.5 Implications of thesis findings for impaired-interference-control-as-cause-of-rumination hypothesis

The experiments reported in the thesis did not examine the predictions of the *impaired-interference-control-as-cause-of-rumination* hypothesis and therefore have limited implications for this predicted causal relationship. The central prediction of this causal hypothesis is that impaired interference control results in increased susceptibility to both the onset and maintenance of rumination. A major limitation to conducting such research to date has been the lack of a valid measure of state rumination. Studies Three to Five indicate the potential value of the use of variants of a goal-cueing procedure combined with thought probes in testing the hypothesis that impaired interference control increases susceptibility to uninstructed rumination. Future studies using cognitive training procedures and control-depleting manipulations (see 9.9 for detailed discussion) will be an important next step in developing a clearer understanding of the causal nature of the relationship between rumination and interference control.

9.6 Implications for a third factor (non-causal) model of rumination and cognitive control

It is possible that a third factor, such as low mood, depressive symptoms, or depressive schemata underpins both interference control deficits and ruminative response tendencies in depressed individuals. According to such an account, in the absence of the proposed third factor, rumination would not be predicted to be associated with interference control deficits.

For example, in contrast to models positing a direct causal association between rumination and executive control (e.g., Joormann, Yoon, & Gotlib, 2007), it has been proposed that depressive schema drive both the preferential processing of self-focused ruminations and processing biases for negative material in depressed individuals (e.g., Ingram, 1984; Everaert et al., 2012). Although Study Two examined the relationship between rumination and resistance to proactive interference from negative (and positive) information in a dysphoric sample, dysphoric individuals could be expected to differ clinically from individuals with a diagnosis of depression (for example, in duration of low mood, symptom severity etc.). Importantly, it is not clear that such individuals would have the well-established depressive schemas that are understood to characterise clinical depression (e.g., Beck, 2008). Future studies that directly examine the impact of interventions that specifically target maladaptive schemata (such as Schema Therapy; Young, Klosko, & Weishaar, 2003) or are established to modify depressive schemas (such as Cognitive Behavioural Therapy; Padesky, 1994) upon both information processing biases and the susceptibility to state rumination in depressed individuals will be useful in examining schema driven models of the association between rumination and interference control.

As discussed in Chapter Two, it has additionally been proposed that low mood may mediate the relationship between rumination and interference control deficits. In Studies Two and Four, rumination was found to worsen mood, but no evidence was found that either rumination, or its affective consequences, caused interference control deficits. Moreover, Study Two found no evidence that dysphoric mood impaired interference control processes. The findings of these studies are therefore not straightforwardly consistent with a model implicating low mood as mediating a causal effect of rumination on interference control. Future studies examining the potential

causal effect of interference control deficits upon rumination amongst depressed individuals will also need to address alternative accounts invoking a causal effect of low mood upon both interference control and rumination.

9.7 Methodological challenges and implications

One difficulty in determining the mechanisms underlying the established correlations between trait rumination and interference control measures is the lack of clarity regarding how trait rumination can be meaningfully conceptualised and operationalized in experimental research. State rumination is likely to be more frequent and intense in individuals high in trait rumination and therefore may have distinct consequences for high and low trait ruminators. However, trait rumination is by definition focused on depressive symptoms, and it remains unclear what trait rumination reflects in individuals who have never experienced depressive episodes and do not have significant depressive symptoms. It is possible that depressive or affective components of information processing drive the association between trait rumination and interference control; however, existing measures of trait rumination cannot fully disentangle a ruminative response style from past or existing presence of depressive symptoms and/or low mood.

Another established difficulty in examining the impact of state rumination upon performance on cognitive tasks is the potentially distracting effects of the task, which is likely to interfere with rumination. Studies Two to Five were somewhat successful in overcoming this difficulty. However, the possibility that the cognitive task was used as a distraction to attempt to block rumination cannot be ruled out and constitutes an alternative interpretation of the findings that rumination appeared to increase efficiency

of task performance in Study Four (although not in Studies Two or Five). It is difficult to find a means to assess cognitive interference that does not also have the potential to involve effortful processing and thereby to potentially disrupt state rumination. Whilst this is logically unavoidable, Studies Three, Four, and Five demonstrated that with a personally relevant uninstructed means to manipulate rumination, it was possible to sustain rumination sufficiently during such tasks to test the hypothesis that state rumination impairs concurrent interference resolution.

Third, whilst Studies Three to Five were successful in directly measuring intrusive ruminative thoughts and found these to repetitively reoccur, they did not directly examine the “stickiness” of these thoughts (i.e., how difficult they were to shift away from in order to reallocate attention to the task) and there was no evidence that rumination resulted in reductions in task-related thought relative to the control condition. Whilst the extent to which ruminative thoughts were recurrent provides some indication that they may have been difficult to disengage from and/or prioritised as important to focus on, the studies did not directly examine the prediction that ruminative thoughts inflexibly occupy attentional focus (Altamirano et al., 2010, Joormann, Levens & Gotlib, 2011).

A significant limitation in the field to date has been the lack of clear measures of state rumination. This is essential in order to experimentally test hypotheses regarding putative causes of rumination, including the predictions derived from *impaired-interference-control-as-cause-of-rumination* models. The procedures developed and validated in Studies Three – Five constitute a potentially useful step in addressing this difficulty and providing the means to directly examine potential proximal causes and moderators of the onset and maintenance of state rumination, such as depleted interference control.

A further notable methodological issue is establishing the construct validity of purported measures of interference control processes, and the extent to which these might invoke a theoretical inhibition construct. Models of rumination and interference control frequently invoke an inhibition or interference resolution construct, but these are often underspecified at the task level, with inhibition being invoked both as a phenomenon to be explained, and as the explanation for the theoretical construct. This leaves the issue of what constitutes a valid measure of the proposed construct controversial and difficult to determine. Few tasks clearly invoke an inhibition construct and successfully address non-inhibitory accounts of task performance (e.g., MacLeod, Dodd, Sheard, Wilson, & Bibi, 2003). Moreover, as noted in Chapter Two, measures of interference control processes frequently do not correlate with other measures purported to index the same processes, raising doubts over the convergent validity of such measures and indicating the need for further empirical work using multiple relatively clear indices of the specific process(es) in question.

9.8 Implications for theoretical models of rumination

The thesis findings have potential implications for a number of theoretical models of rumination. Specifically, the findings have potential implications for resource allocation models (e.g., Hartlage et al., 1993), control theory of rumination (e.g., Carver & Scheier, 1998; Watkins, 2008), Response Styles Theory (e.g., Nolen-Hoeksema, 1991), and the two level model proposed in Chapter Two.

Resource Allocation models

Resource allocation models of depression hypothesise that cognitive resources are preferentially allocated to ruminative thinking about personally important concerns and that this has negative consequences for the performance of effortful cognitive tasks (e.g., Hartlage et al., 1993). Studies Two – Five found no evidence that individuals preferentially allocate resources to ruminative thoughts at the expense of task performance. Whilst state rumination in response to different rumination inductions was observed, the rumination manipulations did not differentially impact on task-related thoughts and did not have negative consequences for task performance. Additionally, Study Three found no evidence that working memory capacity moderated the effect of induced rumination on interference control. It thus appears that individuals were able to shift their attention back and forth between task-relevant and ruminative thought content sufficiently effectively to prevent state rumination causing performance deficits on the task. It is possible that as a response to intrusive ruminations participants increased their efforts to perform the task well in an attempt to compensate for any potentially disruptive effects of rumination.

Hertel (2004) proposed that depressive deficits are greatest on unconstrained tasks that afford rumination. Study Three found evidence that an unconstrained task was conducive to the occurrence of uninstructed rumination and there was no evidence that this caused deficits to task performance in an unselected sample. However, rumination was also observed in the more constrained tasks adopted in Studies Two, Four and Five. Moreover, no rumination-related deficits to task performance were observed, although these studies adopted more constrained tasks for which Hertel's (2004) model would not predict impairments (or rumination).

Both Hertel's (2004) and Hartleige et al.'s (1993) models are specifically concerned with resource allocation in depressed individuals. A notable limitation of the studies reported in the thesis is that the patterns of findings in individuals with major depression are likely to differ from those observed in non-clinical or dysphoric samples, and therefore the findings of the studies reported in the thesis cannot be generalised to depressed individuals where depressive symptoms might be predicted to play a significant role in the potential consequences of rumination. Moreover, it is possible that depressive schema underpin the processing biases that lead to the preferential processing of ruminative content hypothesised by these models (e.g., Everaert et al., 2012). Study Two used a dysphoric sample but, as noted earlier, these individuals may differ in important ways from a clinically depressed sample (for example, duration of low mood, history of depression etc.). Future research examining the consequences of ruminative cues, such as personal goal discrepancies, on allocation of resources to state rumination and concurrent task-related processing in clinically depressed individuals will be useful in directly examining the predictions of resource allocation models of depression.

Control Theory models

Studies Three to Five found evidence to support a central and previously untested prediction of control theory (e.g., Martin & Tesser, 1996), namely, that unresolved personal goal discrepancies elicit state rumination. Control theory predicts that the detection of a discrepancy in progress towards a personal goal elicits rumination about the goal in order to attempt to reduce the discrepancy, and that rumination continues until either anticipated goal progress is restored, or the goal is abandoned. Despite considerable theoretical discussion (e.g., Martin & Tesser, 1996, 2006), Studies

Three to Five constitute the first causal test of this important theoretical model. Across three studies there was convergent evidence that cueing an on-going personal goal discrepancy elicited persistent intrusive ruminative thoughts about the goal relative to cueing a past resolved goal.

According to control theory, goal-focused rumination constitutes an attempt at problem solving and is not necessarily maladaptive or involuntary. A motivational account of the association between rumination and interference control whereby goal-focused ruminations are prioritised over cognitive task performance is more straightforwardly consistent with control theory. Alternatively, goal-focused rumination may be experienced as uncontrollable and intrusive and therefore perceived as a potential threat to task performance and result in compensatory attempts to increase efforts to perform the task well. Studies Three – Five found no evidence to support a motivational account whereby prioritisation of rumination resulted in impaired task performance, and Study Four found some evidence to support the possibility that rumination initiated a compensatory strategy. Studies that directly manipulate the motivation to ruminate, for example through manipulating beliefs regarding whether rumination is helpful or unhelpful and that then measure state rumination upon personal goal discrepancies will be important in examining whether rumination upon personal goals is a voluntary and motivated response or is experienced as more uncontrollable and intrusive, and the extent to which factors such as depressive symptoms and trait ruminative tendencies moderate the role of motivation in rumination.

Response Styles Theory

As predicted by the two-level model outlined in Chapter Two, and consistent with response styles theory (Nolen-Hoeksema, 1991), Studies Three and Four found

that individuals high in trait rumination were more susceptible to uninstructed ruminative thoughts in response to prompts of goal discrepancies than individuals lower in trait rumination. RST conceptualises trait rumination as a habitual response style, implying a role of habit-driven behaviour in state rumination. Future research that attempts to disentangle habitual and motivational components of state rumination on personal goal discrepancies will be an interesting step towards developing a more nuanced integration of the two prominent theories of rumination (control theory and RST).

Two-level model of state and trait rumination

Recent research suggests that the consequences of trait and state rumination for interference control are complex and in some instances potentially contradictory. For example, Whitmer and Gotlib (2012) propose that trait rumination is associated with a narrowed attentional scope such that a single goal is focused on intently at the expense of flexibility in responding to changes in context and task-relevant contingencies. One way of conceptualising the established association between trait rumination and interference control is that high trait ruminators have the tendency to continue to maintain information that is no longer relevant to current task demands in a highly active state in working memory at the expense of activation of information most relevant to task performance (for example, difficulties resisting proactive interference on the modified Sternberg task, difficulties flexibly shifting between competing task goals on a letter naming task). However, at times this appears to be beneficial to task performance and it has been hypothesised that this reflects enhanced maintenance of a single task goal (e.g., Altamirano et al., 2010). This suggests that trait rumination can be

associated with both enhanced and impaired task performance, depending on the requirements of the task.

State rumination is predicted to have deleterious consequences for the performance of effortful cognitive tasks through occupying cognitive resources (e.g., Watkins & Brown, 2002). According to this hypothesis, for tasks implicating goal maintenance, trait and state rumination may have opposing influences upon task performance. However, Studies One to Five found no evidence to support Watkins and Brown's (2002) predictions. Alternatively, the potential consequences of state rumination for interference resolution on tasks implicating goal maintenance may differ for individuals high and low in trait rumination. Consistent with the two level model proposed in Chapter Two, Studies Three and Four confirmed that individuals high in trait rumination are more susceptible to intrusive ruminations in response to personal goal discrepancies. However, there was no evidence to suggest that such intrusive ruminations were detrimental to cognitive control on the modified SART. There was some evidence to suggest that participants who were cued with rumination-inducing goal discrepancies completed the SART more efficiently, which is potentially consistent with the proposal that in some circumstances rumination may enhance performance on cognitive tasks. However, this data awaits replication and on the basis of existing evidence, the potential interaction of state and trait rumination and the ways in which these can be related to interference control remains unclear.

9.9 Future research directions

There are a number of important research avenues that will be useful in clarifying the nature of the relationship between rumination and interference control

processes and in developing the findings of the thesis. The thesis found no evidence to support an *impaired-interference-control-as-consequence-of-rumination* model of the established association between trait rumination and interference control.

Testing the impaired-interference-control-as-cause-of-rumination model

Importantly, no studies to date have directly examined the predictions derived from an *impaired-interference-control-as-cause-of-rumination* model of this relationship. There are a number of potential methods to examine this hypothesis. First, cognitive training techniques designed to modify processing biases or to boost interference control can be used to examine the prediction that reducing depressive deficits in resolving interference from negative material reduces the susceptibility to state rumination. Recent research has investigated the possibility that repeated motor prepotent response inhibition can enhance aspects of executive control both concurrently and prospectively (Verbruggen, Adams & Chambers, 2012). The authors found that short periods of inhibitory training using a task that involves inhibiting motor responses was effective in increasing the ability to suppress risky decisions during a gambling task up to two hours later thereby demonstrating a transfer effect from motor to cognitive domains of self-control (Verbruggen, Adams & Chambers, 2012). This suggests that the effects of inhibitory training programmes are of potential benefit clinically and can have transfer effects to other forms of executive control. The benefits of such a training regime might also be expected to transfer to other aspects of self-control that implicate the theoretical construct of inhibition, such as the interference control processes that are established to be associated with trait rumination. Future studies contrasting this training with a no-training control condition and assessing the potential benefits of such training in reducing rumination in a subsequent situation that

affords rumination therefore offer potential as a means to assess the proposed causal role of interference control deficits in rumination. The goal discrepancy task developed in Study Three combined with a subsequent thought probe task such as the SART described in Chapter Six constitute an important possible means to test the hypothesis that interference control causally influences state rumination through comparing the susceptibility to state rumination about personal goal discrepancies following inhibitory training relative to a non-training control condition.

A second and related approach to potentially enhancing cognitive control is through the use of working memory training programmes (e.g., Jaeggi, Buschkeuhl, Jonides & Perrig, 2008). Such programmes have been demonstrated to improve performance on working memory tasks, and thus an *impaired-interference-control-as-cause-of-rumination* hypothesis would predict that working memory training might reduce susceptibility to ruminate in a potentially rumination inducing situation. However, it is of note that there is some debate over the extent to which the benefits of such training programmes transfer to novel tasks (e.g., Shipstead, Redick & Engle, 2012).

A third approach to boosting cognitive control is through the use of cognitive bias modification (CBM) procedures that target depressive biases in attention, elaboration, or memory (Baert, Koster, & De Raedt, 2011). Such procedures involve repeated practice at selectively attending to mood-incongruent material (e.g., Wells & Beevers, 2009) or at suppressing mood-congruent material in memory (e.g., Joormann, Hertel, Brozovitch, & Gotlib, 2005) and have been demonstrated to successfully alter depressive biases for negative material. If the association between rumination and interference control deficits is driven by depressive difficulties resisting or disengaging from negative material, then such procedures might be predicted to reduce state

rumination in response to a stressor relative to a no-training control condition. However, it is of note that it remains ambiguous whether attentional training programmes train attention preferentially towards (or away from) valenced information, or whether they train the ability to shift attention. There is emerging evidence to suggest that cognitive bias modification interventions can be beneficial in both targeting clinically relevant aspects of cognitive control and also reducing clinical symptoms in depressed and anxious individuals (e.g., Blackwell & Holmes, 2010; Brosan, Hoppitt, Shelfer, Sillence, & Mackintosh, 2011; Joormann, Hertel, LeMoult, & Gotlib, 2009; MacLeod, Koster & Fox, 2009). As consequence, such methods offer potential promise as another means to examine the prediction that depressed individuals experience difficulties resolving interference from negative material, which increases susceptibility to rumination (e.g., Joormann, 2006).

An alternative approach to examining the predictions of *impaired-interference-control-as-cause-of-rumination* models is through the use of methodologies designed to temporarily deplete interference control. One such method is through the use of alcohol. Interference control can be manipulated by randomly allocating participants to ingest either a dose of alcohol or a non-alcoholic placebo. There is evidence that alcohol consumption influences the cognitive control resources that implicate inhibition. Alcohol consumption (as compared to a placebo) is associated with impaired response inhibition on tasks such as a stop-signal paradigm (e.g., Easdon & Vogel-Sprott, 2000) and decrements in the controlled but not the automatic components of performance on a word-stem completion using Jacoby's process dissociation procedure (Fillmore, Vogel-Sprott, & Gavrilesu, 1999). Alcohol consumption has been demonstrated to increase both attentional lapses and errors of commission on the SART, and to reduce individual's ability to recover from attentional lapses (Finnigan, Schulze, & Smallwood,

2007). Consequently, an alcohol manipulation could be combined with the subsequent assessment of state rumination using similar methods to those described in Studies Three – Five in order to examine the effects of depleting interference control on state rumination on personal goal discrepancies.

A second method to temporarily influence ability to resolve interference from unwanted information is suggested by the literature indicating that self-regulation is a limited resource (Muraven & Baumeister, 2000). This literature finds that previous attempts at exerting self-regulation utilise resources that make it harder to engage in subsequent self-control including performance on measures implicating executive control. For example, engagement in self-regulation tasks such as trying to suppress thoughts leads to a reduction in ability to engage in later self-regulation tasks such as suppression of laughter whilst watching a humorous video. This suggests a two-step approach to investigating the hypothesis that deficits in interference control cause increased susceptibility to rumination. Self-regulation could be manipulated through the allocation of participants to a self-control task (e.g., stifling one's emotional response when watching an emotional film, suppressing a forbidden thought) or to a neutral task of comparable effort (e.g. doing arithmetic problems, Muraven, Tice & Baumeister, 1998) and subsequent performance on a clear measure of interference control could then be assessed. If repeated effortful self-control depletes more resources required for interference control than the maths problems, then this should lead to relative deficits on the interference control task. If this hypothesis was confirmed then such manipulations could be used to examine the consequences of depleting interference control for subsequent susceptibility to state rumination in response to a potentially rumination inducing cue, such as the goal-cueing task adopted in Studies Three to Five.

Further examination of the impaired-interference-control-as-consequence-of-rumination model

Impaired-interference-control-as-consequence-of-rumination models posit that state rumination occupies working memory capacity or overloads the central executive. Study Three found no evidence to suggest that working memory capacity moderated the impact of state rumination on cognitive control. A direct causal test of the predictions derived from such models requires the examination of performance on a valid working memory measure before and after a rumination manipulation and the comparison of this with a non-ruminative control condition. In addition, studies that directly examine the impact of state rumination upon other clear measures of interference control such as the Stop-Signal task, and contrast these effects in clinically depressed, formerly depressed, and never depressed individuals will be important to further elucidate the potential consequences of state rumination in the context of depression and depressive vulnerability. Finally, given that rumination has been demonstrated to worsen mood more for depressed than non-depressed individuals, such studies should include a non-ruminative mood induction as a control condition in order to rule out affective accounts of any causal effects of state rumination.

The two-level model of rumination and interference control proposed in Chapter Two predicts that trait and state rumination interact to predict interference control capabilities. Trait rumination is hypothesised to be associated with a narrowing of attentional scope thereby resulting in enhanced maintenance of a single active goal at the expense of flexible processing (e.g., Whitmer & Gotlib, 2012). The potential consequences of state rumination for interference resolution on tasks implicating goal maintenance and cognitive flexibility may thus differ for individuals high and low in trait rumination. Whilst the studies reported in the thesis found no evidence that state

and trait rumination interacted to predict attentional control, these studies did not specifically examine the consequences of state rumination for individuals selected on the basis of being high and low trait ruminators. Studies examining the consequences of induced rumination for goal maintenance and cognitive flexibility in individuals high and low in trait rumination will be a useful step in clarifying the potential interactions of state and trait rumination in different aspects of attentional control.

Evaluating the ecological validity of a laboratory measure of state rumination

Studies Three to Five represent a potentially important methodological development in the examination of the proximal causes and consequences of state rumination. However, an important next step will be to examine the extent to which reports of rumination on such laboratory measures can be related to the experience of rumination about personal goal discrepancies and progress in pursuing such goals in everyday life. Previous studies have related goal pursuit, goal progress and rumination in everyday life using experience sampling methodologies (e.g., Moberly & Watkins, 2008, 2010) and such methods have been established as a valuable approach to examining goal pursuit (e.g., Fulford, Johnson, Llabre, & Carver, 2010). Studies examining the extent to which laboratory measures of goal-focused rumination correspond to goal-focused rumination in everyday life, and the extent to which such measures are predictive of goal progress constitute an important evaluation of the ecological validity of such measures and whether they more closely tap a constructive form of ruminative problem-solving or unconstructive dwelling.

Role of stimulus valence and mood state

As discussed in Chapter Two, the evidence regarding the role of both stimulus valence and depressed mood in the association between rumination and interference control remains unclear and a systematic examination of the potential role of these factors will be an important future development. Future studies examining the potential causal impact of state rumination might consider inclusion of a non-ruminative mood induction as a control condition, although it is of note that this may be methodologically challenging. Additional studies that directly contrast the potential presence of interference control deficits amongst depressed individuals in studies that implicate the same inhibitory subtype but contrast neutral and emotionally valenced materials will be a potentially useful step in clarifying the potential role of emotional material in the relationship between depression and interference control deficits.

Control Theory

A final area for future research indicated by the thesis is further examination of the predictions derived from control theory accounts of rumination (e.g., Martin & Tesser, 1996; Watkins, 2008). Studies Three to Five provided direct experimental support for a central prediction derived from control theory. Control theory generates a number of novel, untested predictions regarding factors determining the consequences of rumination (Martin & Tesser, 1996; Watkins, 2008). Abstract rumination is proposed to interfere with the identification of concrete steps to facilitate problem-solving (Watkins, 2008, 2010, 2011). Trait depressive ruminators are hypothesised to construe their goals in an inflexibly abstract manner resulting in unconstructive rumination and detrimental self-regulatory outcomes (Watkins, 2010, 2011). Future research building on the paradigms developed in Studies Three to Five could empirically evaluate the

untested predictions that high trait depressive ruminators engage in uninstructed rumination on personal goals in a more abstract manner than low trait ruminators and are more inflexibly abstract in their construals of personal goal discrepancies. For example, the thought probe methodology could be adapted to assess whether ruminative goal-focus was construed at an abstract or concrete level. Similarly, task-switching paradigms could be adapted to evaluate the flexibility of high versus low trait ruminators in shifting between generating abstract and concrete goal construals. Such experiments would constitute a potentially important development in the empirical evaluation of recent developments to one of the most prominent theories of rumination.

9.10 *Final summary*

Across five experimental studies, the prediction that state rumination causally impairs performance on measures of interference control was examined in order to test on possible account of the observed correlational association between trait rumination and impaired interference control. Across the five studies, no evidence was found to support this prediction. In both dysphoric and unselected samples, induced rumination was not found to impair either resistance to proactive interference or prepotent response inhibition relative to non-ruminative control tasks. Whilst the absence of evidence does not equate to evidence of absence, the convergence of findings across five studies reduce the likelihood that state rumination directly impairs interference control and strengthens the case for the importance of empirical research to test the reverse causal relationship between rumination and interference control.

Study Four found preliminary evidence that is consistent with the proposal that rumination can enhance task performance in contexts where the maintenance of a single

task goal is beneficial (e.g., Altamirano et al., 2010). Studies Three to Five additionally provide support for the previously untested control theory prediction that personal goal discrepancies elicit state rumination (Martin & Tesser, 1996), and for the prediction that individuals high in trait rumination are more susceptible to uninstructed state rumination in potentially rumination-inducing contexts (Nolen-Hoeksema, 1991).

REFERENCES

- Abramson, L. Y., Metalsky, F. I., & Alloy, L. B. (1989). Hopelessness depression: A theory based subtype of depression. *Psychological Review*, *96*(2), 358-372.
- Aiken, L. S., & West, S. G. (1991). *Multiple Regression: Testing and interpreting interactions*. Newbury Park, CA: Sage.
- Anderson, M. C., Bjork, r. A., & Bjork, E. L. (1994). Remembering can cause forgetting: Retrieval dynamics in long-term memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *20*, 1063-1087.
- Anderson, M. C., & Green, C. (2001). Suppressing unwanted memories by executive control. *Nature*, *410*, 366-369.
- Anderson, M. C., & Spellman, B. A., (1995). On the status of inhibitory mechanisms in cognition: Memory retrieval as a model case. *Psychological Review*, *102*, 68-100.
- Andrews, P. W., & Thomson, J. A. (2009). The bright side of being blue: Depression as an adaptation for analyzing complex problems. *Psychological Review*, *116* (3), 520-564.
- Ansari, T. L., Derakshan, N., & Richards, A. (2008). Effects of anxiety on task switching: Evidence from the mixed antisaccade task. *Cognitive Affective & Behavioural Neuroscience*, *8*, 229-238.
- Altamirano, L. J., Miyake, A., & Whitmer, A. (2010). When mental inflexibility facilitates executive control: Beneficial side effects of ruminative tendencies on goal maintenance. *Psychological Science*, *21*(10), 1377-1382.
- Aron, A. R. (2007). The neural basis of inhibition in cognitive control. *The Neuroscientist*, *13* (3), 1-15.

- Baddeley, A, Emslie, H, Kolodny, J, & Duncan, J. (1998) Random generation and the executive control of working memory. *The Quarterly Journal of Experimental Psychology: Section A*, 51 (4), 819-852.
- Baddeley, A.D., & Logie, R. H. (1999) Working memory: The multiple component model. In Miyake, A., & Shah, P. (Eds.) (1999). *Models of working memory: Mechanisms of active maintenance and executive control*. New York: Cambridge University Press.
- Baert, S., Koster, E. H. W., & De Raedt, R. (2011). Modification of information processing biases in emotional disorders: Clinically relevant developments in experimental psychopathology. *International Journal of Cognitive Therapy*, 4, 208-222.
- Beck, A. T. (2008). The evolution of the cognitive model of depression and its neurobiological correlates. *American Journal of Psychiatry*, 165 (8), 969-977.
- Beck, A. T., Steer, R. A., & Brown, G. K. (1996). *Beck Depression Inventory-II Manual*. San Antonio, TX: Psychological Corporation.
- Beck, A. T., Ward, C. H., Mendelson, M., Mock, J., & Erbaugh, J. (1961). An inventory for measuring depression. *Archives of General Psychiatry*, 4, 561-571.
- Beevers, C. G. (2005). Cognitive vulnerability to depression: A dual process model. *Clinical Psychology Review*, 25, 975-1002.
- Behar, E., Zullig, A. R., & Borkovec, T. D. (2005). Thought and imaginal activity during worry and trauma recall. *Behavior Therapy*, 36 (2), 157-168.
- Berman, M. G., Nee, D. E., Casement, M., Kim, H. S., Deldin, P., Kross, E., Gonzalez, R., Demiralp, E., Gotlib, I. H., Hamilton, P., Joormann, J., Waugh, C., & Jonides, J. (2011). Neural and behavioural effects of interference resolution in

- depression and rumination. *Cognitive, Affective & Behavioural Neuroscience*, *11*, 85-96.
- Bernblum, R., & Mor, N. (2010). Rumination and emotion-related biases in refreshing information. *Emotion*, *10* (3), 423 – 432.
- Bissett, P. G., Nee, D. E., & Jonides, J. (2009). Dissociating interference control processes between memory and response. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *35* (5), 1306-1316.
- Blackwell, S. E., & Holmes, E. A. (2010). Modifying interpretation and imagination in clinical depression: A single case series using cognitive bias modification. *Applied Cognitive Psychology*, *24* (3), 338-350.
- Bradley, M. M., & Lang, P. J. (1999). *Affective Norms for English Words (ANEW): Technical manual and affective ratings*. Gainesville, FL: The Centre for Research in Psychophysiology.
- Brosan, L., Hoppitt, L., Shelfer, L., Sillence, A., & Mackintosh, B. (2011). Cognitive bias modification for attention and interpretation reduces trait and state anxiety in anxious patients referred to an outpatient service: Results from a pilot study. *Journal of Behavior Therapy and Experimental Psychology*, *42* (3), 258-264.
- Brown, R. G., Soliveri, P., & Jahanshahi, M. (1998). Exectutive processes in Parkinson's disease. Random number generation and response suppression. *Neuropsychologia*, *36*, 1355-1362.
- Burnette, J. L., O'Boyle, E. H., VanEpps, E. M., Pollack, J. M., & Finkel, E. J. (2012, August 6). Mind-Sets Matter: A Meta-Analytic Review of Implicit Theories and Self-Regulation. *Psychological Bulletin*. Advance online publication. doi: 10.1037/a0029531

- Carver, C. S., & Scheier, M. F. (1982). Control theory: A useful conceptual framework for personality-social, clinical, and health psychology. *Psychological Bulletin*, *92* (1), 111-135.
- Carver, C. S., & Scheier, M. F. (1998). *On the self-regulation of behaviour*. Cambridge, United Kingdom: Cambridge University Press.
- Channon, S. (1996). Executive function in depression: The Wisconsin Card Sorting Test. *Journal of Affective Disorders*, *30*, 107-114.
- Cherkasova, M. V., Manoach, D. S., Intriligator, J. M., & Barton, J. J. S. (2002). Antisaccades and task-switching: interactions in controlled processing. *Experimental Brain Research*, *144*, 528-537.
- Chuen Yee Lo, B., Lau, S., Cheung, S., & Allen, N. B. (2012). The impact of rumination on internal switching. *Cognition and Emotion*, *26* (2), 209-223.
- Christoff, K., Gordon, A. M., Smallwood, J., Smith, R., & Schooler, J. W. (2009). Experience sampling during fMRI reveals default network and executive system contributions to mind wandering. *Proceedings of the National Academy of Sciences of the United States of America*, *106*(21), 8719-8724.
- Clark, J. M. (1996). Contributions of inhibitory mechanisms to unified theory in neuroscience and psychology. *Brain and Cognition*, *30*, 127-152.
- Clore, G. L. & Gasper, K. (2000). Feeling is Believing: Some Affective Influences on Belief. In N. H. Frijda, A. S. R. Manstead, & S. Bem (Eds.) *Emotions and beliefs: How do emotions influence beliefs?* (pp. 10-44). Cambridge: Cambridge University Press.
- Conway, A. R. A., Kane, M. J., Bunting, M. F., Hambrick, D. Z., Wilhelm, O., & Engle, R. W. (2005). Working memory span tasks: A methodological review and user's guide. *Psychonomic Bulletin & Review*, *12* (5), 769-786.

- Conway, M., Mendelson, M., Giannopoulos, C., Csank, P. and Holm, S. Childhood and adult sexual abuse, rumination on sadness, and dysphoria. (2004) *Child Abuse and Neglect*, 28, 393-410.
- Conway, A. R. A., Tuholsky, S. W., Shisler, R. J., & Engle, R. W. (1999). The effect of memory load on negative priming: An individual differences investigation. *Memory and Cognition*, 27, 1042-1050.
- Cowan, N. (2001). Metatheory of storage capacity limits [reply to commentaries]. *Behavioural and Brain Sciences*, 24, 154-176.
- Curci, A., Lanciano, T., Bianco, A., & Cozzoli Poli, G. (in press). "Can't get you out of my head": The role of working memory in the mental rumination of emotional experiences. *Cognition and Emotion*.
- Daches, S., Mor, N., Winquist, J., & Gilboa-Schechtman, E. (2010). Brooding and attentional control in processing self-encoded information: Evidence from a modified Garner task. *Cognition and Emotion*, 24 (5), 876-885.
- Davis, R. N., & Nolen-Hoeksema, S. (2000). Cognitive inflexibility amongst ruminators and nonruminators. *Cognitive Therapy and Research*, 24 (6), 699-711.
- Demeyer, I., De Lissnyder, E., Koster, E. H. W., & De Raedt, R. (2012). Rumination mediates the relationship between impaired cognitive control for emotional information and depressive symptoms: A prospective study in remitted depressed adults. *Behaviour Research and Therapy*, 50, 292-297.
- De Lissnyder, E., Derakshan, N., De Raedt, R., & Koster, E. H. W. (2011). Depressive symptoms and cognitive control in a mixed antisaccade task: Specific effects of rumination. *Cognition and Emotion*, 25 (5), 886-897.
- De Lissnyder, E., Koster, E. H. W., Derakshan, N., & De Raedt, R. (2010). The association between depressive symptoms and executive control impairments in

- response to emotional and non-emotional information. *Cognition and Emotion*, 24 (2), 264 – 280.
- De Lissnyder, E., Koster, E. H. W., Goubert, L., Onraedt, T., Vanderhasselt, M. & De Raedt, R. (2012). Cognitive control moderates the association between stress and rumination. *Journal of Behaviour Therapy and Experimental Psychiatry*, 43, 519-525.
- De Lissnyder, E. Koster, E. H. W., & De Raedt, R. (2011, February 20). Emotional interference in working memory is related to rumination. *Cognitive Therapy and Research*. Advance online publication. DOI: 10.1007/s10608-011-9352-4
- De Raedt, R., & Koster, E. H. W. (2010). Understanding vulnerability to depression from a cognitive neuroscience perspective: A reappraisal of attentional factors and a new conceptual framework. *Cognitive, Affective, and Behavioural Neuroscience*, 10 (1), 50-70.
- Derakshan, N., & Eysenck, M. W. (2009). Anxiety, processing efficiency, and cognitive performance: New developments from attentional control theory. *European Psychologist*, 14 (2), 168-176.
- D'Esposito, M., Postle, B. R., Jonides, J., & Smith, E. E. (1999). The neural substrate and temporal dynamics of interference effects in working memory as revealed by event-related fMRI. *Proceedings of the National Academy of Sciences of the United States of America*, 96, 7514-7519.
- Deveney, C. M., & Deldin, P. J. (2006). A preliminary investigation of cognitive flexibility for emotional information in major depressive disorder and non-psychiatric controls. *Emotion*, 6 (3), 429-437.
- Donaldson, C., Lam, D., & Mathews, A. (2007). Rumination and attention in major depression. *Behaviour Research and Therapy*, 45, 2664-2678.

- Dozois, D. J. A., Dobson, K. S., & Ahnberg, J. L. (1998). A psychometric evaluation of the Beck Depression Inventory-II. *Psychological Assessment, 10* (2), 83-89.
- Duncan, J., Emslie, H., Williams, P., Johnson, R., & Freer, C. (1996). Intelligence and the frontal lobe: The organisation of goal-directed behaviour. *Cognitive Psychology, 30*, 257-303.
- Easdon, C. M., & Vogel-Sprott, M. (2000). Alcohol and behavioural control: Impaired response inhibition and flexibility in social drinkers. *Experimental and clinical Psychopharmacology, 8* (3), 387-394.
- Ellenbogen, M., Schwartzman, A.E., Stewart, J., & Walker, D. (2002). Stress and selective attention: The interplay of mood, cortisol levels, and emotional information processing. *Psychophysiology, 39*, 723-732.
- Ellis, H. C. & Ashbrook, P. W. (1988). Resource allocation model of the effects of depressed mood states on memory. In K. Fielder (Ed.), *Affect, Cognition, and Social Behaviour* (pp. 25-43). Göttingen: Hogrefe.
- Ellis, H. C., Moore, B. A., Varner, L. J., & Ottaway, S. A. (1997). Depressed mood, task organization, cognitive interference, and memory: Irrelevant thoughts predict recall performance. *Journal of Social Behavior and Personality, 12* (2), 453-470.
- Eriksen, B. A., & Eriksen, C. W. (1974). Effects of noise letters upon the identification of a target letter in a nonsearch task. *Perception & Psychophysics, 16*, 143-149.
- Everaert, J., Koster, E. H. W., & Derakshan, N. (2012). The combined cognitive bias hypothesis in depression. *Clinical Psychology Review, 32*, 413-424.
- Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M. G. (2007). Anxiety and cognitive performance: Attentional control theory. *Emotion, 7* (2), 336-353.

- Fillmore, M. T., Vogel-Sprott, M., & Gavrilesco, D. (1999). Alcohol effects on intentional behaviour: Dissociating controlled and automatic influences. *Experimental and Clinical Psychopharmacology*, 7 (4), 372-378.
- Finnigan, F., Schulze, D., & Smallwood, J. (2007). Alcohol and the wandering mind: A new direction in the study of alcohol on attentional lapses. *International Journal on Disability and Human Development*, 6 (2), 189-199.
- Friedman, N. P., & Miyake, A. (2004). The relations among inhibition and interference control functions: A latent-variable analysis. *Journal of Experimental Psychology: General*, 133 (1), 101-135.
- Frings, C., Wentura, D., & Holtz, M. (2007). Dysphorics cannot ignore unpleasant information. *Cognition & Emotion*, 21 (7), 1525-1534.
- Fulford, D., Johnson, S. L., Llabre, M. M., & Carver, C. S. (2010). Pushing and coasting in dynamic goal pursuit: Coasting is attenuated in bipolar disorder. *Psychological Science*, 21 (7), 1021-1027.
- Garner, W. R. (1976). Interaction of stimulus dimensions in concept and choice processes. *Cognitive Psychology*, 8, 98-123.
- Grant, D., A., & Berg, E. (1948). A behavioral analysis of degree of reinforcement and ease of shifting to new responses in a Weigl-type card-sorting problem. *Journal of Experimental Psychology*, 38(4), 404-411.
- Goeleven, E., De Raedt, R., Baert, S., & Koster, E. H. W. (2006). Deficient inhibition of emotional information in depression. *Journal of Affective Disorders*, 93, 149-157.
- Gotlib, I. H. & Joormann, J. (2010). Cognition and depression: Current status and future directions. *Annual Review of Clinical Psychology*, 6, 285 – 312.

- Greve, K. W., Williams, M. C., Haas, W. G., Littell, R. R., & Rinoso, C. (1996). The role of attention in Wisconsin card sorting test performance. *Archives of Clinical Neuropsychology, 11* (3), 215-222.
- Groome, D., & Sterkaj, F. (2010). Retrieval-induced forgetting and clinical depression. *Cognition & Emotion, 24* (1), 63-70.
- Hartlage, S., Alloy, L. B., Vazquez, C., & Dykman, B. (1993). Automatic and effortful processing in depression. *Psychological Bulletin, 113* (2), 247-278.
- Harvey, A. G., Watkins, E., Mansell, W., & Shafran, R. (2004). *Cognitive behavioural processes across psychological disorders: A transdiagnostic approach to research and treatment*. Oxford: Oxford University Press.
- Hasher, L., & Zacks, R. T. (1979). Automatic and effortful processes in memory. *Journal of Experimental Psychology: General, 108*, 356-389.
- Hasher, L., & Zacks, R. T. (1988). Working memory, comprehension, and aging: A review and new view. In G. H. Bower (Ed.), *The Psychology of Learning and Motivation* (Vol. 22, pp. 193-225). New York: Academic Press.
- Hayes, S., Hirsch, C., & Mathews, A. (2008). Restriction of working memory capacity during worry. *Journal of Abnormal Psychology, 117* (3), 712-717.
- Helton, W. S. (2009). Impulsive responding and the sustained attention to response task. *Journal of Clinical and Experimental Neuropsychology, 31* (1), 39-47.
- Helton, W. S., Head, J., & Russell, P. N. (2011). Reliable- and unreliable-warning cues in the Sustained Attention to Response Task. *Experimental Brain Research, 209*, 401-407.
- Hertel, P. T. (1997). On the contributions of deficient cognitive control to memory impairments in depression. *Cognition and Emotion, 11*, 569-584.

- Hertel, P. T. (1998). Relation between rumination and impaired memory in dysphoric moods. *Journal of Abnormal Psychology, 107*, 166-172.
- Hertel, P. T. (2004). Memory for emotional and nonemotional events in depression: A question of habit? In D. Reisberg & P. Hertel (Eds.) *Memory and Emotion* (pp. 186-216). New York: Oxford University Press.
- Hertel, P. T., & Gerstle, M. (2003). Depressive deficits in forgetting. *Psychological Science, 14*, 573-578.
- Hertel, P. T., & Hardin, T. S. (1990). Remembering with and without awareness in depressed mood: Evidence of deficits in initiative. *Journal of Experimental Psychology: General, 119* (1), 45-59.
- Hertel, P. T., & Rude, S. S. (1991). Depressive deficits in memory. Focusing attention improves subsequent recall. *Journal of Experimental Psychology: General, 120*, 301-309.
- Hester, R., & Garavan, H. (2005). Working memory and executive function: The influence of content and load on the control of attention. *Memory and Cognition, 33* (2), 221-233.
- Ingram, R. E. (1984). Toward an information-processing analysis of depression. *Cognitive therapy and Research, 8* (5), 443-477.
- Jacoby, L. L. (1996). Dissociating automatic and consciously controlled effects of study/test compatibility. *Journal of Memory and Language, 35*, 32-52.
- Jacoby, L. L. (1998). Invariance in automatic influences of memory: Toward a users guide for the process-dissociation procedure. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 24* (1), 3-26.

- Jaeggi, S. M., Buschkuhl, M., Jonides, J., & Perrig, W. J. (2008). Improving fluid intelligence with training on working memory. *Proceedings of the National Academy of Sciences of the United States of America*, *105* (19), 6829-6833.
- Jakab, E., & Raaijmakers, J. G. W. (2009). The role of item strength in retrieval induced forgetting. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *35* (3), 607-617.
- Jermann, F., van der Linden, M., Adam, S., & Ceschi, G. (2005). Controlled and automatic uses of memory in depressed patients: effect of retention interval lengths. *Behaviour Research and Therapy*, *43*, 681-690.
- Johnson, M. K., Mitchell, K. J., Raye, C. L., McGuire, J. T., & Sanislow, C. A. (2006). Mental rubbernecking to negative information depends on task context. *Psychonomic Bulletin & Review*, *13*, 614-618.
- Johnson, M. K., Reeder, J. A., Raye, C. L., & Mitchell, K. J. (2002). Second thoughts versus second looks: An age-related deficit in reflectively refreshing just-active information. *Psychological Science*, *13*, 64-67.
- Jones, N. P., Siegle, G. J., Muelly, E. R., Haggerty, A., & Ghinassi, F. (2010). *Cognitive, Affective, and Behavioural Neuroscience*, *10* (1), 129-140.
- Joormann, J. (2005). Inhibition, rumination, and mood regulation in depression. In R.W. Engle, G. Sedak, U von Hecker, & D.N. McIntosh (Eds.), *Cognitive Limitations in Aging and Psychopathology: Attention, Working Memory, and Executive Functions*, pp. 275-312. New York: Cambridge University Press.
- Joormann, J. (2006). The relation of rumination and inhibition: Evidence from a negative priming task. *Cognitive Therapy and Research*, *30*, 149-160.
- Joormann, J. (2010). Cognitive inhibition and emotion regulation in depression. *Current Directions in Psychological Science*, *19* (3), 161-166.

- Joormann, J., & D'Avanzato, C. (2010). Emotion regulation in depression: Examining the role of cognitive processes. *Cognition and Emotion, 24* (6), 913-939.
- Joormann, J., Dkane, M., & Gotlib, I. H. (2006). Adaptive and maladaptive components of rumination? Diagnostic specificity and relation to depressive biases. *Behaviour Therapy, 37*, 269-280.
- Joormann, 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), 979-983.
- Joormann, J., Nee, D. E., Berman, M. G., Jonides, J., & Gotlib, I. H. (2010). Interference resolution in major depression. *Cognitive, Affective, and Behavioural Neuroscience, 10* (1), 21-33.
- Joormann, J., & Gotlib, I. H., (2008). Updating the contents of working memory in depression: Interference from irrelevant negative material. *Journal of Abnormal Psychology, 117*, 182-192.
- Joormann, J., & Gotlib, I. H. (2010). Emotion regulation in major depression: Relation to cognitive inhibition. *Cognition and Emotion, 24* (2), 281-298.
- Joormann, J., Hertel, P. T., Brozovich, F., & Gotlib, I. H. (2005). Remembering the good, forgetting the bad: Intentional forgetting of emotional material in depression. *Journal of Abnormal Psychology, 114* (4), 640-648.
- Joormann, J., Hertel, P. T., LeMoult, J., & Gotlib, I. H. (2009). Training forgetting of negative material in depression. *Journal of Abnormal Psychology, 111* (1), 34-43.
- Joormann, J., & Tran, T. B. (2009). Rumination and intentional forgetting of emotional material. *Cognition and Emotion, 23* (6), 1233-1246.

- Joormann, J., Yoon, K. L., & Zetsche, U. (2007). Cognitive inhibition in depression. *Applied and Preventive Psychology, 12*, 128-139.
- 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.
- Koch, I., Gade, M., Schuch, S., & Philipp, A. M. (2010). The role of inhibition in task switching: A review. *Psychological Bulletin and Review, 17* (1), 1-14.
- Kofta, M., & Sedak, G. (1998). Uncontrollability as a source of cognitive exhaustion: Implications for helplessness and depression. In M. Kofta, G. Weary, & G. Sedak (Eds.), *Personal control in action: Cognitive and motivational mechanisms* (pp. 391-418). New York: Plenum.
- Koster, E. H. W., De Lissnyder, E., Derakshan, N., & De Raedt, R. (2011). Understanding depressive rumination from a cognitive science perspective: The impaired disengagement hypothesis. *Clinical Psychology Review, 31*, 138-145.
- Koster, E.H.W., De Raedt, R., Leyman, L., & De Lissnyder, E. (2010). Mood-congruent attention and memory bias in dysphoria: Exploring the coherence among information processing biases. *Behaviour Research and Therapy, 48*, 219-225.
- Kramer, A. F., Humphrey, D. G., Larish, J. F., Logan, G. D., & Strayer, D. L. (1994). Aging and inhibition: Beyond a unitary view of inhibitory processing in attention. *Psychology and Aging, 9* (4), 491-512.
- Krames, L., & MacDonald, M. R. (1985). Distraction and depressive cognitions. *Cognitive Therapy and Research, 9* (5), 561-573.

- Kristjansson, A., Chen, Y., & Nakayama, K. (2001). Less attention is more, in preparation of antisaccades, but not prosaccades. *Nature Neuroscience*, *4*, 1037-1042.
- Lavender, A., & Watkins, E. (2004). Rumination and future thinking in depression. *British Journal of Clinical Psychology*, *43* (2), 129-142.
- Lau, M. A., Christensen, B. K., Hawley, L. L., Gemar, M. S., & Segal, Z. V. (2007). Inhibitory deficits for negative information in persons with major depressive disorder. *Psychological Medicine*, *37*, 1249-1259.
- Lavallee, L. F., & Campbell, J. D. (1995). Impact of personal goals on self-regulation processes elicited by daily negative events. *Journal of Personality and Social Psychology*, *69* (2), 341-352.
- Lejuez, C. W., Kahler, C. W., & Brown, R. A. (2003). A modified computer version of the paced auditory serial addition task (PASAT) as a laboratory-based stressor: Implications for behavioural assessment. *Behaviour Therapist*, *26*, 290-292.
- Levens, S. M., Muhtadie, L., & Gotlib, I. H. (2009). Rumination and impaired resource allocation in depression. *Journal of Abnormal Psychology*, *118* (4), 757-766.
- Linville, P. (1996). Attention inhibition: Does it underlie ruminative thought? In R. S. Wyer (Ed.), *Ruminative thoughts: Advances in social cognition* (Vol. IX, pp. 121-133). Mahwah, NJ: Erlbaum.
- Logan, G. D., Cowan, W. B., & Davis, K. A. (1984). On the ability to inhibit simple choice and reaction time responses: A model and a method. *Journal of Experimental Psychology: Human Perception and Performance*, *10* (2), 276-291.

- Loo, C. K., & Mitchell, P. B. (2005). A review of the efficacy of transcranial magnetic stimulation (TMS) treatment for depression, and current and future strategies to optimize efficacy. *Journal of Affective Disorders, 88*, 255-267.
- Lowe, C. & Rabbitt, P. (1998). Test/re-test reliability of the CANTAB and ISPOCD neuropsychological batteries: Theoretical and practical issues. *Neuropsychologia, 36* (9), 915-923.
- Lyubomirsky, S., Caldwell, N. D., & Nolen-Hoeksema, S. (1998). Effects of ruminative and distracting responses to depressed mood on retrieval of autobiographical memories. *Journal of Personality and Social Psychology, 75* (1), 166-177.
- Lyubomirsky, S., Kasri, F., & Zehm, K. (2003). Dysphoric rumination impairs concentration on academic tasks. *Cognitive Therapy and Research, 27* (3), 309-330.
- Lyubomirsky, S., & Nolen-Hoeksema, S. (1993). Self-perpetuating properties of dysphoric rumination. *Journal of Personality and Social Psychology, 65*, 339-349.
- Lyubomirsky, S., & Nolen-Hoeksema, S. (1995). Effects of self-focused rumination on negative thinking and interpersonal problem solving. *Journal of Personality and Social Psychology, 69* (1), 176-190.
- Lustig, C., Hasher, L., & Tonev, S. T. (2001). Inhibitory control over the present and the past. *European Journal of Cognitive Psychology, 13* (1-2), 107-122.
- MacCallum, R. C., Zhang, S., Preacher, K. J., & Rucker, D. D. (2002). On the practice of dichotomization of quantitative variables. *Psychological Methods, 7* (1), 19-40.

- MacLeod, C. M. (1998). Directed forgetting. In J. M. Golding & C. M. MacLeod (Eds.), *Intentional forgetting: Interdisciplinary approaches* (pp. 1-57). Mahwah, N. J.: Lawrence Erlbaum Associates.
- MacLeod, C. M. (2005). The Stroop task in cognitive research. In A. Wenzel & D. C. Rubin (Eds.), *Cognitive methods and their application to clinical research* (pp. 17-40). Washington, DC: American Psychological Association.
- MacLeod, C. M. (2007). The concept of inhibition in cognition. In D. S. Gorfein and C. M. MacLeod (Eds.), *Inhibition in cognition* (pp. 3-23). Washington D.C.: American Psychological Association.
- MacLeod, C. M., Dodd, M. D., Sheard, E. D., Wilson, D. E., & Bibi, U. (2003). In opposition to inhibition. In B. H. Ross (Ed.), *The Psychology of Learning and Motivation* (Vol. 43, pp. 163-214). San Diego, C. A.: Academic Press.
- MacLeod, C., Koster, E. H. W., & Fox, E. (2009). Whither cognitive bias modification research? Commentary on special section articles. *Journal of Abnormal Psychology, 118* (1), 89-99.
- Manly, T., Davison, B., Heutink, J., Galloway, M., & Robertson, I. (2000). Not enough time or not enough attention?: Speed, error and self-maintained control in the Sustained Attention to Response Test (SART). *Clinical Neuropsychological Assessment, 3*, 167-177.
- Manly, T., Heutink, J., Davison, B., Gaynord, B., Greenfield, E., Parr, A., Ridgeway, V., & Robertson, I. H. (2004). An electronic knot in the hankerchief: "Content free cueing" and the maintenance of attentive control. *Neuropsychological Rehabilitation, 14* (1/2), 89-116.

- Martin, L. L., & Tesser, A. (1989). Toward a motivation and structural theory of ruminative thought. In J. S. Uleman & J. A. Bargh (Eds.), *Unintended Thought* (pp. 306-326). New York: Guilford Press.
- Martin, L. L., & Tesser, A. (1996). Some ruminative thoughts. In R. S. Wyer (Ed.), *Ruminative thoughts: Advances in social cognition* (Vol. IX, pp. 1-47). Mahwah, NJ: Erlbaum.
- Martin, L. L., & Tesser, A. (2006). Extending the goal progress theory of rumination: Goal reevaluation and growth. In L. Sanna and E. Chang (Eds.), *Judgements over time: The interplay of thoughts, feelings, and behaviours* (pp. 145-162). New York: Oxford University Press.
- May, C. P., & Hasher, L. (1998). Synchrony effects in inhibitory control over thought and action. *Journal of Experimental Psychology: Human Perception and Performance*, 24 (2), 363-379.
- May, C. P., Kane, M. J., & Hasher, L. (1995). Determinants of negative priming. *Psychological Bulletin*, 118 (1), 35-54.
- Mayr, S., & Buchner, A. (2007). Negative priming as a memory phenomenon: A review of 20 years of negative priming research. *Zeitschrift für Psychologie*, 115 (1), 35-51.
- Mayr, U. (2007). Inhibition of task sets. In D. S. Gorfein & C. M. MacLeod (Eds.), *Inhibition in Cognition* (pp. 27-44). Washington D. C.: American Psychological Association.
- Mayr, U. (2002). Inhibition of action rules. *Psychonomic Bulletin and Review*, 9 (1), 93-99.

- Mayr, U., & Keele, S. W. (2000). Changing internal constraints on action: The role of backward inhibition. *Journal of Experimental Psychology: General*, *129* (1), 4-26.
- McIntosh, W. D. (1996). When does goal nonattainment lead to negative emotional reactions and when doesn't it? : The role of linking and rumination. In L. L. Martin and A Tesser (Eds.) *Striving and Feeling: Interactions among goals, affect, and self-regulation* (pp 53-77). Mahwah, NJ: Erlbaum.
- McIntosh, W. D. & Martin, L. L. (1992). The cybernetics of happiness: The relation of goal attainment, rumination, and affect. In M. S. Clark (Ed.), *Emotion and social behaviour* (pp. 222-246). Thousand Oaks, CA: Sage.
- 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), 196-204.
- Metzler, C. & Parkin, A. J. (2000). Reversed Negative Priming following frontal lobe lesions. *Neuropsychologia*, *38*(4), 363-379.
- 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*, 49-100.
- Miyake, A., & Shah, P. (1999). Towards unified theories of working memory: Emerging general consensus, unresolved theoretical issues, and future research directions. In Miyake, A., & Shah, P. (Eds.) (1999). *Models of working memory: Mechanisms of active maintenance and executive control*. New York: Cambridge University Press.

- Moberly, N. J., & Watkins, E. R. (2006). Processing mode influences the relationship between trait rumination and emotional vulnerability. *Behaviour Therapy, 37* (3), 281-291.
- Moberly, N. J., & Watkins, E. R. (2008a). Ruminative self-focus and negative affect: An experience sampling study. *Journal of Abnormal Psychology, 117* (2), 314-323.
- Moberly, N.J., Watkins, E.R. (2008b). Ruminative self-focus, negative life events, and negative affect. *Behaviour Research and Therapy, 46*(9), 1034-1039.
- Moberly, N. J., & Watkins, E. R. (2010). Negative affect and ruminative self-focus during everyday goal pursuit. *Cognition and Emotion, 24* (4), 729-739.
- Mogg, K., & Bradley, B. P. (2005). Attentional bias in generalized anxiety disorder versus depressive disorder. *Cognitive Therapy and Research, 29*, 29-45.
- Monsell, S. (1978). Recency, immediate recognition memory, and reaction time. *Cognitive Psychology, 10*, 465-501.
- Monsell, S., Taylor, T. J., & Murphy, K. (2001). Naming the color of a word: is it responses or task sets that compete? *Memory and Cognition, 29* (1), 137-151.
- Morrison, R. & O'Connor, R. C. (2008). The role of rumination, attention biases and stress in psychological distress. *British Journal of Psychology, 99*, 191-209.
- Morrow, J., & Nolen-Hoeksema, S. (1990). Effects of responses to depression on the remediation of depressive affect. *Journal of Personality and Social Psychology, 58* (3), 519-527.
- Muraven, M. (2010). Building self-control strength: Practising self-control leads to improved self-control performance. *Journal of Experimental Social Psychology, 46* (2), 465-468.

- Muraven, M., & Baumeister, R. F. (2000). Self-regulation and depletion of limited resources: Does self-control resemble a muscle? *Psychological Bulletin, 126*, 247-259.
- Muraven, M., Tice, D. M., & Baumeister, R. F. (1998). Self-control as a limited resource: Regulatory depletion patterns. *Journal of Personality and Social Psychology, 74*, 774-789.
- Nee, D. E., & Jonides, J. (2008). Dissociable interference-control processes in perception and memory. *Psychological Science, 19*, 490-500.
- Niell, W. T., & Mathis, K. M. (1998). Transfer-inappropriate processing: Negative priming and related phenomena. In D. L. Medin (Ed.), *The psychology of learning and motivation: Advances in research and theory* (Vol 38). San Diego: Academic Press.
- Niell, W. T., & Valdes, L. A. (1992). Persistence of negative priming: Steady state or decay? *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18*, 565-576.
- Nigg, J. T. (2000). On inhibition/disinhibition in developmental psychopathology: Views from cognitive and personality psychology and a working inhibition taxonomy. *Psychological Bulletin, 126* (2), 220-246.
- Nolen-Hoeksema, S. (1991). Responses to depression and their effects on the duration of depressive episodes. *Journal of Abnormal Psychology, 100* (4), 569-582.
- Nolen-Hoeksema, S. (2000). The role of rumination in depressive disorders and mixed anxiety/depressive symptoms. *Journal of Abnormal Psychology, 109* (3), 504-511.

- Nolen-Hoeksema, S., & Morrow, J. (1991). A prospective study of depression and posttraumatic stress symptoms after a natural disaster: The 1989 Loma Prieta Earthquake. *Journal of Personality and Social Psychology*, *61* (1), 115-121.
- Nolen-Hoeksema, S., & Morrow, J. (1993). Effects of rumination and distraction on naturally occurring depressed mood. *Cognition and emotion*, *7* (6), 561-570.
- Nolen-Hoeksema, S., Wisco, B. E., & Lyubomirsky, S. (2008). Rethinking rumination. *Perspectives on Psychological Science*, *3* (5), 400-424.
- Norman, D. A., & Shallice, T. (1986). Attention to action: Willed and automatic control of behaviour. In R. J. Davidson, G. E. Schwartz, and D. Shapiro (Eds.), *Consciousness and Self-Regulation: Advances in Research and Theory* (pp. 1-18). Plenum Press.
- Oberauer, K. (2001). Removing irrelevant information from working memory: A cognitive aging study with the modified Sternberg task. *Journal of Experimental Psychology-Learning Memory and Cognition*, *27*(4), 948-957.
- Oberauer, K. (2005). Binding and inhibition in working memory: Individual and age differences in short-term recognition. *Journal of Experimental Psychology: General*, *134* (3), 368-387.
- Oberauer, K. (2009). Design for a working memory. In B. H. Ross (Ed.), *Psychology of Learning and Motivation: Volume 51. Advances in Research and Theory* (pp. 45-100). San Diego, CA: Elsevier Academic.
- O'Connell, R. G., Bellgrove, M. A., Dockree, P. M., & Robertson, I. H. (2006). Cognitive remediation in ADHD: Effects of periodic non-contingent alerts on sustained attention to response. *Neuropsychological Rehabilitation: An International Journal*, *16* (6), 653-665.

- Padesky, C. (1994). Schema change processes in cognitive therapy. *Clinical Psychology and Psychotherapy, 1* (5), 267-278.
- Papageorgiou, C., & Wells, A. (2004). Nature, functions and beliefs about depressive rumination. In C. Papageorgiou and A. Wells (Eds.) *Depressive rumination: Nature, Theory and Treatment* (pp. 3-20). Chichester, United Kingdom: Wiley.
- Peckham, A. D., McHugh, R. K., & Otto, M. W. (2010). A meta-analysis of the magnitude of biased attention in depression. *Depression and Anxiety, 27*, 1135-1142.
- Peebles, D. & Bothell, D. (2004). Modelling performance in the sustained attention to response task. In *Proceedings of the sixth International Conference on Cognitive Modeling* (pp. 231-236). Pittsburgh, PA: Carnegie Mellon University/University of Pittsburgh.
- Philippot, P., & Brutoux, F. (2008). Induced rumination dampens executive processes in dysphoric young adults. *Journal of Behavior Therapy and Experimental Psychiatry, 39*, 219-227.
- Puterman, E., DeLongis, A., & Pomaki, G. (2010). Protecting us from ourselves: Social support as a buffer of trait and state rumination. *Journal of Social and Clinical Psychology, 29* (7), 797-820.
- Pyszczynski, T., & Greenberg, J. (1987). Self-regulatory perseverance and the depressive self-focusing style: A self-awareness theory of reactive depression. *Psychological Bulletin, 102* (1), 122-138.
- Radloff, L. S. (1977). The CES-D Scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement, 1* (3), 385-401.

- 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), 747-758.
- Rusting, C. L., & DeHart, T. (2000). Retrieving positive memories to regulate negative mood: Consequences for mood-congruent memory. *Journal of Personality and Social Psychology*, *78* (4), 737-752.
- Schwabe, L., Dickinson, A., & Wolf, O. T. (2011). Stress, habits, and drug addiction: A psychoneuroendocrinological perspective. *Experimental and Clinical Psychopharmacology*, *19* (1), 53-63.
- Schwabe, L., & Wolf, O. T. (2001). Stress-induced modulation of instrumental behaviour: From goal-directed to habitual control of action. *Behavioural Brain Research*, *219*, 321-328.
- Seli, P., Jonker, T. R., Solman, G. J. F., Cheyne, J. A., & Smilek, D. (2012). A methodological note on evaluating performance in a sustained-attention-to-response task. *Behaviour Research Methods*. Advance online publication. doi: 10.3758/s13428-012-0266-1
- Shipstead, Z., Redick, T. S., & Engle, R. W. (2012). Is working memory training effective? *Psychological Bulletin*, *138* (4), 628-654.
- Siegle, G. J., Steinhauer, S. R., Carter, C. S., Ramel, W., & Thase, M. E. (2003). Do the seconds turn into hours? Relationship between sustained pupil dilation in response to emotional material and self-reported rumination. *Cognitive Therapy and Research*, *27* (3), 365-382.
- Shilling, V. M., Chetwynd, A., & Rabbitt, P. M. A. (2002). Individual inconsistency across measures of inhibition: an investigation of the construct validity of inhibition in older adults. *Neuropsychologia*, *40*, 605-619.

- Smallwood, J., Davies, J. B., Heim, D., Finnigan, F., Sudberry, M., O'Connor, R., et al. (2004). Subjective experience and the attentional lapse: Task engagement and disengagement during sustained attention. *Consciousness and Cognition, 13*(4), 657-690.
- Smallwood, J., Fitzgerald, A., Miles, L. & Phillips, L.H. (2009). Shifting Moods, Wandering Minds: Negative Moods Lead the Mind to Wander. *Emotion, 9* (2), 271-276.
- Smith, R., Keramatian, K., Smallwood, J., Schooler, J., Luus, B., & Christoff, K. (2006). *Mind-wandering with and without awareness: An fMRI study of spontaneous thought processes*. Paper presented at the 28th Annual Meeting of the Cognitive Science Society.
- Snyder, H. R. (2013). Major Depressive Disorder is associated with broad impairments on neuropsychological measures of executive function: A meta-analysis and review. *Psychological Bulletin, 139* (1), 81-132.
- Spasojevic, J. & Alloy, L. B. (2001). Rumination as a common mechanism relating depressive risk factors to depression. *Emotion, 1* (1), 25-37.
- Sprinkle, S. D., Lurie, D., Insko, S. L., Atkinson, G., Jones, G. L., Logan, A. R., & Bissada, N. N. (2002). Criterion Validity, Severity Cut Scores, and Test–Retest Reliability of the Beck Depression Inventory-II in a University Counseling Center Sample. *Journal of Counselling Psychology, 49* (3), 381-385.
- Steinhauer, S. R., & Hakerem, (1992) The Pupillary Response in Cognitive Psychophysiology and Schizophrenia. *Annals of the New York Academy of Sciences, 658*, 182–204.

- Stober, J., & Borkovec, T. D. (2002). Reduced concreteness of worry in generalized anxiety disorder: Findings from a therapy study. *Cognitive Therapy and Research, 26* (1), 89-96.
- Storm, B. C., & Nestojko, J. F. (2010). Successful inhibition, unsuccessful retrieval: Manipulating time and success during retrieval practice. *Memory, 18* (2), 99-114.
- Strauss, E., Sherman, E. M. S., & Spreen, O. (2006). *A compendium of neuropsychological tests: Administration, norms, and commentary*. Oxford, UK: Oxford University Press.
- Stuss, D. T., & Gow, C. A. (1992) Frontal dysfunction after traumatic brain injury. *Neuropsychiatry, Neuropsychology, & Behavioral Neurology, 5* (4), 272-282.
- Thomas, P., Goudemand, M., & Rousseaux, M. (1999). Attentional resources in major depression. *European Archives of Clinical Neuroscience, 249*, 79-85.
- Thomsen, D. K. (2006). The association between rumination and negative affect: A review. *Cognition and Emotion, 20* (8), 1216-1235.
- Tipper, S. P. (1985). The negative priming effect: Inhibitory priming by ignored objects. *Quarterly Journal of Experimental Psychology Section A- Human Experimental Psychology, 37* (4), 571-590.
- Tipper, S. P. (2001). Does negative priming reflect inhibitory mechanisms? A review and integration of conflicting views. *The Quarterly Journal of Experimental Psychology, 54A* (2), 321-343.
- Tombaugh, T. N. (2006). A comprehensive review of the paced auditory serial addition test (PASAT). *Archives of Clinical Neuropsychology, 21*, 53-76

- Towse, J. N., & Valentine, J. D. (1997). Random generation of numbers: A search for underlying processes. *European Journal of Cognitive Psychology, 9* (4), 381-400.
- Treynor, W., Gonzalez, R., & Nolen-Hoeksema, S. (2003). Rumination reconsidered: A psychometric analysis. *Cognitive Therapy and Research, 27* (3), 247-259.
- Turner, M. L., & Engle, R. W. (1989). Is working memory capacity task dependent? *Journal of Memory & Language, 28*, 127-154.
- Uhart, M., & Wand, G. S. (2008). Stress, alcohol and drug interaction: an update of human research. *Addiction Biology, 14*, 43-64.
- Unsworth, N., Heitz, R. R., Schrock, J. C., & Engle, R. W. (2005). An automated version of the operation span task. *Behavior Research Methods, 37*(3), 498-505.
- Van Randenborgh, A., Huffmeier, J., LeMoult, J., & Joormann, J. (2010). Letting go of unmet goals: Does self-focused rumination impair goal disengagement? *Motivation and Emotion, 34*, 325-332.
- Vanderhasselt, M., Kuhn, S., & De Raedt, R. (2011). Healthy brooders employ more attentional resources when disengaging from the negative: an event-related fMRI study. *Cognitive Affective and Behavioural Neuroscience, 11*, 207-216.
- Vandierendonck, A., Liefoghe, B. & Verbruggen, F. (2010). Task switching: Interplay of reconfiguration and interference control. *Psychological Bulletin, 136* (4), 601-626.
- Verbruggen, F, Adams, R, & Chambers, C. D. (2012). Proactive motor control reduces monetary risk taking in gambling. *Psychological Science, 23* (7), 805-815.
- Vogel, E. K., Woodman, g. F., & Luck, S. J. (2001). Storage of features, conjunctions, and objects in visual working memory. *Journal of Experimental Psychology: Human Perception and Performance, 27*, 92-114.

- Von Hecker, U., & Sedak, G. (1999). Uncontrollability, depression, and the construction of mental models. *Journal of Personality and Social Psychology*, 77 (4), 833-850.
- Von Hippel, W., Vasey, M. W., Gonda, T., & Stern, T. (2008). Executive function deficits, rumination and late-onset depressive symptoms in older adults. *Cognitive Therapy & Research*, 32 (4), 474-487.
- Watkins, E. (2008). Constructive and unconstructive repetitive thought. *Psychological Bulletin*, 134 (2), 163-206.
- Watkins, E. R. (2010). Level of construal, mind wandering, and repetitive thought: Reply to McVay and Kane (2010). *Psychological Bulletin*, 136 (2), 198-201.
- Watkins, E. (2011). Dysregulation in level of goal and action identification across psychological disorders. *Clinical Psychology Review*, 31, 260-278.
- Watkins, E., & Brown, R. G. (2002). Rumination and executive function in depression: An experimental study. *Journal of Neurology Neurosurgery and Psychiatry*, 72, 400-402.
- Watkins, E., Moberly, N.J., Moulds, M.L. (2008). Processing mode causally influences emotional reactivity: Distinct effects of abstract versus concrete construal on emotional response. *Emotion*, 8(3), 364-378.
- Watkins, E., & Moulds, M. L. (2005). Distinct modes of ruminative self-focus: Impact of abstract versus concrete problem solving in depression. *Emotion*, 5, 319-328.
- Watkins, E.R., Mullan, E., Wingrove, J., Rimes, K., Steiner, H., Bathurst, N., Eastman, R., Scott, J. (2011). Rumination-focused cognitive-behavioural therapy for residual depression: phase II randomised controlled trial. *British Journal of Psychiatry*, 199(4), 317-322.

- Watkins, E. R., & Nolen-Hoeksema, S. (under revision). An integrated habit-goal model of pathological rumination.
- Watkins, E., & Teasdale, J. D. (2001). Rumination and overgeneral memory in depression: Effects of self-focus and analytic thinking. *Journal of Abnormal Psychology, 110* (2), 353-357.
- Watkins, E., & Teasdale, J. D. (2004). Adaptive and maladaptive self-focus in depression. *Journal of Affective Disorders, 82* (1), 1-8.
- Watkins, E., Teasdale, J. D., & Williams, R. M. (2000). Decentering and distraction improve overgeneral autobiographical memory in depression. *Psychological Medicine, 30*, 911-920.
- Watkins, E., Scott, J., Wingrove, J., Rimes, K., Bathurst, N., Steiner, H., Kennell-Webb, S., Moulds, M., & Malliaris, Y. (2007). Rumination-focused cognitive behaviour therapy for residual depression: a case series. *Behaviour Research and Therapy, 45*(9), 2144-2154.
- Watson, D., Clark, L.E., & Tellegen, A. (1988). Development and validation of a brief measure of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology, 54* (6), 1063-1070.
- Watts, F. N., Dalgleish, T., Bourke, P., & Healy, D. (1990). Memory deficit in clinical depression: processing resources and the structure of materials. *Psychological Medicine, 20*, 345-349.
- Wells, T. T., & Beevers, C. G. (2010). Biased attention in dysphoria: Manipulating selective attention reduces subsequent depressive symptoms. *Cognition and Emotion, 24* (4), 719-728.
- Whitmer, A. J., & Banich, M. T. (2007). Inhibition versus switching deficits in different forms of rumination. *Psychological Science, 18* (6), 546-553.

- Whitmer, A., & Banich, M. T. (2010). Trait rumination and inhibitory deficits in long-term memory. *Cognition and Emotion, 24* (1), 168-179.
- Whitmer, A., & Gotlib, I. H. (2012, April 2). Switching and backward inhibition in major depressive disorder: The role of rumination. *Journal of Abnormal Psychology*. Advance online publication. DOI: 10.1037/a0027474
- Whitmer, A., & Gotlib, I. H. (2012). An attentional scope model of rumination. *Psychological Bulletin*. Advance online publication. DOI: 10.1037/a0030923
- Wong, A. C. M., & Moulds, M. L. (2008). Depressive rumination and directed forgetting: An examination of encoding style. *Cognitive Therapy and Research, 32* (1), 1-10.
- Young, J.E., Klosko, J.S., & Weishaar, M. (2003). *Schema Therapy: A Practitioner's Guide*. Guilford Publications: New York.
- Zetsche, U., D'Avanzato, C., & Joormann, J. (2012). Depression and rumination: Relation to components of inhibition. *Cognition and Emotion, 26* (4), 758-767.
- Zetsche, U., & Joormann, J. (2011). Components of interference control predict depressive symptoms and rumination cross-sectionally and at six months follow-up. *Journal of Behaviour Therapy and Experimental Psychiatry, 42*, 65-73.

APPENDIX ONE: *Stimuli for the modified Sternberg task*

Positive words		Negative words	
enjoyment	sapphire	slum	dustpan
glory	diploma	infection	grime
triumph	bunny	scandal	pus
joke	cuisine	fraud	mutation
laughter	sailboat	wounds	scum
flower	caress	shotgun	scorpion
champion	lottery	hurricane	termite
honey	jewel	thief	deserter
star	penthouse	overcast	toothache
bath	champ	loneliness	cyclone
legend	flirt	hardship	guillotine
charm	butterfly	menace	terrorist
treat	refreshment	agony	mildew
promotion	astronaut	demon	crutch
christmas	waterfall	nightmare	stench
warmth	puppy	grief	germs
profit	valentine	scar	scapegoat
passion	millionaire	poison	blubber
movie	riches	slaughter	allergy
delight	casino	tomb	mosquito
prestige	nectar	burial	morgue
virtue	spouse	cane	lawsuit
graduate	pizza	neglect	loser
dancer	hug	dentist	massacre
kids	dove	bastard	slime
wedding	bathtub	debt	invader
excitement	rainbow	gossip	abduction
mountain	twilight	pity	avalanche
bride	toy	gloom	snob
gift	bouquet	insect	addict
ocean	yacht	penalty	daggar
sugar	treasure	revolver	leprosy
cash	kindness	python	trauma
foam	glamour	cemetery	vampire
palace	intellect	misery	vandal
comedy	kitten	contempt	tornado
talent	beverage	needle	intruder
joy	fireworks	execution	mucus
queen	thrill	burn	trash
restaurant	garment	bees	idiot
pride	fragrance	assault	alimony
comfort	savior	ignorance	fungus
heaven	outdoors	rage	beggar
fun	ecstasy	tumor	lice
liberty	idol	chaos	measles

dollar	blossom	horror	filth
employment	wink	abuse	maggot
humor	circus	fever	wasp
mail	mobility	flood	madman
vacation	pet	murderer	smallpox
acceptance	trophy	illness	robber
trust	diamond	poverty	deceit
gold	cheer	quarrel	spider
grass	bless	crash	traitor
lake	cake	jail	malice
vision	chocolate	punishment	blackmail
sky	sweetheart	killer	venom
taste	athletics	fault	cockroach
snow	doll	panic	slap
garden	tune	depression	roach
beach	perfume	criminal	hostage
travel	sunrise	devil	blister
victory	patriot	cancer	stink
baby	rabbit	disaster	dummy
pleasure	infant	excuse	malaria
dream	perfection	injury	greed
achievement	reunion	victim	skull
honor	silk	pistol	louse
dress	paradise	bullet	thorn
wonder	incentive	divorce	grenade
song	computer	slave	vomit
beauty	grin	funeral	torture
brother	abundance	damage	dump
advantage	pie	accident	blasphemy
leader	sunset	mistake	ache
dog	breeze	crime	scorn
memory	fantasy	waste	pest
favor	applause	shadow	jealousy
desire	adventure	destruction	outrage
youth	daylight	prison	obesity
king	reward	weapon	nuisance
dinner	scholar	hate	headache
success	optimism	dirt	shriek
health	ace	snake	ulcer
agreement	excellence	mold	handicap
wish	memories	anger	manure
sun	rescue	tragedy	pinch
quality	saint	sin	paralysis
justice	candy	lie	rat
radio	miracle	rifle	sickness
progress	nurse	danger	assassin
couple	voyage	evil	surgery
game	sunlight	knife	ambulance
respect	holiday	crisis	discomfort
truth	kiss	pain	corpse

spring	angel	failure	lump
freedom	affection	hell	carcass
chance	fame	stress	coffin
friend	birthday	fear	garbage
color	crown	trouble	beast
moral	ambition	fall	insult
letter	wit	pressure	despise
knowledge	luxury	cut	riot
earth	melody	death	coward

APPENDIX TWO: Stimuli for the modified Sustained Attention to Response Task

(SART)

Non-targets (go-trials)

apricot	pepper	scientist	football	spatula	magnolia	sunflower
uncle	janitor	screwdriver	silk	bookcase	giraffe	valley
martini	scissors	yellow	ocean	league	father	flannel
kerosene	shrine	cathedral	generation	ladder	mother	mountain
apricot	pepper	scientist	football	spatula	magnolia	sunflower
wrench	ruby	apartment	trumpet	building	blender	poetry
martini	scissors	yellow	ocean	league	father	flannel
raspberry	fiction	squirrel	cellar	gasoline	dictionary	buttercup
blender	poetry	sister	heart	general	iron	major
gymnastics	oxygen	captain	saxophone	destroyer	dandelion	adjective
dictionary	buttercup	radio	century	spoon	brain	decade
dogwood	velvet	aluminum	canvas	television	evergreen	champagne
giraffe	valley	sister	heart	general	iron	major
gymnastics	oxygen	digest	aunt	blue	representative	fireman
mother	mountain	radio	century	spoon	brain	decade
dogwood	velvet	orange	cantaloupe	red	newspaper	diamond

wool	lacrosse	hammer	skillet	leg	president	wrestling	hurricane
blizzard	baseball	poster	donkey	cotton	cabin	alcohol	executive
submarine	drum	pan	preposition	tongue	fork	hill	emerald
sweater	week	vinegar	farmer	green	judge	humidity	tornado
wool	lacrosse	hammer	skillet	leg	president	wrestling	hurricane
eternity	intestine	prune	wolf	nylon	carnation	automobile	interjection
submarine	drum	pan	preposition	tongue	fork	hill	emerald
journal	gold	socks	steel	mile	calcium	nurse	month
carnation	automobile	interjection	wrench	ruby	apartment	trumpet	building
herb	stalagmite	parsley	shirt	pearl	foot	maple	tangerine
calcium	nurse	month	raspberry	fiction	squirrel	cellar	gasoline
yard	passenger	pants	rainbow	manager	book	turquoise	zebra
cabin	alcohol	executive	uncle	janitor	screwdriver	silk	bookcase
herb	stalagmite	parsley	shirt	pearl	foot	maple	tangerine
judge	humidity	tornado	kerosene	shrine	cathedral	generation	ladder
yard	passenger	pants	rainbow	manager	book	turquoise	zebra

building	blender	poetry	sister	heart	general	iron	major
tangerine	gymnastics	oxygen	captain	saxophone	destroyer	dandelion	adjective
gasoline	dictionary	buttercup	radio	century	spoon	brain	decade
zebra	dogwood	velvet	aluminum	canvas	television	evergreen	champagne
bookcase	giraffe	valley	sister	heart	general	iron	major
tangerine	gymnastics	oxygen	digest	aunt	blue	representative	fireman
ladder	mother	mountain	radio	century	spoon	brain	decade
zebra	dogwood	velvet	orange	cantaloupe	red	newspaper	diamond
blue	representative	fireman	eternity	intestine	prune	wolf	nylon
magazine	meter	knife	refrigerator	synagogue	piccolo	secretary	biography
red	newspaper	diamond	journal	gold	socks	steel	mile
steamboat	sapphire	shoulder	lieutenant	house	copper	chimney	electricity
destroyer	dandelion	adjective	blizzard	baseball	poster	donkey	cotton
magazine	meter	knife	refrigerator	synagogue	piccolo	secretary	biography
television	evergreen	champagne	sweater	week	vinegar	farmer	green
steamboat	sapphire	shoulder	lieutenant	house	copper	chimney	electricity

nylon	carnation	automobile	interjection	wrench	ruby	apartment	trumpet
biography	herb	stalagmite	parsley	shirt	pearl	foot	maple
mile	calcium	nurse	month	raspberry	fiction	squirrel	cellar
electricity	yard	passenger	pants	rainbow	manager	book	turquoise
cotton	cabin	alcohol	executive	uncle	janitor	screwdriver	silk
biography	herb	stalagmite	parsley	shirt	pearl	foot	maple
green	judge	humidity	tornado	kerosene	shrine	cathedral	generation
electricity	yard	passenger	pants	rainbow	manager	book	turquoise
poetry	sister	heart	general	iron	major	digest	aunt
oxygen	captain	saxophone	destroyer	dandelion	adjective	arrow	church
buttercup	radio	century	spoon	brain	decade	orange	cantaloupe
velvet	aluminum	canvas	television	evergreen	champagne	sentence	private
valley	sister	heart	general	iron	major	captain	saxophone
oxygen	digest	aunt	blue	representative	fireman	arrow	church
mountain	radio	century	spoon	brain	decade	aluminum	canvas
velvet	orange	cantaloupe	red	newspaper	diamond	sentence	private

aunt	blue	representative	fireman	eternity	intestine	prune	wolf
church	magazine	meter	knife	refrigerator	synagogue	piccolo	secretary
cantaloupe	red	newspaper	diamond	journal	gold	socks	steel
private	steamboat	sapphire	shoulder	lieutenant	house	copper	chimney
saxophone	destroyer	dandelion	adjective	blizzard	baseball	poster	donkey
church	magazine	meter	knife	refrigerator	synagogue	piccolo	secretary
canvas	television	evergreen	champagne	sweater	week	vinegar	farmer
private	steamboat	sapphire	shoulder	lieutenant	house	copper	chimney
automobile	interjection	wrench	ruby	apartment	trumpet	building	blender
stalagmite	parsley	shirt	pearl	foot	maple	tangerine	gymnastics
nurse	month	raspberry	fiction	squirrel	cellar	gasoline	dictionary
passenger	pants	rainbow	manager	book	turquoise	zebra	dogwood
alcohol	executive	uncle	janitor	screwdriver	silk	bookcase	giraffe
stalagmite	parsley	shirt	pearl	foot	maple	tangerine	gymnastics
humidity	tornado	kerosene	shrine	cathedral	generation	ladder	mother
passenger	pants	rainbow	manager	book	turquoise	zebra	dogwood

digest
arrow
orange
sentence
captain
arrow
aluminum
sentence
carnation
herb
calcium
yard
cabin
herb
judge
yard

Targets (no-go trials)

SCIENTIST	FOOTBALL	SPATULA	MAGNOLIA	SUNFLOWER
PRESIDENT	WRESTLING	HURRICANE	APRICOT	PEPPER
WOOL	LACROSSE	HAMMER	SKILLET	LEG
SISTER	HEART	GENERAL	IRON	MAJOR
WRESTLING	APRICOT	SCIENTIST	SPATULA	SUNFLOWER
HEART	IRON	WOOL	HAMMER	LEG
PRESIDENT	HURRICANE	PEPPER	FOOTBALL	MAGNOLIA
SISTER	GENERAL	MAJOR	LACROSSE	SKILLET

APPENIX THREE: *Goal manipulation protocol***Unresolved goal:**

“For the next ten minutes I am going to ask you to close your eyes and focus your attention on a problem and difficulty that is still unresolved and bothering you –so this is an ongoing and unresolved concern that has been repeatedly coming in to your mind over the past week and causing you to feel negative, sad, down or stressed.

When I ask you to begin, please close your eyes and dwell on this current problem or concern, in the way that you usually dwell on and ruminate about unresolved concerns, as intensely as you can, until I ask you to stop and to open your eyes.

Examples of the kind of difficulty that I would like you think about are...(give example topics)

Example topics:

An ongoing concern about an important relationship, which you feel that you should be managing better.

A recent negative event and its impact upon how you have been feeling over the past few weeks.

Concerns that you have failed to achieve a goal that is of personal importance to you.

Feeling that you disappoint someone who means a lot to you.

Feeling that you do not compare favorably to other people with respect to an area of functioning that is important to you.

The problem or difficulty that you think about must be one that has been repeatedly troubling you recently and that you have not resolved, that is, it still bothers you and still comes repeatedly to mind.

Can you think of a problem or difficulty of this kind to think about?

If no remind participant of examples and give them some time to think of a suitable topic. If yes proceed as follows:

Would you mind telling me very briefly what the problem is?

If not an appropriate topic remind participant of the type of concern that we are interested in and the examples and give further time to try to identify a concern of this kind.

Now I would like you to evaluate this difficulty using the following scales.

(Give scales items are: how important it is to you (0-10), how much it bothers you now (0-10) and how much it did bother you at the time it was worst (0-10), how much you have been thinking about it over the last week (0-10), how long has this been a difficulty for you (0-10), and how much does this difficulty relate to more general concerns that you have (0-10).

Please close your eyes and dwell on this current problem or concern, in the way that you usually dwell on and ruminate about unresolved concerns, as intensely as you can, until I ask you to stop and to open your eyes.”

Recorded script items:

Think about the problem and difficulty – what is it?

Focus on what about this problem/difficulty bothers and troubles you.

Think about what is important about this difficulty in terms of your personal goals.

Focus on how this problem reflects a lack of progress on important personal goals.

Think about how the problem/difficulty is still unresolved.

Concentrate on the aspects of the problem that reflect unfinished business

Focus on the aspects of the difficulty that repeatedly come to mind.

Think about any related concerns and unresolved issues that this problem reminds you of.

Resolved goal:

“For the next few minutes I am going to ask you to close your eyes and focus your attention on a recent problem or difficulty that is now resolved and no longer bothering you –so this is an past and resolved difficulty that has not been coming in to your mind over the past week and no longer causes you to feel negative, sad, down or stressed. When I ask you to begin, please close your eyes and think about this past problem or concern, in the way that you usually think about resolved concerns, as intensely as you can, until I ask you to stop and to open your eyes.

Examples of the kind of difficulty that I would like you think about are... (Give example topics)

Example topics:

A concern that you would not achieve a goal that you have now succeeded in achieving.

A past dispute with someone who means a lot to you that has now been resolved and you now feel very positively about this relationship.

A situation or event that you had been finding stressful, but that you have now learned to manage well.

An area of functioning that is important to you, and which you previously felt you did not manage well, but that you now manage as well as other people.

A negative event that happened many years ago and that you have now come to terms with and are not troubled by.

The problem or difficulty that you think about must be one that has not been troubling you recently and that you have now resolved.

Can you think of a problem or difficulty of this kind to think about?

If no remind participant of examples and give them some time to think of a suitable topic. If yes proceed as follows:

Would you mind telling me very briefly what the problem was?

If not appropriate remind participant of the type of concern that we are interested in and the examples and give further time to try to identify a concern of this kind.

Now I would like you to evaluate this difficulty using the following scales.

(Give scales items are: how important it is to you (0-10), how much it bothers you now (0-10) and how much it did bother you at the time it was worst (0-10), how much you have been thinking about it over the last week (0-10), how long has this been a difficulty for you (0-10), and how much does this difficulty relate to more general concerns that you have (0-10).

Please close your eyes and think about this past problem or concern, in the way that you usually think about past resolved difficulties, as intensely as you can, until I ask you to stop and to open your eyes.”

Recorded script items:

Think about the problem and difficulty – what was it?

Focus on what about this problem/difficulty bothered and troubled you in the past.

Think about what was important about this difficulty in terms of your personal goals.

Focus on how resolving this problem reflects progress on important personal goals.

Think about how the problem/difficulty is now resolved.

Concentrate on the aspects of the problem that are now finished and dealt with

Think about any other resolved difficulties that this problem reminds you of.

APPENDIX FOUR: *Mean percentages of each thought type to the thought probes in Studies Three, Four and Five*

The probe response options were based on those used by McVay and Kane (2009) and adapted to include an option pertaining to the resolved/unresolved goal from the goal cueing task. These options were: (a) task (i.e., the stimuli or appropriate response); (b) task performance; (c) current physical state (i.e., conditions such as hunger or sleepiness); (d) the concern identified and thought about in the previous task (i.e., the unresolved/resolved goal, and our index of state rumination); (e) other personal worries that were not connected to the problem identified in the previous task; (f) other thought types. Participants pressed a key corresponding to the option that best described the focus of their attention.

Study 3

Table 1: *Mean percentage responses of each thought type to the thought probes by goal condition*

	Unresolved	Resolved
Thought probe a	27.11%	21.58%
Thought probe b	21.23%	26.13%
Thought probe c	16.1%	18%
Thought probe d	12.02%	3.16%
Thought probe e	6.45%	8.25%
Thought probe f	17.12%	22.88%

Study 4

Table 2: *Mean percentage responses of each thought type to the thought probes by goal condition*

	Unresolved	Resolved
Thought probe a	19.23%	23%
Thought probe b	33.72%	32.17%
Thought probe c	17.37%	19.12%
Thought probe d	6.92%	3.45%
Thought probe e	5.83%	6.78%
Thought probe f	16.92%	15.5%

Study 5

Table 3: *Mean percentage responses of each thought type to the thought probes by goal condition*

	Unresolved	Resolved
Thought probe a	50.30%	46.86%
Thought probe b	13.36%	18.54%
Thought probe c	12.5%	17.35%
Thought probe d	9.23%	1.73%
Thought probe e	4.63%	4.18%
Thought probe f	9.98%	11.32%

APPENDIX FIVE: *Trait brooding and reflection analyses***Study Three***Brooding and state rumination*

Hierarchical regression was used to examine whether trait brooding moderated the effect of the goal manipulation on rumination during the modified SART. Goal condition (1: unresolved goal, 0: resolved goal) and centred RRSbrooding scores (RRSbroodingc) were entered in block one of the regression, and the interaction term (goal condition x RRSbroodingc) in block 2 (Table 1). The interaction term explained a significant increase in variance of state rumination, $\Delta R^2 = 0.189$, $F(1, 35) = 12.017$, $p = 0.001$. Thus, trait brooding was a significant moderator of the effect of the goal manipulation on ruminative thoughts during the modified SART task.

As illustrated in Figure 1, the unstandardized simple slope for participants 1 SD below the mean for trait brooding was -1.352, this was not significantly different from 0, $t(35) = -0.289$, $p = 0.775$. The unstandardized simple slope for participants 1 SD above the mean for trait brooding was 22.004, this was significantly greater than 0, $t(35) = 4.73$, $p < 0.001$. Thus, as predicted, the effect of the goal manipulation on subsequent rumination was greater for participants reporting high levels of trait brooding on the RRS.

Table 1: *Hierarchical linear regression estimating state rumination during the modified SART.*

	B	S.E.	β
Step 1			
Condition	10.411**	3.687	0.405
RRSbroodingc	1.050**	0.503	0.299
Step 2			
Condition	10.326**	3.227	0.402
RRSbroodingc	-0.141	0.558	-0.040
Condition x RRSbroodingc	3.146**	0.907	0.552

Step 1: $F(2, 36) = 6.329, p = 0.004, R^2 = 0.260$

Step 2: $F(3, 35) = 9.517, p < 0.001, R^2 = 0.449$

* $p < 0.05$, ** $p < 0.01$

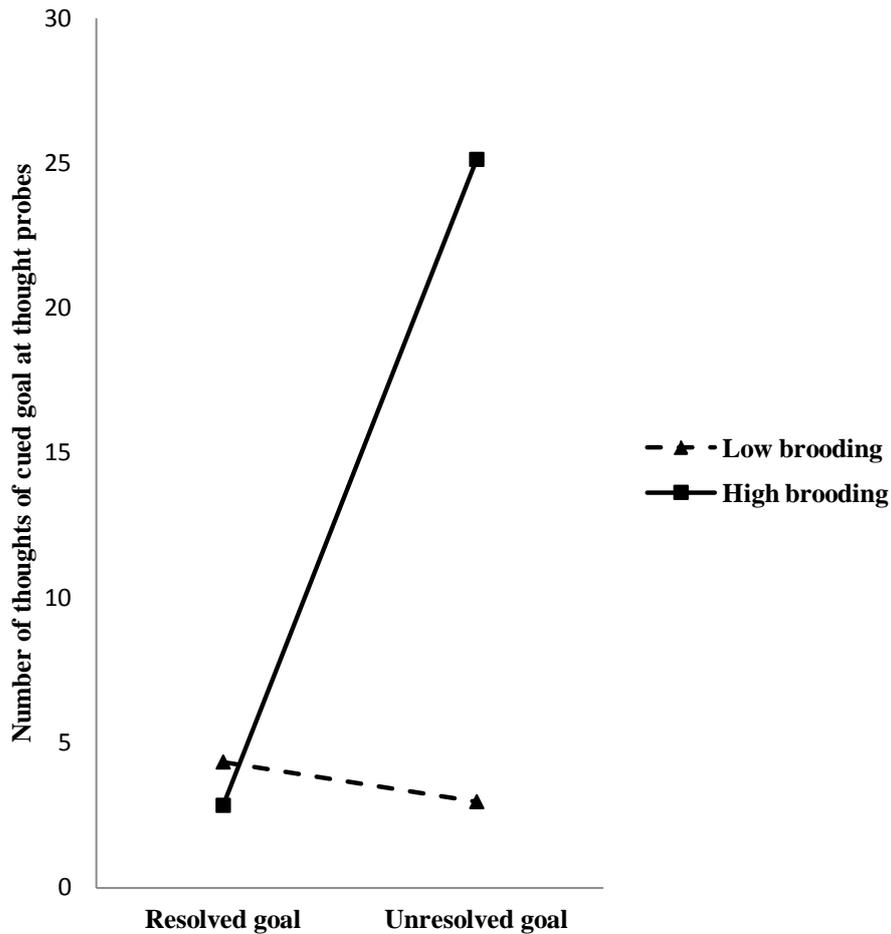


Figure 1: Simple slopes for state rumination one standard deviation above and below the mean RRSbrooding score

Reflection and state rumination

Hierarchical regression was used to examine whether trait reflection moderated the effect of the goal manipulation on rumination during the modified SART. Goal condition (1: unresolved goal, 0: resolved goal) and centred RRSreflection scores (RRSreflection_{nc}) were entered in block one of the regression, and the interaction term (goal condition x RRSreflection_{nc}) in block 2 (Table 1). The interaction term did not explain a significant increase in variance of state rumination, $\Delta R^2 = 0.001$, $F(1, 35) = 0.029$, $p = 0.866$. Thus, trait reflection was not a significant moderator of the effect of the goal manipulation on ruminative thoughts during the modified SART task.

Table 2: *Hierarchical linear regression estimating state rumination during the modified SART.*

	B	S.E.	β
Step 1			
Condition	10.571*	3.929	0.411
RRSreflectionc	-0.066	0.602	-0.017
Step 2			
Condition	10.559*	3.983	0.411
RRSreflectionc	-0.189	0.950	-0.048
Condition x RRSreflectionc	0.211	1.240	0.041

Step 1: $F(2, 36) = 3.711, p = 0.034, R^2 = 0.171$

Step 2: $F(3, 35) = 2.417, p = 0.083, R^2 = 0.172$

Brooding and errors of commission

Hierarchical regression was used to examine whether trait brooding moderated the effect of the goal manipulation on errors of commission during the modified SART. Goal condition (1: unresolved goal, 0: resolved goal) and centred RRSbrooding scores (RRSbroodingc) were entered in block one of the regression, and the interaction term (goal condition x RRSbroodingc) in block 2 (Table 3). The interaction term did not explain a significant increase in variance in errors of commission, $\Delta R^2 = 0.035, F(1,$

35) = 1.652, $p = 0.207$. Thus, trait brooding was not a significant moderator of the effect of the goal manipulation on errors of commission during the modified SART task.

Table 3: *Hierarchical linear regression estimating errors of commission during the modified SART.*

	B	S.E.	β
Step 1			
Condition	-42.480**	13.873	-0.450
RRSbroodingc	2.109	1.892	0.164
Step 2			
Condition	-42.346**	13.749	-0.448
RRSbroodingc	3.990	2.379	0.310
Condition x RRSbroodingc	-4.970	3.867	-0.237

Step 1: $F(2, 36) = 5.220$, $p = 0.010$, $R^2 = 0.225$

Step 2: $F(3, 35) = 4.094$, $p = 0.014$, $R^2 = 0.260$

Reflection and errors of commission

Hierarchical regression was used to examine whether trait reflection moderated the effect of the goal manipulation on errors of commission during the modified SART.

Goal condition (1: unresolved goal, 0: resolved goal) and centred RRSreflection scores (RRSreflectionc) were entered in block one of the regression, and the interaction term

(goal condition x RRSreflectionc) in block 2 (Table 4). The interaction term did not explain a significant increase in variance in errors of commission, $\Delta R^2 = 0.036$, $F(1, 35) = 1.734$, $p = 0.196$. Thus, trait reflection was not a significant moderator of the effect of the goal manipulation on errors of commission during the modified SART task.

Table 4: *Hierarchical linear regression estimating errors of commission during the modified SART.*

	B	S.E.	β
Step 1			
Condition	-39.932**	13.876	-0.423
RRSreflectionc	2.785	2.128	0.192
Step 2			
Condition	-39.616**	13.739	-0.419
RRSreflectionc	6.089	3.276	0.420
Condition x RRSreflectionc	-5.633	4.277	-0.297

Step 1: $F(2, 36) = 5.514$, $p = 0.008$, $R^2 = 0.234$

Step 2: $F(3, 35) = 4.329$, $p = 0.011$, $R^2 = 0.271$

Brooding and RTs

Hierarchical regression was used to examine whether trait brooding moderated the effect of the goal manipulation on RTs to correct go trials during the modified SART. Goal condition (1: unresolved goal, 0: resolved goal) and centred RRSbrooding scores (RRSbroodingc) were entered in block one of the regression, and the interaction term (goal condition x RRSbroodingc) in block 2 (Table 5). The interaction term did not explain a significant increase in variance in RTs, $\Delta R^2 = 0.044$, $F(1, 35) = 1.853$, $p = 0.182$. Thus, trait brooding was not a significant moderator of the effect of the goal manipulation on RTs during the modified SART task.

Table 5: *Hierarchical linear regression estimating RTs during the modified SART.*

	B	S.E.	β
Step 1			
Condition	60.476*	28.238	0.333
RRSbroodingc	-3.545	3.852	-0.143
Step 2			
Condition	60.188*	27.911	0.332
RRSbroodingc	-7.589	4.829	-0.307
Condition x RRSbroodingc	10.685	7.850	0.265

Step 1: $F(2, 36) = 2.665$, $p = 0.083$, $R^2 = 0.129$

Step 2: $F(3, 35) = 2.436$, $p = 0.081$, $R^2 = 0.173$

Reflection and RTs

Hierarchical regression was used to examine whether trait reflection moderated the effect of the goal manipulation on RTs to correct go trials during the modified SART. Goal condition (1: unresolved goal, 0: resolved goal) and centred RRSreflection scores (RRSreflectionc) were entered in block one of the regression, and the interaction term (goal condition x RRSreflectionc) in block 2 (Table 6). The interaction term did not explain a significant increase in variance in RTs, $\Delta R^2 = 0.035$, $F(1, 35) = 1.460$, $p = 0.235$. Thus, trait reflection was not a significant moderator of the effect of the goal manipulation on RTs during the modified SART task.

Table 6: *Hierarchical linear regression estimating RTs during the modified SART.*

	B	S.E.	β
<hr/> Step 1			
Condition	57.286	28.538	0.316
RRSreflectionc	-3.251	4.367	-0.117
<hr/> Step 2			
Condition	58.686	28.362	0.312
RRSreflectionc	-9.508	6.762	-0.342
Condition x RRSreflectionc	10.669	8.830	0.292

RRSreflectionc

Step 1: $F(2, 36) = 2.499, p = 0.096, R^2 = 0.122$

Step 2: $F(3, 35) = 2.174, p = 0.109, R^2 = 0.157$

Study Four

Brooding and state rumination

Hierarchical regression was used to examine whether trait brooding moderated the effect of the goal manipulation on rumination during the modified SART. Goal condition (1: unresolved goal, 0: resolved goal) and centred RRSbrooding scores (RRSbroodingc) were entered in block one of the regression, and the interaction term (goal condition x RRSbroodingc) in block 2 (Table 1). There was a trend towards the interaction term explaining an increase in variance in state rumination, $\Delta R^2 = 0.051$, $F(1, 52) = 3.812$, $p = 0.056$. Thus, there was a trend towards trait brooding moderating the effect of the goal manipulation on ruminative thoughts during the modified SART task.

As illustrated in Figure 1, the unstandardized simple slope for participants 1 SD below the mean for trait brooding was 0.597, this was not significantly different from 0, $t(52) = 0.584$, $p = 0.561$. The unstandardized simple slope for participants 1 SD above the mean for trait brooding was 3.411, this was significantly greater than 0, $t(52) = 3.390$, $p = 0.001$. Thus, as predicted, the effect of the goal manipulation on subsequent rumination was greater for participants reporting high levels of trait brooding on the RRS.

Table 1: *Hierarchical linear regression estimating state rumination during the modified SART.*

	B	S.E.	β
Step 1			
Condition	2.027**	0.733	0.327
RRSbroodingc	0.325**	0.102	0.378
Step 2			
Condition	2.019**	0.715	0.326
RRSbroodingc	0.161	0.130	0.187
Condition x RRSbroodingc	0.392	0.201	0.296

Step 1: $F(2, 53) = 9.156, p < 0.001, R^2 = 0.257$

Step 2: $F(3, 52) = 7.698, p < 0.001, R^2 = 0.308$

* $p < 0.05$, ** $p < 0.01$

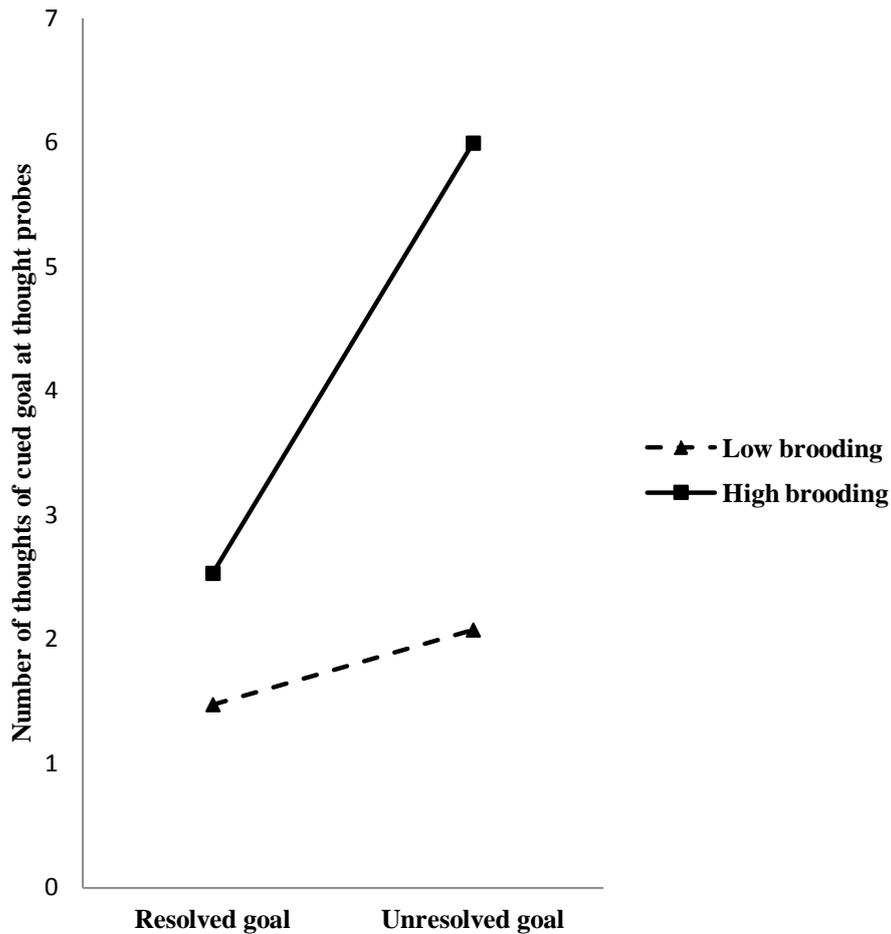


Figure 1: Simple slopes for state rumination one standard deviation above and below the mean RRSbrooding score

Reflection and state rumination

Hierarchical regression was used to examine whether trait reflection moderated the effect of the goal manipulation on rumination during the modified SART. Goal condition (1: unresolved goal, 0: resolved goal) and centred RRSreflection scores (RRSreflection_{nc}) were entered in block one of the regression, and the interaction term (goal condition x RRSreflection_{nc}) in block 2 (Table 2). The interaction term did not explain a significant increase in variance of state rumination, $\Delta R^2 = 0.028$, $F(1, 52) = 1.711$, $p = 0.197$. Thus, trait reflection did not moderate the effect of the goal manipulation on ruminative thoughts during the modified SART task.

Table 2: *Hierarchical linear regression estimating state rumination during the modified SART.*

	B	S.E.	β
Step 1			
Condition	2.065*	0.801	0.333
RRSreflectionc	0.042	0.105	0.052
Step 2			
Condition	2.048*	0.796	0.331
RRSreflectionc	-0.075	0.137	-0.093
Condition x RRSreflectionc	0.276	0.211	0.222

Step 1: $F(2, 53) = 3.489, p = 0.038, R^2 = 0.116$

Step 2: $F(3, 52) = 2.927, p = 0.042, R^2 = 0.144$

* $p < 0.05$, ** $p < 0.01$

Brooding and RTs

Hierarchical regression was used to examine whether trait brooding moderated the effect of the goal manipulation on RTs to correct go trials during the modified SART. Goal condition (1: unresolved goal, 0: resolved goal) and centred RRSbrooding scores (RRSbroodingc) were entered in block one of the regression, and the interaction term (goal condition x RRSbroodingc) in block 2 (Table 3). The interaction term did not

explain a significant increase in variance in RTs, $\Delta R^2 = 0.003$, $F(1, 52) = 0.158$, $p = 0.692$. Thus, trait brooding was not a significant moderator of the effect of the goal manipulation on RTs during the modified SART task.

Table 3: *Hierarchical linear regression estimating RTs during the modified SART.*

	B	S.E.	β
Step 1			
Condition	-58.022	29.664	-0.259
RRSbroodingc	-1.322	4.116	-0.043
Step 2			
Condition	-58.094	29.903	-0.260
RRSbroodingc	-2.722	5.442	-0.088
Condition x RRSbroodingc	3.345	8.410	0.070

Step 1: $F(2, 53) = 1.982$, $p = 0.148$, $R^2 = 0.070$

Step 2: $F(3, 52) = 1.353$, $p = 0.267$, $R^2 = 0.072$

Reflection and RTs

Hierarchical regression was used to examine whether trait brooding moderated the effect of the goal manipulation on RTs to correct go trials during the modified SART. Goal condition (1: unresolved goal, 0: resolved goal) and centred RRSreflection scores (RRSreflectionc) were entered in block one of the regression, and the interaction term

(goal condition x RRSreflectionc) in block 2 (Table 4). The interaction term did not explain a significant increase in variance in RTs, $\Delta R^2 = 0.034$, $F(1, 52) = 2.132$, $p = 0.150$. Thus, trait reflection was not a significant moderator of the effect of the goal manipulation on RTs during the modified SART task.

Table 4: *Hierarchical linear regression estimating RTs during the modified SART.*

	B	S.E.	β
<hr/>			
Step 1			
Condition	-53.886	28.467	-0.241
RRSreflectionc	-8.250*	3.725	-0.282
<hr/>			
Step 2			
Condition	-54.509	28.172	-0.244
RRSreflectionc	-12.877*	4.861	-0.440
Condition x RRSreflectionc	10.888	7.456	0.242

Step 1: $F(2, 53) = 4.557$, $p = 0.015$, $R^2 = 0.147$

Step 2: $F(3, 52) = 3.814$, $p = 0.015$, $R^2 = 0.180$

Brooding and errors of commission

Hierarchical regression was used to examine whether trait brooding moderated the effect of the goal manipulation on errors of commission during the modified SART.

Goal condition (1: unresolved goal, 0: resolved goal) and centred RRSbrooding scores

(RRSbroodingc) were entered in block one of the regression, and the interaction term (goal condition x RRSbroodingc) in block 2 (Table 5). The interaction term did not explain a significant increase in variance in errors of commission, $\Delta R^2 = 0.003$, $F(1, 52) = 0.186$, $p = 0.668$. Thus, trait brooding did not moderate the effect of the goal manipulation on errors of commission during the modified SART task.

Table 5: *Hierarchical linear regression estimating errors of commission during the modified SART.*

	B	S.E.	β
Step 1			
Condition	-3.142	4.837	-0.088
RRSbroodingc	0.547	0.671	0.111
Step 2			
Condition	-3.129	4.874	-0.088
RRSbroodingc	0.795	0.887	0.161
Condition x RRSbroodingc	-0.591	1.371	-0.078

Step 1: $F(2, 53) = 0.530$, $p = 0.592$, $R^2 = 0.020$

Step 2: $F(3, 52) = 0.410$, $p = 0.746$, $R^2 = 0.023$

* $p < 0.05$, ** $p < 0.01$

Reflection and errors of commission

Hierarchical regression was used to examine whether trait reflection moderated the effect of the goal manipulation on errors of commission during the modified SART. Goal condition (1: unresolved goal, 0: resolved goal) and centred RRSreflection scores (RRSreflectionc) were entered in block one of the regression, and the interaction term (goal condition x RRSreflectionc) in block 2 (Table 6). There was a trend towards the interaction term explaining an increase in variance in errors of commission, $\Delta R^2 = 0.071$, $F(1, 52) = 4.034$, $p = 0.050$. Thus, there was a trend towards trait reflection moderating the effect of the goal manipulation on errors of commission during the modified SART task.

As illustrated in Figure 2, the unstandardized simple slope for participants 1 SD below the mean for trait reflection was 6.362, this was not significantly different from 0, $t(52) = 0.937$, $p = 0.353$. The unstandardized simple slope for participants 1 SD above the mean for trait brooding was -12.936, there was a trend towards this significantly differing from 0, $t(52) = -1.936$, $p = 0.058$. Thus, the effect of the goal manipulation on subsequent errors of commission was greater for participants reporting high levels of trait reflection on the RRS.

Table 6: *Hierarchical linear regression estimating errors of commission during the modified SART.*

	B	S.E.	β
Step 1			
Condition	-3.287**	4.853	-0.092
RRSreflectionc	0.460	0.635	0.099
Step 2			
Condition	-3.138	4.721	-0.088
RRSreflectionc	1.527	0.815	0.328
Condition x RRSreflectionc	-2.509	1.249	-0.351

Step 1: $F(2, 53) = 0.460$, $p = 0.634$, $R^2 = 0.017$

Step 2: $F(3, 52) = 1.669$, $p = 0.185$, $R^2 = 0.071$

* $p < 0.05$, ** $p < 0.01$

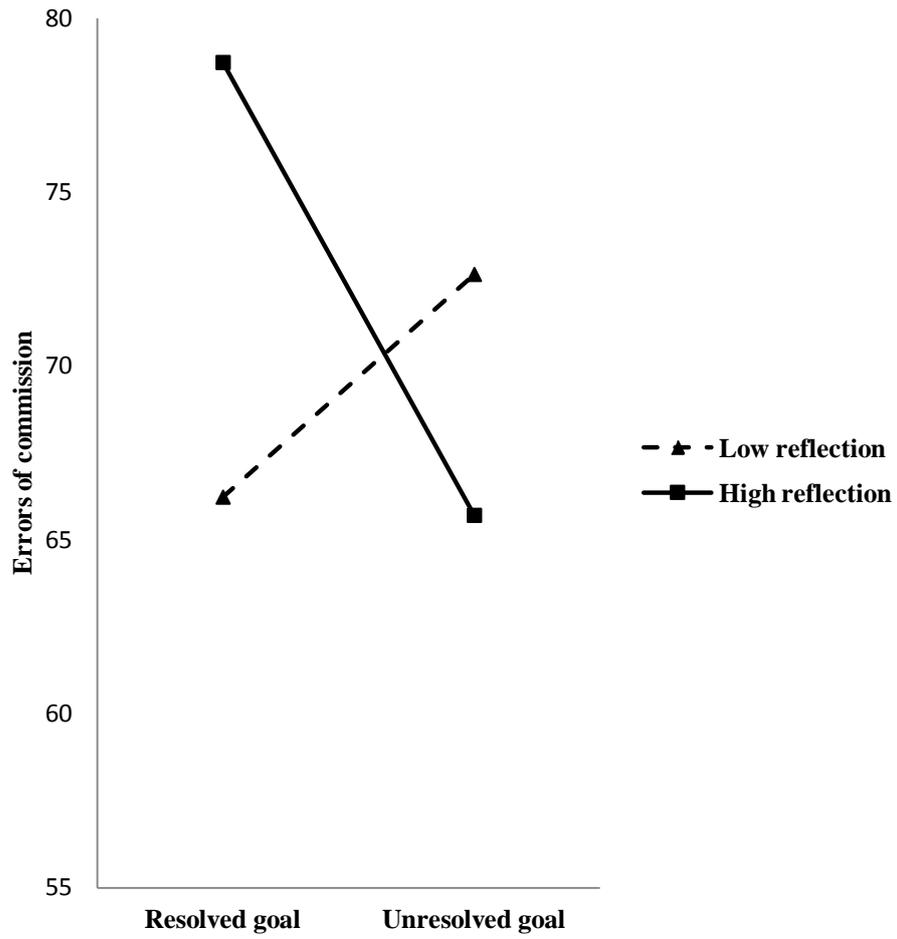


Figure 2: Simple slopes for errors of commission one standard deviation above and below the mean RRSreflection score

Study Five

Brooding and state rumination

Hierarchical regression was used to examine whether trait brooding moderated the effect of the goal manipulation on rumination during the modified Sternberg task. Goal condition (1: unresolved goal, 0: resolved goal) and centred RRSbrooding scores (RRSbroodingc) were entered in block one of the regression, and the interaction term (goal condition x RRSbroodingc) in block 2. The interaction term did not explain a significant increase in variance in state rumination, $\Delta R^2 = 0.003$, $F(1, 54) = 0.162$, $p = 0.689$. Thus, trait brooding did not moderate the effect of the goal manipulation on ruminative thoughts during the modified Sternberg task.

Reflection and state rumination

Hierarchical regression was used to examine whether trait reflection moderated the effect of the goal manipulation on rumination during the modified Sternberg task. Goal condition (1: unresolved goal, 0: resolved goal) and centred RRSreflection scores (RRSreflectionc) were entered in block one of the regression, and the interaction term (goal condition x RRSreflectionc) in block 2. The interaction term did not explain a significant increase in variance in state rumination, $\Delta R^2 = 0.005$, $F(1, 54) = 0.338$, $p = 0.563$. Thus, trait reflection did not moderate the effect of the goal manipulation on ruminative thoughts during the modified Sternberg task.

Brooding and negative intrusion effects

Hierarchical regression was used to examine whether trait brooding moderated the effect of the goal manipulation on negative intrusion effects during the modified Sternberg task. Goal condition (1: unresolved goal, 0: resolved goal) and centred RRSbrooding scores (RRSbroodingc) were entered in block one of the regression, and

the interaction term (goal condition x RRSbroodingc) in block 2. The interaction term did not explain a significant increase in variance in negative intrusion effects, $\Delta R^2 = 0.017$, $F(1, 54) = 1.016$, $p = 0.318$. Thus, trait brooding did not moderate the effect of the goal manipulation on negative intrusion effects during the modified Sternberg task.

Brooding and positive intrusion effects

Hierarchical regression was used to examine whether trait brooding moderated the effect of the goal manipulation on positive intrusion effects during the modified Sternberg task. Goal condition (1: unresolved goal, 0: resolved goal) and centred RRSbrooding scores (RRSbroodingc) were entered in block one of the regression, and the interaction term (goal condition x RRSbroodingc) in block 2. The interaction term did not explain a significant increase in variance in positive intrusion effects, $\Delta R^2 = 0.001$, $F(1, 54) = 0.080$, $p = 0.778$. Thus, trait brooding did not moderate the effect of the goal manipulation on positive intrusion effects during the modified Sternberg task.

Reflection and negative intrusion effects

Hierarchical regression was used to examine whether trait reflection moderated the effect of the goal manipulation on negative intrusion effects during the modified Sternberg task. Goal condition (1: unresolved goal, 0: resolved goal) and centred RRSreflection scores (RRSreflectionc) were entered in block one of the regression, and the interaction term (goal condition x RRSreflectionc) in block 2. The interaction term did not explain a significant increase in variance in negative intrusion effects, $\Delta R^2 = 0.003$, $F(1, 54) = 0.147$, $p = 0.703$. Thus, trait reflection did not moderate the effect of the goal manipulation on negative intrusion effects during the modified Sternberg task.

Reflection and positive intrusion effects

Hierarchical regression was used to examine whether trait reflection moderated the effect of the goal manipulation on positive intrusion effects during the modified Sternberg task. Goal condition (1: unresolved goal, 0: resolved goal) and centred RRSreflection scores (RRSreflectionc) were entered in block one of the regression, and the interaction term (goal condition x RRSreflectionc) in block 2 (Table 17). The interaction term did not explain a significant increase in variance in positive intrusion effects, $\Delta R^2 = 0.001$, $F(1, 54) = 0.080$, $p = 0.778$. Thus, trait reflection did not moderate the effect of the goal manipulation on positive intrusion effects during the modified Sternberg task.

Brooding and negative intrusion effects in terms of errors

Hierarchical regression was used to examine whether trait brooding moderated the effect of the goal manipulation on negative intrusion effects with respect to errors during the modified Sternberg task. Goal condition (1: unresolved goal, 0: resolved goal) and centred RRSbrooding scores (RRSbroodingc) were entered in block one of the regression, and the interaction term (goal condition x RRSbroodingc) in block 2. The interaction term did not explain a significant increase in variance in negative intrusion effects, $\Delta R^2 = 0.012$, $F(1, 54) = 0.671$, $p = 0.416$. Thus, trait brooding did not moderate the effect of the goal manipulation on negative intrusion effects during the modified Sternberg task.

Brooding and positive intrusion effects in terms of errors

Hierarchical regression was used to examine whether trait brooding moderated the effect of the goal manipulation on positive intrusion effects in terms of errors during the modified Sternberg task. Goal condition (1: unresolved goal, 0: resolved goal) and

centred RRSbrooding scores (RRSbroodingc) were entered in block one of the regression, and the interaction term (goal condition x RRSbroodingc) in block 2. The interaction term did not explain a significant increase in variance in positive intrusion effects, $\Delta R^2 < 0.001$, $F(1, 54) = 0.001$, $p = 0.976$. Thus, trait brooding did not moderate the effect of the goal manipulation on positive intrusion effects during the modified Sternberg task.

Reflection and negative intrusion effects in terms of errors

Hierarchical regression was used to examine whether trait reflection moderated the effect of the goal manipulation on negative intrusion effects with respect to errors during the modified Sternberg task. Goal condition (1: unresolved goal, 0: resolved goal) and centred RRSreflection scores (RRSreflectionc) were entered in block one of the regression, and the interaction term (goal condition x RRSreflectionc) in block 2. The interaction term did not explain a significant increase in variance in negative intrusion effects, $\Delta R^2 < 0.001$, $F(1, 54) = 0.013$, $p = 0.908$. Thus, trait reflection did not moderate the effect of the goal manipulation on negative intrusion effects during the modified Sternberg task.

Reflection and positive intrusion effects in terms of errors

Hierarchical regression was used to examine whether trait reflection moderated the effect of the goal manipulation on positive intrusion effects with respect to errors during the modified Sternberg task. Goal condition (1: unresolved goal, 0: resolved goal) and centred RRSreflection scores (RRSreflectionc) were entered in block one of the regression, and the interaction term (goal condition x RRSreflectionc) in block 2. The interaction term did not explain a significant increase in variance in positive intrusion

effects, $\Delta R^2 = 0.001$, $F(1, 54) = 0.031$, $p = 0.860$. Thus, trait reflection did not moderate the effect of the goal manipulation on positive intrusion effects during the modified Sternberg task.